Australia's QUANTUM CROSSROADS

AIIA Response to the National Quantum Strategy Consultation Paper

November 2022

aiia
australian information industry association

Department of Industry, Science and Resources
GPO Box 2013
Canberra ACT 2601

12 November 2022

RE: National Quantum Strategy: consultation paper

Thank you for the opportunity to provide comment on the Draft National Quantum Strategy.

About the AIIA

The Australian Information Industry Association (AIIA) is Australia's peak representative body and advocacy group for those in the digital ecosystem. We are a not-for-profit organisation to benefit members, and AIIA membership fees are tax deductible. Since 1978, the AIIA has pursued activities to stimulate and grow the digital ecosystem, to create a favourable business environment for our members and to contribute to Australia's economic prosperity.

We do this by delivering outstanding member value by:

• providing a strong voice of influence

• building a sense of community through events and education

• enabling a network for collaboration and inspiration; and

• developing compelling content and relevant and interesting information.

We are unique in that we represent the diversity of the tech ecosystem from small and medium businesses, start-ups, universities and digital incubators through to large Australian companies, multinational software and hardware companies, data centres, telecommunications companies and technology consulting companies.

Table of Contents

Summary of Recommendations

1. For government to **make significant investments** in quantum technology; to match our global peers and competitors on a comparative basis, government will need to invest at least $1 billion over the next 5 years.

2. Government will be required to lead, nurture and become an early adopter and customer for strategic and national security-aligned quantum technology, government must **adopt a mindset shift**, **place contracts and assume risk** to produce self-sustaining commercial outcomes in the quantum sector.

3. For government to **identify the specialised areas of value and comparative advantage** in Australian quantum supply chains relevant to quantum technology and **invest** in them to find scale and see quicker, greater returns.

4. For government to **set out clearly established problem statements** affecting Australian industry with plans for targeted research to solve for those problems and **apply this problem-solving approach** to early stages of fundamental research.

5. For government to better integrate the defence industry and quantum industry, coordinating **defence planning, strategy and budgets** when it comes to the investment, integration and adoption of emerging technology, and spearhead **targeted commercialisation projects** in niche areas of competitive advantage.

6. For government to ensure the deployment of the **Critical Technology List** and the **Critical Technologies Fund** is coordinated with **defence** strategy and defence industry plans.

7. For government to leverage quantum technology applications and consider quantum-related challenges for **data breaches, cryptography and de-encryption** of sensitive data, including as part of HNDL (Harvest Now, Decrypt Later) attacks.

8. For government to apply a **concessional tax treatment** to profits derived from eligible intellectual property in quantum technology, including through an **extension of the patent box regime**.

9. For government to make **workforce development**, the **attraction** of international talent, the **retention** of Australian talent and widening the aperture of a **diversified talent pipeline** a priority for the Quantum Strategy (noting the recent budget investment in quantum PhD scholarships).

10. For governments, in collaboration with research institutions and successful quantum sector representatives, to **closely engage with primary schools, secondary schools, and parents** to advance **quantum literacy**.

11. For government to **make quantum technology a priority focus for investment with part of the $1bn Critical Technology Fund** within the National Reconstruction Fund towards quantum projects, start-ups and scale-ups through co-investment schemes.

12. For government to seek **greater visibility, planning and collaboration** around **large-scale quantum investments at all levels of government**.

13. For government to encourage **global quantum research partnerships** and mutually beneficial **collaboration with trusted international partners** in quantum.

Introduction

In May 2020, the CSIRO warned that "*the rest of the world is rapidly accelerating its investments into quantum technology. If Australia wants to remain world-class in this field, it must act now*."[1] Even then, Australia was approaching crossroads against a backdrop of global acceleration and rapid growth. Two years on, with the advent of the proposed framework of the Federal Government's National Quantum Strategy, government, industry and academia must squarely confront this crossroads moment together, with each stakeholder playing its part to kick Australia's fledgling quantum industry into the next gear, realising billions of dollars of growth and opportunity for the good of the Australian economy and community in the decades to come. Achieving this ambition will require bold and decisive action, the right environment for investment and innovation, and effective collaboration.

