Building Excellence in Science and Technology (BEST):

The Federal Roles in Performing Science and Technology

A Report of the

Council of Science and Technology Advisors

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Executive Summary

Preamble

The Council of Science and Technology Advisors (CSTA) was asked by the Cabinet Committee on the Economic Union (CCEU) to provide advice to the government on the roles of the government in performing science and technology (S&T) and its capacity to deliver on those roles. To support this work, we commissioned studies on past experience in Canada and internationally in defining the role of the government in S&T. We also asked federal science-based departments and agencies for data on their past and current S&T activities and functions.

We recognize that there is a changing context within which all governments are operating. The pressures of globalization, the public's need to know that government decisions are based on the best information available, and the transition to a knowledge-based economy are forcing governments to adapt to an environment of continuous and accelerating change. Science and technology occupy a much more prominent place in the knowledge-based economy than they did in the past, largely due to their power to enhance our understanding of the world around us and add value to the products and services we use. Governments are recognizing the need to manage these valuable S&T assets more strategically to ensure the maximum benefit to their citizens. This requires flexible and adaptable policy frameworks. We note that, in many cases, the policy solutions of yesterday cannot be modified to meet the challenges of tomorrow. Entirely new approaches to, and uses for, science and technology need to be developed.

We strongly believe that there is a critical role for the federal government in performing S&T to fulfil the mandates entrusted to it by the Canadian people. We also believe that there is a need for a more horizontal approach to S&T priority setting in government and departments, as well as across the innovation system. The approach should bring together stakeholders for cooperative planning, execution and evaluation.

We strongly believe that there is a critical role for the federal government in performing S&T to fulfil the mandates entrusted to it by the Canadian people.

Priority setting in government and across the innovation system should take a more horizontal approach.

The Continuing Evolution of Canada and Its Innovation System

Canada's innovation system — its S&T institutions and the linkages between them which, together, provide the knowledge needed for a progressive society and economy — is dependent on having complementary

The full potential of Canada's innovation system is not being realized.

strengths in the three key sectors: the private sector, universities and governments. Each of these players needs to fulfil a number of roles and work together in harmony to ensure that our economic and social systems perform well and keep pace with both domestic and international developments in S&T and that the government meets public expectations. The full potential of Canada's innovation system is not being realized. This is only in part a function of weaknesses in some components of the system. It is also a function of competition for funding and a prevailing "win-lose" approach within the system.

We recognize that there will continue to be a dynamic equilibrium between S&T capacity within and outside the government, and believe that there will continue to be core S&T activities that the federal government should perform.

The federal government currently occupies a key place in the innovation system, both as a funder and performer of S&T. This place reflects its history as a nation-builder and the emerging context of globalization with the free flow of knowledge in a knowledge-based economy and growing S&T capabilities outside the government. As Canada and its institutions mature, universities and the private sector are positioned to make a stronger contribution to the innovation system than in the past. The federal S&T role as a performer is not diminished. It is more focused and is somewhat different in nature. In some areas formerly dominated by the federal government, federal leadership may no longer be necessary. In others, however, the need for a federal presence may be as strong as ever and, in some emerging areas, may be essential. We recognize that there will continue to be a dynamic equilibrium between S&T capacity within and outside the government, and believe that there will continue to be core S&T activities that the federal government should perform.

Roles

Key roles identified for the government in performing S&T:

- ***support for decision making, policy development and regulations***
- ***development and management of standards***
- ***support for public health, safety, environmental and/or defence needs***
- ***enabling economic and social development.***

We identified a clear need for the federal government to perform S&T and believe it must have the capacity to deliver the following key roles:

- *Support for decision making, policy development and regulations* — e.g. stock assessments and fisheries biology to manage fish stocks, responses to global warming.

- *Development and management of standards* — e.g. contribution to the resolution of issues such as the dispute with the European Union on pinewood nematode

in Canadian softwood lumber shipments, which depends on the development of standards based on federally performed research.

- *Support for public health, safety, environmental and/or defence needs* — e.g. federal capacity for independent research into food safety assists the government in ensuring the safety of Canadians.

- *Enabling economic and social development* — e.g. research into health service delivery or sustainable farming practices.

Crisis or Opportunity?

We noted a wide range of pressures facing the federal government in fulfilling its role in the innovation system. Some of these are long-standing and some are recent. These pressures present the government with both challenges and opportunities. In this regard, we identified a number of issues related to the government's ability to be a key player in the national innovation system. They relate to the government's capacity to perform S&T and its ability to manage that S&T to ensure maximum value for its investment. We stress, however, that the challenge is not necessarily "rebuilding" or "restoring" capacity to historical levels. It is to identify what capacity is needed to allow the government to meet current needs and enhance its ability to meet future challenges.

Capacity Issues

We found that pressures on federal S&T capacity are threatening the government's ability to deliver on some of its existing mandates and priorities, and limiting its ability to respond to new challenges and opportunities. Key issues related to capacity are:

The challenge is to identify the S&T capacity needed to allow the government to meet current needs and enhance its ability to meet future challenges.

- an impending shortage in the human capital needed to fulfil the government's S&T roles;

- inflexibility in human resource practices and policies; and

- the ageing and obsolescence of facilities, equipment and research platforms.

Management Issues

In our opinion, maximizing the impact of the federal investment in S&T will require stronger management of the S&T capacity, aimed at making the federal government a flexible and agile contributor to the national innovation system and ensuring the well-being of Canada. Key management issues include:

Government-performed and funded S&T needs to be prioritized against departmental mandates and government priorities.

- inadequate S&T management information;
- the need for screening of government-performed and funded S&T against departmental mandates and government priorities;
- the need for more of a "future orientation" in government S&T activities; and
- priority setting for S&T.

Principles

Government decision making requires sound, high-quality science and technology. The government must strive to ensure that the S&T it requires is obtained effectively and efficiently, whether performed in-house or supplied from outside government, and that taxpayers receive the maximum returns from their investment in S&T. We identified three fundamental principles that must be applied to the conduct of all federally performed and funded S&T. We strongly believe that the implementation of these principles is essential if the government is to remain a credible contributor to the national innovation system:

The fundamental principles of alignment, linkages and excellence must be applied to the conduct of all federally performed and funded S&T.

- ***Alignment*** — Federal S&T efforts must be focused where they will have the most benefit to Canada. Federally performed and funded S&T must be demonstrated to be aligned with departmental mandates and the overall priorities of the government. Departments and agencies should only be performing the S&T that is needed to support their mandate and that cannot be obtained more effectively from other sources. (We call upon the government to aggressively follow through on the commitment it made in the report, *Science and Technology for the New Century — A Federal Strategy*, March 1996: "Departments and agencies will regularly and systematically assess whether their performance of S&T might be better carried out by others.")

