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Submission to Department of Industry, Science, Energy and Resources

ATSE SUBMISSION TO NATIONAL QUANTUM STRATEGY CONSULTATION

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ATSE
Australian Academy of Technology & Engineering

GPO Box 4776
Kingston, 2604
ACT, Australia
T + 61 2 6185 3240
F + 61 3 9864 0930
E info@atse.org.au

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The Australian Academy of Technology and Engineering (ATSE) is a Learned Academy of independent, non-political experts helping Australians understand and use technology to solve complex problems. Bringing together Australia's leading thinkers in applied science, technology and engineering, ATSE provides impartial, practical and evidence-based advice on how to achieve sustainable solutions and advance prosperity.

ATSE welcomes the opportunity to make a submission to the Department of Industry, Science, Energy and Resources' consultation on the National Quantum Strategy development.

Australia has an opportunity to leverage its existing quantum strengths for future advances in computing capacity and data encryption. This submission considers four essential pillars to grow the Australian quantum industry: basic research, infrastructure, talent, and business activity. To strengthen these four interrelated aspects and position the National Quantum Strategy for success, ATSE recommends that it includes:

1. Establish a comprehensive research funding strategy to support the development of fundamental knowledge in quantum computing and related areas of national priority.
2. Embed research output and quality (appropriately and accurately assessed) as a measure of success. Ensure that success measures are accurate and unbiased.
3. Include a plan for equitable access to and use of existing major research facilities.
4. Build the future quantum workforce by supporting and delivering programs that encourage school students' capability in and excitement for STEM careers.
5. Support development of the STEM teaching workforce through discipline-based degrees, supporting existing teachers to upskill and providing incentives to attract and retain new STEM teachers.
6. Restore per-student funding levels for university science and engineering subjects, reversing the reduction applied under 'Job-ready Graduates'.
7. Invest in international quantum talent acquisition to scale-up and diversify Australia's quantum workforce and knowledge.
8. Support the existing workforce to upskill in quantum technologies.
9. Support public partnerships with industry through the Higher Education Research Commercialisation (HERC) scheme, including a proposed Intellectual Property registry for university-industry partnerships.
10. Modify the "patent box" scheme to lower the tax rate for quantum technology development, encouraging businesses to invest.
11. Embed in the Strategy diversity and inclusion resources and programs for quantum-focused businesses.

Maintaining a research pipeline

As early quantum research matures enough to be applied and commercialised, there remains a need for ongoing basic research. Many future applications of quantum technologies are still in the early research phase, and while growth has been rapid, further development is needed to refine solutions. Advances in hardware solutions are yet to be made that will make quantum computing scalable and lead to the widespread deployment of new quantum technologies.

Continued investment in basic research is required to support the development of new quantum technologies. Most of this is undertaken in universities, with some scope to also increase research in the private sector. As expounded in ATSE's 2022 pre-budget submission, ATSE recommends a holistic government research funding strategy that is inclusive of the entire research pipeline (Australian Academy of Technology and Engineering, 2022a).

The measures of success for the National Quantum Strategy articulated in the discussion paper focus on economic value, the creation of businesses, and development of the quantum workforce, but do not consider basic research output. Given the early stage of quantum knowledge and technologies, it would be appropriate to add a success measure based on knowledge development (both quantity and quality), as determined by Excellence in Research for Australia.

In addition, success measures must be authoritative and fact-based. For example, the report on Quantum Computing issued by the Critical Technologies Policy Coordination Office (CTPCO) of the Australian Government is sufficiently misleading and inaccurate as to undermine existing quantum computing efforts already underway in Australia.

Recommendation 1: Establish a comprehensive research funding strategy to support the development of fundamental knowledge in quantum computing and related areas of national priority.

Recommendation 2: Embed research output and quality (appropriately and accurately assessed) as a measure of success. Ensure that success measures are accurate and unbiased.

