TRIUMF
Canada's national laboratory for particle and nuclear physics
Laboratoire national canadien pour la recherche en physique nucléaire et en physique des particules

07 February 2014

Honourable Greg Rickford
Minister of State for Science and Technology
Science and Innovation Sector, Industry Canada
C.D. Howe Building
235 Queen Street
Ottawa, Ontario K1A 0H5
E-mail: science-tech-innovation-consultation@ic.gc.ca

Re: TRIUMF Comments on Science, Technology, and Innovation Strategy Consultation

Dear Minister Rickford:

We appreciate the opportunity to contribute to the Government of Canada's consultation on its science, technology, and innovation strategy. TRIUMF is Canada's national laboratory for particle and nuclear physics and delivers value to the nation by advancing knowledge, creating future leaders, and driving growth. Owned and operated by a consortium of 18 Canadian universities, the laboratory is in a unique position to participate in and contribute to Canadian science, technology, and innovation.

Any substantive discussion of the role of science in society must acknowledge a number of simplifying assumptions that allow us to develop useful policy. For instance, although we believe in a causal relationship between fundamental research and eventual technological progress and economic growth, the process is not linear and has never been fully mapped. Likewise, any strategy that seeks to build on strengths and capitalize on success must also acknowledge the prudence of a portfolio-based approach especially in the realm of research where results are truly unpredictable.

However, experience shows that long term investment into cutting edge discovery-driven science and technology development is critical for future technological advances, innovations, and economic gains. The technology leaders of the world (U.S., Japan, Germany, South Korea) are making substantial, long-term investments into discovery-driven science. As noted by AAAS President W.H. Press, technology leaders spend around 3% GDP on R&D and have the highest percentage of scientists and engineers in population (U.S., Germany, Japan, South Korea), while "technology followers" spend about a third less (Canada, Russia, France, U.K., Australia, etc.) and have a lower percentage of scientists and engineers [*Science* 342 (2013) 817].

In our responses below, we seek to distinguish the tools available to the federal government that can be used to further enhance Canada's scientific prowess and long-term health and prosperity. Where possible, we also provide examples in TRIUMF's experience that substantiate our suggestions.

Building on the advice provided by the Expert Panel on Federal Support for Research and Development, what more can be done to improve business investment in R&D and innovation?

To develop a strategy for impacting business investment and even performance of R&D, one first needs a model of the ecosystem so that inputs, outputs, and outcomes can be distinguished.

Conventional wisdom suggests that the private sector would invest more in R&D if they saw sufficient return on investment to warrant the allocation of resources. Some policies tend to focus on incentivizing R&D activities for the private sector so that their ROI calculations shift in a direction to make the opportunities more attractive. Other policies tend to focus on exposing businesses to a larger space of R&D opportunities, with the expectation that sooner or later, a compelling opportunity will be identified. And then other policies focus on creating linkages between existing leading performers of R&D and the private sector with the understanding that relationships are the foundation for stronger partnerships.

All of these approaches have merit and the Government of Canada is engaged in supporting them through a broad selection of programs and incentives.

In TRIUMF's experience, the gap---or perhaps the greatest opportunity---is with medium-sized enterprises and the "public sector as first customer" model. [Note that in literature, the latter is often termed "government as first customer" referring to the fact that public funds are in use.] Medium-sized businesses have roughly between 40 and 100 employees, millions of dollars of annual gross revenues, and have been operating for at least a decade. These businesses are ready to look for the next product and have sufficient survival experience to know what ingredients are necessary for success. Startups and small companies are typically still in the process of product refinement, market penetration, and building the business by exploiting their founding intellectual property. The large multi-national companies are shopping the world for ideas and opportunities and a different set of incentives will attract their investment (typically, key personnel or very specific track records in specialized areas or narrow geographical regions of focused excellence). The greatest opportunity for Canada is to develop programs that provide initial "pilot engagements" between publicly-funded researchers and mid-size private-sector enterprise. The long-term impact will be enhanced business investments in R&D as well a stronger culture of innovation and partnership.

