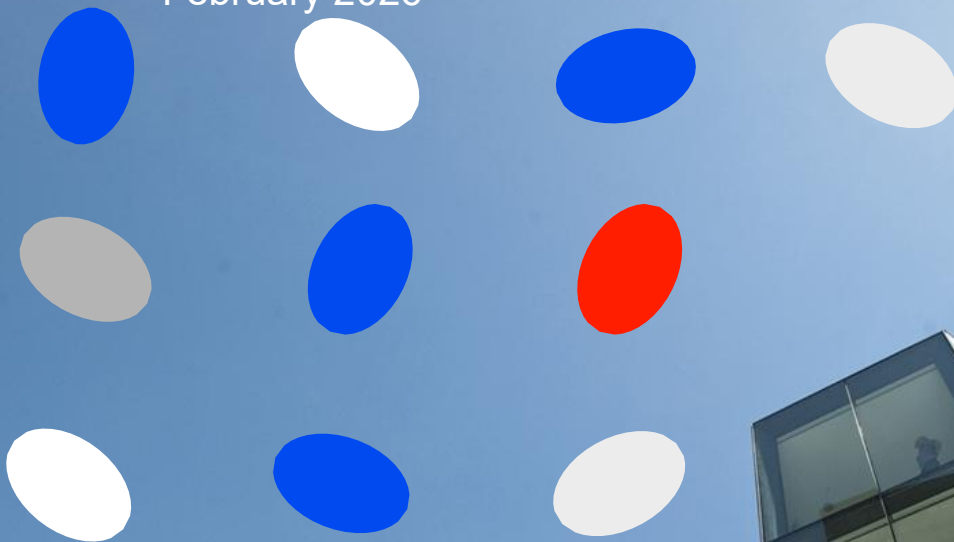


Collaboration in the Australian Quantum Ecosystem

Opportunities and challenges for research security
regulatory frameworks in Australia.

Susanne Lloyd-Jones, UTS Faculty of Law
Kayleen Manwaring, UNSW Faculty of Law and Justice

February 2026



Contents

Introduction	1
Collaboration in the Australian Research Context	1
Collaboration is a paradox	2
Research Gap	3
Structure of Report	3
Methodology	3
Exclusions and limitations of this research	4
Future Research	5
Future Avenues for Publication and Dissemination	5
Spending the Australian Academy of Law Research Grant 2025	5
Part One: Literature Review	6
Research Security	6
Collaboration	6
Part Two: the quantum ecosystem in Australia	8
Quantum technology as transformative research	8
Collaboration in national and international quantum ecosystems	9
Collaboration in the Australian quantum ecosystem	9
Quantum Technology’s link to Research Security	10
Part Three: Preliminary findings from SERD and DTCA submissions	11
The SERD and DTCA reviews – a comparison	11
SERD	11
DTCA	11
Type of Organisations that submitted to SERD and DTCA	12
What role for collaboration in SERD and DTCA?	13
Enablers and Blockers of Collaboration	13
Part Four: International quantum collaborations	15
Collaboration Case Study: QED-C	15
Conclusion	16
Attachment A – Policy Brief	17

Introduction

This report draws on research funded by an Australian Academy of Law Research Grant 2025 (the AAL Grant). It is a scoping analysis of collaboration that was undertaken between July and December 2025 in the context of the 2025 Strategic Examination of Research and Development (SERD) and the 2024 reforms of the *Defence Trade Controls Act 2012* (Cth) (DTCA).

The research identifies a need for a deeper, more nuanced conversation about the meaning and practice of collaboration in the Australian research security context to understand the current and future impact on the quantum technology ecosystem. The research finds that collaboration:

- is repeatedly used in research and development contexts.
- frequently frames discussions and drives research priorities.
- is regularly left undefined.
- is integral to research and innovation for new and emerging technologies.
- is a practice (eg, face-to-face meetings, correspondence and communication, travelling, hosting, attending), a governance mechanism (eg, contracts, partnerships, funding arrangements) and a control or 'nudge' (eg, used to break down silos or influence relationships and research).

Leaving collaboration undefined, especially when communicating about research security frameworks, risks causing confusion and misunderstandings about: the nature of scientific, humanities and social sciences research; who may work with whom; and when collaboration might drift into conduct captured by Australia's export control regime and foreign interference laws.

The research also identifies potential blockers and enablers of collaboration as expressed by a subset of submitters who made submissions to both the SERD and DTCA reviews.

The research will be used to inform future work on:

- the theoretical and practical definitions of collaboration in research contexts.
- evolving national and international research security frameworks and how they might block and enable effective collaboration in the Australian quantum ecosystem.

Collaboration in the Australian Research Context

In Australia, collaboration between researchers, academic institutions, industry participants and government has sustained quantum technology research for over 20 years.¹ Built on decades of collaborative research and development, Australian and international quantum technology ecosystems demonstrate how partnerships between academia, industry and government steer innovation and drive commercialisation. Collaboration makes research possible, bringing together researchers from the same and different disciplines to solve complex, multi-factorial problems arising in human society and in nature.

Research and development policies in Australia and elsewhere encourage industry, government and university collaborations, diversified international partnerships, and responsible research and innovation.² In 2023, the Office of Industry Innovation and Science Australia within the Department of Industry, Science and Resources published its report on the *Barriers to Collaboration and Commercialisation*. The report noted the Australian Government's broader policy objectives to 'increase collaboration and commercialisation to grow revenue and build industry competitiveness.'³

Collaboration was a focal point of the recent Strategic Examination of Research and Development (SERD). The SERD terms of reference included a requirement to address "...barriers to meaningful collaboration".⁴ Led by an independent expert panel, SERD was commissioned by the Department of

¹Department of Industry, Science and Resources, 'State of Australian Quantum' (Report, Australian Government, November 2024) 15.

²See, eg, Quad Investors Network, 'Quantum Science & Technology in the QUAD nations: Landscape and Opportunities' (Report, Quad Investors Network, July 2024) 3.

³Office of Industry Innovation and Science Australia within the Department of Industry, Science and Resources published its report on the *Barriers to Collaboration and Commercialisation*, page 6-7.

⁴Strategic Review of Research and Development, 'Strategic Review of R&D Discussion Paper' (Discussion Paper, 12 February 2025) 5.

