Minister of Innovation, Science and Industry
Ministre de l'Innovation, des Sciences et de l'Industrie
Ottawa, Canada K1A 0H5

The Honourable Joël Lightbound, M.P.
Chair
Standing Committee on Industry and Technology
House of Commons
Ottawa, Ontario K1A 0A6

Dear Colleague:

Pursuant to House of Commons Standing Order 109, I am pleased to submit on behalf of the Government of Canada (the Government) the response to the sixth report by the Standing Committee on Industry and Technology (the Committee) entitled: *How can Canada Remain a Leader in the Global Quantum Marathon?* (the Report), which was presented to the House of Commons on September 28, 2022.

The Government extends its gratitude to the members of the Committee for their work in developing the Report and preparing the recommendations, and to the witnesses who appeared before the Committee to provide evidence and share their advice. The Government supports the efforts of the Committee to examine the challenges and opportunities for quantum computing in Canada. As well, the Government appreciates the Committee's advice on ensuring that the National Quantum Strategy (the Strategy) provides cohesion, coordination, and sufficient funding to the quantum ecosystem, and to ensure that encryption systems are protected from cyber threats.

Advances in quantum science have the potential to transform the way people work and live in Canada and around the world. To amplify Canada's significant strength in quantum research; grow our quantum-ready technologies, companies, and talent; and solidify Canada's global leadership in this area, Budget 2021 announced $360 million over seven years, starting in 2021-22, to launch a National Quantum Strategy. To ensure that this critical funding could continue to support the Canadian quantum community's efforts, early funding opportunities in key areas were rolled out in parallel with the development of a comprehensive strategy.

…2

The National Quantum Strategy, launched on January 13, 2023, provides an ambitious blueprint for strengthening Canada's quantum sector and includes three missions, which focus national efforts on advancing quantum computing and software, communications, and sensing technologies. To foster these missions and other quantum initiatives, the Strategy is built on three pillars – research, talent and commercialization.

In recognition of the potential impacts of, and opportunities afforded by, next-generation quantum technologies on a range of government activities, the Government response to the Committee's Report reflects a collaborative approach among a range of key federal departments involved in quantum science and technology. These include: Innovation, Science and Economic Development Canada; Public Safety Canada; Canadian Security Intelligence Service; Communications Security Establishment Canada; Immigration, Refugees and Citizenship Canada; Business Development Bank of Canada; National Research Council of Canada; and Natural Sciences and Engineering Research Council of Canada.

The Government has carefully considered the Committee's report, and this response addresses all 11 recommendations, within four themes: 1) funding for technology development and commercialization; 2) supporting talent development and retention; 3) creating a cohesive and coordinated National Quantum Strategy; and 4) protecting encryption systems.

Funding for technology development and commercialization
(Response to Recommendations 1, 2, 3, 5, 8 and 9)

The advancement of quantum science and technology for the benefit of Canadians is a Government of Canada priority. The Government of Canada acknowledges that it is of paramount importance to support Canada's ability and capacity to be a leader in the global quantum marathon, so that we may reap the benefits of commercializing and utilizing next-generation quantum technologies. In so doing, the Government also acknowledges that Canada's world-class research can be a valuable target for theft and espionage. Given the vast strategic advantages for possessing such technology, it is anticipated that Canada's adversaries will continue to target all forms of Canadian quantum research, intellectual property, and/or technology for espionage purposes. As such, it will be important that investments in this sector are protected against risks to research security through measures such as the *National Security Guidelines for Research Partnerships*, which integrate national security considerations into the development, evaluation, and funding of research partnerships.

The Committee's recommendations to expedite quantum support is consistent with the advice the Government has previously received from other sources. For example, in 2021, the Government held a series of roundtables with key stakeholders, and opened an online portal for individuals and organizations to submit their input so that the Government could better understand the challenges and opportunities facing firms, institutions and organizations in the quantum sector.

A key takeaway from the public consultations was that more resources are needed to support the Canadian quantum sector to advance technologies from research and proof-of-concept stage through to commercial products that can be widely adopted across different sectors. This includes support to develop expertise, further research, create commercial pathways, strengthen access to venture capital and improve coordination amongst different players.

Stakeholders expressed that Canada has expertise in many technologies with near-term commercial opportunity, including quantum sensors; quantum communications and cryptography; and quantum computing hardware and software, including algorithm design.