The AIIA has led in quantum research and commercialisation advocacy. In its 2021 White Paper, *Growing Globally Competitive Industries*, the AIIA warned that Australia can play a valuable role in the global industry of quantum, but as our global peers invest heavily in their own quantum ecosystems, Australia must act quickly to remain a key player in this global opportunity. The key recommendations of the Paper are both relevant and topical one year on: for government to dedicate resources to identifying potential quantum-era security exposures across all departments and keeping up-to-date in post-quantum cryptography standards to implement solutions as they become available; for government to amplify Australia's strengths in quantum research, commercialising emerging quantum technologies and solidifying Australia's leadership under a national quantum technology strategy (the subject of this response); and calling for an investment of at least $110m over four years in a national quantum centre.[2]

The quantum opportunity; global disparity in investment

By 2030, the CSIRO has conservatively predicted that Australia's quantum opportunity in revenue terms could reach $2.3bn. This number could rise to $3.3bn by 2035, $4.6bn by

[1] https://www.csiro.au/-/media/Do-Business/Files/Futures/Quantum/20-00095_SER-FUT_REPORT_QuantumTechnologyRoadmap_WEB_200518.pdf
[2] https://www.minister.industry.gov.au/ministers/price/media-releases/111-million-investment-back-australias-quantum-technology-future

2040, and $6bn by 2045.[3] The high-growth opportunity that the quantum industry could represent into the next century as the future-state computing technology with deep and diverse applications is well reflected by the Strategy. However, translating the potential to commercial outcomes and contracts in the near future will be essential.

According to a September 2022 analysis by McKinsey and Company, the People's Republic of China has invested USD$15.3 billion (in 2022 A$23.6bn) of public funds in quantum computing investments. According to McKinsey, this equates to more than double that of EU governments (USD$7.2 billion) and eight times the United States' pledge to spend (USD$1.9 billion).[4] Individual global companies, let alone governments, invest handsomely in quantum technology.[5] Together with significant Centre of Excellence grants made through the Australian Research Council across quantum computation and communication technology,[6] quantum biotechnology[7] and engineered quantum systems,[8] Australia's chief strategic investment in quantum technology came in the form of a November 2021 announcement of $111m to support a Quantum Commercialisation Hub and Quantum Strategy. Accounting for the fact that Australia's annual GDP is 9.2% that of China's,[9] a commensurate investment by the Australian government given the size of our economy would be A$2.17bn.[10] If we are to compete with our global counterparts and do justice to Australia's initial reputation as a quantum leader, we must invest even more heavily in scaling up the Australian quantum sector.

Recommendation 1: For government to make significant investments in quantum technology; to match our global peers and competitors on a comparative basis, government will need to invest at least $1 billion over the next 5 years.

Contracts, not (just) grants: government as a natural quantum customer

The Strategy states, "*The Australian Government will **continue to lead**, but wants partners across the ecosystem*." [emphasis added][11] As earlier quoted, the CSIRO's landmark 2020 Report described an urgent juncture for the future of the quantum sector in Australia. Therefore, rather than maintaining course, government must put itself on a bold footing with a view to radically increasing take-up of quantum technology and the enablement of

[3] https://www.csiro.au/-/media/Do-Business/Files/Futures/Quantum/2022-report-QuantumTechnologyIndustry.pdf
[4] https://www.mckinsey.com/featured-insights/coronavirus-leading-through-the-crisis/charting-the-path-to-the-next-normal/betting-big-on-quantum
[5] https://physicsworld.com/a/quantum-computing-gets-down-to-business/#:~:text=Quantum%20computing%20is%20currently%20dominated,investing%20heavily%20in%20quantum%20initiatives.
[6] https://www.arc.gov.au/funding-research/discovery-linkage/linkage-program/arc-centres-excellence/2017-arc-centre-excellence-quantum-computation-and-communication-technology
[7] https://www.arc.gov.au/funding-research/discovery-linkage/linkage-program/arc-centres-excellence/arc-centre-excellence-quantum-biotechnology
[8] https://equs.org/strategic-plan
[9] https://countryeconomy.com/countries/compare/china/australia
[10] 9.2% of A$23.6bn is A$2.17bn.
[11] https://storage.googleapis.com/converlens-au-industry/industry/p/prj221726a232884dc6016a1/public_assets/Consultation%20Paper%20-%20National%20Quantum%20Strategy%20-%20FINAL.pdf National Strategy, p.6.

industrial commercialisation. AIIA members have expressed the view that, across the globe, certain technologies such as space technology and quantum technology are by nature strategic, national areas in which governments will naturally play a key role. In the search for end-users, customers and contracts, the elephant in the room is that government is the natural customer for many quantum applications. Rather than merely seeking grants, or focusing exclusively on exporting, members of the Australian quantum industry are seeking viable contracts from government based on which they may plan and grow.