Industry, Science and Resources. The expert panel published its discussion paper consultation findings and analysis in July 2025.⁵

Collaboration was identified as a key theme in submissions. Enablers and blockers of collaboration were also identified.⁶ Partnerships between universities and industry were seen as crucial to fostering cultures of collaboration and innovation. The panel reported that submissions to its review suggested, among other things, the creation of a 'national innovation collaboration compact' to strengthen partnerships.⁷

Collaboration is a paradox

Collaboration is considered 'a defining quality of science.'⁸ At its simplest, collaboration is a way of working together to address a shared problem.⁹ It is a form of organisation that can achieve a collective outcome. The Organisation for Economic Cooperation and Development (OECD) views collaboration as essential to basic research, which is facilitated by the exchange and mobility of researchers to advance knowledge.¹⁰ Yet, collaboration in both theory and practice is a paradoxical concept. It can also mean treasonous cooperation with an adversary¹¹ and risks enlivening offences under espionage and foreign interference laws.¹²

The paradox presents problems when the practical reality of research collaboration is considered. The Australian Research Council (ARC) recognises a wide range of collaborative activities in the data it collects about international collaboration under its national competitive grants scheme. Applications for ARC funding must state whether a project involves international collaboration. The ARC seeks information about the nature and type of collaboration occurring, which include 'face-to-face meetings, correspondence such as emails and phone calls, attending or hosting a conference, collaborative fieldwork, hosting an international collaborator, or travelling to an international collaborator.'¹³ This demonstrates a more nuanced understanding of collaboration than co-authorship counts.

The percentage of all ARC funded projects that are international collaborations is 62.2%.¹⁴ ARC funded researchers have the highest number of collaborations with the United States, the United Kingdom and Germany. Canada is the fourth highest collaborating country and China is Australia's fifth highest collaborating country.¹⁵ The top 10 administering organisations of ARC funded research projects are in the Group of Eight.¹⁶

International collaboration continues to be crucial to the success of Australia's quantum ecosystem,¹⁷ yet as a dual-use critical technology in the national interest, quantum technology research and development are at risk of criminal misuse, arms proliferation and foreign interference, which hinders international collaboration.¹⁸

The link between critical technologies, national security and research security is an active and evolving conversation between academics, industry and government in many countries. In Canada, for example, higher education institutions must follow the risk-based *National Security Guidelines for Research Partnerships*.¹⁹

⁵Strategic Examination of Research and Development ("SERD"), Discussion Paper Consultation Findings and Analysis (Report, Australian Government, July 2025).

⁶Ibid, 15.

⁷SERD, above n 5, 26.

⁸David Baker and Justin Powell, *Global Mega-Science: Universities, Research Collaborations, and Knowledge Production* (Stanford University Press, 2024) 24.

⁹Pauline Leonard & Lawrence Leonard, 'The collaborative prescription: remedy or reverie?' (2001) 4(4) *International Journal of Leadership in Education* 383-399, 387-388.

¹⁰OECD, Recommendation of the Council on International Co-operation in Science and Technology, OECD/LEGAL/0237, 3,

¹¹Bruce Macfarlane, 'The paradox of collaboration: a moral continuum' (2017) 36(3) *Higher Education Research & Development*, 472-485, 473.

¹²See eg, *National Security Legislation Amendment (Espionage and Foreign Interference) Act 2018* (Cth), s82.3 - Offence of sabotage involving foreign principal with intention as to national security, 82.4 - Offence of sabotage involving foreign principal reckless as to national security, s91.8 - Espionage on behalf of foreign principal, s91.11 - Offence of soliciting or procuring an espionage offence or making it easier to do so, s92.2 - Offence of intentional foreign interference, s92.3 - offence of reckless foreign interference, 92A.1 - Theft of trade secrets involving foreign government principal.

¹³Australian Research Council, 'NCGP Trends: International Collaboration: Understanding the Data' (Web page)<<https://www.arc.gov.au/ncgp-trends-international-collaboration>>.

¹⁴Ibid.

¹⁵Ibid.

¹⁶Ibid.

¹⁷Department of Industry, Science and Resources, 'State of Australian Quantum' (Report, November 2024) 5.

¹⁸Brendan Walker-Munro, 'Moving beyond "dual use" quantum technologies and the need for new research security paradigms' (2025) 12(136) *EPJ Quantum Technology* 1-23, 12.

¹⁹Brendan Walker-Munro, 'Submission to the Department of Industry, Science and Resources Strategic Examination of Research and Development Discussion Paper' (Submission #46, Strategic Examination of Research and Development, 10 March 2025) 6

Research Gap

Nuanced analysis of how important research security frameworks, such as the *Defence Trade Controls Act 2012* (Cth) (DTCA) and the foreign interference regime impact, alter the definition, practice and governance of collaboration in research and development is needed in Australia.

Academic literature on research security, although evolving rapidly in Australia and internationally, tends to consider collaboration through the lens of national security.²⁰ In 2021, the Centre for Security and Emerging Technology at Georgetown University in the United States published a policy brief entitled *Research Security, Collaboration and the Changing Map of Global Research and Development*.²¹ The brief notes that the ‘open research system’ has provided many benefits, including expanding investment and interconnectedness, but also that it has given rise to new research security challenges.²²

CSET’s research shows that countries rely on collaboration (‘collaborative links’) to connect them to the global research network but that there are significant differences in how they collaborate. CSET recommended “[a] more nuanced understanding of those differences is critical for assessing the unique cost/benefit calculations behind decisions to limit open engagement to address security concerns.”²³

This perspective reflects the common lens of risk and security: “[an] effective response to these security risks in international research collaboration will require an up-to-date and nuanced understanding of the changing global research system.”²⁴

The definition of collaboration used by CSET is based on number of publications with more than one author affiliation, organisation and country. Using co-publication metrics is the most common way of defining collaboration.²⁵ This definition tends to exclude the practical, social and political aspects of collaboration, which are harder to qualitatively measure but are equally important to understanding positive and negative impacts.²⁶ CSET notes that further analysis using their data may help to identify different types of collaboration, such as researcher-driven collaboration.²⁷ This is important for building a more complete understanding of the practice and governance of collaboration.

Structure of Report

The report is structured as follows:

- Part One provides a brief literature review of research security and collaboration.
- Part Two describes the quantum technology ecosystem in Australia, noting the breadth and depth of collaboration supporting the ecosystem.
- Part Three considers the views of dual-submitters to the DCTA and SERD consultations. This part takes a deeper dive into the place of collaboration in Australia’s research and development environment and its export control regime, specifically looking at the reform of the *Defence Trade Controls Act 2012* (Cth) in 2024.
- Part Four presents a brief case study of formal, structured collaboration by focusing on the Quantum Economic Development Consortium (QED-C) in the United States.
- Part Five provides a brief conclusion.

Methodology

The research conducted under the AAL Grant applied doctrinal and empirical research methods to:

- conduct a literature review of academic literature on collaboration and research security.
- collect publicly available information and source material on existing collaborations between industry, government and academia both nationally and internationally.

²⁰See, eg, Melissa Flagg, Autumn Toney and Paul Harris, ‘Research Security, Collaboration and the Changing Map of Global R&D’ (Policy Brief, Centre for Security and Emerging Technology, June 2021);

²¹Melissa Flagg, Autumn Toney and Paul Harris, above n 20.