- ***Linkages*** — S&T performed and funded by the federal government must be tied in with other activities within the federal government, with the other sectors in the Canadian innovation system (universities and the private sector), and with the global pool of knowledge and technology. These linkages ensure that federal performance of S&T capitalizes on the best available inputs, regardless of their source, and that overlap and duplication are minimized.

- ***Excellence*** — The S&T performed, funded and used by the federal government must be of the highest quality. It must be demonstrated to meet or exceed international standards for scientific and technological excellence, and deliver social or industrial relevance. This should be achieved through openness, transparency, and regular and appropriate expert review.

Recommendations

The application of these principles will assist the government in ensuring that it maintains a strong capacity to support the health, safety and economic well-being of Canadians through its ability to address science-based issues and decision making for the future. In this regard, the Council recommends that the government and departments:

1. Establish performance metrics and require the principles of *alignment* (with departmental mandates and government priorities), *linkages* (across departments, across the Canadian innovation system, and with the global S&T community), and *excellence* (to the highest standards, assured by openness, transparency, and regular and appropriate expert review) to be integrated into the government's and departments' priority setting, decision making and delivery on S&T.

2. Require the existing annual planning and performance reporting mechanisms to explicitly include a review of S&T priorities and activities on the basis of the principles outlined here and document the status of, and action plans for, the reallocation of resources to priority areas and those that are emerging.

3. Implement and fund new models for S&T that move away from a vertical approach to a more horizontal (i.e. across government and the innovation system), competitive, multi-stakeholder approach.

4. On an urgent basis, commit sufficient resources to federal S&T to ensure that the government has an appropriate capacity to provide a sound scientific platform for delivering on its roles, including its policy and decision making.

5. Establish a robust capability to assess the implementation of these recommendations by:

- requiring S&T advisory bodies to federal science-based departments to take an active role in departmental S&T planning and evaluation (as committed to in the federal S&T strategy);

- requiring each of these advisory bodies to regularly assess departmental and agency reports on the implementation of these recommendations and report to, and review with, their minister and the full CSTA; and

- requiring the CSTA to report regularly to the CCEU on government-wide success in that implementation.

Introduction

In March 1996, the government released *Science and Technology for the New Century — A Federal Strategy*. The aim of the strategy was to ensure that the federal government's science and technology (S&T) activities were well oriented to meet the challenges and opportunities of the future. The strategy outlined goals for federal S&T and a new governance structure to assist the government in making the most of S&T as drivers of growth in a modern economy. A key component of the strategy was the creation of the Council of Science and Technology Advisors (CSTA), established to provide the Cabinet Committee for the Economic Union (CCEU) with expert, external advice on internal federal government S&T issues that require strategic attention. In a climate of increasing expectations and decreased resources for federal S&T, the CCEU asked the CSTA for advice on the roles that the federal government should be fulfilling in performing S&T. It also asked the CSTA to provide advice on the current and future capacity of the federal government to fulfil the roles identified.

This report contains principles and recommendations aimed at ensuring that the federal S&T system can contribute to the protection of Canadians and their environment, and the sustainable development of Canada's economy and society.

As asked, we are providing the government with our views on federal roles in science and technology. We believe strongly that a confirmation of these roles is needed urgently, as is a commitment to ensure that adequate resources are available to allow departments and agencies to fulfil those roles and deliver on their mandates.

Definitions

The CSTA sought to understand and advise the government on its role in performing S&T, as distinct from its broader role in funding S&T in universities and industry. In Canada, S&T is understood to include two distinct but linked sets of activities:

- *Research and Development (R&D)* — Creative work undertaken on a systematic basis to increase the stock of knowledge, including the knowledge of humans, their culture and society, and the use of this stock of knowledge to devise new applications of science and/or technology.

- *Related Scientific Activities (RSAs)* — Those activities that complement and extend R&D by contributing to the generation, dissemination and application of scientific and technological knowledge. Examples include data collection, testing, scientific and technical information services, and museum services. RSAs include many activities not normally performed by university or private sector researchers such as monitoring and disease surveillance.

Context

The Changing Place of the Government in the Innovation System

Until the post-World War II period, the federal government played a central role in the development of Canada's S&T and in the associated innovation system. In this earlier period, there was a requirement for S&T capacity to respond to specific national needs, and the federal government established the required facilities. Research positions in federal labs were coveted and were a key component of many scientific career paths. Linkages between the various players in the innovation system (university-industry, government-industry, government-university) were weak, as the government housed almost all of Canada's S&T facilities, infrastructure and expertise.

After World War II, the government began to invest heavily in S&T capacity in the universities. Through the National Research Council Canada (NRC), the government initiated a program of capital grants to universities, helping them to build faculties of science and engineering, and new scientific laboratories. Other NRC programs gave grants to research scientists and engineers. These programs were made independent from the NRC over time, to become two of Canada's university research granting councils, the Medical Research Council of Canada and the Natural Sciences and Engineering Research Council of Canada. Another council, the Social Sciences and Humanities Research Council of Canada (SSHRC), was created on the same model out of the Canada Council.

The government also made extensive efforts to support R&D in industry by offering tax incentives; opportunities for industry to do collaborative research in partnership with government laboratories; and, in a few cases, actual cash grants to assist in the establishment of privately owned research facilities.

The current situation is much different. Canada's universities have become highly research intensive and are recognized as world leaders in many fields. Similarly, Canada's industrial R&D is world-class in many fields. Government programs and shared needs for the best possible S&T have encouraged linkages between many S&T performers. However, we believe there is still considerable scope for strengthening both the individual components and the linkages within the innovation system. This will require not only strategic investment in priority areas, but also changes to the "culture" in each of the sectors and improvements in the management of S&T activities towards a shared vision for Canada's future. In this evolving context, the government's role in the national innovation system has changed in many science or technology fields, from being a leader, funder and the dominant provider, to being more of a catalyst and a facilitator.

The government's role as a performer of S&T is no less important to the innovation system than it was in the past, but it has evolved to become more focused, addressing key activities mandated to it by the people of Canada. For example, while the predecessors of Agriculture and Agri-Food Canada were responsible for the development of the wheat varieties upon which the prairie economy was based, the development of the next generation of Canadian agricultural biotechnology products will be the product of a broad combination of industrial, university and government research efforts.

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Canada has not evolved as a nation in isolation. With the emergence of a global, knowledge-based economy and society, it has been thrust into a world of accelerating change, one of increasing technological complexity and aggressive technology-based business competition. The evidence indicates that the S&T environment will continue to change rapidly and sometimes unexpectedly.