The quantum community also highlighted that quantum technologies are evolving quickly, but have lengthy development timelines that can require long-term research and development support. Even when a quantum innovation reaches the proof-of-concept stage, intensive research is still needed to scale it into a commercially viable technology. Participants in the consultations felt that this interplay underscores the importance of industry-academia-government collaboration throughout the development lifecycle.

Like the Committee Report, the quantum community highlighted that, with large multi-nationals in the international quantum marketplace, Canadian companies need more resources to compete effectively. In addition to addressing challenges in securing investment, the sector needs to scale by identifying Canadian first adopters of its products and growing connections to international supply chains. We have heard that larger Canadian firms and the Government of Canada could benefit from adopting new quantum innovations, and need to play a more active role in working with the quantum sector to drive product development. This will enhance the ability to succeed in a more competitive and technologically enabled global environment.

The Government of Canada is committed to making quantum a Canadian scale-up success story by continuing to support growth as the industry expands and global competition for investment becomes fiercer.

…4

To achieve this, the Government has invested over $1 billion (2012 to 2021) in federal funding, helping establish Canada as a leader in quantum science and technologies. In addition, private investors and philanthropists have committed more than $1 billion toward quantum science, innovation and companies since 2002. Provincial governments have also made significant investments in centres of quantum leadership, including in Quebec, Ontario, Alberta and British Columbia.

This is in addition to the aforementioned Budget 2021 investments, which provided $360 million over seven years, starting in 2021-22, to launch a National Quantum Strategy. This funding will help drive a more integrated and ambitious government effort that will link and leverage existing federal quantum investments. Going forward, the Government's investments will be guided by the Strategy.

As was noted during the Committee's proceedings and public consultations on the Strategy, Canada's investments to date have built a growing ecosystem that includes world-class centres of quantum expertise in universities across the country and pioneering, industry-leading companies. In recent years, other countries have ramped up their efforts to develop quantum technologies.

To retain a leading position and continue to partner effectively amid growing international commitments and investments, Canada must build on its quantum advantage as the impacts of these technologies expand globally. As such, federal funding focuses on critical areas such as research and development, industry-academia-government collaboration, procurement, venture capital, and the international promotion of Canada's quantum industry.

Research and development and industry-academia-government collaboration

The Government agrees with the Committee and stakeholders that investments into research and development that encourage collaboration between different sectors are essential for a successful quantum ecosystem. This is why, over several decades, Canada has supported research through competitive peer-reviewed programs and targeted investments in research institutes and hubs.

One major Government of Canada program is the Canada First Research Excellence Fund, which helps competitively selected Canadian post-secondary institutions turn their strengths into world-leading capabilities, and has invested $176.3 million in quantum projects to date.

In addition, the Natural Sciences and Engineering Research Council of Canada and the Canada Foundation for Innovation have provided more than $200 million and $180 million, respectively, in funding for quantum researchers and infrastructure since 2012.

…5

The Natural Sciences and Engineering Research Council of Canada's Alliance grants provide a flexible instrument for support of multiple types of collaborations. These grants support research projects led by strong, complementary, collaborative teams to generate new knowledge and accelerate the application of research results, to create benefits for Canada. Alliance Quantum funding opportunities help advance Canada's research, innovation and talent development in quantum science and technology through domestic and international collaborations.

Under the Strategy, the Government of Canada has announced three new quantum-specific Alliance grants funding opportunities:

- Alliance Quantum grants ($62.4 million over seven years) to reinforce, coordinate and scale up Canada's domestic research capabilities;
- Alliance Consortia Quantum grants ($40.4 million over seven years) to develop large-scale research collaborations across institutions that connect to government needs and industry applications; and
- Alliance International Quantum grants ($29.7 million over seven years) to allow Canadian academic researchers to connect to international opportunities.

Also under the Strategy, the Government of Canada has committed $50 million over seven years to expand the National Research Council of Canada's Internet of Things: Quantum Sensors Challenge, and to launch its Applied Quantum Computing Challenge. The two challenges will enable the development of revolutionary sensors to provide enhanced precision, sensitivity, rates and range of measurable phenomena and support commercial innovation in applied quantum computing by developing new algorithms and applications that harness the power of quantum computers.