²²*Ibid*, 1

²³*Ibid*.

²⁴*Ibid*, 3.

²⁵Bruce Macfarlane, above n 11, 475.

²⁶*Ibid*, 482.

²⁷Melissa Flagg, Autumn Toney and Paul Harris, above n 20, 9.

- examine legal regimes, such as dual-use goods and export control regimes, which may enable and block collaborative arrangements.
- select 1 international collaboration case study for further comparative analysis.
- analyse a subset of public policy submissions of university, government and industry stakeholders who submitted to both the Strategic Examination of Research and Development (SERD) and the review of the *Defence Trade Controls Act 2012* (Cth) (DTCA).

The approach allowed preliminary analysis of stakeholder perspectives of selected organised groups engaged with issues of export control and research and development. The research identifies a subset of 15 submitters who fall into this category.

By reviewing submissions to both reviews, the research identifies which submitters were sufficiently engaged to submit to both reviews, how submitters regarded collaboration in the context of SERD and the DTCA, and whether quantum technologies were mentioned in submissions. This analysis also provides scoping information about the composition of submitters to both reviews and how submitters approached collaboration.

The research did not require ethics approval as it involved desk-based research of publicly available information and source materials.

Exclusions and limitations of this research

The research funded by the AAL Grant was undertaken with a view to supporting future research.

Due to the unavoidable limits imposed on the research scope by funding and resource constraints, its findings are scoping in nature. The research focuses on the rules that are most relevant to research on quantum computing technologies as critical technologies in the national interest. For this reason, the research considers the impact of Australia's export control regime, in particular the *Defence Trade Controls Act 2012* (Cth) and the Defence Strategic Goods List (DSGL) on collaboration.

The research presented in this report does not consider all possible legal rules that might apply to researchers. There are clearly other legal and governance frameworks that restrict opportunities for effective collaboration. These include intellectual property law, laws relating to foreign interference, foreign investment and critical infrastructure regulation.

Submissions to the reviews of the foreign interference regime, which includes the foreign influence transparency scheme, were not examined under the AAL Grant due to funding and resource constraints. However, it is important to note that during the passing of the *Foreign Influence Transparency Scheme Act 2018* (Cth), the international collaborative work of universities and academics was excluded from key operative definitions in the scheme.²⁸ Additionally, the University Foreign Interference Taskforce (UFIT) developed the Guidelines for countering foreign interference in the Australian university sector. The guidelines are relevant to this research to the extent that they mention collaboration in the context of research security.

Other developments in Australia include the Australian Security Intelligence Organisation's *Protect Your Research: Collaborate with Care*, a booklet aimed at informing researchers about foreign interference and espionage,²⁹ and the ARC's strengthened research security initiatives, which are the result of amendments to the *Australian Research Council Act 2001* (Cth) in July 2024. The ARC developed the risk-based *ARC Countering Foreign Interference Framework* for managing national security risks across the national competitive grants program life-cycle.³⁰

Legal frameworks aimed at research security, such as the export control regime and foreign interference, operate as enablers and blockers of collaboration. These frameworks enable collaboration with some countries yet exclude collaboration with others.

²⁸See *Foreign Influence Transparency Scheme Act 2018*(Cth), s 11.

²⁹Australian Security and Intelligence Organisation, *Protect Your Research: Collaborate with Care* (Booklet, May 2023) <<https://bjbs-news.csu.edu.au/wp-content/uploads/sites/4/2023/05/Protect-Your-Research-Collaborate-with-Care-Booklet.pdf>>.

³⁰Australian Research Council, 'Research Security' (Web page, 1 July 2024) <<https://www.arc.gov.au/funding-research/research-security#arc-countering-foreign-interference-framework>>.

Future Research

Australian quantum technology researchers and companies are some of the most successful and mobile in the world. Continuing to foster collaboration in the quantum ecosystem in Australia is important to its future success. Research security frameworks have the potential to both enable and block collaborations.

For this reason, future research might:

- Review and analyse the final report of SERD and its views on collaboration.
- Enquire into the theoretical and practical definitions of collaboration used in research contexts for more nuanced and precise understanding of the concept and thus understanding of the impact of restrictive frameworks.
- Conduct qualitative research on how the export controls scheme and the foreign interference regime impact research collaboration in the quantum technology ecosystem.
- Enquire into how different concepts of collaboration operate in research security contexts.
- Examine collaborative quantum technology research and innovation impacted by research security frameworks.

Future Avenues for Publication and Dissemination

The publicly available information and data collected for the project, including literature and policy submissions, will be used as a basis for further development, publication and dissemination. It is hoped that the preliminary research will lead to:

- Evidence to support an application for further funding on the topic of collaboration and research security in the quantum ecosystem.
- Submission of a co-authored journal article to a high quality Australian or International law and legal technology journal, such as the *ANU Journal of Law and Technology* or *EPJ Quantum Technology*.
- Acceptance of an abstract to a national or international conference presentation, such as the British and Irish Law Education and Technology Association (BILETA) Annual Conference 2026 or the 13th Governance of Emerging Technology and Science Conference 2026.
- An article pitched to *The Conversation*.
- Advice for government on how to better protect and develop collaboration and innovation in the quantum technology ecosystem.
- A stakeholder workshop or research symposium on collaboration and research security.

Spending the Australian Academy of Law Research Grant 2025

This report provides evidence of scoping research funded by the AAL Grant.

The research was undertaken by Dr Susanne Lloyd-Jones, the grantee, with research assistance provided by Ms Jennifer Westmorland.

All money received under the AAL Grant was spent in accordance with the AAL Grant Activity. The AAL Grant funds were used to employ Ms Jennifer Westmorland as a casual UTS Higher Education Worker under the UTS Staff Agreement 2021 at Level 6, Step 1 (\$65.64 per hour, increasing to \$66.62 on 1 August 2025), plus 30% oncosts, for approximately 63 hours, in total \$4936.55.

Associate Professor Kayleen Manwaring provided in-kind support for this project as a research collaborator and mentor. Associate Professor Manwaring is a co-author of the report and the attached policy brief (Attachment A).