Consider two examples.

For its ISAC-II accelerator of exotic isotopes, TRIUMF chose a modern technology that was not yet commercially available in Canada. On an R&D basis, this "SRF technology" (superconducting radio-frequency cavities for particle acceleration) was emerging around the world and TRIUMF scientists and technologists were developing expert proficiency. A key element of assembling the technology requires precision machining, welding, and surface treatment. TRIUMF selected a mid-sized Canadian vendor in this domain (Richmond, BC based PAVAC Industries, Inc.) from which not only to procure these services, but also to develop and transfer its technology into Canadian industry. PAVAC had the business experience, in-house equipment and staff, and readiness to take on the risk of developing a new product.

In the "government as first customer model" of technology transfer, TRIUMF ordered several of these specialized, never-before-made-in-Canada SRF cavities from PAVAC—and then devoted time and resources to help PAVAC build them. Perhaps most importantly, and this was perhaps a key hurdle, both organizations (TRIUMF and PAVAC) had a good-faith understanding that was silent on proprietary information and licensing fees.

Because the SRF components addressed a mission need for TRIUMF, the laboratory was able to focus a portion of its publicly-funded resources on the technology-development activity. An external funding program from NSERC or IRAP or similar would have complicated the relationship, required reams of legal analysis of potential IP, added to TRIUMF's workload, and slowed progress.

PAVAC and TRIUMF worked hand-in-hand on the first few deliverables. PAVAC successfully produced the SRF cavities for TRIUMF's ISAC-II accelerator which began operations at full power in 2010. TRIUMF then placed a second order for components needed for its ARIEL project and introduced PAVAC to collaborators in India, China, and the U.S. PAVAC is now manufacturing and selling cavities to customers in each of these countries. PAVAC has expanded its product and services offering from electron-beam welding company to now include SRF accelerator cavities. This transfer would not have been possible if PAVAC had not already had success and experience and if TRIUMF did not have the ability to pursue a good-faith exchange of information. PAVAC invested hundreds of thousands of dollars to recruit staff, expand floor space, and tool up in order to become stand-alone in SRF cavity fabrication.

Although the early transfer of SRF cavity technology to PAVAC is essential royalty-free, the next chapter of the story illustrates the power of this model. PAVAC's customers are demanding not only SRF cavities (which price at hundreds of thousands of dollars) but also the superconducting cyromodules that house and support the cavities (aka the life-support systems for the SRF cavities; these price in the millions of dollars). Based on the excellent relationship developed on the first SRF cavities, TRIUMF and PAVAC are now negotiating a technology license for the cryomodule technologies. This deal is being brokered by Advanced Applied Physics Solutions (AAPS), Inc., the commercialization arm of TRIUMF originally launched via the CECR program. In other words, TRIUMF entered the relationship with a hand-shake, not a hand-out.

In a second example, TRIUMF and Advanced Cyclotron Systems, Inc. (ACSI) have embarked on a business-driven product-development project facilitated by AAPS that will transfer TRIUMF technology for high-resolution precision magnets into the market place. Again, as above, ACSI is a medium-sized company that traditionally manufactures medical cyclotrons and has enjoyed 15-20% of the world market over the past five years. These cyclotrons are based on a TRIUMF design of 20 years ago and still lead the market in terms of performance. In the same "government as first customer" model, the first high-resolution isotope separation magnet from ACSI will be co-built with TRIUMF and will be installed at TRIUMF as a proof of the technology. AAPS is bringing a million dollars to bear on this technology-development and licensing activity and ACSI is investing hundreds of thousands of dollars to develop some of the core infrastructure at their manufacturing facility to make these magnets. The result is that TRIUMF will receive a powerful new research tool, ACSI will have a new product line and a satisfied customer, and Canada will have business leadership in a niche market that capitalizes on its intellectual assets.

These two anecdotes show the value of working with mid-sized enterprise and the ways in which "government as first customer" can facilitate technology transfer from product development to product demonstration. The challenge is finding the opportunities where this approach work; most "first dates" are not free and take a decade of collaboration and partnership to accumulate the requisite success and the trust.