The capacity of governments to engage quantum companies was showcased when Australian quantum company Quintessence Labs made the approved products list for a $2 billion program run by the U.S. Department of Homeland Security, focused on strengthening data protection across participating agencies.[12] Government is a natural early adopter and customer for quantum given the strategic and national security-aligned applications of the technology.

In the quest to commercialise the sector and produce a mature market for quantum technology, it will be contracts, not grants, that secure these ends. A mindset shift whereby government is willing to place contracts and assume risk will be indispensable in assisting industry to achieve translation of research to self-sustaining commercial outcomes.

Recommendation 2: Government will be required to lead, nurture and become an early adopter and customer for strategic and national security-aligned quantum technology, government must adopt a mindset shift, place contracts and assume risk to produce self-sustaining commercial outcomes in the quantum sector.

Practical Applications

Quantum covers a broad range of areas, with the Critical Technologies List[13] including post-quantum cryptography, quantum communications, quantum computing, and quantum sensors. Each area is at a different level of maturity, use cases and commercialisation; a one-size-fits-all approach will not work, and areas of comparative advantage such as quantum software in which Australia has strengths should be targets for public and private investment for maximum yield. Australian companies particularly thrive in the global market when they find their niche within a supply chain and play to that strength. Rather than attempting to 'do it all' in Australia, the government should focus on doing more of what Australians are doing well. Identifying where the value is in the supply chains relevant to quantum technology and driving hard at ramping up in that specialised area will see quicker, greater returns. Government needs to consider the specialist areas of the emerging quantum industry Australia is best able to capture as the country progresses to greater investment and maturation of the ecosystem. Early-stage considerations such as quantum-safe cryptography solutions can provide early revenue, which has a flow-on effect of generating participation in the overall ecosystem as quantum technologies mature.

Driving deeper on practical applications for quantum technology and enabling researchers to probe this question is an important next step. Clearly established problem statements

[12] https://techcrunch.com/2021/10/26/australian-quintessencelabs-grabs-25m-series-b-to-scale-quantum-safe-crypto-solutions/
[13] https://www.pmc.gov.au/sites/default/files/publications/ctpco-critical-tech-list-of-63.pdf

affecting Australian industry with plans for targeted research to solve for those problems is a lens that needs to be applied at early stages of fundamental research.

The CSIRO in 2019 nominated the following application areas: computing, simulation, sensing, imaging, navigation, timing, measurement, communications and encryption; quantum simulation for drug and materials development, quantum encryption solutions for secure communications, and quantum sensors for mineral exploration and defence applications.[14] Further applications are being explored by teams of researchers associated with Google's Digital Future Initiative, which is partnering with quantum researchers at Macquarie University, the University of Technology, Sydney, the University of Sydney and UNSW Sydney.[15]

The applications range from designing more efficient fertilizer production, designing faster-charging, longer-range batteries for electric cars, and new quantum algorithms for simulating chemical reactions to better understand how pollution affects the atmosphere. At more technical levels, true quantum random number generation and continuous-variable quantum key distribution are important for data and cryptography,[16] while molecular dynamics simulations have applications for drug design, chemical synthesis, energy storage and nanotechnology;[17] while quantum machine learning (QML) is promising for potential speedups and improvements in conventional machine learning (ML) tasks.[18]

A paper by Quantum Brilliance founders in *Digitale Welt*[19] outlined opportunities for researchers and companies in novel high-impact science and high-value products and services in relation to accelerators:

- *Discovery and development of **applications of quantum accelerators**.*
- *Design and development of programming languages and software to efficiently employ, manage and optimize **integrated clusters of classical computers and quantum accelerators**.*
- *Design and development of **software** to optimize the **compiling of programs** for and performance of quantum accelerators.*
- *Co-design and -development of **quantum accelerator hardware** for targeted applications.*

Recommendation 3: For government to identify the specialised areas of value and comparative advantage in Australian quantum supply chains relevant to quantum technology and invest in them to find scale and see quicker, greater returns.