Dr Susanne Lloyd-Jones

13 February 2026

Part One: Literature Review

Research Security

At its simplest, research security means measures to protect academic research from national security threats.³¹ Research security is not a new concept, as such measures have arguably been in place since humans began researching and developing inventions and innovations to fight each other and defend sovereign territory. However many commentators point to the international arrangements that followed the Second World War, the period of the Cold War and its subsequent demise from the late 1980s and early 1990s with the collapse of the Soviet Union.³² Walker-Munro's study defines research security as 'a set of actions taken by governments or other public or funding bodies, usually in collaboration with academia and research institutes, to safeguard against the risk of undesired technology transfers, interference in or misuse of research, and threats to research integrity.'³³

However, research security is defined in different ways depending on the country you are in. The G7 defines research security as

The actions that protect our research communities from actors and behaviours that pose economic, strategic, and/or national and international security risks. Particularly relevant are the risks of undue influence, interference, or misappropriation of research; the outright theft of ideas, research outcomes, and intellectual property by states, militaries, and their proxies, as well as by non-state actors and organized criminal activity; and other activities and behaviours that have adverse economic, strategic, and/or national security implications.³⁴

The OECD defines research security as

Research security means anticipating, preventing and managing risks to the research and innovation system, including the misappropriation of R&D that could harm national or economic security; foreign interference or malign influence; and violations of the freedom of research. It focuses on avoiding the undesirable transfer of critical knowledge and technology (including dual-use) through proportionate and risk-based safeguards that keep international co-operation as open as possible and as closed as necessary.³⁵

The OECD further adds that the 'main goal of research security is to protect the research ecosystem and thus protect legitimate national and economic interests.'³⁶ The OECD identified over 300 policy instruments related to research security, which includes national export controls and foreign interference regimes.³⁷

In the context of research security, collaboration, especially international collaboration, is central to the operation of the research ecosystem and links to freedom of scientific research and values considered worth protecting, such as reciprocity, equity and non-discrimination.³⁸ It is considered an essential element of a properly-functioning global research ecosystem and plays a significant role in scientific and technological discovery.³⁹

Collaboration

Collaboration is a paradoxical concept, despite its frequent, undefined and ambiguous use in academic and policy literature. Whether collaboration is positive or negative depends on the context. In the context of research security, collaboration is often marked as formal contracts and partnerships, which look like commercial arrangements. However, the literature shows that collaboration can mean different things. It can operate as a practice, as a governance mechanism and as a control or nudge, to break down silos or

³¹Brendan Walker-Munro, above n 18, 2.

³²See for example, Peter Burgess, 'The Future of Research Security in the Social Sciences and the Humanities (Discussion Paper, Standing Committee for the Humanities, European Science Foundation, July 2014) 7-10.

³³Brendan Walker-Munro, above n 18, 4.

³⁴James, A., Flanagan, K., Naisbitt, A., & Rigby, J. (2025). European research security: threat perspectives and the responses of policy makers and research performing organisations. *Manchester Institute of Innovation Research*. 9-10

³⁵Yoran Beldengrun, 'What is research security and why does it matter for global science?' OECD (Blog, 21 November 2025): <https://www.oecd.org/en/blogs/2025/11/what-is-research-security-and-why-does-it-matter-for-global-science.html>

³⁶OECD, *Research Security Portal*, STIP Compass: <https://stip.oecd.org/stip/research-security-portal>

³⁷Ibid.

³⁸OECD, *Research Security Portal*, STIP Compass: <https://stip.oecd.org/stip/research-security-portal>.

³⁹James, A., Flanagan, K., Naisbitt, A., & Rigby, J, 'European research security: threat perspectives and the responses of policy makers and research performing organisations' (2025) *Manchester Institute of Innovation Research* 9

control individual researchers.⁴⁰ Collaboration may also cause conflict, impede academic freedom and restrict dissemination of research.⁴¹

Due to its widespread use in policy and higher education contexts, collaboration requires more interrogation and examination. A brief review of the literature reveals contradictory meanings of collaboration. Citing the Oxford English Dictionary, MacFarlane notes that it can mean both 'the action of working with someone to produce something' to 'traitorous cooperation with an enemy.'⁴²

There are different forms of collaboration in university contexts when academics work with a range of research partners, including colleagues, students and research assistants. It can mean collaboration with international colleagues and in partnership with international research institutions and private industry.⁴³ According to MacFarlane, collaboration involves sharing facilities and laboratories, research data, researchers across institutions and national boundaries, and cooperation between institutions at a national and international level.⁴⁴

The relative success (or failure) of collaboration in research is often assessed using a quantitative 'measurement' approach. In academia, collaboration is often defined in terms of co-authorship of academic publications and numbers of partnerships and is measured in this way. Many studies use co-authorship and co-publication as the measure of collaboration, particularly international collaboration.⁴⁵ This measure of collaboration is not without its critics. Even though bibliometric evidence of co-authorship can measure certain kinds of collaboration, it excludes the social and political dynamics of collaboration.

There are also downsides to collaboration that are not captured by the quantitative approach, such as competition between researchers, inequalities based on gender and race in international collaborations, loss of authorship, hiding conflicting research priorities between researchers and groupthink.⁴⁶ The positive and negative effects of collaboration need to be understood, including that the focus on measurement systems means that other forms of collaboration, such as mentoring and intellectual generosity, are not measured.

Collaboration in a research security context is difficult policy and regulatory terrain as it shows that if you just measure partnerships and co-authorship, then other fundamental relationships may be missed, which create problems for research security. MacFarlane concludes that 'reward and recognition systems take little account of such forms of collaboration because they are hard to measure in terms of individual output even though they are essential to the nurturing of early career researchers and the advance of science as a common goal for the benefit of wider society.'⁴⁷

The sole use of a measurement approach to collaboration obscures its political and social dimensions, and its pluralist and contradictory nature. A narrow view of collaboration that is built around a measurement frame is likely to ignore the potentially larger impact of restrictive frameworks on intellectual generosity, mentoring and communication, and runs the risk of perpetuating discrimination, inequality and maintaining the current unequal status quo between researchers.

Collaboration is better defined and viewed with more nuance than a mere measurement frame, to reveal the actual dynamics at work and examine its different meanings and affordances in different contexts.

⁴⁰Bruce MacFarlane, above n 11, 477

⁴¹Ibid.

⁴²Ibid, 473.

⁴³Ibid, 473-475.

⁴⁴Ibid.

⁴⁵See for example, Melissa Flagg, Autumn Toney and Paul Harris, above n 20, 2-4.

⁴⁶Bruce Macfarlane, above n 11, 473-475.

⁴⁷Ibid, 482.