Federal S&T as a Necessary "Enabling Step"

Although federal S&T has a critical role to play in the proper functioning of the national economic and social system, the Canadian innovation system is no longer dominated by the federal government. The ability of the government to set policy in emerging technology areas, to regulate increasingly sophisticated products (so that they get to market quickly without unnecessary risks to Canadians), to protect the environment, and to assess and use effectively knowledge from external sources in the delivery of legislated mandates requires it to have an appropriate in-house S&T capacity. Where the government is unable to mobilize its S&T resources in support of its mandated regulatory, economic and social development roles, there can be a significant adverse impact on university and private sector activities in knowledge creation, and economic and social development.

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Challenges, Pressures, Threats and Opportunities

Change as a Way of Life

The changes that have occurred in the post-World War II period have completely reshaped social and economic structures, bringing national governments into a global, knowledge-based economy and society. Governments recognize that these changes will continue and that the pace of change will continue to accelerate. Standing still, or trying to create a steady state, will mean falling behind and becoming uncompetitive in the global marketplace. A further complication of falling behind is the inability of governments to anticipate and recognize potential problems and opportunities, and to take appropriate action to protect their citizens and/or capitalize on the opportunities.

Accelerating changes in the global economy are creating a new environment in which governments must operate and to which federal S&T must contribute. (For example, in Canada, R&D spending by industry is growing faster than in any other member countries of the Organisation for Economic Co-operation and Development (OECD). The change that this implies in the nature and dynamics of the Canadian innovation system means that the government S&T effort must be flexible and adaptable in order to keep pace). These changes are creating both opportunities and threats for governments and the S&T required to support them. Underlying this situation is a shift in the "policy environment" (including public expectations concerning what federal S&T can and should provide), making it significantly different from when the federal S&T system was established.

This environment of continuous change is characterized by a number of factors that are shaping the global economy and the place of governments within it. These factors are outlined below.

Globalization-Internationalization

A key characteristic of the process of globalization is the accelerating integration of all markets, domestic and foreign. There are no longer any "safe" domestic markets, where firms are protected from competitors by tariff walls. The forces of globalization are also changing the context for government S&T activities. Policy decisions must be backed up with world-class science and technology. S&T is playing a more prominent role in trade disputes and their resolution. Pressures for global harmonization of standards and regulations require that national S&T activities meet international standards. In order for national governments to be able to enforce a unique national identity and economic sovereignty in the global marketplace, they must be able to back up their policies with internationally accepted science. In short, national S&T efforts, facilities and equipment need to be world-class in the academic, private sector and government arenas.

Increased Public Expectations

Canadians look to their governments for assurance that their interests are being addressed (i.e. health and safety, security, economic and social well-being, etc.). While the amount and quality of information available for independent decision making is better now than in the past, Canadians still look to the government to take action where the available information is incomplete, or is overwhelming in volume and/or complexity.

Also, there are many areas where national decisions are required for which Canadians rely on the federal government to ensure the proper, fair functioning of the marketplace. They also look to their governments to provide other services in the public interest such as research, education, defence, a supportive business environment, social programs and infrastructure. These factors have raised public expectations concerning what government can and should be doing, as well as the level of involvement the public should have in government decision making. Increasingly, openness, transparency and internationally recognized excellence in both science and decision making are expected by citizens.

Advances in Knowledge and Technological Change

The pace of technological change and the rate of advancement in knowledge are unprecedented and appear likely to continue to accelerate. New products and technologies often require new types of regulatory responses or new needs for regulatory science. (Biotechnology is a prime example.) Governments need to be able to keep pace with these developments to ensure the safety of their citizens and the environment, and to ensure that commercial development is not adversely affected by government delays in product/process approvals. In some rapidly advancing, technology-intensive fields, government scientists need a level of expertise that often requires hands-on, continuing experience in leading-edge research to understand the results they are required to assess.

Knowledge-based Economy and Society

The central role of knowledge and S&T in economic growth and social progress is changing the dynamics of these processes and the role of governments in them. Increasingly, governments are focusing on the strategic role of innovation systems and the linkages between the players within them. With science and technology being basic components of most public policy issues, there are increased expectations and demands for a major contribution from federal S&T capabilities.

A key characteristic of the knowledge-based economy and society is the growing functional identity and market value of knowledge. Knowledge-intensive goods and services tend to be higher value added, while less knowledge-intensive goods and services tend to be lower value added. Another key characteristic is that knowledge itself is the foundation of business competitiveness.

Pressures to Control Government Spending

Governments around the world are being pressured by their citizens to reduce government spending and to ensure top value for that spending. There is much stronger pressure to demonstrate clear needs for federal investments in S&T. Governments are under pressure to prioritize their spending on S&T and/or to try innovative approaches to meeting their S&T needs.

Diversity of Options

Federal laboratories are no longer the primary sources of S&T facilities and expertise in Canada. With strong S&T capabilities available in universities and the private sector, decision makers have many more options for accessing the S&T knowledge they require. They can fund work in universities, contract it out to industry, or access it internationally, either from foreign laboratories, or, in some instances, over the Internet. Thus, the rationale for performing S&T within government needs to be based on a demonstration that the work is relevant to specific needs of government; that it can be done more effectively and/or efficiently in government facilities than elsewhere; and that, if the government did not do it, it would either not get done, or else would be done in a manner or a time frame that is not suitable for responding to the needs of the government.

The rationale for performing S&T within government needs to be based on a demonstration that the work is relevant to specific needs of government; that it can be done more effectively and/or efficiently in government facilities than elsewhere; and that, if the government did not do it, it would either not get done, or else would be done in a manner or a time frame that is not suitable for responding to the needs of the government.

It is important to note that the federal government needs to have a degree of scientific and/or technological capacity to exercise the option of outsourcing the research. The government department or agency should have a clear understanding of its needs for the specific scientific or technology research and/or development. It also needs to have a capability for a clear understanding of the results of the S&T work, their implications for the required decisions, and their strengths and weaknesses. It must also have the ability to assess the quality of the work with reference to leading-edge standards.

The International Experience

Governments around the world are all experiencing the impacts of this changing knowledge-based context for governance. We commissioned a review of the international experience on this subject. It was clear from this review that different governments are

It is interesting that all of the governments surveyed have this active in-house R&D function, including even the highly private-sector-oriented governments.

taking different approaches in dealing with these challenges, based on their political systems and the historical development of their S&T systems. (For example, the United States system has a strong private sector orientation, while France's central government performs a substantive amount of S&T work it believes to be needed either internally by the government or by its private sector clients).