Developing quantum computing infrastructure

Presently, the potential of quantum computing has not been matched with a viable hardware solution. It is critical to invest in further research and development for the most promising hardware solutions. However, we do not recommend purchasing commercial quantum computing infrastructure at this stage as no solutions yet exist which can achieve quantum advantage on problems of meaningful value. If a viable solution is developed in the future, investment will be needed in quantum computing infrastructure as well as facilities to manufacture quantum computing components at scale; this should be revisited when the National Quantum Strategy is reviewed.

Existing National Collaborative Research Infrastructure Strategy (NCRIS) facilities, including particle accelerators and fabrication facilities, provide shared research infrastructure promoting collaboration between universities and industry. At the establishment of the current NCRIS Roadmap, ATSE noted the need for NCRIS facilities to be supported by the recruitment of talent to ensure they are maintained and utilised to their full potential research (Australian Academy of Technology and Engineering, 2019). This need remains. The role of NCRIS facilities in industry or collaborative research, and how these facilities are to be supported, must be considered as part of the National Quantum Strategy. In addition, industry partners may seek out research partnerships to gain access to academic facilities. These facilities require stable funding to ensure they are in place as industry demand increases. At the same time, academic and NCRIS facilities need additional resourcing to provide services and collaboration with industry and undertake outreach to proactively seek these partnerships. Attempting to undertake these efforts within the constraints of existing resources would curtail potential use for basic research and research training.

Recommendation 3: Include a plan for equitable access to and use of existing major research facilities.

Enhancing Australia's strength in producing quantum talent

To retain Australia's existing strength and competitive advantage in quantum research, and build scale as a leader in quantum technologies, more physics and software engineering professionals will be needed. An even deeper pool of talent will be required if the National Quantum Strategy is successful in attracting international investment and the development of new quantum start-ups. Two pressing challenges pose a threat to Australia's potential future quantum workforce: tertiary enrolments in physical sciences and engineering, and university teaching capacity.

A lack of understanding of and excitement for quantum physics careers at the secondary school level is an obstacle to building a pipeline of talent. The recent reduction in senior secondary students undertaking mathematics subjects to an all-time low (Wienk, 2022) will further exacerbate the pressure, given the importance of mathematics as requisite knowledge for tertiary qualifications in relevant science and engineering fields. School students must be positively engaged with physics, mathematics, engineering, and computer science – and potential careers enabled by these fields – to empower them to consider the career paths built on these skills and knowledge. Capable STEM teachers are needed to facilitate this; however, as previously raised by ATSE, this is hampered by a shortage of STEM teachers and consequent out-of-field teaching, particularly in rural, regional, and remote schools (Australian Academy of Technology and Engineering, 2022a). Possible solutions to this include: requiring new teachers to have a degree in their discipline and encouraging university education departments to offer one year certificates in pedagogy for those with an undergraduate science/engineering degrees; upskilling existing STEM teachers; and providing incentives to enter and remain in STEM teaching. Another strategy is to implement programs to support out-of-field teachers. For example, ATSE's CS in Schools program provides free, world-class, curriculum-aligned computer science materials, supporting out-of-area secondary school teachers to confidently provide a practical approach to building digital skills, that's accessible to students regardless of socio-economic status. Building on this effort, there is the opportunity to embed quantum computing within the computer science curriculum.

In addition to programs encouraging school children to learn STEM and consider technological careers, ATSE recommends further investment in supporting under-represented groups to pursue tertiary STEM qualifications, such as the Government's Elevate: Boosting Women in STEM program, which will provide 500 scholarships for women to study tertiary STEM. Targeted initiatives for under-represented groups provide a mechanism for building the size of the quantum workforce by encouraging students who would not otherwise have considered STEM (science, technology, engineering, and mathematics) careers.

