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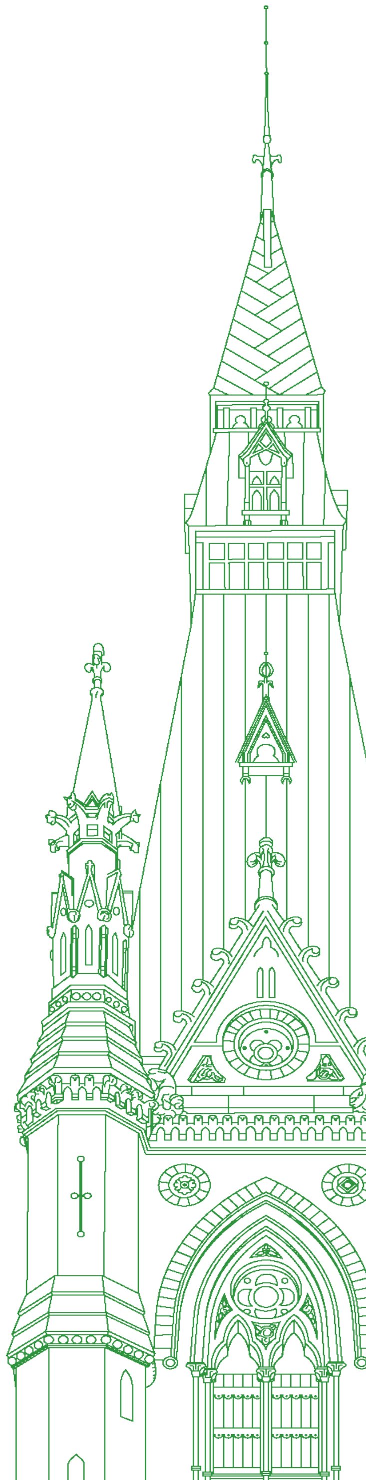

Chair: Mr. Joël Lightbound

Standing Committee on Industry and Technology

Friday, April 1, 2022

● (1305)

[*Translation*]

The Chair (Mr. Joël Lightbound (Louis-Hébert, Lib.)): I call the meeting to order.

Good afternoon.

Welcome to meeting number 15 of the House of Commons Standing Committee on Industry and Technology. Pursuant to Standing Order 108(2) and the motion adopted by the committee on Tuesday, March 1, 2022, the committee is meeting on quantum computing.

Today's meeting is taking place in a hybrid format, pursuant to the House order of November 25, 2021. Members are attending in person in the room and remotely using the Zoom application. As a reminder, all those attending the meeting in person must follow the public health rules in place, which everyone should be familiar with.

I would like to welcome the witnesses and thank them for being with us today. My apologies for the delay. Before we get started, I would ask the witnesses to make sure that their microphones are properly positioned.

Joining us are Anne Broadbent, professor and holder of the university research chair in quantum information and cryptography, department of mathematics and statistics, University of Ottawa, as an individual; Dr. Edward McCauley, president and vice-chancellor, University of Calgary; Andrew Fursman, co-founder and chief executive officer of 1QB Information Technologies Inc.; and Dr. Stephanie Simmons, founder and chief quantum officer of Photonic.

Luc Sirois of the Conseil de l'innovation du Québec will probably be joining us.

Also, Allison Schwartz, vice-president of global government relations and public affairs at D-Wave Systems, will join us later if she's able to connect to the meeting.

Ms. Broadbent will start us off. Go ahead, Ms. Broadbent. You have about six minutes.

Dr. Anne Broadbent (Professor and Holder of the University Research Chair in Quantum Information and Cryptography, Department of Mathematics and Statistics, University of Ottawa, As an Individual): Thank you, Mr. Chair and members of the committee, for inviting me to take part in today's meeting.

I am very glad to contribute to this important study on the domestic quantum computing industry, as well as Canada's talent retention and competitive advantages.

My name is Anne Broadbent, and I am the university research chair in quantum information and cryptography in the University of Ottawa's department of mathematics and statistics. I am proud to say that my academic career has been 100% Canadian.

The focus of my research is the design of new security protocols that use quantum computing for new functionalities. I am recognized internationally for my role in inventing blind quantum computing, a secure method to perform online quantum calculations.

[*English*]

When I started grad school 20 years ago, Canada was the place to be for all things quantum. We're still leading the world, but many countries are hot on our heels.

Gilles Brassard at the Université de Montréal is the most prominent Canadian pioneer in quantum information science, and I am fortunate to be one of his former Ph.D. students. His research in quantum cryptography and teleportation back in the eighties is the foundation of virtually all breakthroughs in the current evolution of quantum. He was recently awarded the Wolf Prize, which is generally a precursor to a Nobel prize.

In the past 10 years, the quantum landscape has drastically accelerated. This is a huge opportunity for Canada. With the advent of big data, the Internet of things, 5G, machine learning and e-commerce, digital transformation is affecting just about every sector, and quantum presents several global socio-economic challenges.

The research firm Gartner projects that by 2023, 20% of organizations will have earmarked quantum computing in their budgets, compared with less than 1% in 2018. In 2045, quantum is expected to be a $140-billion dollar industry, with almost 210,000 jobs and $42.3 billion in returns.

Canada is already contributing to this growth. Our nation has a dynamic quantum ecosystem featuring fast-growing quantum companies, and universities and research institutes dedicated to pushing the boundaries of quantum research. With over 50 professors working in the area, the University of Ottawa is internationally renowned for its research on quantum communications, sensing and cryptography.

At the uOttawa cybersecurity hub, we are facilitating a transition to e-commerce that is designed to be safe in the era of quantum computers. In my view, this is where the breadth of the impact of quantum is possibly the largest. It affects every Canadian industry with a cyber presence. uOttawa is also partnering with several very exciting quantum companies like Xanadu, headquartered in Toronto, which was previously mentioned in this committee.

However, as with other technology industries in Canada, companies and talent in quantum are facing difficult choices about staying in Canada or leaving for competing jurisdictions. The U.S., U.K., EU and Netherlands, as well as France, Germany and China all have aggressive quantum strategies. The Netherlands, for example, has established a national organization, which is a connection point for all things quantum. It even includes a quantum child care pilot program.

There is a global competition worldwide, and we are losing talent to foreign, high-paying companies. We are losing highly skilled talent in universities to more attractive opportunities outside of Canada.

[*Translation*]

What does that mean for a faculty member like me and the broader academic community?

My job, as a professor in the department of mathematics and statistics, is to teach science and engineering students in all years the art of logical thinking, problem solving and science communication—the building blocks of their disciplines and careers.

[*English*]

Today's science discovery is tomorrow's innovation advantage.

Academia has a responsibility as one of the fundamental pieces of the ecosystem, and there is an urgent need for skills and development. There is a need for more professors who foster environments for cutting-edge research, and a need across many disciplines, like computer science, math, engineering and physics, but also social sciences and law.

Post-secondary institutions are spearheading research and innovation initiatives that align with industry-relevant research and the translation of research-derived innovations to products and start-ups. Entrepreneurs are shaped in our institutions and, as my experience confirms, quantum companies of all shapes and sizes rely on the university's knowledge base and talent.

There was an interesting discussion at the last meeting about the need to attract, retain and train talent. I would like to contribute a diversity lens to this topic. For me, it's a privilege to be a woman in quantum in Canada. I say this, because it gives me an almost instant camaraderie with a small group of amazing, distinguished women working in this area. Equity, diversity and inclusion are recognized as catalysts to innovation, and there is a potential for Canada to benefit from further efforts in this area.

In conclusion, I feel strongly that the Government of Canada needs to continue to fund inclusive quantum research and its talent pipeline, with the goal of strengthening Canada's position at the global scale.

Thank you for the opportunity to appear before you today. In closing, I would like to extend a warm invitation to the members of the committee to visit the University of Ottawa and see first-hand some of the next generation of talent and our research at work.

● (1310)

The Chair: Thank you very much, Madam Broadbent.

I will now turn to Mr. McCauley for six minutes.

Dr. Edward McCauley (President and Vice-Chancellor, University of Calgary, As an Individual): Thank you.

[*Translation*]

Thank you for inviting me to appear before the parliamentary committee today.

[*English*]

Quantum computing and, more generally, the applications of quantum science are extremely important for Canada's economic prosperity into the near and far future. We have a strong position globally in these areas, but countries around the world are investing significantly in quantum research. This should be a strong signal for the Government of Canada about the potential impact on both our immediate and future economic growth and prosperity.

I have three requests for the committee to consider. First, continue to invest in the quantum Canada strategy currently being implemented by ISED. We need to support talent development, particularly at the graduate student level, and talent attraction. Otherwise, we will weaken our competitive position. Countries around the world are investing billions of dollars, if not trillions of dollars, in quantum science and initiatives. Historically, Canada has invested, but these investments have been piecemeal and somewhat ad hoc. The quantum Canada strategy is a vehicle to support a national investment in a more coordinated fashion.

My second request is to support initiatives across the country rather than simply all in a particular geographical region. The reasons are simple. For Canada's diverse regions to benefit, industrial sectors need applications. These are often best developed through industry-university collaborations that are often local in character, reflecting the needs of industry. We need to think about how regions can contribute quantum applications for various industrial sectors, such as energy, agriculture, transportation and logistics. As a country where 70% of business is small and medium enterprises, or SMEs, local collaborations matter. Universities serve as hubs to build industries in quantum science, providing access to machines and talent, and then universities collaborate with each other across the country to create an ecosystem.

My third request is don’t boil the ocean. Competition is international. Identify those areas where we have a competitive advantage and build on those—areas such as quantum information storage, quantum security and information transfer, and of course quantum computing.

The University of Calgary is proud to be a major contributor to the quantum ecosystem. We have tremendous expertise in the area of quantum cybersecurity, building the next generation of the quantum Internet using secure information transfer. We have expertise in quantum information storage, and are building a major industry-facing laboratory for prototyping and manufacturing. Finally, we have expertise in quantum computing algorithms and applications.

The University of Calgary is creating a major vision for activating Calgary as a quantum city. We have attracted Mphasis, one of the world’s largest computer supply companies, to establish their national headquarters here in Calgary, bringing 1,000 employees and partnering with the University of Calgary on developing quantum applications in a variety of areas, including health, finance and commerce, energy, agriculture, and transportation and logistics.

The University of Calgary is also a major collaborator with other regions where critical masses of researchers exist. Please exclude the pun, but our scholars in quantum research are entangled across the country. The University of Calgary has major collaborations with the Université de Sherbrooke and the University of Waterloo, among many.

Finally, I must point out a source of pride for our university. This year the University of Calgary has been recognized as being in the top five for research universities across the country. We have joined the ranks of the University of Toronto, McGill, UBC and Université de Montréal, based on our external research revenue of $504 million. We are the youngest university to achieve this recognition as part of the U15. We were also named as number one in the country in terms of new start-up company creation, surpassing the University of Toronto and the University of Waterloo. These are all audited quantitative results that are based on data, not subjective interpretation.

Thank you for your attention.

● (1315)

[*Translation*]

Please feel free to ask any questions you have in French. I would be happy to answer them.

The Chair: Thank you, Mr. McCauley.

We will now hear from Mr. Fursman, of 1QB Information Technologies.

Go ahead, Mr. Fursman.

[*English*]

Mr. Andrew Fursman (Co-Founder and Chief Executive Officer, 1QB Information Technologies Inc.): Thanks for inviting me to share my experience with you today.