Another finding is that governments of all OECD countries (with the exception of New Zealand) have some in-house R&D capability. In smaller countries, this capability is a relatively important fraction of the overall national R&D system; in larger countries, in-house R&D is a relatively smaller fraction. However, it is interesting that all of the governments surveyed have this active in-house R&D function, including even the highly private-sector-oriented governments such as the United States.

The Canadian Government in the Changing World

Interdependence Within Innovation Systems

In successful innovation systems, the primary constituents (governments, universities and industry) collaborate and draw strength from each other.

In successful innovation systems, the primary constituents (governments, universities and industry) collaborate and draw strength from each other. The S&T performed by government, universities and industry each responds to different needs and time frames and often requires different skills and a different researcher culture. Because of these differences, different performance criteria and standards are sometimes necessary. In many cases, S&T from one of these sectors cannot be substituted for any of the others. As innovation systems mature and become more specialized, the degree of overlap within the system (i.e. how effectively each of the three major constituents can respond to the needs of the other two sectors) appears to decrease, though by no means disappear, with all the players focusing on their respective niches.

With the increasing complexity of S&T, there is a need for increasing specialization and greater sophistication. This lends itself to focusing the efforts of individual players, combined with stronger linkages across the system. The differences between the players are also highlighted in the area of performance criteria where, for example, the reports required by government or industry decision makers to answer specific questions in narrow time frames may not be written or prepared in a way that would allow these reports to be published in scientific journals. A third area of difference is the increasing separation of the questions and, hence, the objectives being pursued by the three constituents.

As the differences between the constituents of innovation systems become more prominent, the need to collaborate and complement each other's strengths increases. Again, a characteristic of more mature national innovation systems is that inter-sector collaboration is more effective than in the less sophisticated and mature innovation systems, which are frequently dominated by a single player.

Integration of S&T into All Government Decision Making

Science and technology are important contributors to government decision making, but while scientific input is often a necessary input, it is seldom a sufficient basis for many decisions. In particular, economic and social factors will often play a fundamental role in shaping decisions.

A key message in the CSTA's report* Science Advice for Government Effectiveness (SAGE) *is that the government must have the capacity to access and/or deliver excellent science as the basis for government decision making.

In view of ministers' accountability for the decisions they make, and the public expectation that those decisions will be made based on the best available information, ministers need to have access to the highest possible quality scientific and technological information in a time frame that meets their needs. Failure to use the best available data and analysis could expose ministers and the government to political consequences and/or liabilities for damages caused by those decisions. Also, ministers need the best available data to enforce and defend their decisions. Failure in this regard could potentially limit their ability to promote the nation's interests in both domestic and international arenas. A key message in the CSTA's report *Science Advice for Government Effectiveness (SAGE)* is that the government must have the capacity to access and/or deliver excellent science as the basis for government decision making.

Science is playing an increasingly important role in trade disputes. For example, several months ago, Canadian officials found that the Asian Long Horn beetle might be imported into Canada in the slats and pallets used in transporting cargo, primarily from China. There is no known cure, eradication or North American predator for this voracious eater of trees — particularly Canadian maples. The only known response is to quarantine any infested area, and cut up and destroy every tree and bush in the area. Battling threats such as this beetle requires an ability to recognize and assess the threat, and to devise effective countermeasures.

In this case, the Chinese government protested Canada's ban on the use of skids and pallets made from untreated wood in cargos from China, saying that this was an unjustified restraint of trade. Canada defended its position with the help of entomological studies of the Asian Long Horn beetle and an assessment of its ability to survive and prosper in Canada's climate and forest conditions.

Another current high-profile trade case where science is playing a dominant role is the European Union's (EU's) ban of beef imports from the United States, because of human health concerns over the US beef producers' use of growth hormones in their cattle. The EU is concerned about the effects of these hormones and their residuals on people; the United States is responding that the hormones occur naturally and are equally present in both treated and untreated cattle. It is clear that only the highest quality scientific investigation could satisfy both sides. Also, such an investigation must produce definitive and unequivocal results. Finally, the studies must fully satisfy both sides' demands for neutrality, as the EU would tend to distrust, for example, studies paid for by the US beef industry, while the US would distrust work contracted by consumer interest advocates in Europe. Research done by government scientists on both sides of the Atlantic would be less distrusted; results of research collaboration by EU and US scientists likely would be the most acceptable type of evidence.

Science and Technology Are Needed by Government

Governments require S&T capabilities to deliver a number of key roles, including:

- *Support for decision making, policy development and regulations* — e.g. stock assessments and fisheries biology to manage fish stocks, responses to global warming.

- *Development and management of standards* — e.g. contribution to the resolution of issues such as the dispute with the EU on pinewood nematode in Canadian softwood lumber shipments, which depends on the development of standards based on federally performed research.

- *Support for public health, safety, environmental and/or defence needs* — e.g. federal capacity for independent research into food safety assists the government in ensuring the safety of Canadians.

- *Enabling economic and social development* — e.g. research into health service delivery or sustainable farming practices.

To fulfil these roles, and as a consequence of fulfilling them, the government carries out a number of functions that provide significant benefits to the Canadian S&T system. These include:

- providing testing and evaluation services;

- evaluating and assessing the quality, validity and relevance of S&T inputs from other sources;

- improving understanding and response to technology change;

- advancing knowledge; and

- supporting public outreach and communications.

Although the government requires high-quality S&T in the delivery of its responsibilities, this does not imply that it must perform all of this S&T itself. Government departments and agencies need to involve themselves in S&T activities through funding, facilitating and/or performing, where the public rate of return exceeds the private rate of return; where their mandates explicitly require S&T work; or, where failures in the marketplace make government the only party that could perform the required S&T work to the satisfaction of all affected parties. We strongly believe that there is a critical role for the federal government in performing S&T to fulfil the mandates entrusted to it by the Canadian people.

The growing strength of S&T in Canadian universities, industry and non-profit research institutes means that there are more S&T skills, knowledge and capabilities available from outside government than in the past. Also, the Internet has considerably improved the availability of data from around the world. Nonetheless, there are valid reasons why the government needs an in-house S&T capability. In general, the government involves itself in performing S&T in areas where that S&T is required to deliver on legislated mandates and is not available from other sources. The reasons why governments perform S&T include the following:

- some departments are required by legislation to carry out specific S&T tasks;

- there are specific requirements for S&T in support of policy formulation and government decision making that, in many instances, cannot be conducted at arms' length by third parties;

- in selected fields, an in-house S&T capability is an essential element in the government maintaining the credibility it requires to be an effective regulator, negotiator in international trade disputes and partner in multi-stakeholder projects (this in-house capability also lends credibility to the interpretation and assessment of externally obtained research results in response to government needs);

- the need for a flexible, rapid response capability on high-priority or strategic issues;

- the need for independence and impartiality in making scientific assessments to engender public confidence;

- the need for confidentiality in working with third parties, with government scientists acting as an “honest broker” in bringing together partners that would normally be competing; and

- the need to maintain long-term data collection and analysis programs that, otherwise, would not be done by the private or university sector (e.g. weather data collection, genetic seed banks).