[14] https://www.csiro.au/-/media/Do-Business/Files/Futures/Quantum/Quantum-Technology-Discussion-Paper-2020-revision.pdf
[15] https://blog.google/intl/en-au/company-news/technology/investing-in-quantum-computing/
[16] https://iopscience.iop.org/article/10.1088/1674-1056/26/4/040303
[17] https://digitaleweltmagazin.de/fachbeitrag/quantum-accelerators-a-new-trajectory-of-quantum-computers/ p.76 and p.77
[18] https://arxiv.org/abs/2202.01899
[19] https://digitaleweltmagazin.de/fachbeitrag/quantum-accelerators-a-new-trajectory-of-quantum-computers/

Recommendation 4: For government to set out clearly established problem statements affecting Australian industry with plans for targeted research to solve for those problems and apply this problem-solving approach to early stages of fundamental research.

Case Study: Quantum-Safe Encryption Powered by Quantum Cloud (Australia Cloud)

In October 2022, AIIA Member Australia Cloud (AUCloud) announced the general availability of the Asia Pacific region's first Quantum Safe Symmetric Key Agreement Software. This is an example of software excellence in Australia pairing with like-minded allies in the United Kingdom, a kind of collaboration that could increase under the AUKUS alliance.

Powered by Arqit's QuantumCloud™, the service is provided by AUCloud as a Platform as a Service (PaaS), enabling quantum-safe encryption capability for the Australian market and near-region customers from Asia and the Middle East. The service focuses on protection against "Harvest Now, Decrypt Later" quantum computing attacks, improving the security while maintaining performance for a variety of IoT, defence and financial services applications. Using UK-developed Arqit code and software Australia has developed, enabled by Quintessence Labs' truly random number generation leading to quantum-safe cryptographic solutions, is an Australian export success story.

Case Study: Quantum Emulation (Vault Cloud)

In 2019, through a matched grant from the AustCyber Projects Fund, AIIA Member Vault Cloud developed secure cloud storage, search and collaboration on encrypted data solutions by using Ziroh Labs' homomorphic encryption technology and Quintessence Labs' true quantum random number generator. Vault is emulating the quantum hardware environment in its cloud, allowing the coding of the software applications that will run off that future hardware when it advances. In a future state, Vault will swap the quantum emulation component with real quantum hardware components and run that same software much faster, continuing to operate the security side of quantum cloud.

Defence considerations

Defence industry imperatives and capability can benefit from the coordinated delivery of the quantum strategy, with the Australian Strategic Policy Institute finding in a report that quantum computing power will open a 'wide opportunity space' when it comes to 'Defence's technology edge'.[20]

[20] https://ad-aspi.s3.ap-southeast-2.amazonaws.com/2021-04/Quantum%20technologies.pdf?VersionId=DkcL10fHh64pka9GWPzAR14IWKrF4IKe

Quantum can protect devices in space that are of a military or other critical nature using advanced quantum key distribution (**QKD**) cryptography, with quantum realising efficiencies using symmetric keys rather than asymmetric keys, which often rely on space-situated missions for the refinement of the cryptography. QKD saves time and resources by enabling the issuing of new, tamper-evident keys to space assets without pre-coordination, post-field-deployment. China is a prime mover in using quantum keys and entanglement-based QKD in space.[21] QKD can also have terrestrial applications, including for 5G networks.[22]

Initiative 7.4 outlines government supporting defence and national security requirements for quantum research and capability growth, without outlining any proposed actions. Government must better integrate the defence industry and quantum industry and spearhead targeted commercialisation projects in niche areas of competitive advantage. Rather than duplicative and uncoordinated investments in quantum, defence imperatives and industry-facing investments by non-defence agencies must be linked and collaborative.

Seeking better integration of defence planning, strategy and budgets when it comes to the investment, integration and adoption of emerging technology is important, as well as coordinating with the way in which the Critical Technology List is operationalised following the 2022 Review of the List. As industry innovates at the cutting edge of quantum applications in sensing, navigation, geospatial, cryptographic and communications domains, defence's quantum capabilities must advance as a corollary.