My name's Andrew Fursman and I'm the CEO of 1QBit. We're a Canadian company focused on a software-first approach to quantum computing. While many companies take a qubit-first approach—where they select photonics, ion traps or superconducting technologies, usually matching their founder's expertise and then building the best possible devices, hoping to win the hardware race—1QBit starts with an industrial need. We conceive of new algorithms useful to solving specific industrial problems, and then we select the computing technology that's best suited to compute the answer to those problems, usually based on evidence.

We recognize that a computer is only as valuable as the problems it solves, so we partner with hardware companies to ensure that their devices are designed and optimized to solve specific, important problems.

By way of background, I've studied economics at the University of Waterloo, political science and philosophy of science at UBC, financial engineering at Stanford and Hong Kong, and I'm now on the Singularity University faculty in Silicon Valley, where I'm focused on advanced computing.

I was previously co-founder of the Nasdaq-traded company Satellogic, where we put a large number of small satellites in low-earth orbit for Earth observation. I'm a founder of Minor Capital, where we invested in B.C. deep-tech companies, including General Fusion, D-Wave and Kindred. I'm also an adviser in Cambium Capital, focused on advanced computing and investing in companies like IonQ and Seeqc in the quantum world, and Groq in the AI space. I'm an adviser to NATO's one-billion euro deep-tech investment fund. I'm also the industry board chair of Mitacs, as well as a member of the World Economic Forum's council on the future of computing.

I've studied and invested in many deep technologies. I've learned a lot, enjoyed some substantial returns and I'm delighted to share a few ideas with you today.

I wanted to start by making two statements. One, quantum computing is an important industry for Canada's future. Two, quantum computing is not yet industrially useful. These aren't incompatible ideas. There's a lot of hype around quantum technologies and computing right now, because of the transformative potential for a new form of information processing.

Quantum computing is the first revolution in computing, and its development is happening right now. However, because quantum computing is not yet competitive against traditional computers, it's hard to summon the political will to pragmatically support this infant industry, despite the fact that the infant industry argument is one of the most solid economic cases for government investment.

It's important to recognize that promoting the procurement of current quantum computers is not a very helpful way to grow domestic quantum capabilities. I'd like to share why, to help frame how the government can be more helpful.

At Satellogic, we originally envisioned a constellation of hundreds of satellites working together, but at first, we were only able to launch a small number of individual satellites. Individual satellites are less useful than an entire constellation, but they're still able to provide value individually, observing Earth, but revisiting every place on Earth less frequently than a full constellation.

Quantum computing's a little different. It's at a bit of an earlier state. We're not building small, useful quantum computers that will one day become large quantum computers. We're still building the theory and components that will one day become the smallest useful quantum computers. Half of a quantum computer is basically a pile of qubits. It's like a fence that goes halfway around your farm. Half of the satellite constellation is roughly half as useful as the full constellation, but half of a fence is about as useful as no fence at all. While every fence is at some point half of a fence, it doesn't have real value until it's complete.

The current misconceptions around the state of quantum computing mean that as governments look to support the infant quantum computing industry, they are frequently trying to incentivize domestic consumption of current quantum computers. This is kind of like asking farmers to install new half-fences around their fields.

Quantum computers are not yet industrially useful, and they aren't expected to be for a few years. To recognize the current realities and truly help incubate infant industries, governments shouldn't encourage the adoption of half-fence solutions today, but should instead focus on incentivizing the long-term development of full quantum systems in Canada, including talent development, software design, architectures, control and manufacturing methods.

Pushing quantum computers on industrial users today is like pushing half-fences on farmers.

● (1320)

If governments really want to support the infant quantum computing industry, governments should know that the current goal within our industry is to make quantum computers better than classical computers at any industrially usable task.

Until then, consistent and reliable direct investment in technology development is needed, similar to the great work happening in Quebec—building a formal quantum innovation zone around Sherbrooke—and in many other regions around the world. It's direct investment like this that will help Canadian technology companies weather the hype cycles and business cycles over the next decade, and focus on building real technology over the long term instead of generating absurd short-term marketing hype, and help Canada incubate this infant quantum industry until quantum computers begin to compete against traditional classical computers by delivering real industrial value.

To echo Ray Laflamme from earlier this week, quantum computing is happening now, but it's a marathon, not a sprint.

I hope Canada's national quantum strategy can be focused around winning the game, not the match.

I really appreciate your time today and I look forward to our discussion.

Thank you.

The Chair: Thank you very much, Mr. Fursman.

We'll now move to Allison Schwartz.

Ms. Allison Schwartz (Vice-President, Global Government Relations and Public Affairs, D-Wave Systems Inc.): On behalf of D-Wave Systems Inc., thank you for the opportunity to appear before the committee, and I ask that my full written statement be included into the record.

As background, D-Wave is the leader in development and delivery of quantum computing systems, software and services and is the world’s first commercial supplier of quantum computers. With our headquarters and our quantum engineering centre of excellence based near Vancouver, D-Wave is passionate about preserving Canada’s global leadership.

The quantum computing industry is an important one. We appreciate the attention from the government and look forward to supporting the work of this committee.

D-Wave is a full-stack provider, which means our technology, products and services include hardware, software, cloud platform, professional services, developer tools and more. D-Wave is the only company building both annealing quantum computers and gate-model quantum computers, so our platform-agnostic approach can provide broad industry perspective.

Quantum computing is inherently interwoven across a variety of academic disciplines and touches upon a variety of different technologies. This guides our recommendation of inclusivity of academic disciplines and access, as well as integration with different technologies.

We recommend that engagement on quantum be multidisciplinary. The quantum ecosystem requires a workforce with skills encompassing everything from engineering, cryogenics and software to IP and business strategy. What is often forgotten is that to be successful, users must bring existing skills from a variety of sciences, theoretical and applied, to ensure that the business value of quantum computing is unlocked.

Cloud access to quantum computing technology is another key tool to promote inclusive and diverse use of the technology.

A federal quantum user access program via the cloud should be created. The United States is working on a similar user access idea called QUEST, aimed at expanding access to quantum hardware and enhancing research through a government-funded program.

A similar program should be considered in Canada, but we recommend going one step further and including a national quantum training program. This could serve as a beacon for workforce development by engaging Canadian companies like D-Wave and others to provide skills training on their individual technologies. This program could be open to academia, government, as well as industry to accelerate quantum fluency. It could easily be stood up as a pilot in 2022 through existing organizations, such as the Digital Technology Supercluster, the Quantum Algorithms Institute and the Creative Destruction Lab, all of whom have existing relationships with industry, government, end-users and academia.

As highlighted in the recent consultation report released by ISED, quantum hybrid technology should be supported. This sentiment is also echoed in the United Kingdom.

There will likely always be a need for classical computation as part of the solution for many problems, but the most complex part of those problems are often best suited for quantum computers. For example, the quantum hybrid solvers in D-Wave’s Leap quantum cloud service combine the best of both classical and quantum computing technologies.

Government should think of quantum computing in a holistic manner and note that quantum computing technology will likely be integrated with and work alongside a variety of other technologies. One project to consider is building a domestic high-performance computing data centre that is integrated with quantum.

Lastly, there's a real need to showcase the technology's capabilities for today. D-Wave delivers customer value and practical applications for problems as diverse as logistics, AI, drug discovery and financial modelling for organizations like Volkswagen, Lockheed Martin and even Save-On-Foods for grocery optimization.

In September 2020, we released our Advantage quantum systems that includes more than 5,000 qubits and an expanded hybrid solver service capable of running problems with up to one million variables. This combination gives businesses and governments the ability to run in-production applications today. Yet, with all of this, the first question we hear most often is “What can you do with the technology today?”

Different systems have different capabilities. Our annealing quantum computers are best suited for tackling optimization problems, while gate-model systems are expected to be able to solve problems in quantum chemistry and materials design. We are but one voice trying to showcase the art of the possible.

A dedicated government program, such as a quantum sandbox that supports rapid near-term application development, will accelerate innovation, adoption and commercialization.

Other governments are already focusing on application development. A presidential advisory committee in the United States recommended a quantum sandbox for communications resiliency. The Australian Army is looking at quantum applications for optimizing autonomous vehicle resupply. The Australian government is looking at quantum to optimize their transportation system. In Japan, an application has been piloted that optimizes waste collection while also reducing CO2 emissions by nearly 60%.

● (1325)

The Information Technology and Innovation Foundation's report highlighted near-term quantum applications and showcased global use cases across a variety of industries.

As heard during the ISED round tables, there is a need to nurture a quantum ecosystem and scale commercial activities. The quantum sandbox would directly address that recommendation.

In conclusion, there is a need to act swiftly and in a multipronged fashion. Federal efforts should be inclusive of all technologies, incorporate many academic disciplines, support cloud-based access to the system and online training, and create a quantum sandbox to expedite commercialization. All of these efforts should be in addition to the continued promotion of longer-term quantum computing R and D advancements.

I appreciate your time today, and I am happy to answer any questions.

Thank you.

The Chair: Thank you very much, Madam Schwartz.

We'll now move to Madam Simmons, for six minutes.

[*Translation*]

Dr. Stephanie Simmons (Founder and Chief Quantum Officer, Photonic Inc.): Thank you, Mr. Chair.

[*English*]

Good morning. Thank you for inviting Photonic Inc. to contribute.

I am Stephanie Simmons, the founder and chief quantum officer at Photonic. I've been part of computer science and mathematics departments at IQC at Waterloo, material sciences at Oxford, and the School of Electrical Engineering at UNSW. I am here as an associate professor of physics at Simon Fraser University. I am also a CIFAR fellow, a Canada research chair and an hounouree of Canada's Top 40 Under 40.

To my knowledge, I am the only Canadian to have won Physics World's “top 10 breakthroughs of the year” twice, in 2013 and 2015, both of them for my quantum computing breakthroughs, which were covered by The New York Times, Wired, the BBC, the CBC and others.

Photonic Inc. is a majority-owned Canadian company, founded in 2016 for IP, and has been in operation since 2021. We have attracted significant world-class talent and now have over 60 full-time employees based here in Metro Vancouver, in four provinces nationally and in multiple countries.

We are in stealth mode. We are not disclosing our funding, our road map or our pace of progress, but what we can say is that our core technology is on the spin-photon interfaces that enable true modularity of quantum processors and quantum networks, as well as silicon-grade scaling.

The previous quantum sessions at this committee have been fascinating. I agree with much of what has been said, but I hold alternative opinions on many key issues.

I agree with the previous panels of experts that predicting the scope of impact for quantum technologies today is very much like predicting the scope of the two previous times that we commercialized a branch of physics, one with the semiconductor transistor in 1945, and the other with nuclear fission in 1939.

Although the specifics are difficult to predict, I would say that transformative technologies follow quite regular patterns in their adoption. After incubation within academia for decades, there is a shift, a mass proliferation of entrepreneurial activity around many distinct approaches, and then finally, a dominant design emerges. This is a key moment, after which there is a substantial talent shortage and a mass consolidation into a handful of winners. We believe that the quantum dominant design is not yet here, but it will become apparent in the next few years.

I agree with the previous panels of experts that Canada's goal should be to be the home of one of those winners, and that picking winners before a dominant design emerges does entail some risk, but the risk of wait-and-see is much greater. Through the public lens, however, quantum technologies will initially be seen as a sincere cybersecurity challenge. Essentially, unless we defend our cybersecurity infrastructure properly now, the advent of a quantum computer could be positioned as the information-security equivalent of the nuclear bomb.

Quantum computers will break the asymmetric, or RSA, layer of modern encryption. RSA is used everywhere—in all civilian passwords, online communications, the SWIFT payment system, critical infrastructure logins, government and military communications and files and old legacy code that is no longer supported. It all needs to be replaced.

The concern is very asymmetric. Everything needs defending, whereas only one RSA-capable quantum computer needs to be built by an adversary to have god-like access to all modern and stored communications.