Part Two: the quantum ecosystem in Australia

According to the *State of Australian Quantum* report published in November 2024 by the Department of Industry, Science and Resources (DISR), the quantum ecosystem in Australia is thriving. The ecosystem is comprised of 26 organisations pursuing quantum technology research, 16 of which are universities, 4 are government research agencies and 6 are Australian Research Council (ARC) Centres of Excellence.⁴⁸

In December 2025, the ARC awarded funding to 2 new centres of excellence: the ARC Centre of Excellence in Mathematics for Quantum Era Security and Trust (MathQuEST) and the ARC Centre of Excellence for Quantum Computer Performance and Integration.⁴⁹

There are over 50 facilities and laboratories undertaking quantum technology research and development. Australia has 38 quantum businesses, the majority of which are head-quartered in Australia. The State of Quantum report notes that there were 22 new domestic collaborations with quantum businesses across several sectors of the economy. There have been 19 new international collaborations since the launch of the national quantum strategy in 2023.⁵⁰

Additionally, Australia established 5 quantum related international arrangements, and investment in quantum businesses is steadily increasing, with the Australian and Queensland governments entering a joint investment of \$940 million in PSI Quantum, a company co-founded by Australians with its Asia-Pacific head-quarters in Brisbane.⁵¹

Quantum technology as transformative research

Quantum mechanics emerged as a field of physics in the early 20th century.⁵² Considered the 'first quantum revolution', quantum mechanics led to the development of laser technologies, transistors and semi-conductors, X-ray and other imaging.⁵³

At its simplest, quantum technology uses the 'building blocks of nature', that is, subatomic particles, to improve many aspects of life, including aspiring to meet human, animal, environmental, medical, defence, economic and energy needs.⁵⁴

Quantum technologies are based on the same quantum mechanics that are responsible for the underlying function of computer chips, medical imaging and other commonplace technologies of modern life.⁵⁵

Quantum technology is transformative research.⁵⁶ The National Science Foundation of the United States defines transformative research as ideas 'that have the potential to radically change our understanding of important an existing scientific or engineering concept or leading to the creation of a new paradigm or field of science or engineering. Such research also is characterized by its challenge to current understanding or its pathway to new frontiers.'⁵⁷

The success of transformative research usually depends on some form of collaboration, which involves a combination of connection, trust and friendship between researchers.⁵⁸ Transformative research is also

⁴⁸Department of Industry, Science and Resources (DISR), 'State of Australian Quantum' (Report, Australian Government, November 2024) 15.

⁴⁹Australian Research Council, *8 new ARC Centres of Excellence set to transform Australia's future* (Media Release, 9 December 2025).

⁵⁰Department of Industry, Science and Resources, above n 48, 6-7.

⁵¹Ibid.

⁵²Ibid, 44.

⁵³OECD, *Quantum technologies as a new paradigm for digital economies and societies* (Policy Brief, 4 February 2025) 1

⁵⁴Ibid.

⁵⁵Gary Marchant et al, 'Learning from Emerging Technology Governance for Guiding Quantum Technology' (2025) 31(2) *Richmond Journal of Law & Technology* 266, 269-276.

⁵⁶OECD, *Mapping the global quantum ecosystem – A comprehensive analysis based on innovation, firm, investment, skills, trade and policy data*, December 2025, 113. See also Philip Inglesant, Carolyn Ten Holter, Marina Jirotko and Robin Williams, 'Asleep at the wheel? Responsible Innovation in Quantum Computing' (2021) 33(11) *Technology Analysis and Strategic Management* 1364, 1366 (the authors argue that the transformative capacity of quantum technologies, such as quantum computing, should be approached with care and forethought.)

⁵⁷Jeanne Fair, *Scientific Collaboration: Strategies for Successful Research Teams* (2023, John Hopkins University Press), 26.

⁵⁸Ibid, 26.

usually dependent on partnerships with industry and government, as well as a close alignment with defence, research and development and/or innovation policy.⁵⁹

Collaboration in national and international quantum ecosystems

Due to the complexity, cost and scale required for quantum technology development, collaboration must be seen as a critical factor in advancing quantum technologies, promoting innovation and international cooperation.⁶⁰

In December 2025, the OECD published a comprehensive analysis of the global quantum ecosystem,⁶¹ which outlines the features of national and international quantum ecosystems. The report also highlights the nature of collaboration in the global quantum ecosystem, including tracking international collaborations identified from patenting activity,⁶² identifying cross-country collaborations,⁶³ government collaboration⁶⁴ and international scientific collaboration.⁶⁵ The report also outlines a case study of QED-C, a strategic collaboration between industry, academic institutions and the United States government.⁶⁶

International co-operation is important to most countries' quantum strategies.⁶⁷ The importance is evidenced in the number of international collaborations relating to quantum. In many countries, independent organisations and bodies have been created to oversee quantum initiatives, and foster collaboration and co-operation in the ecosystem.⁶⁸

However, there is a view that the 'intensity' of international collaboration may be slowing down. The OECD reports that rates of cross-country co-authorship are in decline, linking it to 'rising geopolitical tensions around technologies deemed critical and associated policies such as the widened use of export controls with a bearing on quantum technologies.'⁶⁹

The OECD notes that 'international relations in quantum science and technology are increasingly influenced by strategic considerations.'⁷⁰ Geopolitical tensions between the United States and China over critical technologies and minerals have increased scrutiny of cross-country research collaborations. The OECD notes that export controls have become a key tool for restricting the transfer of sensitive technology, listing the countries that have enhanced their controls, including Australia, France, Canada, China, the United States, several European countries, Japan, Korea, New Zealand and the United Kingdom.⁷¹

The strategic partnership between the United States, the United Kingdom and Australia through the AUKUS arrangement has changed export control regimes in each country. Foreign interference and influence legislation has also impacted universities and industry partnerships.

Collaboration in the Australian quantum ecosystem

The quantum ecosystem in Australia is supported by sustained investment and funding from government and industry.⁷² It is built on formal and informal collaborative relationships, structures and partnerships, from university centres of excellence to public private partnerships and joint ventures between industry, government and academic institutions.⁷³

Partnerships with industry and government are purposeful and aligned and are formalised through agreements. For example, Australian company Q-Ctrl has commercial relationships with Network Rail,

⁵⁹OECD, OECD Science, 'Technology and Innovation Outlook 2025: Driving Change in a Shifting Landscape' (Report, 19 September 2025) 14-15.

⁶⁰OECD, 'Mapping the global quantum ecosystem – A comprehensive analysis based on innovation, firm, investment, skills, trade and policy data' (Report, December 2025) 2

⁶¹Ibid.

⁶²Ibid, 52.

⁶³Ibid, 54, 66.

⁶⁴Ibid, 113-127.

⁶⁵Ibid, 130.

⁶⁶Ibid, 124

⁶⁷OECD, 'An Overview of National Strategies and Policies for Quantum Technologies' (OECD Digital Economy Papers No.379, December 2025), 6.

⁶⁸Ibid,16.

⁶⁹OECD, above n 60, 124

⁷⁰OECD, above n 59, 16.

⁷¹Ibid, 20.

⁷²DISR, above n 1, 15.

⁷³Ibid, 10-12.