The Government of Canada has also supported the incubation, start-up and scale-up of leading quantum businesses of all sizes. For example, the National Research Council of Canada's Industrial Research Assistance Program has provided funding and business supports for Canadian quantum small and medium-sized enterprises. Quantum technology firms have also received Government of Canada funding through Innovative Solutions Canada and regional development agencies such as the Federal Economic Development Agency for Southern Ontario, Western Economic Diversification and Canada Economic Development for Quebec Regions.

Within the Strategy, the Government will continue to support business development using a number of programs and calls. For example, in June 2022, the Federal Economic Development Agency for Southern Ontario launched a

…6

funding call to support eligible businesses to advance and commercialize their quantum products and solutions for domestic and global markets. In October 2022, Canada Economic Development for Quebec Regions launched a complimentary funding call for businesses in Quebec under the Strategy. Furthermore, Pacific Economic Development Canada and Prairies Economic Development Canada both launched calls to support commercialization of quantum technologies in December 2022.

Under the Strategy, the Government of Canada will also provide $14 million over seven years to the Global Innovation Clusters to speed up growth in Canada's quantum technologies industry by encouraging industry leaders, small and medium-sized enterprises, and post-secondary institutions to collaborate on large-scale quantum projects.

In addition, the Government of Canada has supported large projects and national innovation ecosystems through the Strategic Innovation Fund, including a $40-million contribution to Vancouver, B.C.-based D-Wave Systems Inc. in March 2021.

Most recently, Budget 2022 announced the Government's intention to establish a Canadian innovation and investment agency and committed $1 billion over five years, starting in 2022-23, to support its initial operations. Using best practices established by similar agencies around the world, including Business Finland (formerly Finnish TEKES) and the Israel Innovation Authority, the Canadian agency will work to help new and established Canadian firms innovate, commercialize research, and create new economic opportunities for workers and businesses in Canada.

The Government of Canada also funds commercial projects that support strategic priorities such as defence and security. For example, in 2019 the Department of National Defence's Innovation for Defence Excellence and Security program supported innovators with $8.2 million to develop solutions to overcome the scientific and technical barriers to quantum-sensing systems for defence and security purposes.

Procurement

Stakeholders have also expressed that since Canada's domestic market is small with a modest number of large Canadian first-buyer companies, the Government of Canada has a significant importance as a first buyer. Stakeholders felt that government procurement will be pivotal to de-risk product development and secure commercial success.

We have heard the stakeholders' and the Committee's recommendations. Supply chain issues will be considered to ensure that Canadian quantum researchers and companies have stable access to critical components, either domestically or

through enhancing supply chain security in collaboration with international partners.

The Government has committed to using procurement to help the quantum community reach its goals. One example is the Innovative Solutions Canada program, which enables the Government of Canada to use its research and development procurement spending (contracts) and grants to support the growth and scale-up of firms. Under the Strategy, the Government of Canada will assist innovative Canadian businesses solve pressing challenges by facilitating operational-prototype testing of late-stage research and development. The program has launched numerous calls on quantum technologies, such as:

- Development of a quantum-level biophoton optical imager;
- Development of ultrasensitive spectroscopy systems for quantum photonics;
- Support pre-commercial quantum sensor prototypes that can measure a variety of physical quantities, including electric or magnetic fields, precise timing, temperature, and chemical or biological processes;
- Quantum Computing as a Service solutions to optimize complex problem solving;
- Development of a scaled down dilution refrigerator in support of quantum computing technologies; and
- Testing pre-commercial quantum computing prototypes that address a variety of federal government priorities.

As a world leader in quantum science, Canada can conquer the technical challenges, transition these technologies out of the lab and into the field, and lay the groundwork for a lucrative, high-tech industry.

In regard to a sandbox program, it should be noted that the Innovative Solutions Canada program is a flexible mechanism that can support many of the same objectives, as it enables its 21 participating federal departments and agencies to issue challenges or test innovations via two streams of dedicated funding. The Challenge Stream supports early-stage research and development to prove feasibility and develop a prototype while the Testing Stream allows for departments to test late-stage, pre-commercial prototypes from innovative Canadian small and medium-sized enterprises in an operational environment. Outside of the Innovative Solutions Canada program, the Government will continue to explore other options, including implementing a sandbox program, in particular for facilitating researcher access to quantum computers and technologies.

…8

Venture capital

The Government has heard from stakeholders and agrees with the Committee that the industry has significant needs for venture capital given the evolving nature of quantum technologies, and that satisfying this need would lead to better commercialization opportunities in Canada.