Researchers have been working for decades on a potential solution to this issue, to build trust in an alternative, post-quantum algorithm. I strongly support intense development in this area, in all forms, because the cost of failure here is so high. No one knows if these post-quantum codes will hold up against future quantum attack or even a classical computing attack. I sincerely hope they do, but there is optimism and no hard proof. Three of the top candidate post-quantum algorithms have fallen, one at a time, over the past years, including one just a few weeks ago.

We can hope for the best, but we should plan for alternatives. Canada should adopt many layers of protection here. In addition to RSA, we can layer on all post-quantum encryption contenders that are standardized in software so that adversarial organizations must break all of them to get through. This will buy us time. For critical infrastructure, I suggest we additionally layer in provably secure defences during this encryption transition, for insurance purposes. There are two provably secure replacements for RSA—one-time pads, and quantum key distribution or QKD. The physical distribution of one-time pads can be initiated immediately at scale. The second, QKD, requires the targeted development of quantum repeaters, and in the Canadian setting, this means quantum satellites.

Fortunately, this quantum infrastructure is exactly what will be needed for the upcoming quantum internet over which we can deploy blind quantum computing, which was alluded to earlier this morning and offers unique applications of its own. Canada has a big choice to make here, and urgently. We need to replace all of RSA, and decide how much additional insurance we need around critical infrastructure. That choice is substantial because its outcome also determines if we lead the world in building, deploying and exporting technology to enable the global quantum internet.

● (1330)

I disagree with the previous committee members about a few key items. The first is time scales. The history of nuclear fission may be illustrative here. In 1933, the world's leading nuclear physicist, Rutherford, ridiculed the idea of ever getting energy from nuclear transmutations. That was the predominant scientific view at the time; if it weren't impossible, it was at least 20 to 30 years away. However, it was a mere seven years between the demonstration of nuclear fission a few years later in 1938 and the first nuclear bomb explosion. This is the power of a dominant design and a Manhattan-like mobilization to organize and bring it into reality. We at Photonic believe that quantum technologies are much closer than they currently appear.

The economic benefits will not be evenly distributed. We are the country of the Avro Arrow, the CANDU reactor, Nortel, BlackBerry and Bombardier. We are the home of the first transistor patent, filed first in Canada 20 years before the first Bell Labs demonstration, and where is that?

Many quantum technologies were invented here in Canada, and these are cautionary tales. We have an opportunity to break through this pattern of inventing but not reaping the rewards.

I have six specific recommendations. However, I believe my time is up, and I am happy to yield the floor. If you would like it, I could take two minutes to summarize these six recommendations.

The Chair: Please go ahead, Madam Simmons.

Dr. Stephanie Simmons: Thank you so much.

The first is talent. I came back to Canada to launch Photonic Inc., specifically in Vancouver with its high quality of life, because ultimately this competition will be won or lost through the talent we attract and retain. We train lots of talent, but we do not retain it. We need to match global professional quantum salaries, which are roughly five to 10 times the Canadian national average salary. Salaries will grow further when the dominant design emerges and the talent shortage is at its peak. Ultimately Canadian firms need substantial revenue, not small-scale grants, to compete on the salary front.

Second is procurement. A quantum SIF stream that accepts applications from all quantum companies, including pre-revenue companies, would be good. However, the major need is for major procurement contracts or DARPA-like moon shot contracts to companies. There is an immediate need for the procurement of today and future processors for Canada-wide talent development for all those students to train on as well as quantum network infrastructure, as I alluded to.

Third, the government needs to employ a full-time quantum due diligence team so that it can procure or potentially use these tools. Without procurement contracts, the entire Canadian quantum industry will slip away to other jurisdictions that procure from domestic bidders with these due diligence teams, which are under way in the U.S., the UK, France and Germany. There is no team within the Canadian government right now to even initiate a discussion on procurement contracts for the Canadian government.

Fourth is supply chain investment. Other countries can terminate, obviate or forcibly consume our efforts by dominating quantum supply chain items. There are several government cross-platform supply chain investments I can recommend to be made so that we retain a hope of future digital sovereignty.

Fifth is corporate espionage. We need deep support and CSE and CSIS infrastructure support for all quantum tech companies, including the screening of personnel and cybersecurity infrastructure assistance.

Furthermore, we must mandate that all universities publicly disclose all international research contracts around national security items such as this. Substantial funding way beyond Canadian funding standards is easily available, and these research contracts purchase the resulting IP from Canadian universities and specifically insist in that contract upon secrecy as a precondition for funding. Finally, we need to help firms with the post-quantum encryption transition.

Sixth, the scale and openness to immigration is a key strength of Canada, but as we have heard many times, it is simply too slow. Canadian fast-track immigration programs in the 1990s are almost singlehandedly responsible for the Ottawa telecom boom. We need the same for quantum. I have heard from some of the most prominent global quantum researchers. Yes, they were trained in Canada, but they ultimately left because the permanent residency process was too difficult for their families to endure. People want to live here. They want to do quantum here. Let's pay them well and welcome them back.

Thank you. I am very grateful for the chance to share my views. I look forward to the discussions to come. If there is interest, I would be happy to extend these conversations privately. I appreciate your attention.

● (1335)

The Chair: Thank you, Madam Simmons for a very interesting presentation. Thanks to all of our witnesses. It's been fascinating. I'm sure members will have many good questions for you.

We'll start without further ado with Madam Gray for six minutes.

Mrs. Tracy Gray (Kelowna—Lake Country, CPC): Thank you, Mr. Chair, and thank you to all of the witnesses for being here today.

My first question will be for Allison Schwartz. You referenced a quantum training program in your testimony today. Does this or should this also include proactive security training so that people are trained to secure encryption and online security for companies and public institutions to protect data?

Ms. Allison Schwartz: Thank you so much for the question today. I appreciate it.

The problem with quantum computing is that a lot of people don't understand how to use the different technologies that are out there, and each individual technology has its own unique areas. The quantum training program that I was looking at was really on how to create a quantum algorithm on a D-Wave system versus an additional system.

Obviously, training on security is critically important, and that could be something else that's considered to be factored in, but it was not where I was going with the testimony for D-Wave. It was more about actually building folks who know how to use the different systems that are out there and figuring out what those capabilities are.

Mrs. Tracy Gray: Great. Thank you very much.

My next questions are for Dr. Simmons.

You brought up a number of important gaps that the government needs to deal with, and I have some questions for you here today. Maybe, if there are things you also have to say that don't come out in this testimony, you can also do that a written submission.

Do you have any recommendations or thoughts on current privacy laws and whether they're sufficient with the potential growth of quantum computing?

Dr. Stephanie Simmons: Thank you very much. I really do appreciate the question.

I think the major issue here is that the transition to a post-quantum environment is going to be much more palatable if we take our time to do so. I do think that the privacy laws should recognize that there is going to be an asymmetry in access to information with whoever owns these systems, and so there should be some decision put into how these things are wielded and who gets access to them while that transition is under way.

My preference would be, of course, that the transition happens before an RSA-capable computer gets booted up to our knowledge, but of course, we're not going to have knowledge about what's happening in clandestine environments in adversarial countries.

● (1340)

Mrs. Tracy Gray: Great. Thank you.

What legislation or action should the government be taking right now so that our systems are protected from the emerging hacking methods that can take place with quantum computing?

Dr. Stephanie Simmons: Thank you so much.

In the coming weeks, NIST is going to be recommending some post-quantum algorithms. I would recommend that the Canadian government mandate or look into how to encourage businesses, in a regulatory sense, to invest in this. I don't exactly know how that would look, but it certainly needs to be considered. Internally within the government, it should be considered how to ensure that the critical infrastructure is provably secure.

This post-quantum encryption may or may not actually hold up over time. One of the finalists for that NIST competition, which has been under way for years, just fell to a classical computer laptop hack, so it's not clear if these things will stand up. I absolutely hope they do. I think we should layer them all in and, in addition, put some insurance down on QKD or one-time pad infrastructure for the critical infrastructure.

Mrs. Tracy Gray: Great. Thank you. That actually flows into another question I have, which is about awareness.

What do you think should be done to increase awareness and ensure that we're ahead of the curve in protecting Canadian security and privacy? Do you believe that not only governments but also institutions like banks, schools and hospitals are aware of the emerging security risks from quantum computing?

Dr. Stephanie Simmons: What I would suggest is that, at the moment, people don't feel the urgency, and they need to. What I would say is that 10 years ago people were suggesting that full-scale quantum computers were 30 to 40 years away. Today, in many testimonies, you'd hear that it will be within 10 years. We think it will be sooner. It's going to be a bit of a “hockey-stick” transition, and we don't want this to be a tsunami that overwhelms everybody.

It's absolutely within our power to make these changes now. You don't need quantum talent to start to layer in and look at your infrastructure in terms of all of the different gaps. The problem is that with so much of our computational infrastructure using software as a service, it's difficult to figure out where all the leakage points with RSA are. It's a huge undertaking, and it will be much more convenient if we start now and learn best practices before these capabilities come online and surprise us, because once scale is unlocked it will come very quickly.

Mrs. Tracy Gray: Great. Thank you.

I know that you had touched on the immigration process that we have here, the huge backlog and a number of the inefficiencies that we have, but to tag onto that, when it comes to ensuring that we have workers in training to be big players in this quantum computing space, do you think that our post-secondary institutions are ready for this, or do they need improvement? Do they have the right capabilities to be able to be training and retaining people here in Canada?

Dr. Stephanie Simmons: Thank you again for the question, and I'm happy to yield the floor. I'm sure there are other opinions around the table on this.

Universities have a fairly good time at getting students in. The challenge is getting permanent residency for said students who wish to stay. That is difficult, and the melange of immigration policies to bring people in, in a professional setting, is where we're going to make or break this technology, right? Students offer training, but it's going to be the professional class that's actually going to make this thing live as a true ecosystem.

To bring those people in, we have to move faster. We can't have 20-week terms, and we can't make permanent residency so difficult for them to achieve. We lose them that way. They want to stay here. We just have to make it possible.

The Chair: Thank you, MP Gray. That's about all the time we have.

We'll now move to Mr. Dong for six minutes.

Mr. Han Dong (Don Valley North, Lib.): Thank you very much, Chair.

Chair, I want to thank you for giving Ms. Simmons the extra two minutes so we could hear specific suggestions. That was very, very helpful.

I'm going to start my questions with Mr. Fursman. I really liked your half-fence analogy. If we're maybe not fully ready for mass commercialization, what advice do you have for the government and for legislators to strategically position Canada as a future competitor in quantum science? I'm speaking to whether it's the education infrastructure, whether it's the energy infrastructure or whether it's the broadband infrastructure. Is there anything we must do now to secure that position?

I apologize in advance. I will cut you off at the three-minute mark, so you have about two minutes to answer this.

● (1345)

Mr. Andrew Fursman: Sure. The quick answer is yes. I think that, although qubit count is not the only thing that we should be thinking about, if you don't have enough qubits, it's like not having enough pickets in your fence—you either can or you can't solve the problem you're looking to solve.

There are many things scaling up on the technology side. We're currently, as I think you heard earlier, in sort of the 100-qubit regime and we're looking to get towards sort of the millions-of-qubits regime going forward. That will take some time still.

I think there is a lot of time for us to be thinking about everything from our training programs to building up the domestic production of talent and attracting foreign talent to our universities at the graduate level. I think there is a lot of opportunity to take the fledgling efforts being made in Canada and to make sure there is the maximum amount of interaction between universities and these companies, which are really the only places in Canada where you can get practical hands-on experience with the types of devices that are being built outside of university labs.