Clearly, however, the government cannot continue to assure Canadians that it is maximizing their S&T investment unless it demonstrates a continuing review, indicating where the S&T results can most effectively and efficiently be obtained.

General Observations on Federal S&T Capacity

We sought out information from a number of sources on the government's current S&T capacity and its expected capacity to meet future needs. Sources included Statistics Canada, direct surveying of departments and agencies, the federal S&T capacity initiative carried out by assistant deputy ministers of federal departments and agencies, and our personal exposure to S&T capacity concerns through our participation on our respective departmental S&T advisory bodies. More detail on our findings is available in the Appendix.

Overall, we were disappointed with the information that was available on S&T capacity.

Overall, we were disappointed with the information that was available on S&T capacity. The available, routinely collected data on federal S&T activities was inadequate to properly understand the federal role in the national innovation system or to analyse appropriate levels of effort within the federal S&T system. We believe the available information is inadequate. Even with this caveat, we recognize the effort that was made by departments and agencies in collecting and reporting the data. We respect the limitations in the process, and we believe that the data made a useful contribution to understanding the trends in federal in-house S&T spending.

It is clear from the information available that federal S&T is facing capacity challenges. On the human resources front, the federal S&T community is facing both a demographic challenge and a need to change the skills mix. The anticipated retirement of over 5000 scientists over the next five years is expected to put a strain on science-based departments and agencies in delivering on their mandated responsibilities and in successfully addressing the challenges of the future. As well, it appears in a number of cases that there has been a long-term under-investment in facilities and equipment. This has resulted in buildings that no longer meet current fire and health and safety codes, wiring that cannot meet the needs of computer and networking requirements, and equipment that is not up to current performance requirements. At the same time, the demands being placed on federal S&T are changing and, in many cases, expanding.

The changing policy environment within which federal S&T operates is placing changing demands on the system. Understanding the implications of this change for current and future federal S&T needs is an essential first step in determining whether there is adequate capacity to meet those needs. Undoubtedly, some of the federal S&T capacity built up in the past is no longer needed. (Some of this excess capacity may have been shed during Program Review). Some equipment and personnel nearing retirement likely do not need to be replaced. On the other hand, new technology areas such as biotechnology and electronic business require the government to have entirely new sets of skills and capabilities. Thus, the challenge is not necessarily "rebuilding" or "restoring" capacity to historical levels. It is to identify what capacity is needed to allow the government to meet current and future needs, and to enhance its ability to meet these future challenges.

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Departments and agencies need to have excellent capacity to meet their mandated and priority needs. However, they must continually examine their work agendas to ensure that they are not performing S&T that falls outside their departmental mandates and/or broader government priorities.

Themes and Observations

We note that, to some extent, the federal S&T system has shown itself to be adaptable to changing needs, but we believe that more effort is needed for the government to remain a strong contributor to the innovation system. We are providing a somewhat different perspective on the future directions and needs of federal S&T, and offer our guidance to the process of renewal that is under way.

We recognize that there is an important debate on what S&T the government needs to perform in-house. One position holds that the government's role in the innovation system should be one of funder and facilitator of S&T, not performer. According to this argument, in addition to the knowledge produced by the S&T, there are benefits in having the S&T performed outside of government (e.g. training the next generation, in the case of university research; and building industrial research capacity, in the case of the private sector). The opposing position argues that the federal government needs to maintain a strong S&T performance role in order for the entire national innovation system to function effectively.

This debate was apparent in our own deliberations. However, we were able to find some common ground. There was general agreement that with the maturation of Canada's innovation system, the federal government's role does not need to be as extensive as it has been in the past. There was general support for the statement in the 1996 federal S&T strategy, which said, "Departments and agencies will regularly and systematically assess whether their performance of S&T might be better carried out by others." We caution, however, that moving all S&T activities outside government would have unwanted impacts on the government's ability to carry out its mandates. These impacts could include a loss of "institutional memory" on key, longer-term policy issues; a de-coupling of government policy making from the forefront of scientific knowledge; and the loss of the ability for independent decision making on key issues. We are also concerned that a federal government without S&T capabilities in key areas would be unable both to fulfil departmental or governmental priorities and to create a climate for investment in leading-edge S&T fields, as has been the case for numerous "technology clusters" that have grown up in Canada. At this stage in the evolution of the Canadian innovation system, it is not completely clear that there is a sufficient private sector or university capacity, or interest in many fields in taking on some of the tasks currently performed by in-house federal S&T.

With this in mind, and looking at the full spectrum of activities considered as S&T (not just R&D), we concluded that there is a core set of S&T activities that the government must perform. We note, however, that these activities can only be considered "core" at this particular time in the evolution of Canada's innovation system, since it should be expected that the balance of activities performed inside and outside government will be a dynamic one.

We have a number of observations and messages we believe should be considered when examining government S&T priorities and roles:

- *The government needs high-quality science advice to support its decision making*. Modern S&T has a much greater power to inform government decision making. Increased access to scientific knowledge by the general public and interest groups demands an even higher standard from the government, requiring access to excellent independent science and scientific assessment capabilities. As we noted in our report *Science Advice for Government Effectiveness*, "scientific advice should be a necessary, but not necessarily sufficient, component of all government decision making." It will also lend credibility to government policy in both domestic and international contexts.

- *Science and technology are vital components for the proper functioning of Canada's economic and social systems.* S&T is taking on increased importance in all facets of life. Not only can advances in science and technology offer a better quality of life, they can also point out where there are threats to that quality of life. The average Canadian has access to, and demands, much fuller information on which to base life decisions.

- *The government must continually try to maximize the impact of its S&T investment. The CSTA encourages the government to aggressively follow through on the commitment it made in its 1996 S&T strategy:* "Departments and agencies will regularly and systematically assess whether their performance of S&T might be better carried out by others." We encourage the government to make the maximum possible use of the federal S&T investment to strengthen the Canadian innovation system.