To meet the industry's risk capital needs for a number of disruptive technologies, the Business Development Bank of Canada launched the $200 million Deep Tech Venture Fund in 2021 and has since invested in Xanadu of Toronto and Nord Quantique of Sherbrooke. As Canada's largest and most active venture capital investor, the Business Development Bank of Canada is a strong supporter of quantum start-ups, having engaged and supported many across the country through a number of different programs and funds. The Business Development Bank of Canada was an early investor in D-Wave Systems Inc., and continues to monitor the development of the venture capital sector.

International promotion of Canada's quantum industry

As Canada's domestic market is small, its quantum strategy needs to leverage international partnerships and markets. Stakeholders have noted that the Canadian sector will need to grow connections to international supply chains and markets in order to scale. This is why the Government is engaging in efforts to promote Canada's quantum industry abroad.

Global Affairs Canada's Trade Commissioner Service, in partnership with Invest in Canada, is supporting the Canadian quantum industry through the Foreign Direct Investment Attraction Strategy by promoting foreign direct investments from, and research and development partnerships with, like-minded countries, while keeping security implications in mind. The Trade Commissioner Service and Canada's network of missions are also supporting the quantum community through Canadian International Innovation Program investments and by facilitating international partnerships and activities in line with objectives of the Strategy.

Global Affairs Canada also delivers the Canadian International Innovation Program, in partnership with the National Research Council of Canada's Industrial Research Assistance Program, which has delivered funding to Canadian small and medium-sized enterprises to undertake collaborative research and development, as well as technology matchmaking missions with foreign industrial partners in the quantum space. Two recent examples include a quantum mission to Germany in spring 2022, and the announcement of an NRC Industrial Research Assistance Program/Innovate UK joint funding call in November 2022.

Supporting talent development and retention
(Response to Recommendation 6)

The Government of Canada agrees with the Committee that developing, attracting and retaining talent are critical for the country to succeed in quantum science and technology. The Government foresees that the talent shortages already faced by industry and research institutions will intensify as more quantum technologies, products and services become available for broader use. For the economic potential of quantum technologies to be realized, talent is a key driver.

Stakeholder consultations for the Strategy also stressed the importance of:

- recruiting, retaining and developing quantum talent in academia, industry and government;
- expanding national support for cutting-edge research to serve as a magnet for top talent and foster a vibrant start-up community;
- partnering strategically with international expertise that complements Canadian strengths;
- fostering a diverse and inclusive quantum workforce; and
- harnessing expertise in a wide variety of fields, such as social science and humanities, business, and engineering.

While research and technical talent are critical, growing Canada's quantum sector will also require efforts to build and retain a cross-disciplinary quantum-literate workforce from diverse backgrounds. This includes business and marketing talent that can support sector growth, and university and college-trained talent that can apply quantum technologies across the economy. There is also a need to develop complementary social science and humanities-related skills to ensure that the advantages arising from the applications of quantum technologies can benefit all Canadians in a fair and equitable way.

To address the talent shortage, the Government of Canada has undertaken actions in the following categories: developing domestic talent, attracting international talent, and fostering a diverse and inclusive quantum workforce.

Developing domestic talent

Given the global competition for quantum talent, the Government is investing in developing and retaining quantum expertise in this country, as well as accessing global pools of talent to meet Canada's current and future needs. With respect to domestic talent, offering an environment and culture that support cutting-edge research will be key. As noted previously, the Government of Canada has made

significant investments developing talent through investments in researchers, including over $380 million in funding through the Natural Sciences and Engineering Research Council and Canada Foundation for Innovation alone, with an additional $132.5 million under the Strategy for quantum-specific Alliance grants funding opportunities.

The Government of Canada also recognizes that increasing industry-academia collaboration can draw research talent into the private sector, increase commercialization, and ensure strong readiness to engage and create value from quantum applications. Consultations revealed that training and internship programs that provide work experience and cross-disciplinary skillsets are key to advancing research toward commercialization.

Internships have a proven track record in transitioning talent to industry and retaining expertise in Canada. In 2019-2020, the Government of Canada supported talent mobilization in the quantum sector via more than $3 million in Mitacs internships, which will be supplemented by an additional $40 million to Mitacs over six years under the Strategy. This funding supported the attraction, training, retention and deployment of highly qualified personnel in quantum science and technology through internship experiences and professional skills development for post-secondary students, recent graduates and postdoctoral fellows.