I am particularly fond of how the Mitacs organization is able to bridge that together and work closely, and I think these are very important pieces of what we are looking to do.

Mr. Han Dong: I like Mitacs as well.

I'm sorry, but I don't have much time.

What are your thoughts on strategic planning for manufacturing capacity as well as on broadband and energy infrastructure? How does that come into play in the quantum world?

Mr. Andrew Fursman: I think those items are not directly relevant to the current process within quantum computing, but I do think there's the possibility that advanced computing will impact all of those areas you've discussed. It's just important to recognize that at the moment there is nothing we can do better, faster or cheaper with today's quantum computers compared to what's possible classically, but we expect that to change within some of these narrow areas we're focusing on. I think it's important to recognize whether or not the specific areas you're looking at are actually directly connected to developments within quantum computing.

Mr. Han Dong: Thank you.

I would like to direct my next questions to Ms. Simmons.

You brought forward six points. I'm going to start with your point about reaping the rewards. Can you expand on that a little bit? How can our future generations in Canada benefit from today's research? Is it through IP protection? What can legislators do to make sure we get a piece of the pie?

Dr. Stephanie Simmons: Thank you so much.

Yes, I think procurement contracts is a big one, but within the government you need to have a talented due-diligence team. There's no single point of quantum due diligence within the government right now, so there's no point in even having procurement discussions, because there's no way for the government to navigate this.

I think we should be procuring infrastructure on quantum networks so we can secure coast-to-coast communications. I think we should be buying some of the computers so that these students can train on them.

In terms of IP, I can mention them again, but I do think there are things that can be done from a policy perspective to insist that research contracts disclose all those funding mechanisms. There's a lot of international money buying IP in Canada right now, and that's not being openly discussed. We also need to help firms with the post-quantum encryption transition.

Does that answer your question?

Mr. Han Dong: Yes, it does, actually. Thank you.

On the salary front, you say that the salaries are perhaps five times or some number times what they're getting here in Canada, but the Canadian social environment, the medicare and all these social benefits do come into play to attract talent and to retain them. Is that right?

Dr. Stephanie Simmons: Right, and I have no problem paying five times the Canadian national salary average for my quantum researchers—no problem whatsoever—but we need the procurement contracts so that we can go and raise the private.... Companies in this space are raising more money in single rounds than the entire national quantum strategy, right?

Mr. Han Dong: As they should, because—

Dr. Stephanie Simmons: Right, and that's how private investment works—exactly—but private investment is only unlocked with contracts, really, so it's getting those contracts here. We're at a stage where it's very much like Kitty Hawk. I would say that quantum computers compared to classical computers are like flight compared to cars. They unlock completely different things, and the first time you have a flight taking off, it lasts maybe a couple of hundred metres and then lands. Without investment and industry to actually bring that to scale, you don't unlock satellites and large-scale.... There's so much—

● (1350)

Mr. Han Dong: That's very helpful.

I have one more question that I want to get in. You talked about the talent retention immigration time frame. I would just want to put that in perspective. Then you talked about security issues. To do the due diligence on immigration, it takes time, right?

Dr. Stephanie Simmons: Yes, sir.

Mr. Han Dong: On talent retention, we have to show the open doors and whatnot, but it may not work in the same conversation if we're talking about security issues.

Dr. Stephanie Simmons: Yes, sir.

Mr. Han Dong: Where do you see the balance? How do we balance these to make sure that we can attract and retain talent?

The Chair: It's a tough question.

I'll need a brief answer, Madam Simmons. We're out of time.

Dr. Stephanie Simmons: Absolutely: CSE and CSIS to screen applicants—to work/partner with the Canadian quantum industry and help them screen applicants, and once they're approved by CSE, fast-track them. Get them in there in under six weeks.

Mr. Han Dong: Thank you.

The Chair: Thank you very much.

[*Translation*]

Mr. Lemire, you have six minutes. Go ahead.

Mr. Maxime Blanchette-Joncas (Rimouski-Neigette—Témiscouata—Les Basques, BQ): Mr. Chair, I am standing in for Mr. Lemire, so I will be speaking today.

It's a pleasure to be here. Good afternoon to my fellow members. Good afternoon, as well, to the witnesses, and thank you for being here today.

My first questions are for Mr. McCauley.

I share your sense of pride, Mr. McCauley. You talked about how the University of Calgary was a major hub for research. The Université du Québec à Rimouski, a university in Quebec, has also made a name for itself as one of Canada's top research institutions among similar-sized universities.

I'd like you to help clear some things up for me about the state of science and research in Canada. I am looking at the brief submitted by the U15 Group of Canadian Research Universities, which includes the University of Calgary.

I'm trying to paint a picture of Canada's investments in research and development, especially through research chairs and universities.

It's clear from the brief that Canada is lagging behind. To put it bluntly, Canada is the only G7 country that has reduced its R and D spending over the past two decades. It is also the only country where the number of researchers has declined over the last six years. On top of that, Canada's ranking on the Global Innovation Index has dropped considerably. From 2001 to 2019, Canada went from eighth to 17th place on the Global Innovation Index. It is important to note that Canada's expenditures are not what they should be, making the country less attractive to researchers who want to use their talent to advance innovation and science.

As the vice-chancellor of the University of Calgary, how does that state of affairs affect you on a day-to-day basis?

[*English*]

Dr. Edward McCauley: Thank you very much. I appreciate the question.

Again, I'm on the board of Universities Canada, as well as a former board member of Mitacs, so I really support that. I was also part of the submission from the U15.

Our submissions from both Universities Canada and U15 actually are synonymous with many of the points that Dr. Simmons and also Dr. Broadbent made about the particular quantum area. We are a nation that needs to be able not only to support talent development, but also to be able to attract talent from outside the country, to nurture that talent. An additional piece is not to lose that talent. My university has lost some amazing investigators to Europe and to the U.S. in the quantum area in particular, which we would really like to retain here.

Canada has I think a very robust ecosystem for investing in people, and I would encourage the federal government to ramp up that investment, because talent really is our future. Whether it be in quantum or in other areas, it really is about talent. We have tremendous programs in the country to support undergraduate students. We also I think need a bigger investment in graduate students who are going to come here from around the world, work with us and, hopefully, as Dr. Simmons said, stay and provide contributions to the Canadian economy and the future growth.

It is about talent, making it easy for people to come, making it easy for people to stay, and making it easy to nurture the people we have. That, in essence, is supporting the Universities Canada and the U15 documentation on the submission for this budget.

[*Translation*]

Mr. Maxime Blanchette-Joncas: Thank you, Mr. McCauley.

You talked about talent, but I'm talking about the reality in my region. In Quebec, more than 25% of people with Ph.D.'s, so one in four, do not have access to funding, and it's not due to a lack of expertise or projects. It's due to the fact that funding isn't available. Canada currently invests 1.57% of GDP, whereas its competitor, the U.S., invests 2.9%. At the end of the day, we are at the bottom of the global pack.

We have tremendous programs, as you mentioned, but we are not tending our garden, so it's hard to nurture talent.

What do you think, Mr. McCauley?

● (1355)

[*English*]

Dr. Edward McCauley: Thank you. I appreciate that.

The tri-council agencies have requested additional funding to support growth across the country in a variety of areas. There is no doubt that the competition is severe, whether you're talking about NSERC, CIHR or SSHRC, for example, across the entire country.

Yes, an investment, I think, would be very much appreciated, once again to grow talent across the country, because that's what is producing the ideas we're going need to help build our very productive future and to support our aspirations for the various industries across the country. Therefore, an investment in talent and an investment in funding for research would benefit all Canadians.

[*Translation*]

Mr. Maxime Blanchette-Joncas: Thank you, Mr. McCauley.

I again want to refer to the brief submitted by the U15 group. As the vice-chancellor of the University of Calgary, an institution that is highly research-oriented, you are ideally placed to talk about research. The research support fund is a key program, of course, but the funding formula penalizes universities that are research-intensive. It is those universities that are especially affected. On average, the funding rate across the U15 group of universities is 20%, which is the established threshold. The corresponding rate among universities in the U.S. is 52%.

Obviously, money is the biggest factor, but are there other gaps?

What actions would you want to see the federal government take to put Canada at the top of the pack and, ideally, to help universities of every size undertake research in their areas of expertise in a meaningful way?

[*English*]

Dr. Edward McCauley: Thank you. I appreciate the comment.

I was a professor at the University of California, so I know about the relative differences in investments between Canada and the U.S.

Canada is desperately in need of increasing investment in research support for universities, whether that be to support the direct costs of research from the federal government.... The rates you referred to are actually quite accurate.

Those, what are referred to as, indirect costs are very important for universities across the country, as far as Universities Canada or U15 go to actually support the aspect of research security. We talked about cybersecurity, which is very important for protecting our information, and participating in those discussions.

Federal government funding to help the research security in those areas would be very much appreciated and would enable Canada to keep up on the international stage.

The Chair: Thank you, Mr. McCauley.

We'll move now to MP Brian Masse.

Mr. Brian Masse (Windsor West, NDP): Thank you, Mr. Chair.

Thanks to our witnesses who are here.

I'm just wondering whether in our private sector, or maybe in our public sector too, anyone is taking advantage of the science, research and development tax credits. Is anyone out there actually taking advantage of them, and what's your experience so far with them?

I don't know if Mr. Fursman or anybody else has done that. They're being used by a lot of different sectors, but I'm not sure if quantum computing is actually accessing those right now.

I'll leave that open to whoever wants to jump in.

Mr. Andrew Fursman: Thank you. I think you're referring to the scientific research and experimental development tax credits, commonly known as SR and ED?

Mr. Brian Masse: Yes, I mean SR and ED.

Mr. Andrew Fursman: I would say that's been particularly helpful, especially at the very early stages of setting up 1QBIT. Our company is almost a decade old now, and being able to recoup some of the money we have invested in the experimental research we do has been very helpful.

It's one of the easiest programs to access and it's open to basically anybody in this field in Canada. I think it's a very good program.

Mr. Brian Masse: Have you been able to make application yourself or are you using a third party to do so? This committee spent a lot of time in the past, and I'll maybe pass this on to the analyst to look at what we have recommended before, because it was very difficult. There was almost a cottage industry set up to help people get through the application process, so they would lose some of that money to pay for people to do applications.

It's good to hear, and it's been a real focus for a long time here. I'm just wondering if you have any suggestions on how to make it more accessible.

● (1400)

Mr. Andrew Fursman: This will probably not make me any friends, but my suggestion would be to not use any of these advisers and to do the work yourself. It's not that challenging if you get a handle on it.

I think most organizations probably have the processes already in place that track the work of their employees in order to make this a fairly straightforward process if you've been through it once or twice. It's also easiest to start at the beginning, doing it yourself and growing along, but anyone with a finance organization within their company should be capable of doing this without having to pay significant sums to third parties.

Mr. Brian Masse: That's excellent.

Is there anyone else who would care to jump in on this subject matter?

Dr. Stephanie Simmons: Yes, I would like to.

SR and ED is fantastically helpful, and I echo everything that has been said. It's easy enough to do. It's phenomenal. It's absolutely a giant competitive advantage.

I can't say the same for the bureaucratic red tape around the SDTC program or the SIF program or any of those other kinds of organizations, but for SR and ED—phenomenal.

Mr. Brian Masse: Do you have any suggestions on the other ones or do you want to submit them later if there are a couple of things...?

On SR and ED, this is really positive. This is about the first time I've heard about this type of experience. I'm sure the analysts will come back.... It goes back to our original manufacturing study ages ago, so this is really encouraging, to be quite frank.

Do you have any suggestions on the other systems? That would be really good.

Dr. Stephanie Simmons: Yes, absolutely, and I'm happy to extend all of these conversations privately.