Transport NSW, the Australian Army, the University of Hull and many other entities, both public and private.⁷⁴

In Australia, the establishment of Quantum Australia in 2024 institutionalised collaboration across the quantum ecosystem. Quantum Australia's stated role is to 'drive growth of Australia's quantum ecosystem by delivering programs to support the National Quantum Strategy'.⁷⁵

Quantum Australia's mission, among other things, is to implement collaborative programs to grow and integrate quantum technologies into diverse sectors of the Australian economy. It does this through connecting researchers and industry participants, partnerships, funding opportunities, idea incubators and other training development and development.⁷⁶

The quantum ecosystem in Australia will continue to face ongoing pressure from the growing incidence of national and international measures to protect quantum technologies.

Quantum Technology's link to Research Security

Collaboration plays a significant role in the quantum ecosystem in terms of research and development and in the context of the DTCA.

Quantum technologies are listed on the *Defence Strategic Goods List*.⁷⁷ They are also listed as critical technologies in the national interest by the Australian government.⁷⁸

Collaboration and research security operate as twin goals of dual-use and critical technology research and development policies. The next section looks at collaboration in the context of research and development (SERD) and research security (DTCA).

⁷⁴See, eg, Q-Ctrl, 'Accelerating the schedule for quantum-enhanced rail' (Web page) <<https://q-ctrl.com/case-study/accelerating-the-schedule-for-quantum-enhanced-rail>>.

⁷⁵Quantum Australia, 'About Us' (Web page) <<https://www.quantum-australia.com/about-us>>.

⁷⁶Quantum Australia, 'Programs' (Web page) <<https://www.quantum-australia.com/programs>>.

⁷⁷*Defence Strategic Goods List 2024* (Cth) s 4.2, s 4.A.901, s 5.A.002.c.

⁷⁸Department of Industry, Science and Resources, *List of Critical Technologies in the National Interest* (19 May 2023) Department of Industry, Science and Resources < <https://www.industry.gov.au>>.

Part Three: Preliminary findings from SERD and DTCA submissions

A subset of submissions of two recent Australian Government consultations: one on the recent Strategic Examination of Research and Development (SERD) and the other on the 2024 reforms of the *Defence Trade and Controls Act 2012* (Cth) (DTCA) were examined for the purpose of ascertaining stakeholder positions on collaboration in two related but distinct contexts.

The research examined a subset of submissions where submitters contributed to both SERD and DTCA. The focus on a subset of submitters was necessary due to funding and resource constraints.

Choosing a subset of submitters who made submissions to both reviews offered a complete, manageable data set of interested industry, government and university stakeholders. The research identified a subset of 15 submitters to both reviews.

The comparison of the treatment of collaboration in these contexts reveals what submitters believe are the enablers and blockers of collaboration in general and specific terms. The research revealed that there is mostly convergence and some divergence between the submissions on the blockers and enablers of collaboration in research contexts.

The SERD and DTCA reviews – a comparison

SERD

As part of a consultation process launched in 2024, the SERD expert panel was tasked with reviewing the current and comparative state of Australia's research and development system, including considering opportunities to 'strengthen linkages between research and industry, allowing greater mobility of researchers and innovators between sectors and addressing barriers to meaningful collaboration.'⁷⁹ SERD was focused on the structural elements of research and development, such as funding, strategy and creating research precincts.

The SERD expert panel emphasised the importance of collaboration in research and development. The National Science and Research Priorities, which 'emphasise the science and research collaborations Australia will need to solve our greatest challenges', was cited with approval in the discussion paper. In addition, AUKUS is acknowledged as an arrangement that will 'improve sovereign capability and strengthen international collaborative R&D relationships.'⁸⁰

Pillar II of AUKUS, which includes arrangements concerning critical technologies in the national interest, will be key in securing collaboration between research in mostly defence-led R&D. Collaboration also arises in the context of foreign interference, with SERD commenting that '[e]ffective integrity measures, research security, and coordination with international partners will be critical to secure collaborations and safe foreign investment in R&D.'⁸¹

Looking more closely at academia and industry collaborations, the SERD discussion paper noted that Australia's focus on basic and applied research means that there is poor collaboration and research translation between industry and academia.⁸² SERD's figures tend to suggest that industry partners are not benefitting from collaborations with research institutions.⁸³ More flexible collaboration is recommended to give flexibility to all players in the R&D system. Collaboration was discussed in submissions to SERD but largely left undefined. Solutions to create the conditions for collaboration are discussed below as 'enablers' of collaboration.

DTCA

In 2024, following the *Defence Strategic Review 2023*, Australia began its reform of its export control framework, primarily implemented under the *Defence Trade Controls Act 2012* (Cth) (DTCA), which was subject to review by the Senate Standing Committees on Foreign Affairs, Defence and Trade. The DTCA

⁷⁹Department of Science, Industry and Resources, Strategic Examination of R& D Discussion Paper (Issues Paper, 12 February 2025) 5.

⁸⁰*Ibid.*, 14.

⁸¹*Ibid.*

⁸²*Ibid.*

⁸³*Ibid.*, 19.

controls the support, publication and brokering of tangible and intangible goods and technology listed on the Defence Strategic Goods List, and in that way constitutes a major Australian tool of research security.

Due to Australia's international obligations under the multilateral export control regimes of which Australia is a member, export controls were in operation in Australia before the enactment of the DTCA.⁸⁴ The export controls framework routinely incorporates dual-use technology and were originally designed to limit arms proliferation.⁸⁵

The DTCA gave effect to the Australia-United States Defence Trade Cooperation Treaty signed by the Howard government in 2007. The *Defence Trade Controls Act 2012* (Cth) (DTCA) is now an established part of the defence export controls legislative framework that is comprised of the *Customs Act 1901* (Cth) and Customs (Prohibited Exports) Regulation 1958, the *Weapons of Mass Destruction (Prevention of Proliferation) Act 1995* (Cth).⁸⁶

The DTCA contains criminal offences for the supply of goods, software and technology, and the provision of certain services without a permit. It also establishes a permit regime for certain activities and entities. In 2021, Australia, along with the United Kingdom and the United States entered into the AUKUS arrangements. Part of the AUKUS arrangements involved changes to the export control regimes of the three countries to 'enable collaboration at the speed and scale required' to meet the challenging and evolving geopolitical environment. As a consequence, Australia, the UK and the US implemented a licence-free environment in their export controls regulation between the three countries.⁸⁷

Type of Organisations that submitted to SERD and DTCA

The figure below shows the type of organisation that submitted to both DTCA and SERD.