The Natural Sciences and Engineering Research Council's Collaborative Research and Training Experience (CREATE) program has been successfully used to build quantum talent by supporting training experiences relevant to academic and non-academic careers. Four quantum-focused initiatives funded under the program from 2010 to 2018 collectively supported 306 trainees. Under the Strategy, the CREATE program will target the development of academic quantum expertise in areas of industry priority, supported by $5.4 million over six years. The program will develop research skills; training in areas such as professional skills, communication and collaboration; and mentoring activities for trainees. It will involve a group of accomplished researchers who work collaboratively to offer a defined research training program to trainees in areas aligned with priorities under the Strategy.

The Government will also continue studying the option of implementing a national quantum training program and other opportunities for supporting the development of quantum expertise, in collaboration with universities.

Attracting international talent

In terms of international talent, the Government is working to make it as easy as possible to bring and keep individuals with quantum expertise in Canada, to work with our researchers and businesses. In collaboration with our international

…11

partners, Canada also has a role to play in growing the overall global talent pool for our mutual benefit.

Although Canada is an attractive destination for foreign talent, we face strong global competition; stakeholders have suggested creating mobility programs that offer international training and internships, adopting immigration measures, and developing agreements with other countries to complement Canada's home-grown talent supply. To better help quantum firms and researchers navigate the existing suite of immigration programs, the Government of Canada will has launched a series of interactive information sessions with stakeholders.

Immigration, Refugees and Citizenship Canada has a suite of programming that can help facilitate visas and fast-track the immigration process for quantum talent. On immigration, international talent can apply through Express Entry programs, including the Canadian Experience Class, which targets skilled workers who have Canadian work experience and want to become permanent residents; the Federal Skilled Worker Program, for those with foreign work experience who want to immigrate; and the Federal Skilled Trades Program, for high-skilled workers to become permanent residents. Immigration, Refugees and Citizenship Canada also works with provinces and territories through the Provincial Nominee Program, which is a jointly administered immigration program that enables provinces and territories to address their specific economic development needs while distributing the benefits of economic immigration across all regions of Canada.

Canadian quantum companies want to attract top talent to work for their company, and they want a fast and predictable process to do this. To help employers find these highly skilled workers faster, Immigration, Refugees and Citizenship Canada introduced the Global Skills Strategy. The strategy features faster application processing times, work permit exemptions and enhanced customer service.

Employment and Social Development Canada also offers the Global Talent Stream for timely, responsive and predictable client-focused service to help Canadian firms access highly skilled global talent. This Stream, which is a part of the Temporary Foreign Worker Program, is designed for innovative firms in Canada that are referred to Employment and Social Development Canada by a designated referral partner and that need unique and specialized foreign nationals in order to scale-up and grow. It is also intended for firms in Canada that need to fill an in-demand highly skilled position on the Global Talent Occupations List.

Stakeholders also stressed the importance of linkages to international pools of talent to complement Canadian strengths. Under the Strategy, the Government announced $30 million over seven years for the Natural Sciences and

…12

Engineering Research Council's Alliance – International Quantum to allow Canadian researchers and trainees to work with international counterparts to further academic-led projects.

Mitacs also attracts international trainees to Canada. For example, the Mitacs Accelerate International program supports bilateral research collaborations between interns, universities and industry partners in Canada and abroad, allowing trainees from partner countries to undertake projects in Canada.

Additionally, several federal departments, including Immigration, Refugees and Citizenship Canada and Global Affairs Canada, are working to attract quantum talent to Canada by including quantum expertise in the list of desired qualifications.

Fostering a diverse and inclusive workforce

To ensure Canada benefits from the perspectives of a representative pool of talent, the Government is committed to ensuring a diverse and inclusive quantum sector workforce. Indeed, the Strategy is an opportunity to build an inclusive talent ecosystem in an area of national priority, by testing new approaches to attracting diverse talent to the field, supporting under-represented groups at all career stages and addressing systemic bias in the selection of talent for the quantum workforce.

Stakeholder consultations showed broad support for a diverse and inclusive quantum workforce. Participants put forward an array of ideas to address demographic imbalances, ranging from human-centric programming that expands the pool of potential hires, to new post-secondary programming that attracts science, technology, engineering and math students from other fields, both domestically and from abroad.