Generally, the SDTC process is too slow.

The SIF process is too slow, it's opaque and it's not quantum specific in any way, so it doesn't tackle the fact that this is a very quickly moving industry. What you propose as a project that would be approved 18 months later may no longer be relevant by the time it's actually approved, right?

You have to start mobilizing.

Mr. Brian Masse: That's excellent.

Can I now switch quickly to you, Ms. Broadbent?

You mentioned something very unique that we haven't heard in this committee discussion so far. It was about the diversity with regard to the field. Can you elaborate a little more, with more emphasis on that? I think that's really critical. In this committee, under Industry, we're responsible for corporate board governance models with regard to diversity and equity. That's part of the mandate under Industry Canada.

I'm just wondering if you have more thoughts about that, because there has been an attempt on the corporate side to have.... We went with Canada's “comply or explain” model for equity and representation on boards, and other countries have done different things. I'm wondering if you have any thoughts on how to improve that aspect for Canada, because we are a little bit behind other countries for that representation.

Dr. Anne Broadbent: Thank you very much for sharing these concerns and expressing the efforts that are being undertaken right now.

I mentioned “camaraderie”. The reason I mentioned it is that we visibly recognize, I think, common experiences and challenges. I think it's fair to say—and I have anecdotal evidence—that women face a much higher barrier to success in the field.

I mentioned that EDI is recognized as a catalyst for innovation, but the contrapositive of this is that threats to EDI are limitations to innovation. If you make that equation in your mind, you really see the advantage that you can gain by having EDI-enhancing initiatives. I believe that these threats should be formally treated as threats, just as any other ones. Ways to mitigate this risk include incentivizing equity-enhancing measures and career-building measures—

Mr. Brian Masse: Is there anyone...I'm sorry. I don't mean to cut you off. Please go ahead.

Dr. Anne Broadbent: If I have another minute, another question I would like to treat is harassment.

For instance, there are some things that have been done. In 2017, the American Geophysical Union revised its ethics policy to treat harassment, discrimination and bullying as scientific misconduct just as it does any other type of misconduct such as fabrication, falsification and plagiarism.

I also mentioned the support system for child care. The years of early parenthood often coincide with the critical career-building years for highly qualified personnel, and women are particularly affected. Please note that these early years of education are characterized by a very precarious employment situation. We're talking about one- or two-year post-doc contracts, and that's very difficult to balance with thoughts of building a family.

Mr. Brian Masse: Those are excellent points. I was going to raise your notation on child care as well.

Mr. Chair, do I have any more time?

The Chair: No. It would be too brief to have an answer, Mr. Masse. In any event, we'll come back to you in a subsequent round.

We'll move to Michael Kram for six minutes.

● (1405)

Mr. Michael Kram (Regina—Wascana, CPC): Thank you very much, Mr. Chair.

I believe all of my questions will be for Dr. Simmons.

Doctor, earlier this week, the committee heard testimony that once quantum computing becomes widespread, all of the encryption algorithms used by the Canadian banking sector will be obsolete. Do you agree with this analysis?

Dr. Stephanie Simmons: I would go further than that. You only need one quantum computer that is capable of breaking this for all of those things to be obsolete. You don't need them to be widespread. It's very asymmetric: We need to defend everything, whereas only one from an adversarial country would absolutely eradicate trust in all online communications of all forms—banking, and everything else. It's very important that we consider this.

Mr. Michael Kram: Okay. Specific to the banking sector, if this country's banks don't take any protective measures and one bad actor develops quantum computing, what would it be like when Canadians go to the banks to withdraw cash? What would that look like?

Dr. Stephanie Simmons: It wouldn't work. I don't think it would be recognized right away. I think there would be major theft and we wouldn't recognize it, and then there would be an erosion of trust and it would be a very difficult situation.

We have to start layering in provably secure communications, one-time pad or QKD for these kinds of critical things. With regard to the SWIFT infrastructure, for example, SWIFT payments and interbank lending overnight all need to be considered, because they all use a lot of third party software that may themselves have RSA leaks. It's a major undertaking, and I am aware that the banks are aware, and I am aware that our security services are aware.

However, I think that the undertaking is bigger than we've been describing. I think it's going to be a substantial undertaking because of how integrated the software world is and because there are so many layers of obsolete legacy software that are going to be difficult to go back and figure out how to patch. This is the ultimate zero-day problem, because there's no known patch that's provably secure at the moment.

Mr. Michael Kram: I just want to make sure I understood that last point. If these bad actors develop quantum computing and you have your life savings in a Canadian bank, would you keep it there?

Dr. Stephanie Simmons: I'm not sure how the banks are going to respond...what their risk-mitigation strategy is. Maybe they would shut down all access. It's a difficult situation to imagine. This is one of the reasons that I didn't spend my five minutes talking about how great my company is. I spent the time warning people. We need to get ready.

Mr. Michael Kram: I wonder if you can elaborate, then, on how difficult it would be for the banking sector to secure our financial system. I'm gathering that there would be more than one program or changing a few lines of code.

Dr. Stephanie Simmons: Yes, sir. It's going to be a substantial undertaking. It's going to be a very substantial undertaking, and I think it's going to take years.

Mr. Michael Kram: Obviously Canadians have to have confidence in the banking sector if they're depositing their life savings there. What laws or regulations do you think the federal government should implement to make sure that Canadians have confidence in the banking sector?

Dr. Stephanie Simmons: As I said, I'm happy to take these conversations off-line privately, but there are many things, and it doesn't need the quantum-specific expertise which I bring to the table to answer those kinds of questions.

I think it's fairly easy to imagine ways to ensure compliance in short order on certain items. One of the precursor elements are going to be the NIST standardization process along post-quantum cryptography, because many large organizations are loath to make next steps until there exists some standard to adopt. My recommendation is to say to adopt all of those standards, layer them on so that they have to all be hacked to get through, and put in these additional layers of protection that are provably secure, because none of those post-quantum algorithms are actually proven to work.

As I said, there were three that were put forward that have been suggested as ultimately resilient against quantum attack, and three of them have fallen. It's not all of them, but we haven't yet subjected any of these post-quantum algorithms to attack like RSA has seen over decades of work, and that's quantum attack or classical attack.

My suggestion is for critical infrastructures, such as interbank lending, to start with—but also things to do even with consumer banking. Imagine some solution using one-time pad distribution, or ultimately QKD for renewal outside of keys.

Mr. Michael Kram: Dr. Simmons, I have only about another 10 seconds, and I don't think that's enough time to get through all of your recommendations. If you could make a written submission specific to banking policy, I would find that very helpful.

● (1410)

Dr. Stephanie Simmons: Thank you so much.

The Chair: Thank you, Mr. Kram.

We'll move to Mr. Fillmore for five minutes.

Mr. Andy Fillmore (Halifax, Lib.): Tremendous thanks to the witnesses today for helping to illustrate the magnitude of the challenge that lies ahead, as well as the magnitude of the opportunity.

In listening to each of you, when I think of this kind of Manhattan project-scale effort that's required, it strikes me that there are probably—and correct me if I'm missing anything—three components to that: one is talent, one is dollars, and one is policy. These are the things that have come up today, and in our previous meeting as well.

In the time that I have, I want to touch briefly with our academic witnesses today on the talent piece, with Dr. Simmons on the dollar piece, and with Allison from D-Wave on the policy piece, given that you're the government-relations expert on the panel today.

To Dr. Broadbent and Dr. McCauley, are the graduates at your universities, and Canadian institutions in general, leaving school with the requirements that the industry is looking for right now to build a quantum talent base in Canada?

Dr. Edward McCauley: Dr. Broadbent, do you want to begin, and I'll follow up?

Dr. Anne Broadbent: Go ahead.

Dr. Edward McCauley: I mentioned that many of our universities have very strong quantum science programs, and they are collaborating extensively. My joke about entanglement really is there.

I think we need to make an extra-special effort, as Dr. Simmons mentioned and also Allison from D-Wave mentioned, with respect to how we can actually increase the talent pool. Our undergraduates are very interested in this area, but I think we need stronger graduate programs in particular. I also think we need to have graduate programs that perhaps integrate some of the skills, in terms of AI, machine learning and quantum pieces, to combine the expertise we have.

We're developing them. All of our universities are putting them forward.

Mr. Andy Fillmore: Okay.

Dr. Broadbent.

Dr. Anne Broadbent: I would like to add that at the undergraduate level in mathematics, we're developing transferable skills. We could really invest in more of that, in people with inquisitive minds and logical thinkers.

I see a huge need and interest in more quantum as well as cryptography studies. It would be really great to bolster the offer we have, in terms of master's programs, as well as internships and opportunities that will link students with their future careers.

Mr. Andy Fillmore: Okay. Thank you for that.

Dr. Simmons, I think you illustrated most starkly the scale of the challenge ahead. Can you frame for us the kinds of financial investments that government or the private sector needs to make to solve this?

Dr. Stephanie Simmons: Yes, and if you'll forgive me, I'll also speak with my professor hat on and say that actually, yes, we are training phenomenal talent. The challenge is that they're all going elsewhere. We are training phenomenal talent. We're very successful at Photonic because we can recruit them back, but that's unusual.

To your point about funding, we've heard on many panels before this that a very successful model is a DARPA-like model. Having an objective that could be bid on and met by any of a number of corporate organizations as well as research organizations would be a phenomenal way to model this, in addition to having procurement contracts. You can have a contract for an objective rather than for an actual physical deliverable. Both would be fantastic models, but they're not the same as a grant.

One example is that of a satellite repeater. I wanted to discuss the opportunity to build out the quantum Internet across Canada, which has a unique satellite-based deployment that is not being focused on in Europe to the same degree. We have an opportunity to have a giant competition for bids, and yes, to have some companies with ratchet clauses, such that if they're not meeting their milestones, they don't get it. The scale of the funding needs to be at the level of $50 million to $100 million per project for it to be competitive with what is on offer by the U.K., the U.S. and Europe.

Mr. Andy Fillmore: Okay. Thanks for that.

Mr. Chair, I hope there's a minute left.

Allison, on the policies, I think we'll probably have to speak to this idea of a single front door, a concierge kind of approach, perhaps, for the Government of Canada to rationalize our work on this. Maybe it's our commitment to create CARPA, our version of DARPA.

Do you have any thoughts on what government needs to be doing in terms of policy, funding aside?

● (1415)

Ms. Allison Schwartz: I think that policy-wise, leaning into public-private partnerships and looking at existing organizations that already have relationships with the industry, academia and government are going to be key. Then it's about utilizing those already-existing P3s in order to focus on what those grand challenges are. What are the public sector needs? How do we optimize vaccine distribution? How do we tackle some of the issues we have on sustainability? How do we train up folks about the different systems that are out there?

From a policy perspective, I think that you look into and lean into public-private partnerships. That's the way to scale up quickly.

Mr. Andy Fillmore: Okay. Thanks for that.

I hope, in future answers today, we get to hear a little bit more about people's thoughts on CARPA, the Canada advanced research project agency. Thanks so much for all of your input.

[*Translation*]

The Chair: Thank you, Mr. Fillmore and Ms. Schwartz.

We now go to you, Mr. Blanchette-Joncas, for two and a half minutes.

Mr. Maxime Blanchette-Joncas: Thank you, Mr. Chair.

Ms. Broadbent, you talked about the added value of equity, diversity and inclusion criteria in relation to individuals. However, in the federal funding ecosystem, those criteria do not exist at the institutional level; the factors are not part of the funding criteria for research grants.

I would say the University of Ottawa is better off than small and medium-sized universities in the regions. The critical mass of those universities is a consideration. In some cases, the programs are too big for small and medium-sized universities to apply for funding.