These successes are offset by a dozen failures and missed opportunities. With tightly focused performance objectives and milestones, TRIUMF can only "afford" the time and money to transfer and train industry when the specific product addresses a mission need at the laboratory. The so-called "espresso-maker" dose-on-demand medical cyclotron product that TRIUMF proposed in 2008 was abandoned because there was no free energy to pursue the project. The technology is now under development by General Electric in Sweden, a missed opportunity for Canada and its domestic cyclotron manufacturer ACSI.

We suggest that the federal government consider programs and policies that (a) encourage a "government as first customer" model for innovative and challenging product development across the high-tech research and development sector, (b) focus on product-development success as well as IP management and corporate governance, (c) provide incentives for mid-sized enterprises to partner with research performers to take on high-risk projects to explore new products. We might call this "start with a handshake" or "first dates should be subsidized" model.

What actions could be taken, by the government or others, to enhance the mobilization of knowledge and technology from government laboratories and universities, colleges and polytechnics to the private sector?

The transition of knowledge and technology from the public to the private sector depends critically on the direct interaction between researchers in academic institutions and business people. Progress comes down to people, people with a base of shared experience and some shared objectives. Opportunities for businesses and research-performers to interact and occasionally join forces are the genesis of the longer-term relationships that create the environment for successful knowledge mobilization. This interaction can be facilitated well in the multidisciplinary environment of a national laboratory where discovery-driven research and applied sciences together with a product-development platform can lead to an effective knowledge and technology transfer to industry.

For example, TRIUMF's broad science portfolio of accelerator-based research has led to successes in isotope production, most recently addressing the nations need for non-reactor-produced technetium-99m, as well as geotomography using modern particle-detector technology, and the transfer of accelerator technology to Canadian companies (ACSI, PAVAC, D-Pace).

As referenced above, we recommend that the federal government pursue mechanisms to encourage contact and initial collaborations between public-sector researchers and mid-sized enterprise in the private sector.

How can Canada continue to develop, attract and retain the world's top research talent at our businesses, research institutions, colleges and polytechnics, and universities?

Programs like the Canada Research Chairs and the Canada Excellence Research Chairs are good tools to attract and retain top, global talent but sustained support for operating the research infrastructure is needed. Even if one adopts the "brain circulation" model for global research talent (which says that circulation is more important than long-term retention), the outlook becomes grimmer. Global talent comes to Canada, creates new capability or capacity, and then the facilities are abandoned when the research leaves Canada. The challenge for Canada is not so much the retention of the top talent but full and sustained capture of the contributions they made while in Canada by maintaining the research and development infrastructure.

How might Canada build upon its success as a world leader in discovery-driven research?

We comment specifically on the areas of accelerator-driven science where TRIUMF has leading expertise and experience. As reported by the Council of Canadian Academies, particle and nuclear physics is one of the key drivers of Canada's world-leading position in physics and astronomy research. Moreover, Perimeter Institute, SNOLAB, and TRIUMF together form a unique team that can build on this success.

Canada's continued success in these areas will require several ingredients:

1. Continued capital investment in modern and pioneering research infrastructure;
2. Predictable, reliable programs of operating support for this infrastructure;
3. Flexible, effective, and efficient governance of large-scale research infrastructure; and
4. A reasoned and thoughtful strategy that balances leadership opportunities offshore and the need for a strong domestic platform to optimally capture those benefits.

Successful discovery-driven research often takes place at the edge of the "comfort zone;" that is, it challenges performance and sensitivity limits or combines tools in novel ways to achieve new measurements or predictions. These efforts require state-of-the-art tools and talent. The Canada Foundation for Innovation has emerged as the premier vehicle for selecting and investing in cutting-edge research tools for the Canadian community and it is to be commended. One obstacle that limits its strategic effectiveness is the ever-present uncertainty about its existence. As a result, everyone asks for everything in each competitive selection process and the ability to construct and upgrade capital-intensive research infrastructure over the course of a decade is compromised.

