



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

August 4, 2017



UNIVERSITY OF
WATERLOO



Institute for
Quantum
Computing

EXECUTIVE SUMMARY

Quantum technologies have the potential to transform and revolutionize industry and society. As with any race, the best and the fastest are the winners. Canadian quantum information research and development is at the forefront of global efforts to capitalize on the transformative potential of quantum technologies. Nations and firms from across the globe are realizing the opportunities of the quantum revolution and are making significant investments.

Canada's position is at risk. To maintain our lead, strategic investments must continue. It's the only way that Canada can maintain the pace of quantum innovation and remain a pre-eminent nation for quantum research and development. To maintain our lead, Canada must:

- Continue to attract and retain top **talent**, including internationally renowned faculty, outstanding young researchers and postdoctoral fellows, and exceptional graduate students;
- Continue to make significant research and infrastructure **funding** available for quantum research and technology development;
- Maintain a focus on the importance of **fundamental research** as a driver of innovation and economic prosperity;
- Establish a funding stream for **high-risk/high-reward** research initiatives such as quantum information research.

Canada has the potential to win the quantum race and bring Canadian quantum technologies to the world.

CANADA HAS THE POTENTIAL TO
WIN THE QUANTUM RACE AND
BRING CANADIAN QUANTUM
TECHNOLOGIES TO THE WORLD.

IQC has
established
Waterloo, and
Canada, as the
world-leading hub
for research in
quantum
technologies and
their
applications.

- Stephen Hawking
June 2017

INTRODUCTION

Canada is a world leader in quantum information research. Our researchers are discovering how to harness quantum mechanics - the fundamental behaviour of nature - for the development of transformative technologies. These discoveries are no longer just research endeavours. Quantum technologies are emerging from labs at a rapidly increasing pace. We are on the cusp of realizing the tremendous commercial and societal potential of quantum technologies across a broad range of sectors.

Imagine the impact when Canada fully realizes the results of fundamental quantum research: quantum computers with the processing power to understand complex biological processes; quantum sensors able to provide a new lens on our environment; ultra-secure cryptography impenetrable to cyber-attacks. These are just a few of the revolutionary technological opportunities the quantum revolution holds... and Canada has the opportunity to lead the world in seeing these quantum technologies come to life.

Over the past 15 years, Canadian quantum research is recognized as a global powerhouse. We have made significant investments in people, research infrastructure, and educational programs. Waterloo Region is known worldwide as a hub for the development and commercialization of quantum technologies. Our ecosystem, the Quantum Valley, is the model other nations look to as they ramp up initiatives in quantum research. Canada has a lead in the global quantum race.

Now we need to keep it.

As the Standing Committee on Finance examines the opportunities for Canada in Budget 2018, sustained investments for fundamental quantum research are imperative. Strategic, consistent, and sustainable funding will keep Canada in a leadership position in quantum research and its resulting technologies.

Let's own the scientific podium. Let's keep Canada a quantum nation and bring Canadian innovation to the world.

THE WORLDWIDE QUANTUM RACE

In 1982, Richard Feynman first proposed the idea of a quantum computer – a computer that would harness nature's most fundamental behaviour and transform the boundaries of computational power. Global research efforts have been working ever since to realize Feynman's vision. Now, just three decades later, we are on the cusp of the development of a universal quantum computer, with many envisioning this reality in as few as five years. The field of quantum research has advanced and evolved faster than imagined. The path to quantum technologies is clearer and we are recognizing the substantial societal and economic potential these technologies present.

Global investment in quantum computing is expected to grow significantly. Quantum research budgets currently stand at approximately \$2 billionⁱ worldwide. Canada holds about 7% shareⁱ of the current global quantum computing budget. Yet, forecasts expect these budgets to increase three-fold to an estimated \$6.5 billionⁱ — potentially leaving Canada at significantly reduced position.

Recent global government investments include:

- United Kingdom - **£270 million** quantum technologies initiative in 2014
- European Union - a **€1 billion** flagship initiative on quantum technologies in 2016
- Australia - a **\$70 million** partnership in quantum computing in 2016
- The Netherlands - a **€135 million** investment in 2017

Other nations such as the United States and China continue to make significant advances and investments in quantum research.

Major industry players are now jumping into the quantum race. In June, Google revealed its plan for a 49-qubit chip by the end of 2017ⁱⁱ. Late last year, Microsoft strengthened its bid to build a quantum computer by partnering with researchers in the Netherlands and Denmarkⁱⁱⁱ. Industrial funding is rapidly increasing with Intel and IBM also making strategic bets on quantum^{iv}.

These national and industrial investments will further accelerate quantum information research and development, propelling these nations and firms to the head of the pack in the global pursuit of quantum excellence, innovation and economic impact.

CANADA'S POLE POSITION

In the global quantum race, Canada holds a leadership position thanks to nearly two decades of investment and support for quantum research.

The Institute for Quantum Computing (IQC) at the University of Waterloo has significantly raised the bar for excellence in quantum research. IQC's research infrastructure spans over 55,000 square feet across three buildings on the Waterloo campus. A community of over 200 faculty, postdoctoral fellows and students advance the field of quantum information and uncover opportunities to develop transformative quantum technologies. IQC is now regarded as the largest institute in the world for quantum research^v. It is driven by its private/public partnership with the Government of Canada, the Province of Ontario, the University of Waterloo and private donors. IQC stands as Canada's flagship quantum institute and partners with centres across the country and around the world to enhance our nation's position in this rapidly advancing field.

Strategic national programs such as the Canada First Excellence Research Fund, have provided substantial investments for Canadian quantum research. From the University of British Columbia to Université de Sherbrooke to the University of Waterloo, these strategic investments are accelerating the pace of quantum research across the country. Programmatic funding from the Tri-Council Agencies and the Canada Foundation for Innovation have been essential to attracting and retaining talented researchers, supporting early-career researchers and providing the best-in-class research infrastructure. These investments supported Canada's researchers and positioned Canada well ahead in the global quantum race.

To keep our lead, we cannot stop now.

As we look to 2018 and beyond, continued strategic investments will ensure Canada maintains its lead and wins the race to realize the vast benefits of the quantum revolution. To remain as a world leader in quantum information science, Canada must:

- Continue to attract and retain top **talent**, including internationally renowned faculty, outstanding young researchers and postdoctoral fellows, and exceptional graduate students;
- Continue to make significant research and infrastructure **funding** available for quantum research and technology development;
- Maintain a focus on the importance of **fundamental research** as a driver of innovation and economic prosperity;
- Establish a funding stream for **high-risk/high-reward** research initiatives such as quantum information research.

We have what it takes to continue to lead the world in the development of revolutionary quantum technologies. Continued focus and investment will ensure Canadians experience the immense opportunities quantum technologies will provide.

Canada has a leadership position in the global quantum race. Let's go further. To do so, we must keep the pace through strategic investments in quantum information research and development.

Let's own the scientific podium. Let's bring Canadian quantum technologies to the world.

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ⁱ De Yong, M. (2016). Global Developments in Quantum Technology (Rep.). McKinsey & Company

ⁱⁱ <https://www.newscientist.com/article/2138373-google-on-track-for-quantum-computer-breakthrough-by-end-of-2017/>

ⁱⁱⁱ <https://blogs.microsoft.com/next/2016/11/20/microsoft-doubles-quantum-computing-bet/>

^{iv} <https://www.technologyreview.com/s/603495/10-breakthrough-technologies-2017-practical-quantum-computers/>

^v <http://uknqt.epsrc.ac.uk/files/ukquantumtechnologylandscape2016/>