I'd like to hear what you think about the fact that the institutional dimension isn't taken into account. Wouldn't you say that's a form of territorial inequity?

Dr. Anne Broadbent: Thank you for your question.

At the University of Ottawa, we have to deal with inequity as well. Being a bilingual institution, we often find ourselves penalized for providing bilingual services because it requires additional funding.

I apply for funding to the Natural Sciences and Engineering Research Council of Canada, NSERC, and it has a significant focus on equity, diversity and inclusion. I've seen that the federal government uses a gender-based analysis plus, or GBA+, framework. I believe you're talking about a different type of inequity, though—one that has more to do with the university's size.

Is that right?

Mr. Maxime Blanchette-Joncas: That's right.

From what I've seen, the federal government does not take into account small or medium-sized universities. Large universities have the upper hand because the funding criteria give preference to universities that have previously received research funding.

I'm trying to figure out how small and medium-sized universities can be included to make the process fairer for them.

Dr. Anne Broadbent: When I was on the NSERC selection committee for fellowships and scholarships, we would consider the merits and excellence of the person, not necessarily of the research facility. We looked at the opportunities previously provided to them.

That's what the process is missing and needs to incorporate. In other words, consideration should be given to the opportunities researchers present, and the assessment should focus on their ability to maximize funding opportunities.

Mr. Maxime Blanchette-Joncas: Thank you, Ms. Broadbent.

Now I have a quick question for you. You said that you—

The Chair: Thank you, Mr. Blanchette-Joncas.

Unfortunately, you're out of time. You'll get an opportunity to ask your question in the third round.

We now go to Mr. Masse for two and a half minutes.

[*English*]

Mr. Brian Masse: Thank you, Mr. Chair.

I want to thank our analysts, who have already provided me with a response on the SR and ED tax credits and what we had called for. I really appreciate it. I'll make sure that we get it around to the rest of the committee members. I want to thank them for that, because there's more we could probably do with regard to some of the things that are checked off. At any rate, I want to acknowledge that.

I want to move really quickly to Mr. McCauley with regard to keeping and retaining students. I raised this at the last meeting and it has been raised at this meeting. I'm also wondering whether we're doing enough—I'm not seeing it in my neck of the woods at the University of Windsor—in dealing with international and graduate students, and also having them have access to their family members to join them over here in Canada.

Some of their hours aren't counted in our immigration system, which I think is really weak response by our country. On top of that, reuniting family members to stay in the country is something that is a problem. Are there any thoughts about how we can improve that to retain talent? If you retain the family here, I think you would have a much better chance of having them stay longer.

● (1420)

Dr. Edward McCauley: Thank you.

I think Canada needs to look at all of these different policy options you talked about. I know that Dr. Simmons raised some as well.

I know that when we're recruiting here to the University of Calgary, whether it be for graduate student positions or a faculty member, we actually consider the family, because we're recruiting a family unit, and if we want to retain those individuals, having the appropriate policies in place to support them as they transition here to Canada...and then try to figure out how we can make sure that we can retain them if at all possible.

I think that the other issue we probably need to look at in Canada is how we include work-integrated learning opportunities for our undergraduate and graduate students as part of the labour issues around retention in Canada.

I think there's a variety of areas that IRCC can be looking at. I know that they are very active in this area because, as you said, the retention of talent is just so important, and it is about families and their contributions to the local communities as well as to Canada.

Mr. Brian Masse: Yes, and there are restrictions on how many hours they can work, as well as volunteerism and a series of things. Would you include those types of elements as well?

I'm just going by the experiences that I have seen. I think the stronger the bonds we create within the community, the more opportunity we'll have to keep them there, and then we also get local champions who want to keep them there. They're not stealing jobs; there's such a lack of support that.... At any rate, I will let you talk.

Dr. Edward McCauley: Yes. Those are the policies I was referring to for what we could be doing. Those areas you mentioned are exactly the ones we have been discussing.

Mr. Brian Masse: Thank you very much.

[*Translation*]

The Chair: Thank you, Mr. McCauley and Mr. Masse.

Go ahead, Mr. Deltell. You have five minutes.

Mr. Gérard Deltell (Louis-Saint-Laurent, CPC): Thank you, Mr. Chair.

I would also like to thank the witnesses for being here this afternoon. Their insight is quite impressive.

[*English*]

Dr. Simmons, you said earlier, and I will quote you from memory, “instead of speaking about how great my company is...”. I don't know how good your company is, but I know how great your testimony was today. It was very impressive.

I want to continue the questioning by Mr. Kram.

Sometimes it's great, but sometimes it's also a little bit alarming.

[*Translation*]

Ms. Simmons, I won't go as far as to say that your comments today scared me, but quantum computing certainly does give rise to security questions.

A few days ago, a witness told the committee that either Canada or the U.S. would be the first to achieve viable technology. If that's true, we aren't doing too badly.

Do you know whether other foreign powers are currently in the running? Could they get ahead of us?

[*English*]

Dr. Stephanie Simmons: Yes. Thank you very much.

Once the dominant design emerges, it's only a matter of time. I would say it's the kind of situation where if we get there first, that's great. We're not going to be the ones to use it adversarially, but the information will be out there.

It is of essential importance, from a national security perspective, for so many countries, especially in a difficult world, to have that technology on hand. I think that it's only a matter of time, and one of the things that drew me to the nuclear bomb analogy is that once the information is out there, you can't put that genie back in the bottle.

I don't think it's just a question of Canada versus the U.S. I think corporate espionage is a major issue and we are kind of on a clock. There's a lot of work to be done, because it's so asymmetric, right? The workload is going to be a very asymmetric one, so we should get started immediately.

Mr. Gérard Deltell: Let me go with a clear, direct and very incisive question. Where are the Russians and where are the Chinese?

Dr. Stephanie Simmons: The Chinese, I think, if they're not the winners, they will follow along within two years. I think the Russians have their own effort. They would be further behind, but I think they would work with organizations to get up to speed. As I said, they have some critical infrastructure that the rest of the world relies upon, so it's going to be a logistics supply chain thing.

That brings me back to one of my other recommendations. We have to be thinking about sovereignty here, because there will be a lot of geopolitical tensions once the dominant design emerges, and I don't think it's very far away.

Mr. Gérard Deltell: It's not very far away. Do you have a time frame for us?

Dr. Stephanie Simmons: Not one that I'm willing to disclose in this format.

● (1425)

Mr. Gérard Deltell: As a human being, I would say I'm not sure that I feel comfortable with this answer.

I will address another issue, to talk about the Canadian team, that the government should take the lead in grabbing all the Canadian brains that we have.

[*Translation*]

It's crucial that we not repeat the mistakes we made in the past to avoid experiencing those same losses. Two situations that come to mind are the CF-105 Arrow aircraft manufactured by Avro in the 1950s and the Avro Canada Jetliner in 1949.

Do you think it is the government's responsibility to provide that leadership? If so, what should a Team Canada look like?

[*English*]

Dr. Stephanie Simmons: Is that question directed to me?

Mr. Gérard Deltell: Yes.

Dr. Stephanie Simmons: I think we need to have some kind of Manhattan-style project, or something similar, that concentrates focus and collaboration on what looks like a dominant design through prize or DARPA-like projects. People do mobilize. There's an array of programs that could be adopted. We don't need to reinvent the wheel; we just need to actually coordinate and work towards goals.

One very natural goal is a computer, yes, but another very natural goal is a repeater, so that we can develop the quantum network infrastructure that Canada will uniquely need because of our geography.

There are a lot of ways to incentivize collaboration, but it has to come through procurement contracts. It's not going to be built in a university. Universities are absolutely fantastic for training people, but that's not where these large-scale systems are going to go. They should be collaborating with organizations on these large-scale, large investment projects—$50 million to $100 million. Let's do the moon shot. Let's own it. We absolutely have the talent for it. We just need the support.

Mr. Gérard Deltell: Dr. Simmons, I really like your historical comparisons, because we have some ideas of what happened before and what we should do for the future.

I have one last question.

Mr. Kram raised the issue of the banking system. Do we have to be concerned also about our defence system, our army system?

Dr. Stephanie Simmons: Yes, sir. RSA is everywhere. It's medical records. It's every classical communication that is still.... The biggest risk actually is that people are storing communications right now for the near term, but quantum computers will be able to go back and retroactively read them all. If you layer on all of these other post-quantum algorithms, that will buy us time, but if all of those do eventually fall under attack, then all of those will be read in the future as well.

It's foundational. If we can get in front of it, this is the opportunity. I don't want to be the harbinger of something negative here. If we get in front of it, then quantum computers will come online and be seen as the fantastic contribution to human technological progress that they should be known for being. We have an absolute opportunity to entirely redefine how we think about chemistry, how we do drug discovery and material discovery. Imagine if we were actually finally able to simulate the brain and room-temperature superconductors. There's going to be so much good that comes from this technology, but I don't want the public's first impression of quantum computers to be, “Oh my goodness, they broke the Internet.”

The Chair: Thank you.

We will now move to Mr. Gaheer for five minutes.

Mr. Iqwinder Gaheer (Mississauga—Malton, Lib.): Thank you, Chair, for the opportunity.

Thank you to the witnesses for making time.

Dr. Simmons, your testimony is, I think, scaring all of us a little bit. My question is about research contracts, which you talked about, with public universities, for which secrecy is contracted and IP could be taken.

Could you expand on that a little bit? Why don't universities have more leverage here?

Dr. Stephanie Simmons: The business model for universities is undergoing a dramatic shift, and this speaks to some of the research funding that's happened recently. The Canadian research system is fantastic. The NSERC system and the tri-council agencies are truly fantastic, but they need about 10 times the amount of funding.

Correspondingly, there is an incentive for professors to seek external research contracts from a whole host of organizations, both domestic and international, at basically any cost. It's how they compete globally. Correspondingly, those can come with all kinds of terms, but they're typically IP terms. We are going through a mass sale of our IP right now because research contracts usually come with this proviso.

The secrecy element was surprising to me when I found out about it, but it's pervasive. If you look at the research funding across universities, over the last 10 years in particular, there's been this massive teeter-totter shift in how research is funded. It's not across the board. It's quite disproportionate for different sectors and different researchers, and I want to bring that to your attention because I think it's important.

● (1430)

Mr. Iqwinder Gaheer: Do you think universities in America, for example, or elsewhere are doing a better job than Canadian universities are at fighting this imbalance of power?

Dr. Stephanie Simmons: They have different funding mechanisms, so they're not so desperate. They have more funding by far. They have more research funding, so they're not so desperate. At the same time, yes, I am aware that this is how the IP tends to go. That's what this tech translation office is. They use research contracts in this format as a mechanism to measure success. More is better, right? That's their incentive right now.

They want more research contract funding, but they don't recognize the value of the IP they have. This is just the new funding model for corporate R and D. They don't do it in-house anymore; they do it through these research contracts. Instead of having just internal R and D teams, they have those as well as all of these IP purchase arrangements with universities globally.

Mr. Iqwinder Gaheer: That's great.

My next question is for Dr. McCauley.

You mentioned that quantum information storage and security in quantum computing are areas in which Canada is currently leading. I'm wondering where we are in relation to other countries, our competitors in these fields, and what they are doing better than we are and what we should replicate.

Dr. Edward McCauley: First of all, I'm not an expert in quantum computing, but I have been involved with several other presidents of universities in Canada, including UBC, the University of Waterloo and the Université de Sherbrooke, as well as Andrew, in terms of trying to bring forward to ISED the notion of a quantum Canada strategy.