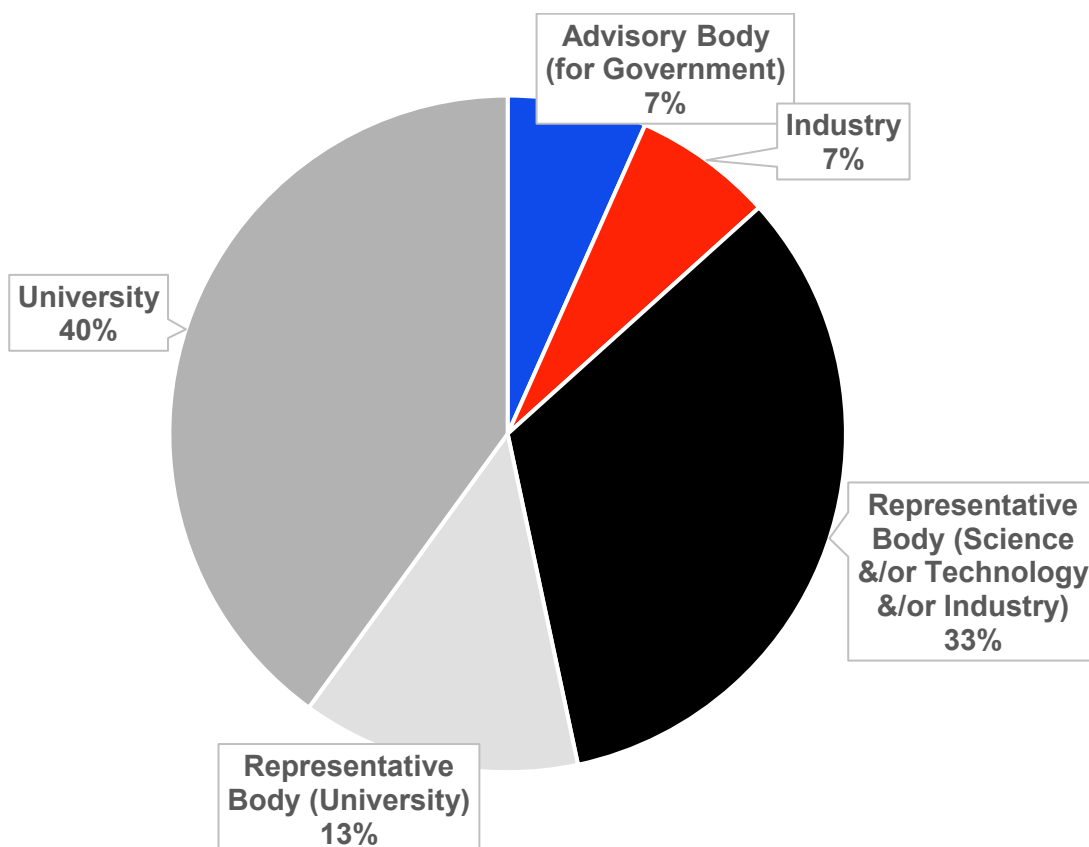


Figure 1: Type of Organisation that submitted to both DTCA and SERD.

⁸⁴Department of Defence, 'Export Controls Framework – International Obligations' (Webpage) <<https://www.defence.gov.au/business-industry/exporting/export-controls-framework/international-obligations>>.

⁸⁵Brendan Walker-Munro, above n 18, 10-11; Department of Defence, above n 84.

⁸⁶Department of Defence, above n 84.

⁸⁷Department of Prime Minister and Cabinet, 'Fact Sheet: Implementation of the Australia-United Kingdom – United States Partnership (AUKUS)' (Fact Sheet, Australian Government, September 2021) 1-3 <<https://pmtranscripts.pmc.gov.au/sites/default/files/AUKUS-factsheet.pdf>>.

What role for collaboration in SERD and DTCA?

University submitters were the most common submitters to both reviews and had the most to say about collaboration. Using document analysis, we identified the common types of collaboration discussed by submitters. The table below charts the discussion of collaboration by submission type (either SERD or DTCA).

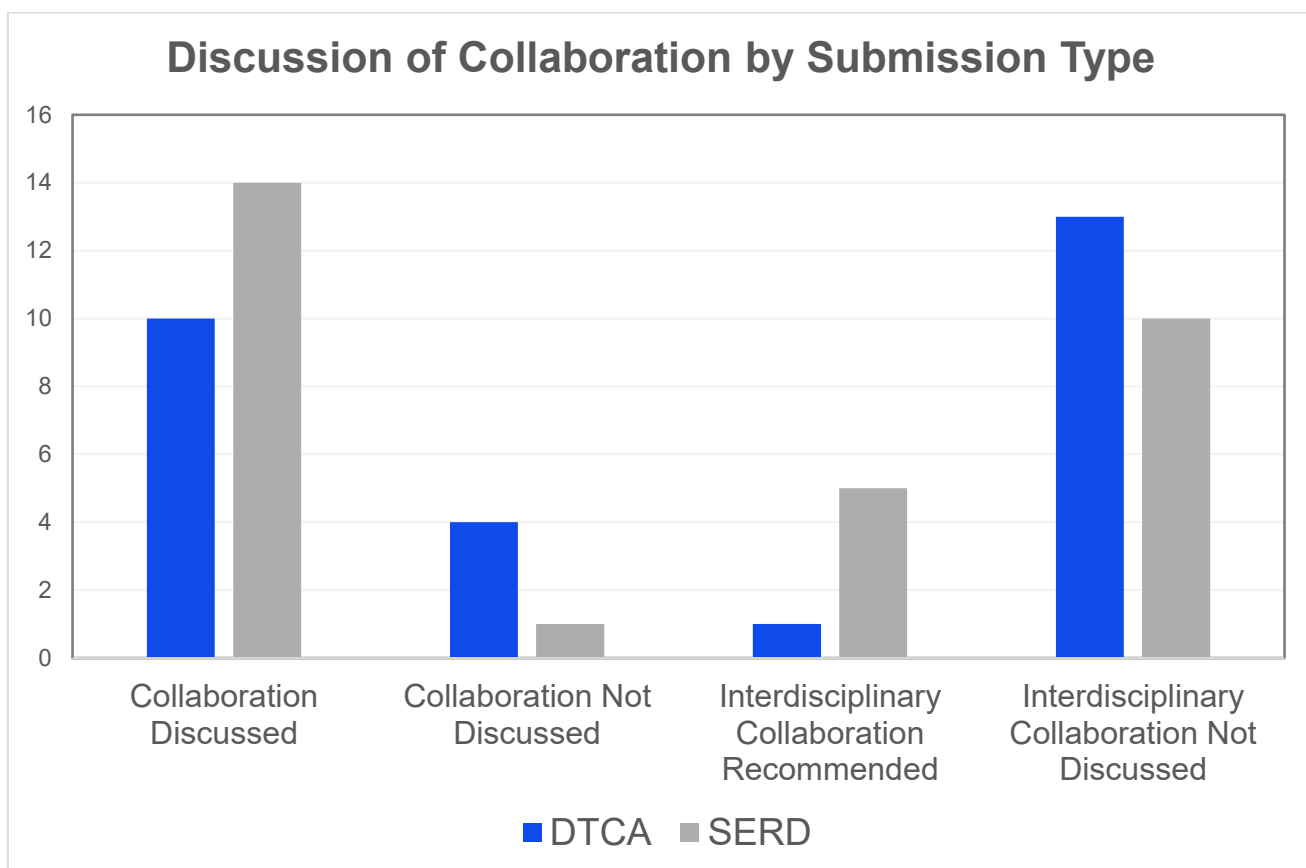


Figure 2: Type and number of submissions in which collaboration was discussed

Enablers and Blockers of Collaboration

The tables below provide a high-level summary of the findings from the submissions.