The Government of Canada has heard from stakeholders and is actively addressing this challenge. Innovative Solutions Canada asks businesses with which it partners to participate in the Government of Canada's 50-30 Challenge, launched by Innovation, Science and Economic Development Canada to encourage greater corporate diversity. The goal of the program is to challenge Canadian organizations to increase the representation and inclusion of diverse groups within their workplaces, while highlighting the benefits of giving all Canadians a seat at the table.

The 50-30 Challenge asks that organizations aspire to two goals:

- Gender parity (50% women and/or non-binary people) on Canadian boards and/or in senior management; and

…13

- Significant representation (30%) on Canadian boards and/or senior management of members of other equity-deserving groups, including those who identify as racialized, Black, and/or people of colour ("members of visible minorities"), people with disabilities (including invisible and episodic disabilities), 2SLGBTQ+ and/or gender and sexually diverse individuals, and Indigenous Peoples. The program and participants recognize First Nations, Métis and Inuit as founding Peoples of Canada and are underrepresented in positions of economic influence and leadership.

Calls and programs supported by the Strategy will be delivered by a number of federal departments such as Innovation, Science and Economic Development Canada, the National Research Council of Canada and Regional Development Agencies. All of these organizations collect and monitor equity, diversity and inclusion data to identify representation gaps. Given a highly competitive international market for talent, sustained effort over time will be required to realize meaningful progress.

In tackling greater and sustainable diversity, the Government of Canada believes that promoting skills development and engagement in science, technology, engineering and math should start early. Since 2015, Innovation, Science and Economic Development Canada has provided $22.5 million to Let's Talk Science, an organization that delivers science, technology, engineering and math programs to youth, increases career awareness among students and teachers, and offers career-building volunteer opportunities to post-secondary students. Additionally, this broad community-based approach encourages youth from under-represented groups, including girls, Indigenous youth, youth with disabilities, at-risk youth, and those in rural or remote locations, to develop lifelong learning habits and curiosity toward science, technology, engineering and math fields such as physics, quantum science and technologies.

The Government has supported a number of organizations that actively work to increase diversity in the quantum sector. For example, the Perimeter Institute has initiatives to enhance equity, diversity and inclusion in theoretical physics and related fields including the Perimeter Scholars International Masters program and the International Summer School for Young Physicists, which have trained nearly equal numbers of participants across genders. To attract and retain more students, Perimeter is also launching the Perimeter Scholars International Start program, which aims to increase the numbers of undergraduate students from under-represented groups who pursue further studies in physics. The program will offer online schooling, as well as opportunities for a select number of trainees to participate in research with scientists at Perimeter.

…14

Under the Strategy, programs will continue implementing gender-based analysis measures to advance equity, diversity and inclusion. For example, the Natural Sciences and Engineering Research Council, through the Tri-Agency Equity, Diversity and Inclusion Action Plan, aims to support equitable access to funding opportunities for all researchers and students. The Natural Sciences and Engineering Research Council's Alliance and CREATE programs include equity, diversity and inclusion as an integral consideration in the assessment of applications, and both programs require grantees to report on practices that support those considerations.

These types of activities will remain essential to growing expertise in quantum technologies among people of all communities, and establishing a pipeline to supply Canada's research and businesses sectors.

Creating a cohesive and coordinated National Quantum Strategy
(Response to Recommendations 3, 7, 10 and 11)

Canada's investments in quantum technologies and research over many decades have made the country a global leader in the field, with a growing ecosystem of world-class centres of quantum expertise in universities and businesses across the country. As the rest of the world expands its own quantum programs, the Government recognizes the need to invest and innovate if it is to stay ahead.

Based on our extensive consultations with stakeholders, the National Quantum Strategy takes into account the needs and capabilities of the Canadian quantum community. One important element is collaboration, both domestically and internationally. The Government of Canada recognizes that working together between government, academia and industry and across Canadian jurisdictions is key to succeed in the quantum technologies marathon.

Budget 2021 provided funding to establish a secretariat at Innovation, Science and Economic Development Canada to coordinate the Strategy. The National Quantum Strategy Secretariat also provides a focal point of contact, internal and external, to connect the ecosystem, providing information on opportunities and sources of support, and facilitating the adoption of quantum technologies by bringing together the user community and developing use cases in key sectors.

To help grow the quantum sector and ensure that the Strategy remains on track, a Quantum Advisory Council will be established to provide impartial advice to government. The Council will draw on expertise, experience and knowledge of best practices from the industry, academic, not-for-profit and investment communities, as well as receptor industries.