Recommendation 5: For government to better integrate the defence industry and quantum industry, coordinating defence planning, strategy and budgets when it comes to the investment, integration and adoption of emerging technology, and spearhead targeted commercialisation projects in niche areas of competitive advantage.

Recommendation 6: For government to ensure the deployment of the Critical Technology List and the Critical Technologies Fund is coordinated with defence strategy and defence industry plans.

Cyber security applications

As the Department of Home Affairs prepares to release a new Cyber Security Strategy and the nation grapples with high-profile data breaches, both the applications and challenges presented by quantum technology when it comes to de-encrypting data and cryptography should be front of mind for governments. As recommended in *Growing Globally Competitive Industries*, the AIIA's 2021 White Paper, "government needs to dedicate resources to identify the potential quantum-era security exposures across all departments and keep abreast of the developments in post-quantum cryptography standards, to implement solutions as they

[21] https://www.scientificamerican.com/article/china-reaches-new-milestone-in-space-based-quantum-communications/
[22] https://ieeexplore.ieee.org/document/9333787

become available."[23]

Cyber security futurists with an understanding of future quantum applications must be embedded in both research and industry ecosystems, and organisations must be 'quantum-ready'; Canberra-based Quintessence Labs has developed quantum resilience products for global corporate clients in light of HNDL (Harvest Now, Decrypt Later) attacks.[24]

Recommendation 7: For government to leverage quantum technology applications and consider quantum-related challenges for data breaches, cryptography and de-encryption of sensitive data, including as part of HNDL (Harvest Now, Decrypt Later) attacks.

Creating a favourable, attractive and retentive quantum environment

To encourage innovative companies to remain in Australia and to encourage all quantum companies to base their operations in Australia, government should apply a concessional tax treatment to profits derived from eligible intellectual property in quantum technology. In 2021 the Australian Investment Council recommended "*the patent box design principles should extend beyond the scope of the medical and biotechnology and clean energy sectors to include industries where Australia has a comparative advantage in areas … quantum computing.*"[25] The Group of Eight, in its submission to the 2021 Patent Box Consultation, noted that "*there are other significant areas of innovation, notably space, artificial intelligence, quantum, agtech … that should not be excluded from this measure without clear rationale*."[26]

Workforce development should be a priority in the implementation of the Strategy, with equal focus on attracting international talent, retaining Australian talent (which will be a corollary of making it more attractive to be headquartered in Australia via R&D-based tax concessions), and widening the aperture to diversify the quantum talent pipeline. There ought to be a focus on attracting rural and regional talent, women, neurodiverse individuals, and people from culturally and linguistically diverse backgrounds. The EQUS Strategic Plan identifies access to mentoring, skill building, and talent development programs as important for growing Australia's research community.[27] Engaging with primary and secondary schools as well as parents to advance quantum literacy will be crucial.

Recommendation 8: For government to apply a concessional tax treatment to profits derived from eligible intellectual property in quantum technology, including through an extension of the patent box regime.

Recommendation 9: For government to make workforce development, the attraction of international talent, the retention of Australian talent and widening the aperture of a

[23] https://35hddx2cwawgt701l2sq0v5c-wpengine.netdna-ssl.com/wp-content/uploads/2021/08/AIIA-Growing-Globally-Competitive-Industries.pdf, p.7
[24] https://www.sdxcentral.com/articles/analysis/harvest-now-decrypt-later-concern-boosts-quantum-security-awareness/2022/09/
[25] https://treasury.gov.au/sites/default/files/2022-02/c2021-177849-australian-investment-council.pdf
[26] https://treasury.gov.au/sites/default/files/2022-02/c2021-177849-the-group-of-eight.pdf
[27] https://equs.org/strategic-plan

diversified talent pipeline a priority for the Quantum Strategy (noting the recent budget investment in quantum PhD scholarships).

Recommendation 10: For governments, in collaboration with research institutions and successful quantum sector representatives, to closely engage with primary schools, secondary schools, and parents to advance quantum literacy.