- *There are key activities that are best performed by the government in-house. These activities will vary across sectors of the economy and from department to department*. We believe that a strong national innovation system requires a balance in its S&T and harmony between universities, the private sector, other levels of government and the federal government. The government's ability to apply S&T to its regulatory, stewardship and decision-making responsibilities is critical to the process of turning new knowledge into commercial and/or social benefits for the country. In a number of cases, the federal government performs S&T that would not be carried out by other players in the system. In other cases, the federal government requires independence and confidentiality that is best assured by performing activities in-house. In still others, the government is legally obligated to perform the S&T upon which its decisions are made.

- *Whatever the source, S&T used by the government should be conducted as openly as possible and efforts should be made to put it in the public domain*. The government can be confident it is receiving the best quality S&T advice and can demonstrate to its critics that the advice is of the highest quality only if that science is open to scrutiny. Of course, the nature of some government S&T does not allow for public discussion, but efforts to remain open and transparent should be encouraged.

Crisis or Opportunity?

We did not see the partnership in a "Team Canada" approach to using all our national S&T resources to meet the challenges of today and the future.

As representatives of S&T advisory bodies to federal departments and agencies, each of us could cite examples of how the federal government is doing an excellent job in adapting its S&T efforts to a changing world and is contributing to the strengthening of the national innovation system. However, in taking a system-wide, cross-government view, we were disappointed to conclude that the innovation system is not working to its full potential and that the federal S&T establishment, along with the private sector and universities, must share the responsibility for this situation. We identified a number of reasons for this situation, many of which related to the need for "culture changes" across the innovation system. While we feel that competition for resources is a healthy mechanism for priority setting, in many parts of the innovation system, we saw a win-lose approach. (For example, resources assigned to a particular

project were simply reallocated from another project). In addition, we did not see enough evidence of corporate priority setting for federal S&T and consideration of how the full range of departmental resources could be applied (each in its own fashion) towards meeting mutually developed goals. We saw this approach extend beyond individual departments, resulting in inadequacies in cross-government planning and priority setting, and we saw that the same issue extends to the other partners in the innovation system. Lastly, we did not see the partnership in a "Team Canada" approach to using all our national S&T resources to meet the challenges of today and the future.

Although federal departments and agencies point to significant changes in their way of doing business since the implementation of the 1996 S&T strategy, we believe that there remains room for significant improvement. To become a stronger contributor to the national innovation system, the federal S&T establishment needs a culture change, more flexibility in its operational policies and a renewal of its management systems. Without these changes, further investments in federal S&T capacity will likely not achieve their maximum possible benefit to Canadians.

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Drawing on our experience with our respective S&T advisory bodies, the information we assembled and the principles laid out above, we identified a number of priority issues related to the government's capacity to play its key role in the national innovation system. The issues fall into several key groupings related to capacity and management.

Capacity Issues

Human Resources

- outdated staffing rules that make it difficult to have a current and flexible work force;
- lack of career advancement opportunities for scientists and technicians, coupled with outdated, inflexible promotion criteria;
- an ageing work force, coupled with inadequate recruitment of new workers;
- inflexible rules for matters such as international travel to conferences, impairing both professional development and the diffusion of state-of-the-art knowledge;
- uncompetitive wages;

- difficulties in filling key positions in some sectors, resulting in long periods (three to six months or longer) of sub-critical mass in research teams; and

- an inability to attract the best and brightest researchers.

In the post-World War II period, Canadian federal S&T laboratories attracted the cream of the crop of researchers from around the globe. Salaries were high, projects were exciting, facilities were state-of-the-art, and the research teams were world leaders. The CSTA recognizes that this is no longer the case. Much of that wave of researchers has either retired or moved to exciting opportunities in the private sector. Conversely, many workers have "indeterminate" contracts, meaning that renewal of the work force cannot proceed as fast as changes in the scientific "marketplace." The equipment and facilities are ageing. In a much more competitive market for scientific and technological talent, federal S&T facilities appear to be at a disadvantage. We note that it is no longer necessary for the federal government to be a central player in all areas of S&T, but where it was deemed that a federal presence was necessary, federal S&T organizations need to be able to compete with the best to attract a strong research work force. This requires more flexibility to hire workers on shorter terms, competitive compensation (salaries and benefits), modern facilities and a stimulating research environment.

"Rust-out" of Facilities and Platforms

There was some evidence of long-term failure to maintain S&T facilities and equipment, including:

- research facilities that have fallen below current health, safety and building codes;

- in some cases, building infrastructure (utilities, wiring, etc.) that is inadequate to meet the current demands for computer networking; and

- some research platforms, such as ships, that are ageing and inadequate to meet current and projected needs.

We note, however, that in high profile and "new" research areas, facilities appear to be modern and well-equipped. We saw little evidence of regular processes of review to ensure that facilities are still needed to address current and future mandates. We are, thus, led to question whether there truly is a continuing need for some of the "rusting-out" facilities identified by departments and agencies.

We were disappointed to see that current efforts on federal S&T capacity continue to focus on "restoring," "replacing" and "rebuilding." We see limited evidence that the government is giving serious consideration to answering the question, "S&T capacity for what?" With clear indications that there will be significant new demands on federal S&T resources, departments and agencies appear reluctant to seriously take up the task of reallocating resources away from lower priority areas (and those that have become less relevant) towards new challenges.

We see limited evidence that the government is giving serious consideration to answering the question, "S&T capacity for what?"

Management Issues

Management Information

We believe that in many departments and agencies, and on a government-wide basis, the currently available information on federal S&T activities is inadequate for the purposes of understanding the federal contribution to Canada's innovation system. Moreover, from our external perspective, we believe that (by private sector standards) the available information is inadequate for the proper management of federal S&T.

Ability to Address Mandates

We heard a number of comments about the inability of departments and agencies to address currently mandated responsibilities (e.g. weather forecasting, food safety). Departments were either reluctant or unable to provide details on either the specific responsibilities or the implications for Canadians.

Equally of concern, we found little evidence that departmental and institutional mandates were being regularly reviewed to ensure that they were aligned with government and departmental priorities.

We note that it is essential that federal departments and agencies be given adequate resources to deliver on their mandates in the highest quality fashion.

Forward Outlook

We note that significant challenges for the federal S&T effort are already here, or are on the horizon, challenges that cannot be met using traditional solutions and existing resources (e.g. biotechnology). We recognize that increased investment is likely needed to address these challenges.

Lack of Priority Setting

Evidence of the reallocation of resources was limited. In departments where S&T activities were discontinued and the resources reallocated, the remaining facilities and activities seemed to be under less pressure than in departments where cuts were made across the board. However, examples of this type of reallocation appeared to be the exception rather than the rule. Notwithstanding the government's stated commitment to S&T, individual departments and agencies do not appear to be backing up this priority with appropriate levels of resources.