I highlighted some areas where I know we excel. Dr. Simmons mentioned them, as well as Dr. Broadbent. This notion of building the next secure quantum Internet I think is something that we in Canada can take and have taken a very, very strong role in, and I want to reinforce that as one area.

I believe that in some of the recent analysis we've looked at historically over the last decade—and I think Andrew can comment on this as well—Canada was ranked at about number five in terms of a variety of different areas of quantum, but as I mentioned in my opening comments, and as other people today have mentioned in their testimony, we're losing ground.

The U.S., China and the EU are investing huge dollars in this area, for all the reasons that I think have come in front of this community. We need increased funding in this area to support our existing position, and if we're going to improve, we need another multiplier, which is why I was advocating for the quantum Canada strategy.

I also think, as the other members have testified today, that we need this to really clearly identify public-private partnerships and a pull—i.e., procurement contracts, as Dr. Simmons mentioned. Developing the Canadian equivalent, CARPA, or a challenge-based approach to supporting this as a mechanism, I think is a really strong vehicle for the way forward. It's investing in talent, and it's making sure that we can develop the product with industry and it can be rapidly mobilized around the world.

Mr. Iqwinder Gaheer: That's great. Thank you.

My final question is open for the panel.

Is this an area where we can work in conjunction with other countries? Or do you think our technologies and strategies in this area have to be developed locally and kept local as well?

Ms. Allison Schwartz: I'll try to answer that, since I do global government relations.

I think Canada has a leadership role in many aspects of quantum, but not in all, so yes, you do need to partner internationally. You need to partner with folks in the United Kingdom and in Europe. You need to partner with folks in the U.S. Australia is actually looking at application development for transportation systems. I do think that there is international co-operation and international partnership that needs to be had amongst allied nations, so I think this is an area in which to lean in.

As to a CARPA-style program, if you look at what DARPA is already doing right now, they have a quantum program on benchmarking. They're looking at how to build a quantum computer in a phased approach. I mentioned in my testimony the quantum sandbox with application development. That could also be within one of these styles of programs, wherein you're actually building the applications while also looking at how to make the systems better.

To answer your question, yes, it does need to be in an international fashion.

[*Translation*]

The Chair: Thank you, Ms. Schwartz.

Go ahead, Mr. Généreux. You have five minutes.

Mr. Bernard Généreux (Montmagny—L'Islet—Kamouraska—Rivière-du-Loup, CPC): Thank you, Mr. Chair.

Thank you for your contribution, Ms. Simmons.

One of your recommendations was to create a committee within government.

Do you think industry stakeholders should sit on the committee? Something I've noticed since the committee began its study is that Canada's quantum industry is relatively small. Everyone seems to know everyone, and mutual respect is widespread.

In light of that, should the committee you are recommending be supported by the private sector? I, personally, think it should.

Should such a committee make recommendations?

As you know, NSERC is currently active in quantum computing. The para-governmental institution provides financial assistance in various areas of quantum computing.

Where should the committee start its work? When should the committee start that work? I imagine the answer is as soon as possible.

● (1435)

[*English*]

Dr. Stephanie Simmons: The flavour of how that group of people is formed is very important. If it is simply a part-time job, staffed by people who have skin in the game, there is going to be squabbling over more funding for their own particular version of quantum and their own particular flavour.

The model that I would like to recommend is a team of people that is funded separately, independently and well. The salaries here are in the hundreds of thousands of dollars, but you need to have a team of people that the government could go to and say "Is this bid or this application warranted?" They can be the ones, for example, to choose external experts to do some due diligence.

It's the lack of due diligence, awareness and consulting capability within the government that means we have no single point to go to talk to. There's no team of people, and teams exist. They exist in the U.S. They exist in the U.K. They exist in Australia. I know all of them. I know the ones in Germany. I know the ones in France. There are none in Canada.

I can't even go and speak with a team of quantum experts who are paid by the government to be able to offer policy recommendations to the government. It should not necessarily be me and my part-time staff, or any of the other people around this table. Although we have our views, you need to have a team of independent experts who could navigate or help navigate the space. They're going to be expensive, and they're only going to be more expensive over time.

It's important that they have that independence and not currently wear another hat. Otherwise, you have that natural bias that creeps in, when people start to think territorially.

[*Translation*]

Mr. Bernard Généreux: Ms. Simmons, you talked about the importance of retaining talent and matching global quantum salaries, which are sometimes five to 10 times the Canadian national salary average.

If we look at Quebec's technology sector, we see that the province has become an expert in the video game arena. In fact, the government gives companies a 40% refundable tax credit on salaries. Ubisoft and others have significantly benefited from the tax credit.

Are provinces aware of what is happening in the quantum industry?

[*English*]

Dr. Stephanie Simmons: What I would say is that SR and ED takes this role and, if anything, there should be a quantum addition. It's phenomenal. It's absolutely how we can help to compete, but the only way we can ever match those kinds of salaries is for these companies to be able to raise that kind of capital. That capital can only be raised if we have contracts.

[*Translation*]

Mr. Bernard Généreux: I'll end on a very positive note.

Ms. Simmons, I'm going to compare you to the actor Will Smith. You pulled a Will Smith, so to speak, by giving the Government of Canada a wake-up call today.

I have to tell you that your comments felt like a slap in the face. What you told us is absolutely incredible. The reality you've described is this:

[*English*]

Move your butt, because we're not going to be far behind. We have to move really quickly.

I hope that among the committee recommendations that we'll see, the first one will be this committee that you want to create. Thank you very much.

[*Translation*]

The Chair: Thank you, Mr. Généreux. I agree with you. This is a helpful and necessary wake-up call.

Thank you to all the witnesses for their insight.

Go ahead, Ms. Lapointe.

Ms. Viviane Lapointe (Sudbury, Lib.): Thank you, Mr. Chair.

[*English*]

My question is for Ms. Schwartz. Your company says you're the world's only commercial supplier of quantum computers. With your experience in government policy, I'd like to hear your thoughts on how current government policy helps or hinders your business as a global supplier.

● (1440)

Ms. Allison Schwartz: Thank you so much for the question. Governments are focusing on the research side of how to get the hardware systems bigger and better, because they want to be the first ones, as Steph has mentioned, to have a quantum computer inside their geography.

Where governments are not going is procuring and utilizing the technologies that are available today and helping to advance them. In Australia, you're looking at it for transportation. The army is looking at it for autonomous vehicle resupply. In Japan, they've looked at it for piloting and for tsunami evacuation route optimization, as well as how to reduce CO2 emissions during waste collection.

Canada does not have any focus on anything in the near term. If you were to ask if there are different quantum funds and foci out there, and what could be utilized to see benefits within the next one to five years, it might end up being a big zero. Governments can lean in and look at what they are doing for the near term, mid term and long term. That's the one to five years, five to eight years, eight to 10 years, and 10 years and beyond. That's where you're looking at the hybrid technologies that are out there, such as HPC and data centres. That's going to be critically important to navigate through.

There's also no supply chain domestically within Canada. We use superconducting chip fabrication. There is no domestic, commercial-sized superconducting chip fabrication plant in Canada. We have to use one in the United States.

Ms. Viviane Lapointe: Thank you. We have heard about supply chain issues from other witnesses.

My next question is for Mr. Fursman.

We've heard a lot about the talent pool. I'd like to ask for your thoughts on how we can attract and also develop the talent pool here in Canada.

Mr. Andrew Fursman: I think we're doing a great job of attracting talent to Canada. Most of the best graduates in this space from Canadian universities have probably not been through Canadian elementary schools. I'm noticing that a lot of people come over after their undergrads to go to our grad schools, and they end up being some of the top graduates.

Attracting students is something that I think our universities are doing very well. It might be worth noting, for example, that a typical Mitacs intern might come and work at 1QBIT, with a starting salary—while they're part of the Mitacs program—at around, say $45,000 and slightly higher. These are the levels that grad students might expect to make as they're going through school. Within about two years, we find that these people are receiving offers at the equivalent of $200,000 Canadian and above to go and staff up many of the organizations around the world, in the United States, Australia, Singapore and Japan.

We understand that we're creating incredible value within these students as they go through the very end of their development process, but we are also investing in those students and making them significantly more valuable, so then retaining them is a nice problem to have. You're creating an investment in students that is making them much more valuable, but because they are much more valuable, they are also therefore more expensive. If you don't compensate them more, then they will be acquired by other organizations.

The important thing is recognizing that because having an opportunity to work at one of these companies is still the bottleneck for giving people industrial experience, once you have someone with that experience, they become tremendously valuable. Keeping them in the country at that point is really a matter of matching the new global standard of salaries that we're seeing emerge.

Ms. Viviane Lapointe: I'm not sure how much time I have left, but I'd like to ask you a similar question that I asked Ms. Schwartz.

With regard to government's role in developing policies, what do we need to stop doing and what do we need to start doing?

Mr. Andrew Fursman: The things you can keep doing include investing in all of the things at the beginning of the talent pipeline. It seems that there is great work happening there, and things that can be incrementally improved on that front.

What might be something that we can start doing is thinking about the nuts and bolts of Canada's national quantum strategy. How do we define success? What does success look like there? Then, how do we make sure that we're going to be investing in the long term?

Compared to my colleagues here, I'm slightly less optimistic about the very short timelines around quantum computing, even though I'm very aligned in terms of the impact. My concern is that we can't have spikes of funding that then disappear and expect to retain people through that process. I would want to look at a 10-year program that has an understanding of how that scaling up of funding can grow with the organizations and whether we should see an acceleration of this process, to be able to understand that we would need to accelerate that funding, and also to recognize that this is something that's likely to play out over the next 100 years, even though it is just starting now and we can expect some tremendous development over the next decade.

● (1445)

The Chair: Thank you very much.

[*Translation*]

We now go to you, Mr. Blanchette-Joncas. You have two and a half minutes.

Mr. Maxime Blanchette-Joncas: Thank you, Mr. Chair.

I have two questions, and the first is for Ms. Broadbent.

Ms. Broadbent, I want to revisit something you said earlier. You mentioned how the University of Ottawa's bilingual status affected your dealings with NSERC.

My understanding is that you have to submit the paperwork in both languages. Do you face other barriers because the University of Ottawa is a bilingual institution?

Right now, some francophones do not have the option to conduct research in their mother tongue—to use one of Canada's two official languages.

Can you tell us more about that?

Dr. Anne Broadbent: Thank you for your question.

I was referring to the fact that we have to allocate double the resources to provide instruction and services to the entire student body in both official languages.

As far as funding applications are concerned, they can be submitted in the language of the applicant's choice.

Mr. Maxime Blanchette-Joncas: Ms. Broadbent, what do you think of the fact that people aren't able to study certain science disciplines in Canada in one of the country's two official languages?

Dr. Anne Broadbent: I don't have any data on that, specifically, but I would encourage them to come to the University of Ottawa, where they can study in the official language of their choice.

Mr. Maxime Blanchette-Joncas: I don't think certain research chairs carry out their work in French, but I would be glad to visit you and provide you with some information.

Ms. Schwartz, one of the things you talked about was alignment between applications and quantum technology, especially to support the energy transition.

Canada is a country rich in resources and minerals, many of which are found in Quebec. The committee has done studies on that area.

Do you think your work in quantum technology could be leveraged to support the energy transition and efforts to combat climate change?

Ms. Allison Schwartz: Thank you for your question.

[*English*]

The answer is, yes, there is a lot of work being done in the energy field. E.ON, a German company, is looking at distribution of energy and how to put energy back onto the grid as you're driving an electric vehicle.

As I mentioned, in Japan they're looking at AI and are piloting quantum applications looking at waste collection and reducing CO2 emissions by 60%.