Intellectual Property and Spin-Outs from Higher Education

The government should encourage a devolved, private-sector-centred, flexible approach to intellectual property, including by universities. Universities such as the ANU that have generous arrangements enabling spin-out companies to thrive, with ANU Vice-Chancellor Brian Schmidt setting a goal in February 2021 for the University to build a billion-dollar company by 2025. The Technology Transfer Office at the ANU currently takes just a 10% stake in spin-out companies in exchange for the company having IP access.[28] This approach would be instructive for government.

Case Study: Quantum Brilliance

ANU spin-out Quantum Brilliance raised $13.7m in partnership with QxBranch founders (QxBranch - Australia's first quantum computing applications company, founded in 2014 and acquired by Rigetti in 2019) and the Main Sequence investment consortium. The Australian company aims to deliver their room temperature quantum accelerators the size of a lunchbox with over 50 qubits by 2025.[29]

Venture Capital Considerations

The $1bn Critical Technologies Fund, which is earmarked for investment in the 63 critical technologies featured on the Critical Technologies List, is a welcome co-investment initiative of this government and will provide the funding mechanism for elements of this Strategy. Strategically deploying the funds in this portion of the National Reconstruction Fund to quantum projects, start-ups and scale-ups through co-investment should be a priority in satisfying the Quantum Strategy.

Accelerator programs and funding packages supported by government must be tailored to the varying stages of technical and commercial maturity within research and industry collaborations, from fundamental physics all the way up to having a product ready to sell. The government must seek to support an ecosystem of established players who have assurance that there is dealflow coming out of higher education institutions, giving venture capitalists confidence that there are companies from whom they may procure quantum-backed products or technology they may access, license or joint-venture internally. The flow, alignment and synchronicity by which compelling products are created in a university context

[28] https://www.innovationaus.com/anu-spin-outs-offer-commercialisation-insights/
[29] https://www.anu.edu.au/news/all-news/anu-spin-out-company-secures-millions-in-seed-funding

and then picked up and scaled by industry players must be realised. Genuine quantum commercialisation will take confidence-building, derisking and validation mechanisms, whereby practical merit is the rule run over products of laboratories.

Case Study: Australian Research Council Centre of Excellence for Engineered Quantum Systems (EQUS) Translational Research Program

The Centre of Excellence for Engineered Quantum Systems (EQUS) flagship Translational Research Program provides resources, advice and industry connections to develop its research into prototypes and technical demonstrations. It helps researchers translate EQUS research outcomes into wider societal impact. The Translational Research Program's activities include education and mentoring, as well as building and facilitating industrial, government and commercial relationships for the benefit of EQUS researchers.
The TRP has established three primary programs for directly supporting research translation in the Centre:

- ***Translation Stipends**, which provide for a PhD candidate to undertake translational research without affecting their main research.*
- ***Translation Fellowships**, which allow a postdoctoral fellow to dedicate some of their time to translational research.*
- ***Facilitation Projects**, which fund the costs of equipment and resources required to build a prototype or demonstration technology.*[30]

When researchers can directly test the applications of their study and innovation in specific industrial environments, strong feedback loops back to university contexts are established. Such feedback loops can create added value and improve development of commercial quantum technologies. The channels of communication must be improved between the fledgling quantum industry and academia, including by match-making-style exercises and a focus on problem-solving.

Capital incentives for private investors at the very early stage of investment in start-ups will assist in commercialisation. The Early Stage Venture Capital Limited Partnerships (**ESVCLP**) program jointly administered by the Department of Industry, Science and Resources (**DISR**) and the Australian Taxation Office (**ATO**) is a strong example of incentives and concessions for innovative investments by private industry. Early venture funding models by which private investment is backed with government money, leveraging dollar-for-dollar with a full or partial co-investment contribution for every private equity dollar, will be pivotal to success. These models have been used by the Singaporean government and can be operationalised under the National Reconstruction Fund.[31] [32]

Recommendation 11: For government to make quantum technology a priority focus for investment with part of the $1bn Critical Technology Fund within the National

[30] https://equs.org/translational-research-program
[31] https://www.enterprisesg.gov.sg/financial-assistance/investments/investments/seeds-capital/overview
[32] https://www.industry.gov.au/news/national-reconstruction-fund-diversifying-and-transforming-australias-industry-and-economy

Reconstruction Fund towards quantum projects, start-ups and scale-ups through co-investment schemes.