Secondly, there continues to be a gap in supporting the operations of Canada's fleet of medium-to-large scale research infrastructure. TRIUMF is uniquely able in Canada to steward research infrastructure installed as part of its Vancouver complex; this capability was enabled decades ago by the wisdom of placing it on a core operating budget from Industry Canada with oversight and accountability by the National Research Council of Canada. Discovery-grant programs and mid-scale research initiatives are beginning to flounder as Canadian researchers struggle to choose between new research equipment and operate existing infrastructure. Incentives by the federal government could help support the work of funding agencies to appropriately support both of these crucial aspects of the research enterprise.

For large-scale research infrastructure, we recommend the TRIUMF model for governance accountability. University owned and operated, TRIUMF has been at the forefronts of research in particle and nuclear physics for four decades and is among the world leaders in developing pathways to economic impact for its core science and technology. With core operating funds secured for five-years at a time through a comprehensive, intensive international review and evaluation, TRIUMF has the ability to operate a fleet of research equipment in service of Canadian objectives. The model for TRIUMF might serve as a good basis for other activities in Canada.

Finally, a new science, technology, and innovation strategy for Canada needs to include an international element. In the modern world, some of the most promising frontiers of science must be probed with globally unique and capital-intensive research infrastructures, such as the Large Hadron Collider at CERN in Geneva, Switzerland.

Is the Government of Canada's suite of programs appropriately designed to best support research excellence?

In short, we suggest that Canada is well along the road to supporting research excellence. Setting aside the challenges of keeping up with the increasing appetite for research (and therefore the escalating budget requests), the federal government has programs and policies in place to support new initiatives, rebalance existing portfolios, build new networks, engage international

collaborators, and partner with the private sector. There are some troubling gaps however and we comment on those. But, on balance, Canada should be proud of its program of support and the accomplishments that it has enabled.

The challenge of supporting operations and maintenance of new research infrastructure remains a plaguing problem. The challenge is most acute at the mid and large scales. Funding agencies such as the Canada Foundation for Innovation create opportunities for new equipment, infrastructure, and laboratory facilities. But after the Infrastructure Operating Funds are exhausted, the new capability must be supported by funding programs that also support students and original research. Simply adding money is not a sustainable solution; there needs to be a process that can help researchers and institutions balance the portfolios in a manner that takes into account primary support for discovery research, acquisition and procurement of new capital equipment, and long-term operations. In addition to a mechanism or process, Canada would do well to develop a specific set of strategies or objectives to help guide the portfolio management.

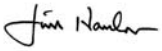
In the world of subatomic physics, the lack of a useful process is evidence in the challenges experienced with the annual proposal evaluation process for the so-called "NSERC subatomic physics envelope." This tool allows the Canadian subatomic physics research community to invest in people, ideas, and tools but with annual budget authority frozen against even inflationary corrections, the envelope's spending has become increasingly dominated by operations of existing world-class equipment and facilities, sacrificing the students and scientists and original research ideas.

We applaud the recent Council of Canadian Academies report that identified area of Canadian global excellence in research. Rather than redirecting existing funds, new investments should seek to capitalize on those strengths and look for ways to enhance discovery-driven research as well as build partnerships across sectors and even internationally. One of the challenges in the present model is that the Networks of Centres of Excellence program ends up focusing its investments on networks that include industrial collaboration and investment, reducing the chances for Canadians in a top research discipline to further pool and partner to maintain the world-leading position. That is, TRIUMF recognizes that there is a strong need for federal incentives to encourage academic and industrial partnerships, but we should allow some research networks to compete on a level footing without requiring industrial matching funds---especially when the success factors for industrial engagement are not yet clear.

We hope that these thoughts are useful in your deliberations. We make ourselves completely available for any follow-up discussions. The revised policy document you are crafting is important, timely, and very welcome.

With warm regards,

Sincerely,



Jim Hanlon
Interim Chief Executive Officer / Chief Administrative Officer