In the United States, there was just a workshop in the Office of Electricity, which D-Wave participated in, looking at a variety of areas where we could utilize quantum computing and quantum hybrid applications for energy.

So the short answer to your question is, yes, there are lots of places to look. We need to get the smart minds together to identify those. That's where a quantum sandbox could throw those questions out and start to develop answers coming in.

[*Translation*]

The Chair: Thank you.

Mr. Masse, you have two and a half minutes. Go ahead.

[*English*]

Mr. Brian Masse: Thank you, Mr. Chair.

I'll continue with you, Madam Schwartz, with regard to global competition and other international groups. Is there a strong quantum computing coalition, almost like a lobby group, in the private sector in the United States or in Europe? What is the lay of the land for those elements? In many industries there are associations and so forth, and I'm not familiar with the quantum computing ones. I'm more familiar with auto and other heavy industry, but not those aspects.

Are those happening? Are they effectively lobbying on that in Washington, for example?

Ms. Allison Schwartz: Absolutely. Yes. The Quantum Economic Development Consortium, the QED-C, was actually created by congressional law. It has industry, academia, the national labs and government. It's starting to open up its membership to other countries as well, and Canada is one of them.

You also have the Quantum Industry Coalition in the United States, which is a factor of quantum industry. Similarly, we have the quantum industry council in Canada, which Steph and I are both members of. There's also stuff in Japan with Q-STAR. Other consortiums and other think tanks are looking at this in Europe and in the U.K. as well.

We are very coordinated in our efforts. A lot of the focus is on exactly what's been discussed today. How do governments prepare? How do we actually utilize the technology today? How do we look at supply chains? How do we identify talent? What are the best ways in which to navigate?

● (1450)

Mr. Brian Masse: On that, are you part of the Canadian business council in the United States? I'm a vice-chair of the Canada-U.S. parliamentary association. We lobby quite a bit there and a lot of businesses have joined from the Canadian perspective, but I haven't yet run into any quantum organizations.

Is this just kind of emerging, or are there things we can do as members of Parliament and also in our trade councils to get you further support and get your voices across the country and also, more importantly, internationally? What can we do to help?

Ms. Allison Schwartz: I appreciate that. We are not members yet of the Canadian business council. However, it is on my list of things to look at. We have been focusing on quantum specifically, because a lot of the issues that these larger organizations tackle are above and beyond where quantum needs to focus.

Over the next year, at the end of 2022 and in 2023, I think those are the areas that a lot of these different quantum organizations are going to navigate into, especially with some use cases in the auto industry—which I'm happy to follow up on privately—of areas that auto manufacturers are looking at for PFAS as well as optimizing manufacturing floors.

Mr. Brian Masse: Excellent.

Thank you very much and thank you, Mr. Chair.

[*Translation*]

The Chair: Thank you.

We now go to you, Ms. Gray, for five minutes.

[*English*]

Mrs. Tracy Gray: Thank you, Mr. Chair.

My first question is for Dr. Simmons. We've heard some shocking testimony today of how behind Canada is on the security issues around quantum computing and the security issues that they can pose.

My question is about quantum hacking of social media platforms and accessing people's personal information, messages, photos, and encrypted messaging apps. Are they all secure?

Dr. Stephanie Simmons: No.

The way encryption works right now is that there's an asymmetric layer and a symmetric layer. Everybody needs that asymmetric layer for the symmetric part to work. That's every communication we have on the Internet. It's the SWIFT banking system. It's how you send communications between government buildings. Everything relies on the fact that RSA is just really hard.... It has been shown to be the case that classical computers have not been able to get at it.

I don't want to be the one who.... Yes, I am trying to get attention to this issue because the risk of failure is so high. I think it's entirely plausible that these post-quantum algorithms will be successful. I would be over the moon because then it removes us from being seen as a cybersecurity threat, and then the technology gets to be enjoyed for all these wonderful things.

However, we have to get them in and it's going to take time. If it doesn't work and if these aren't sufficient, then we're in a real bind.

I just wanted to bring that to everyone's attention. I'm sorry to be the one to shock you all into being aware of this, but it is coming. I think it's perhaps hard to imagine the scale of the shift that needs to happen in time for this to come on.

Mrs. Tracy Gray: Great. Thank you.

What needs to be done to protect these platforms and all of the information that's on there?

Dr. Stephanie Simmons: I don't think there's anything we can do, using RSA, to protect the communications that are being stored right now by adversarial nations. All of that information is going to be openable to adversarial governments if they've stored it, and I know they have. There's really nothing we can do about that.

Nonetheless, we can start to protect all the communications going forward by layering in RSA and all of these other layers of defence.

I think we should go so far, especially for critical infrastructure like access to power grids and to nuclear facilities, for goodness sake. Anything that has access using RSA of course has additional infrastructure, but it is a weak point. The only thing that's been proven to block that is going to be a one-time pad or a QKD solution.

Fortunately, Canada is a global leader on QKD. I can't tell you how fantastic it is to be in a country that is leading the world on this. We have quantum satellites at IQC, and the invention thereof, which was mentioned before by Gilles Brassard We have the talent to do it, but we need to mobilize because it's not sufficient for the researchers to just say it needs to happen.

There's a lot of work to be done.

• (1455)

Mrs. Tracy Gray: For clarification, do you mean that if these were hacked and this information did become available, all of those messages that were stored in history or are considered encrypted and safe right now, and that we think won't be seen, could all be accessible at some point? Is that what you're saying today?

Dr. Stephanie Simmons: Yes, that's right.

We know that they've been storing messages for decades because they've known since 1995 that this is possible. It's just a matter of time.

Mrs. Tracy Gray: Wow.

In your best knowledge, are these platforms addressing this right now? Are they putting these different layerings in or is it part of their plans based on what you know?

Dr. Stephanie Simmons: I know that people are thinking about it, but I know that there's almost zero sense of urgency. I think that's a mistake.

Mrs. Tracy Gray: What do you think needs to be done right now? What steps could they be taking right now based on the technology that's available right now?

Dr. Stephanie Simmons: Thank you.

I think a lot of large organizations are wary of adopting standards that haven't been stress tested. NIST is coming through with a recommendation for post-quantum cryptography. It's rumoured that this will be coming through in the next few weeks or perhaps months.

I think that should be layered on top of RSA because it should be sufficient.... You have to at least have a quantum computer to break RSA, but you should also layer in all of those. For the most secure critical infrastructure, we should have a one-time pad solution. A one-time pad solution means loading up a lot of preloaded keys and actually physically distributing them between the locations we want to secure communications between.

I know that very few organizations are thinking about this. QKD is the other one, but that's a bigger infrastructure play. I think it deserves investment because that's absolutely the future, but it's going to take time. We're not going to be able to deploy it quickly enough before we need to secure our communications.

As I said, the communications that are happening today are being stored to be opened tomorrow.

The Chair: Thank you very much, Dr. Simmons.

I'll move now to Mr. Erskine-Smith for five minutes.

Mr. Nathaniel Erskine-Smith (Beaches—East York, Lib.): Thanks, Joël.

For some clarity on procurement, I want to pick up on what may be a difference between the testimony given, but may not be.

My understanding from listening to Mr. Fursman is that much of the technology is akin to a “half fence” and doesn't have current value but will have future value.

Ms. Simmons, you've identified this need to procure today. How do I square those two ideas?

I'll start with Mr. Fursman and move to Ms. Simmons.

Mr. Andrew Fursman: I think you've understood me exactly correctly.

My belief is that the government needs to understand that quantum computers today are not a better, faster, cheaper solution to any known problem in terms of their ability to actually deliver that, and yet we know that there are many areas where only quantum computers will likely be able to do this work in the future.

I think the real question is, without forcing a half fence on industry, how do we make sure that we are procuring in ways that recognize the current state, going into this with eyes open and saying that we need this work to happen over, say, the next decade? We also need to recognize that if you're using a quantum computer to do a solution today, you're not using the best available solution, so for studying how quantum computers work, this is very important, but to say that everyone should switch to quantum computers today is nonsense. It's impossible, and it's not something that's in line with the technology and the technological reality.

Mr. Nathaniel Erskine-Smith: Thanks, Mr. Fursman.

Ms. Simmons, from the government's perspective, with the public dollars we could put into play in procurement, what is an example of something that you would like to see the government procure and that they are not procuring today in the quantum space?

Dr. Stephanie Simmons: Yes. The national quantum strategy just invested a third of the strategy into training, essentially. Why don't we have these quantum computers procured for that training purpose? Why are we not buying.... We are building fledgling airplanes, right? Yes, they don't cross the ocean yet, but we know where they're going. If we can support local industry, we can build more and more of these things and actually pay the salaries to keep the professionals here.

I completely agree with Andrew: These things do not move the commercial needle from a computational perspective yet, but we all know where these are going. We tend to overestimate the short term, but underestimate the long-term, applications of these things. This is commercializing a branch of physics. It's going to transform everything. If we give people hands-on training in these training organizations, then we don't need to rely so much upon industry for this detailed training.

I would add one more thing. There are quantum technologies that are useful today. QKD is one of them. It's only a short-distance...but it's provably secure. It's something that you can purchase. I think that one of the things the government could procure is a demonstration. You could procure the demonstration of a repeater. This is what DARPA does, right? They procure milestones on technological road maps. It's not a grant. It's actually a case of, “Can you procure this deliverable?” It makes a big difference to the ability to raise the capital necessary to actually keep the talent here, in Canadian organizations. They want to keep it.

● (1500)

Mr. Nathaniel Erskine-Smith: You referenced commercialization. It seems to me that there's probably more to do with respect to training and retaining talent. The government seems to have identified that as a core priority in the course of the dollars it has spent so far.

In relation to the consultations so far in the “what we heard” report, I'll ask all of our witnesses this question—but I'd be interested in Ms. Schwartz's view to start with, then Ms. Simmons' and then Mr. Fursman's, if we have time.

There's this open question of how you best spend the public dollar. There are large organizations. There are.... You can make small bets on large organizations and a small or large number of bets on small organizations as they relate to commercialization. There's an open question in the “what we heard” report as to the way the government ought to pursue this. Do you have a view as to how the government should be spreading the rest of the money around in terms of commercialization in particular?

Ms. Allison Schwartz: I appreciate the question. I've heard you raise that questions in previous hearings as well.

Many quantum computers, if not most of them, are available through the cloud. You're able to access the system and build the talent. You're able to identify areas of utilization of the technology today in a quantum hybrid format, as I talked about. That is also an area that's helping these smaller start-ups get their systems ready and available through a cloud.

If there were a domestic high-performance computing centre integrated with quantum, you could have some quantum systems there, and in a variety of sizes. Maybe some of them are the smaller ones that are really looked at just for research, and others could be commercial-sized ones and navigate through that.

From the government's perspective, I don't think it's an “or”. I think it's an “and” in terms of actually looking at how we navigate to get these different systems up to a level. Once they're already there, how do we push them for their technology readiness to push them into a mature market?

The Chair: Thank you, Ms. Schwartz and Mr. Erskine-Smith.

Thanks to all of our witnesses.

That's all of the time we have. It was a very interesting discussion. I'm sure it was eye-opening to many listening and to my colleagues here at the committee.

I'll also take a brief moment because I know that last week PM Kram had questions on quantum as it pertains to crypto. There was an interesting discussion that I quite enjoyed a few months back with Mr. Fursman on Preston Pysh's investorpodcast.com. If you want to learn more about quantum as it pertains to encryption in the financial sector, that was a very interesting discussion.

Thank you, Mr. Fursman. While we have you here, I wanted to thank you for that.

I wish all of the witnesses and all members a great weekend. Thanks to the analysts, the interpreters and the clerk.

This meeting is adjourned.