Case Study: Silicon Quantum Computing

In an example of the synergy that can be achieved between private industry, governments across state and federal levels, and tertiary institutions, a consortium of funders from government and corporate sources capitalised Australian scale-up Silicon Quantum Computing. This launched in May 2017 with over A$83 million of capital funding from the Australian Commonwealth Government, UNSW Sydney, the Commonwealth Bank of Australia, Telstra Corporation and the State Government of New South Wales.[33]

Case Study: Main Sequence

The spin-out of the CSIRO, Main Sequence, aims to 'turn scientific breakthroughs into the next century's giants', inviting pitches from start-ups with connections to the public research sector, 'amplifying connections between industry, research and infrastructure to accelerate deep technology development' and investing in 39 companies[34] *since its formation just five years ago in 2017. It seeks to address the 'valley of death' between research and commercialisation. By amplifying connections between research, industry and infrastructure, Main Sequence both accelerates sound commercial development and ensures economic returns from commercialisation are re-invested in Australia's scientific foundations.*[35] *It has contributed to the creation of over 1,200 jobs since its launch.*[36] *Main Sequence claims that "global productivity is slowing. Our next acceleration will come from new technologies, just as steam power, electricity and computing did in past centuries." Quantum companies in which Main Sequence has invested include Quintessence Labs, Quantum Brilliance, and Q-CTRL.*[37]

Need for better coordination and satisfaction of national strategic outcomes; quantum ecosystem and bilateral collaboration

One of the outcomes of a National Strategy ought to be coordination with state and territory priorities and investments. Collaboration with states and territories is rightly called out in the proposed framework. The Federal Government should seek greater visibility, planning and collaboration around large-scale quantum investments at whichever level of government they are made.

Collaboration with other governments, overseas institutions and trusted international partners is a vital part of strengthening Australia's quantum ecosystem, including through alliances such as AUKUS, the Australia-United States Ministerial Consultation (AUSMIN),

[33] https://sqc.com.au/
[34] https://csirostaff.org.au/news/2022/02/15/csiro-fund-wins-big-as-government-splashes-the-cash/
[35] https://www.growag.com/listings/commercial-opportunity/venture-capital-investment-and-company-building-expertise
[36] https://www.csiro.au/en/work-with-us/funding-programs/funding/main-sequence
[37] https://www.mseq.vc/portfolio-companies

the Five Eyes (FVEY) and the Quadrilateral Security Dialogue (QSD). The Australian Strategic Policy Institute (ASPI), in its 2021 Special Report *The impact of quantum technologies on secure communications*, recommended formalising and prioritising mission-focused bilateral programs led by defence departments and the intelligence community across trusted partnerships.[38] Global research partnerships and cross-pollination between quantum companies should be encouraged while ensuring Australian talent and commercial success is in a strong position.

Recommendation 12: For government to seek greater visibility, planning and collaboration around large-scale quantum investments at all levels of government.

Recommendation 13: For government to encourage global quantum research partnerships and mutually beneficial collaboration with trusted international partners in quantum.

Case Study: Aerostructures Innovation Research Hub (AIR)

The Aerostructures Innovation Research Hub (AIR) based at Swinburne University, Melbourne, is a sound example and useful analogue of a research and industry collaboration. The Hub develops the 'next generation of aerostructures for use in civil aviation, eVTOLs, UAS, AAM and space'.[39] The provision of tangible, practical, industry-facing applications in a university-embedded facility is a helpful model for the quantum sector.

Australian and global research developments on the road to commercialisation

Australian quantum research is exemplary and world-leading. In the quantum ecosystem research forms the foundations for the sector's success across the board, including commercial success. In focusing on commercialising quantum technologies and growing the sector, a retained focus on research collaboration and strength will be crucial for government. The announcement of funding for 20 Doctorates of Philosophy in quantum technology at the October 2022 budget was welcome. Further, strategic collaboration between institutions with quantum excellence, including with trusted international partner universities, will be instrumental in retaining strong and innovative academic foundations.