…15

Ongoing stakeholder engagement will be critical to achieving the goals of each of the three Strategy missions. Mission-specific working groups representing the full innovation continuum will develop roadmaps including activities, milestones and potential investments. The Government of Canada will use the roadmaps to inform future quantum investments.

For the Strategy to succeed, the Government recognizes that quantum efforts of federal departments and agencies must be better coordinated and aligned. An inter-departmental Quantum Committee involving all federal departments with an interest in quantum science and technology will ensure coordination and connections to the broader Canadian quantum ecosystem. The National Quantum Strategy Secretariat will support these groups to facilitate the implementation of external advice and identify needs, opportunities, activities and programming.

The Government also agrees that mutually beneficial collaboration will be critical to the success of the Strategy, including among domestic businesses and researchers, within federal departments, with provincial governments, and between Canadian stakeholders and international partners. Ensuring that activities across federal, provincial and territorial governments are united and coordinated will optimally position Canada to compete globally.

The Government of Canada and provincial governments engage regularly with each other on quantum technologies and on potential areas of collaboration. Several provincial governments have identified quantum as a priority in their science and research agendas and provided funding to the quantum hubs in their provinces.

Investments in regional quantum ecosystems, including through four of the Regional Development Agencies (Canada Economic Development for Quebec Regions, Federal Economic Development Agency for Southern Ontario, Prairies Economic Development Canada and Pacific Economic Development Canada), will help strengthen local quantum activities, which connect to a robust national network in support of the Strategy. This includes investments in key components of the Quebec and British Columbia quantum ecosystems, such as the MiQro Innovation Collaborative Centre and the Quantum Algorithms Institute. The Government of Canada has supported regional quantum ecosystems with additional investments from the Canada First Research Excellence Fund, Natural Sciences and Engineering Research Council and the Canada Foundation for Innovation.

Going forward, the Government of Canada will seek out collaboration opportunities with all provinces and territories, and provide funding to expand activities and partnerships. The Strategy will help align Canada's efforts to build quantum capabilities across the country.

…16

Beyond academia and industry, developing and retaining quantum talent and expertise across government departments and agencies is also essential to effective implementation of the Strategy. Given the wide-ranging implications of quantum technologies that cut across Ministers' mandates, many federal departments and agencies are already active in connecting and supporting the quantum community. For example, the National Research Council of Canada conducts and funds research in quantum sensing, communications, and computing. The Communications Security Establishment, Canadian Space Agency and Department of National Defence are supporting and studying the development and impact of quantum technologies relevant to their respective mandates.

Efforts are underway to further develop the Government's quantum expertise. For instance, Budget 2022 proposed $17.7 million over five years, starting in 2022–23, and $5.5 million thereafter until 2031–32, for the Communications Security Establishment to establish a unique research chair program to fund academics to conduct research on cutting-edge technologies relevant to Communications Security Establishment's activities such as quantum technologies and artificial intelligence. The National Quantum Strategy Secretariat will also act as a focal point for the Government of Canada quantum ecosystem and expertise.

Under the Strategy, a new program, called the Quantum Research and Development Initiative, will be introduced to grow Government of Canada quantum capabilities and expertise. The program will help de-risk emerging quantum technologies for key sectors and advance applications to support government priorities. It will also bring together federal departments and agencies to work on collaborative quantum research and development projects, and engage with the broader Canadian quantum ecosystem in support of cross-cutting departmental mandates and priorities to address issues important to Canadians.

The Government also ensures that it is able to effectively evaluate quantum proposals, which are assessed according to the specific programs they have been submitted under. For example, under the Natural Sciences and Engineering Research Council's Alliance program, the agency makes use of peer review to determine the merit of the application. This means that the agency may leverage existing peer review or seek out the opinion of experts in the same, or a closely related, field of the application to assess applications against the funding program's merit evaluation criteria. In funding programs where proposals are in direct competition with one another, the Natural Sciences and Engineering Research Council may make use of a two-step process. In step one, peer review opinions, in writing, would be sought. In step two, a panel of experts in the field (peers) would be assembled to evaluate the proposals that had been submitted.

…17

The panel may be informed in their assessments by the written reviews. The panel would then determine which proposals merit funding, and in most situations a rank-ordered list of applications is prepared, recommending which proposals merit funding.