Summary of enablers and blockers of collaboration from SERD submissions

Enablers	Blockers
Secondments	Funding complexity
Dual appointments	Fragmented processes
Funding for collaboration	Complex Intellectual property negotiations
National facilities access	Visa and immigration restrictions
International collaboration opportunities	

Clockers and enablers of collaboration from the DTCA submissions in the context of the export controls framework reform process:

Enablers	Blockers
Statutory exemptions for fundamental research	Legal ambiguity
Expanded Foreign Countries List	Narrow Foreign Country List
Streamlined permit system	Administrative burden of compliance
Proportional liability	Slow permit regime
Detailed guidance for researchers and industry participants	Harsh penalties for non-compliance

The preliminary results of our review of the subset of SERD and DTCA submissions showed that SERD submissions emphasised building collaboration through structural changes, such as funding and institutional arrangements. On the other hand, DTCA submitters focused on protecting collaborations, including current and future collaborations, from regulatory complexity, including disproportionate and unintended impacts of regulation.

Part Four: International quantum collaborations

The Department of Industry, Science and Resources of the Australian Government describes Australia as a country 'recognised as a global quantum leader' and the National Quantum Strategy of Australia envisions Australia to be the 'leader of the global quantum industry in 2030'.⁸⁸The importance of international collaboration in the quantum ecosystem cannot be overstated. In July 2024, the Quad Investors Network (QUIN) committed to increasing collaboration in the quantum ecosystem at all levels among the Quad nations of Australia, India, Japan and the United States.⁸⁹

Submitters to SERD raised international collaboration as a means of building research collaborations nationally and internationally. At the national level, industry-university partnerships were favoured in the SERD submissions.

To diversify sources of collaborations and funding, some submitters recommended that international research consortia and collaborations should be pursued. For example, the Group of Eight recommended that Australia pursues an association with Horizon Europe and its successor from 2028, the European Union's Framework Programme for Research and Innovation (FP10).⁹⁰

In the United States, the Quantum Economic Development Corporation (QED-C) is an industry consortium whose mission is to advance quantum technologies through innovation and collaboration.⁹¹ Unlike Horizon Europe,⁹² QED-C's specific purpose is to foster collaboration between businesses, research institutions and government agencies to develop and strengthen the quantum technology ecosystem.

QED-C was chosen as a case study for future research because it provides an example of a formal approach to collaboration for the development of quantum technology. Its core purpose is to advance quantum technologies by facilitating collaboration between industry, government and academia. Research about how QED-C operates in practice will provide lessons for understanding quantum specific collaboration, especially how it practices collaboration and encourages collaborative relationships within the United States and with other countries in the current strategic and geopolitical environment.

Collaboration Case Study: QED-C

QED-C was founded in 2019 with support from the National Institute of Standards and Technology (NIST) and is part of the United States' quantum strategy for advancing quantum information science as called for by the *National Quantum Initiative Act of 2018*.⁹³

QED-C is a vehicle for a range of collaboration from formal and structured collaboration through to networking relationship building. QED-C appears to be inclusive, with membership available to various types of members (corporations, academics, research institutions and other entities related to the quantum industry), and not limited to those in the US.

It is also open to the rest of the international community; it extends to members that are headquartered in or have most of the ownership or control in 39 countries.⁹⁴

⁸⁸DISR, 'National Quantum Strategy: Building a thriving future with Australia's quantum advantage' (Strategy, 3 May 2023) 6.

⁸⁹Quad Investors Network, 'Quantum Science & Technology in the QUAD nations: Landscape and Opportunities' (Report, Quad Investors Network, July 2024) 3.

⁹⁰Group of Eight, SERD Submission #428, 17.

⁹¹Quantum Economic Development Consortium, 'About QED-C: Our Mission' (Web page) <<https://quantumconsortium.org/about/>>.

⁹²Cf Australia has commenced 'non-binding exploratory talks with the European Union on a possible association with Horizon Europe.' See Department of Industry, Science and Resources, 'Possible Association to Horizon Europe: request for information' (Web page, 10 September 2025) <<https://consult.industry.gov.au/association-to-horizon-europe/>>.

⁹³Quantum Economic Development Consortium, 'About QED-C: Our History' (Web page) <<https://quantumconsortium.org/about/>>.

⁹⁴Quantum Economic Development Consortium, 'About QED-C: Our Members and Their Impact' (Web page) <<https://quantumconsortium.org/about/>>.

Conclusion

The research provides an overview of collaboration in a research security context and argues that it is essential for both research and development and research security in the quantum ecosystem.

Policy documents, research reports and academic literature demonstrate that collaboration is regarded as critical to successful research and innovation:

- Universities see collaboration as necessary for participation in global science, for accessing the best researchers and gaining access to research laboratories and other infrastructure.⁹⁵
- Industry views collaboration cautiously but understands that collaboration leads to innovation, commercialisation and problem solving for complex technological challenges.⁹⁶
- Peak industry and sector bodies see collaboration as good for productivity, sovereign capability and competitiveness.⁹⁷
- Governments consider collaboration to be vital for an increasingly complex, geopolitically challenging global environment.⁹⁸

The examination of a subset of submissions to both the SERD and DTCA reviews shows that on the one hand, collaboration needs to be encouraged through investment, coordination and shared infrastructure. On the other hand, collaboration must be protected from security threats, uncertainty and concerns about criminal liability.

Collaboration sits at the intersection of innovation policy, national security, international engagement, geopolitical uncertainty and immigration policy.

It is hoped that further work based on the research funded by the AAL Grant will consider, among other things:

- The definition and utility of the concept of collaboration in the evolving research security context.
- Lessons for quantum technology collaborations in the context of global research security frameworks.

Australia, like the rest of the world, must maintain a fine balance between openness and security.

⁹⁵See, eg, University of Melbourne, SERD Submission #363, 3; University of Melbourne, DTCA Submission #11, 3; Australian Academy of Science, SERD Submission #436, 3.

⁹⁶SERD, above n 5, 15-16.

⁹⁷Ibid; See also Australian Industry Group, SERD Submission #430, 7.

⁹⁸See, eg, Department of Defence, DTCA #22, 2-4; see also Department of Industry, Science and Resources, 'Partnering with Australia on Innovation, Science and Research' (Booklet, March 2020) 14.

Attachment A – Policy Brief