As an example of Australian research excellence, a team of researchers at AIIA Associate Member UNSW[40] set a dramatic record in showing that 'spin qubits' – which are electron properties representing the basic units of information in quantum computers – may hold

[38] P. 27, https://ad-aspi.s3.ap-southeast-2.amazonaws.com/2021-04/Quantum%20technologies.pdf?VersionId=DkcL10fHh64pka9GWPzAR14IWKrF4IKe

[39] https://www.swinburne.edu.au/research/platforms-initiatives/air-hub/

[40] https://archive.ph/HikMD

information for up to two milliseconds; a 'coherence time' 100 times longer than previous benchmarks in the same quantum processor.

The 'quantum advantage' and advanced calculative power in the development of qubits with silicon donor atom, silicon quantum dot and hybrid systems and optical quantum computing[41] distinguish Australia's researchers and innovators on the world stage.

Error mitigation and error correction are fundamental areas for headway to be made,[42] as is increasing the number of qubits in quantum processors so that quantum technology can represent the next age for computational power, just as the classical computer made exponential progress in the 20th century.

Providing models of access to apparatus and facilities for researchers as outlined in the draft Strategy, the AIIA notes its members IBM, AWS and Microsoft have programs to enable researchers, sometimes in a contained fashion, to access processors for research or have allowed vendors to connect to potential end-users using their platforms.[43] IBM, which in November 2022 announced a new 433-qubit processor, 'Osprey',[44] made its quantum processors available via cloud services, one example of commercially produced prototypes being available in this way.[45] AIIA member Fujitsu, together with scientific research institute Riken, will become the first Japanese company to provide 64-qubit quantum computers for research projects, starting in 2023.[46]

Conclusion and feedback on first-order priorities and the relationship between objectives

The first objective outlined by the proposed framework is crucial, including 1.1 (supporting industry growth), 1.2 (investing in a pipeline of investment-ready activities under the Critical Technology Fund), 1.3 (increasing investment) and 1.4 (quantum being leveraged to solve national problems).

The remaining objectives should exist around and feed into this prime objective. If Australia is to be a global heavyweight on the quantum stage, it will take capital flowing into this fledgling industry. It will also take clarity of communication around the power quantum has to address the problems facing Australia today. Natural disasters are a timely example.

If the quantum sector in Australia is visualised as a building, research excellence serves as the foundation; workforce development forms the essential materials; a strong supply chain represents scaffolding; international partnerships act as a bridge to other viable quantum industries; and building trust, inclusivity and balancing national interests are key structural

[41] ASPI, 'The impact of quantum technology on secure communications' https://ad-aspi.s3.ap-southeast-2.amazonaws.com/2021-04/Quantum%20technologies.pdf?VersionId=DkcL10fHh64pka9GWPzAR14IWKrF4IKe
[42] https://research.ibm.com/blog/advancing-quantum-error-correction#fn-1
[43] Ibid, p. 15 https://ad-aspi.s3.ap-southeast-2.amazonaws.com/2021-04/Quantum%20technologies.pdf?VersionId=DkcL10fHh64pka9GWPzAR14IWKrF4IKe
[44] https://newsroom.ibm.com/2022-11-09-IBM-Unveils-400-Qubit-Plus-Quantum-Processor-and-Next-Generation-IBM-Quantum-System-Two
[45] Ibid p.15 https://ad-aspi.s3.ap-southeast-2.amazonaws.com/2021-04/Quantum%20technologies.pdf?VersionId=DkcL10fHh64pka9GWPzAR14IWKrF4IKe
[46] https://au.pcmag.com/computers-electronics/95775/fujitsu-to-start-selling-quantum-computers-in-2023

supports. However, it is industry growth, contracts, customers, commercial viability and investments that enable the work, the productive yield, and the *raison d'etre* of the entire quantum 'building'.

Australia must ensure the foundations are solid, the scaffolding is resilient, the bridges are mutually beneficial, and the structural supports are sound. However, if the industry is not growing, contracts are not being awarded, and there is no end-customer for whom to design and innovate, the sector will not make the leap required to kick the sector up into the next dimension of growth and success.

The AIIA thanks the Department for the opportunity to respond to the proposed Strategy. If you have any questions about the content of this submission, please contact the AIIA via rachel@aiia.com.au.

Yours sincerely

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