



UNIVERSITY OF
WATERLOO



Institute for
Quantum
Computing

Pre-Budget Consultation
Submission to the House
of Commons Standing
Committee on Finance

Executive Summary

The Institute for Quantum Computing (IQC) thanks the Standing Committee on Finance for the opportunity to participate in the 2017 pre-budget consultation process. IQC is widely regarded as a world leader in quantum information research and the essential link between foundational science (Perimeter Institute) and commercialization (Quantum Valley Investments and others) in Canada's emerging "Quantum Valley ecosystem." The research taking place at IQC is harnessing the most fundamental laws of nature to develop powerful new technologies which will drive the 21st century economy.

Advances made through quantum information science will have a transformational impact across the globe and drive a new engine of economic development and growth. At IQC, we are already witnessing the impact of the discoveries made in quantum information science in areas such as healthcare, IT and security, climate and the environment, and natural resource development. We are only touching the edges of what will be possible in the future and the only limit is our imagination.

We need to ensure that Canada can realize all of the benefits that this quantum revolution will bring. Too often, innovation begins in Canada but is completed elsewhere. Thanks to IQC, this is not the case in the area of quantum information science.

IQC was established in 2002 and, because of this head start, has the first mover advantage over its international competitors in creating the ecosystem necessary for success. We already recruit the best researchers and build the best infrastructure, both of which are crucial for success. We are at the cusp of tremendous early stage commercialization that can be built in Canada and remain in Canada. To take advantage of this tremendous opportunity, this momentum must not be lost.

IQC is proposing a federal recapitalization investment of \$25 million over five years to ensure that Canada maintains its competitive advantage as a world leader in quantum information science.

With the Government of Canada funding essential research, training and knowledge transfer, Canada will lead the world in research and developing the new companies that will build the quantum information industry.

The Role of Quantum Technology in Canada's Economy

The Information Age, or the first quantum revolution, saw incredible advances in information technologies that transformed society, such as the invention of transistors and lasers. We are now at the beginning of the next great technological revolution. Some call it the Fourth Industrial Revolution while others call it the Second Quantum Revolution, but all agree: the next revolution will be driven by advances in quantum information science and it will have a transformational impact on production, consumption, and quality of life across the globe.

Harnessing the power of quantum information science for computing, among other things, will lead to a fundamental shift in our society, our economy, and our understanding of nature. These revolutionary technologies will drive the creation of new tools, techniques and companies now and well into the future.

Quantum technologies and technology companies are no longer the dream of researchers. Technology harnessing quantum behavior is emerging from laboratories today. IQC alone has six spin-off

companies. Major technology firms like Google, Microsoft and IBM have significant quantum computing groups and research partnerships. Although a useful, universal quantum computer may be years down the road, quantum sensors and quantum communication devices are already in the marketplace, presenting a multitude of new opportunities.

Through Continued Support of IQC, Canada has the Opportunity to Lead the Second Quantum Revolution

New discoveries in quantum information will spark an entirely new industry in quantum technologies, with far-reaching impact on businesses and the economy as a whole. Companies that can adapt will excel, and those that cannot may fall by the wayside. For Canadian businesses to survive and thrive in this transformative environment, Canada needs to maintain its position as a global leader in quantum information science. We also need to position ourselves correctly to leverage quantum technology into commercial opportunities that will drive Canada's future economy.

As an international expert in the field, and through its position as one of the world's preferred destinations for talent and investment in new quantum industries, IQC is ideally positioned to pursue new opportunities in this technological revolution on Canada's behalf.

From a standing start fourteen years ago, IQC has made great strides in positioning itself as one of the world's top centres for quantum information research. It continues to aggressively hire the world's best faculty and support them with world class infrastructure, research, postdoctoral fellows, and graduate students.

IQC is already doing what needs to be done for Canada to claim its rightful place as a world leader in quantum information science. Our track record speaks for itself.

Research Excellence

Since 2002, IQC has achieved:

- Over 1,100 publications in some of the most prestigious scientific journals in the world;
- Significant discoveries by faculty members in areas such as quantum information theory, quantum algorithms, quantum complexity, and quantum cryptography, many of which have already been patented;
- An emerging start-up ecosystem with six early-stage companies created;
- Strong endorsements on audits and internal investments; and
- Status as an unmatched destination for researchers from every corner of the world that routinely recruits and collaborates with leading centres such as MIT, Harvard, Stanford, Cornell, Caltech, TU Delft, Maryland, University of Vienna, University of Queensland, and the Korean Institute of Science and Technology, to name just a few.

Successful Public-Private Partnerships

IQC has successfully leveraged an initial private investment of \$100 million from Mike and Ophelia Lazaridis into \$480 million in total investments since 2002. The private-public partnership model has enabled IQC to become a centre of excellence with top international caliber researchers, world class infrastructure, and an award-winning outreach program.

Award Winning Scientific Outreach

As the world edges closer to the Second Quantum Revolution, public awareness and understanding of quantum technologies is key. IQC's award-winning conferences and visitor programs enable the world's best scientists and engineers to contribute to the growth of the field. IQC's public outreach and

education programs get research and innovation knowledge out of the labs and into the hands and minds of the next generation of Canadian innovation talent. These programs also educate companies about this next technological revolution and provide advice on which actions they must take to stay ahead of the curve.

Canada Needs to Maintain its Competitive Advantage in the Area of Quantum Information Science

To continue as a world leader in quantum information science, IQC must:

- Continue to attract top talent by reaching and maintaining a critical mass of research personnel headed by an internationally renowned complement of faculty;
- Continue to attract significant research funding through competitive grant programs; and
- Achieve financial sustainability at scale by helping to build a strong and highly supportive quantum information industry in Canada.

The Institute for Quantum Computing requests renewed funding from the Government of Canada of \$25 million over five years. IQC specifically requests that the Government of Canada provide:

- \$18 million over 5 years to support Research, Highly Qualified Personnel Development, and Innovation at IQC;
- \$3.5 million over 5 years to support IQC programs in Scientific Outreach and Communication; and
- \$3.5 million over 5 years to support Management and Administration of the Institute.

This federal funding builds on the Government of Canada's cumulative investment of \$65 million in the strategic development of IQC and will enable IQC to maintain its position as an expert in quantum information science and technology, and bolster Canada's reputation as a world leader in the field.

IQC is working to expand its cluster of spin-off companies and develop next generation technologies that will benefit everyone in Canada. The Institute's ongoing work provides the foundation for a full ecosystem that will deliver a quantum technology commercialization industry in Canada and be at the frontier of both basic and applied quantum research.

No other place in the world has a quantum cluster that brings together organizations that link fundamental research to application and commercialization. IQC has played the key role in bringing together the right ingredients to make the quantum ecosystem a global success:

- Top scientific talent with a shared vision of the possible;
- Early adopters to address real world challenges;
- Experienced staff to translate technology into real world solutions; and
- Industry partners to turn technologies into commercial opportunities.

Further, venture funders are keeping their attention focused on IQC and the Waterloo ecosystem and are keen to partner to enable start-ups.

Renewed federal funding will enable IQC and Waterloo to entrench its position as the headquarters of "Quantum Valley" and firmly position Canada as a leader in the Second Quantum Revolution. With the Government of Canada funding essential research, training, and knowledge transfer, Canada can continue to lead the world in research and the new companies and start-ups that will be at the forefront of the quantum information industry. With continued investment, Canada will be at the centre of the next information revolution.