Furthermore, the National Research Council of Canada has a diverse range of relevant expertise in areas such as quantum physics, communications, devices, sensors, algorithms and metrology, and regularly provides scientific advice to support government programs (e.g., Innovative Solutions Canada, Natural Sciences and Engineering Research Council) and Canadian researchers in academia and the private sector.

Protecting encryption systems (Response to Recommendation 4)

The Government of Canada recognizes the potential risk posed by fully realized quantum computers to many current-day cryptography methods, and the need to take urgent action to protect Canada against those risks.

There are government activities underway to protect existing encryption systems from the quantum computing threat. In the short term, the Government of Canada will encourage operators of encryption systems to adopt mitigations such that if encrypted data is stored by malicious groups, it will not be vulnerable to future quantum computing technology. The Communications Security Establishment (CSE), the Government of Canada's national cryptologic agency and authority on communications security, has undertaken activities to ensure that highly sensitive government and military communications are protected against the quantum threat. These activities are coordinated with our allies to maintain interoperability. These activities are largely governed through the Canadian Cryptographic Modernization Program which is led by CSE in conjunction with the Department of National Defence and Government of Canada partners.

CSE is committed to ensuring the availability of a practical and standardized cryptographic capability that will remain secure against quantum computers. It has supported the international efforts towards the standardization of post-quantum cryptography by the National Institute of Standards and Technology in the United States of America. The Government of Canada is participating in international standards development organizations, critical infrastructure partnerships, and industry engagements with stakeholders to encourage the adoption of National Institute of Standards and Technology recommended post-quantum cryptography in standards, industry specifications, and commercial products.

CSE is also providing technical guidance to organizations on the transition to post-quantum cryptography through publications, presentations and tailored client advice. Additionally, CSE is promoting awareness and providing guidance on the quantum threat to non-government sectors as well. For example, CSE and Innovation, Science and Economic Development Canada are members of the Quantum-Readiness Working Group of the Canadian Forum for Digital Infrastructure Resilience. CSE provided technical advice on the Working Group's *Canadian National Quantum-Readiness: Best Practices and Guidelines* produced in cooperation with members of Canada's financial sector. CSE, Treasury Board of Canada Secretariat and Shared Services Canada are working together to prepare and plan for the transition of wider Government of Canada systems. Public Safety Canada, Innovation, Science and Economic Development Canada and CSE will work with industry stakeholders, to ensure Canada's critical infrastructure is protected from the quantum threat.

The Canadian Security Intelligence Service investigates and advises the Government of Canada on threats to Canadian national security from hostile state actors. Data protection laws limiting transmissions to foreign jurisdictions may reduce the exposure of data to collection, but it would have to be balanced against the potential negative impacts on Canada's competitiveness in an increasingly data-driven global economy. Moreover, hostile state actors are unlikely to be restricted to networks within their jurisdiction, such that we must assume any encrypted data transiting global untrusted networks could be collected and stored by our adversaries.

In the longer term, the National Research Council of Canada is performing research and development on quantum technologies that will lead to a quantum internet and enable alternate secure communications solutions, such as quantum key distribution. The National Research Council of Canada and the Communications Security Establishment continue to assess the readiness of quantum key distribution and its applicability to securing sensitive Canadian government communications.

These efforts will support the mission under the Strategy on quantum communications, which aims to ensure the privacy and cyber-security of Canadians through a national secure quantum communications network and a post-quantum cryptography initiative. The Government plans to work with researchers and industry to support the adoption of post-quantum cryptography in technologies vulnerable to future quantum-enabled threats; work towards a secure Government of Canada quantum network; and support the assessment of commercial prototypes to demonstrate their cyber-security, resiliency and interoperability.

…19

The Government would like to reiterate its gratitude to members of the Committee for their hard work and dedication to the study on quantum computing. The Government recognizes the concerns expressed and has taken the Committee's thoughtful and well-articulated recommendations into consideration as Canada takes further steps towards success in quantum.

Quantum technologies are evolving quickly. As the technologies mature and the opportunities and challenges become clearer, the Government of Canada may explore additional actions to support Canadian excellence and meet the needs of the quantum community. The Government of Canada will also maintain an ongoing dialogue with stakeholders and partners to ensure that Canada is positioned to succeed in a quantum-enabled future.

Please accept my best wishes.

Sincerely,

The Honourable François-Philippe Champagne, P.C., M.P.