The messages from the federal government point to a strong belief in the importance of S&T to Canada's social and economic future. However, these messages do not seem to have been applied to the federal government's own activities. Many departments and agencies appear to have been resting on their scientific laurels, neglecting to make the necessary investments to maintain their world-class standing. In individual departments and agencies, years of under-investment in the future and the impacts of Program Review seem to have disproportionately hit S&T activities. Only a few departments appear to have taken Program Review as an opportunity to shed outdated activities and focus on emerging new challenges and opportunities.

Principles

Three fundamental principles have dominated our discussions almost from the outset. We believe that by applying these concepts and adhering to them, the government will be able to ensure that it has the best possible S&T for its use and that taxpayers are receiving full value for their investment. We strongly believe that these principles (outlined below) must be applied to the conduct of all federally performed and funded S&T.

- ***Alignment*** — Federal S&T efforts must be focused where they will have the most benefit to Canada. Federally performed and funded S&T must be demonstrated to be aligned with departmental mandates and the overall priorities of the government. Departments and agencies should only be performing the S&T that is needed to support their mandate and that cannot be obtained more effectively from other sources. (We call upon the government to aggressively follow through on the commitment it made in the 1996 S&T strategy: "Departments and agencies will regularly and systematically assess whether their performance of S&T might be better carried out by others.")

Departments and agencies should only be performing the S&T that is needed to support the minister's mandate and that cannot be obtained more effectively from other sources.

We strongly believe that adherence to this guideline would serve to focus the federal S&T effort. It would imply that some federal S&T activities would decrease, others would increase, and there would be more resource flexibility to respond to emerging challenges. We feel that there is some inertia in federal S&T performance, where activities are maintained because of their excellent records rather than their current relevance to departmental and/or national needs.

We also recognize a legitimate need to have "ready capacity" to deal with emergencies or emerging policy issues. Rather than maintaining excess capacity, we feel that the key to this response capability is an agile federal S&T organization.

- ***Linkages*** — S&T is a global enterprise. S&T performed and funded by the federal government must be tied in with other activities within the federal government, with the other sectors in the Canadian innovation system (universities and the private sector), and with the global pool of knowledge and technology. It is equally important that the federal government be capable of contributing to this pool. These linkages ensure that federal performance of S&T capitalizes on the best available inputs, regardless of their source, and that overlap and duplication are minimized.

In stressing the concept of linkages, the CSTA hopes to encourage federal departments and agencies to focus their S&T efforts on those tasks that federal S&T is uniquely equipped to deliver.

"Partnership" is a much used term in government circles, but the concept of linkages goes much farther. Linkages result in planning and priority setting being done based on broad stakeholder participation. Linkages draw on the best possible expertise, be it in other federal departments and agencies, universities, the private sector, or even the global pool of knowledge. In stressing the concept of linkages, the CSTA hopes to encourage federal departments and agencies to focus their S&T efforts on those tasks that federal S&T is uniquely equipped to deliver.

- ***Excellence*** — The S&T performed, funded and used by the federal government must be of the highest quality. It must be demonstrated to meet or exceed international standards for scientific and technological excellence, and deliver social or industrial relevance. This should be achieved through openness, transparency, and regular and appropriate expert review.

We believe strongly that where a need is identified for federally performed S&T, that work must be of the highest quality. Maintaining high standards has numerous benefits for the government, including confidence about the credibility of its S&T, the efficient use of finite resources, and the creation of a research environment that is able to attract the brightest and best researchers.

Maintaining excellence in government research requires a number of things. Resource levels must be adequate to maintain world-class research. Facilities and equipment need to be at the leading edge. The research environment must be dynamic and exciting, not only to attract and retain the best scientists, but also to attract other economic and research activity.

Assessing excellence in government science implies the ability to apply a range of different measures and processes, some the same and some different from those used for non-governmental science, while recognizing that many of the criteria are similar.

We recognize that excellence in government science may need to be assessed differently from university science (peer review) or private sector science (impact on the bottom line). This is a critical challenge, one that we feel the government should take very seriously. While it is likely that some government science will result in scientific papers published in refereed journals, most of it will be focused more directly on the specific problems or needs of the government. Similarly, some results of government S&T may lead to patents and commercial activity, but this is not usually the intended end result of the work. Recognizing these constraints, we still believe that, to the fullest extent possible, scientific findings and analysis from federal S&T should be publicly accessible. Assessing excellence in government science implies the ability to apply a range of different measures and processes, some the same and some different from those used for non-governmental science, while recognizing that many of the criteria are similar.

These include excellent people, qualified to carry out the intended work, proper facilities and equipment, well-thought-out proposals that advance the state of knowledge (i.e. do not duplicate information available from elsewhere), and relevance to some need. Citations (where appropriate), numbers of graduate students and post-doctoral fellows, and the number and quality of links with external partners are also measures that can be applied to government research. Excellence requires not only assessment up front of the merit of the proposal, but also review of the results and outcomes of the research. One method for ensuring excellence in government research is stakeholder involvement throughout the research process from planning through to review of results. We feel that this sort of outside involvement is the absolute minimum requirement; we encourage the government to go farther in ensuring the excellence of the S&T upon which it depends for its decision making.

We are aware that most science-based departments and agencies have external S&T advisory bodies in place. However, not all of these bodies have a comprehensive role in ensuring the excellence of departmental S&T, and even fewer have any ability to assess whether that S&T is being carried out to the same standards as government S&T in other countries.

Considerations

We do not believe that it is our place to set S&T priorities for the government. We were asked to provide the government with advice on its performance of S&T, and we are offering principles and the recommendations that follow as guidance to the government in its priority setting. We feel that the federal S&T role is an important one, and we welcome the commitment in the October 12, 1999, Speech from the Throne: "The Government will also ensure that it has a modern and effective research and science capacity to promote the health, safety and economic well-being of Canadians." We believe that such a commitment on the part of the federal government will require new resources to allow departments and agencies to deliver those roles.

We strongly believe that the application of the principles we have developed will assist the government in ensuring that it maintains a strong capacity to use science to address issues and make decisions for the future. We feel it is important to stress that the implementation of the principles will, necessarily, vary from department to department.

Time limitations and the evolving nature of some of the programs did not allow us to closely examine some of the newer models for funding and performing S&T in the national interest, which are currently under discussion. From what we were able to learn, however, we feel that the government should consider some of the innovations in these programs in developing any forward-looking plan for federal S&T.