To ensure STEM-engaged secondary students pursue and succeed in these subjects at the tertiary level, there exists a broader need for secure public investment in Australian university teaching and research – a nexus that has been dispelled by recent legislative reform. Recent threats to universities' revenue models have made the potential loss of the tertiary physics research and teaching workforce a genuine risk. The risk is posed on three fronts: proposed research block grants reform (Australian Academy of Technology and Engineering, 2022b), the loss of international enrolment revenue during the pandemic, and reduced per-student funding in science and engineering under the 'Job-ready Graduates' legislation (Daly & Lewis, 2020). ATSE urges the Government to reverse the reductions under its remit, in order to protect the physics teaching and research workforce that will be essential to maintaining and building upon Australia's strength quantum computing.

To strengthen our quantum knowledge and potential, Australian universities need to be attractive workplaces for noted international scholars. The Sydney Quantum Academy can be considered as an exemplar that could be replicated nationally to attract (and develop) quantum talent. Australia's existing investment in international talent attraction is very small by comparison with international

competitors such as India which plans to invest $1.4 billion over five years in quantum technology, including talent attraction (Brennen, Devitt, Roberson & Rohde, 2021). Talent acquisition requires strategic investment if Australia is to be competitive with international programs.

In addition to developing a new quantum workforce, scaling up the capacity to deliver key tertiary qualifications, and attracting international quantum talent, there will also be a need to develop existing skilled workers to facilitate the capability of industry to adopt quantum computing. For example, business analysists, information technology and operational staff will be required to have competencies in quantum computing as new technologies are developed and deployed. This could be addressed through a micro-credentialling framework that could be delivered by national quantum academies as suggested above.

Recommendation 4: Build the future quantum workforce by supporting and delivering programs that encourage school students' capability in and excitement for STEM careers.

Recommendation 5: Support development of the STEM teaching workforce through discipline-based degrees, supporting existing teachers to upskill and providing incentives to attract and retain new STEM teachers.

Recommendation 6: Restore per-student funding levels for university science and engineering subjects, reversing the reduction applied under 'Job-ready Graduates'.

Recommendation 7: Invest in international quantum talent acquisition to scale-up and diversify Australia's quantum workforce and knowledge.

Recommendation 8: Support the existing workforce to upskill in quantum technologies.

Expanding the quantum industry

As new quantum technologies and applications emerge, it can be anticipated that this will create a fertile landscape for start-ups and spinouts to develop. There has been increased business activity over the past five years, with Silicon Quantum Computing, which is working towards improving quantum computing technology, being a notable recent Australian quantum success story.

The National Quantum Strategy should include a robust framework for fostering successful outcomes and best practices for emerging quantum businesses, both publicly-owned and privately-owned.

Building on the Higher Education Research Commercialisation (HERC) scheme, there is an opportunity for government to incentivise and encourage research partnerships through a coherent national scheme to support industry-university-government research collaboration, translation, and commercialisation (Australian Academy of Technology and Engineering, 2022c). The existing HERC scheme's Intellectual Property templates do not go far enough to support the development of partnerships and flexibility in arrangements. Implementing ATSE's recommendations on the HERC scheme, including additional partnership development resources and a publicly available intellectual property registry, would support embryonic start-up and spinoff activity including for quantum businesses.

Another possible mechanism to support improved industry-university research collaborations and encourage the development of new quantum businesses include expand the patent box scheme by lowering its tax rate or attaching a premium for quantum technologies. Making this scheme more attractive would enable more and smaller businesses to enter the quantum market.

Building on efforts to embed diversity in the quantum talent pipeline, as part of the National Quantum Strategy quantum, businesses should be encouraged to attract and retain a diverse workforce. ATSE recommends resources such as the Diversity and Inclusion Toolkit, which was created by ATSE to

provide a framework for STEM-engaged small and medium sized enterprises to develop inclusive policies and practices.

Recommendation 8: Support public partnerships with industry through the Higher Education Research Commercialisation (HERC) scheme, including a proposed Intellectual Property registry for university-industry partnerships.

Recommendation 9: Modify the “patent box” scheme to lower the tax rate for quantum technology development, encouraging businesses to invest.

Recommendation 10: Embed in the Strategy diversity and inclusion resources and programs for quantum-focused businesses.

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