There is a need for a more horizontal approach to S&T priority setting in government and departments, as well as across the innovation system. We recognize that existing programs such as the Panel on Energy Research and Development and new programs such as the Canada Foundation for Innovation and the Canadian Institutes for Health Research may represent useful approaches in many areas. Whichever models are selected, they should include:

- multi-stakeholder partnerships aimed at fulfilling national needs through the most appropriate combination of resources (government, industry, university);

- excellence assured by appropriate expert review in the selection of projects and the assessment of results and performance;

- openness and transparency in decision making and the dissemination of results; and

- competition amongst proposals to ensure that the highest priority issues are addressed.

Recommendations

The application of these principles will assist the government in ensuring that it maintains a strong capacity to support the health, safety and economic well-being of Canadians through its ability to address science-based issues and decision making for the future. In this regard, the Council recommends that the government and departments:

1. Establish performance metrics and require the principles of *alignment* (with departmental mandates and government priorities), *linkages* (across departments, across the Canadian innovation system and with the global S&T community), and *excellence* (to the highest standards, assured by openness, transparency, and regular and appropriate expert review) to be integrated into the government's and departments' priority setting, decision making and delivery on S&T.

2. Require the existing annual planning and performance reporting mechanisms to explicitly include a review of S&T priorities and activities on the basis of the principles outlined here and document the status of, and action plans for, the reallocation of resources to priority areas and those that are emerging.

3. Implement and fund new models for S&T that move away from a vertical approach to a more horizontal (i.e. across government and the innovation system), competitive, multi-stakeholder approach.

4. On an urgent basis, commit sufficient resources to federal S&T to ensure that the government has an appropriate capacity to provide a sound scientific platform for delivering on its roles, including its policy and decision making.

5. Establish a robust capability to assess the implementation of these recommendations by:

   - requiring S&T advisory bodies to federal science-based departments to take an active role in departmental S&T planning and evaluation (as committed to in the federal S&T strategy);

   - requiring each of these advisory bodies to regularly assess departmental and agency reports on the implementation of these recommendations and report to, and review with, their minister and the full CSTA; and

   - requiring the CSTA to report regularly to the CCEU on government-wide success in that implementation.

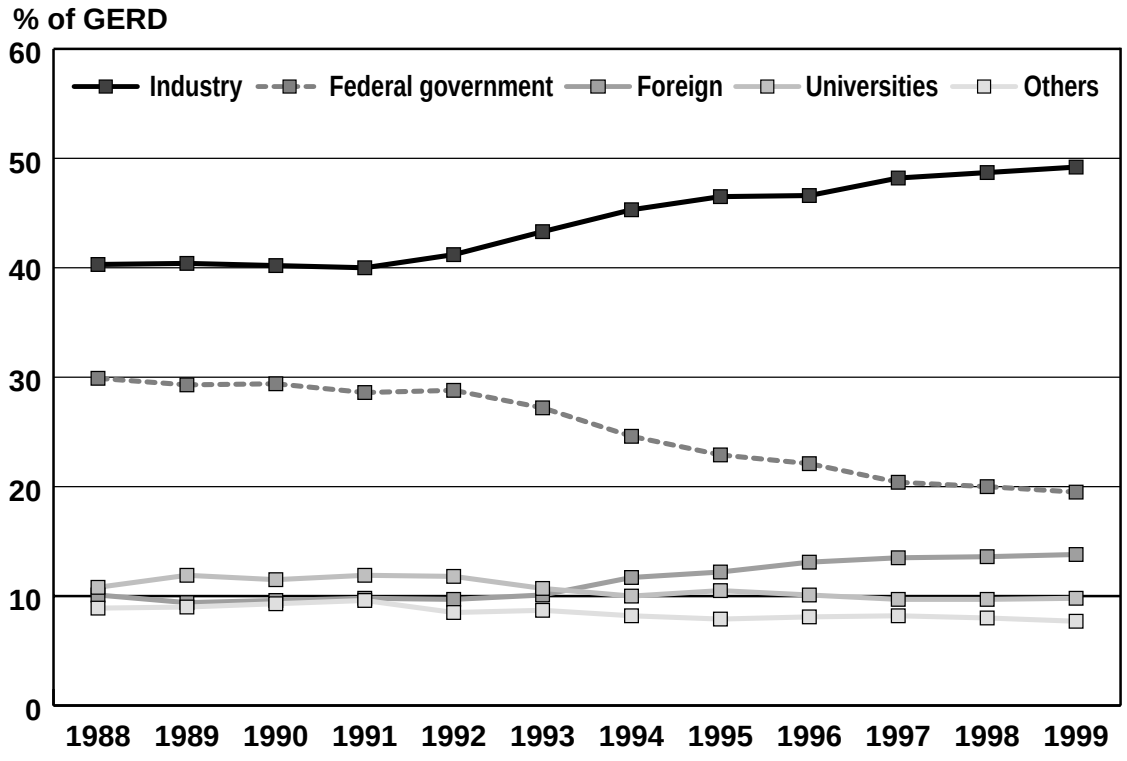
Appendix: Federal S&T Capacity — Summary of Information Collection

In identifying the roles of the federal government in performing S&T, we looked at available information sources and, where additional information was needed, approached departments and agencies. The following summarizes what we learned.

At 1.6 percent of gross domestic product (GDP), Canada ranks 13th among OECD nations and sixth among the Group of Seven (G-7) nations in terms of its gross domestic expenditures on R&D (GERD). From a relatively low level of 1.2 percent in 1981, Canada's GERD to GDP ratio increased throughout the 1980s and early 1990s before reaching a plateau at 1.6 percent in 1994. This growth was fuelled largely by a strong and sustained increase in funding from the business enterprise sector and from abroad. The federal contribution, on the other hand, increased initially only modestly and, in the past few years, has decreased in both real and absolute values. Consequently, there has been a major decrease in the share of the national R&D effort that is federally funded.

The federal government now funds about one fifth of Canada's GERD, down from its 30 percent share of a decade ago (see Figure 1, p. 30). As a performer, federal institutions conduct about 12 percent of the national effort, down from 17 percent in the earlier period. Thus, over time, the federal government has been waning in importance both as a source of funds and as a performer of R&D. Across the OECD, governments at all levels fund about 31 percent of the national effort and perform about 11 percent. These values are roughly in line with those for Canada. However, more recently, governments in many of the major industrialized nations have stepped up their funding for public sector R&D infrastructure. The Japanese government, for example, will have doubled its R&D spending in the five-year period ending in the year 2000.

Figure 1: GERD by major sources of funds, 1988 to 1999

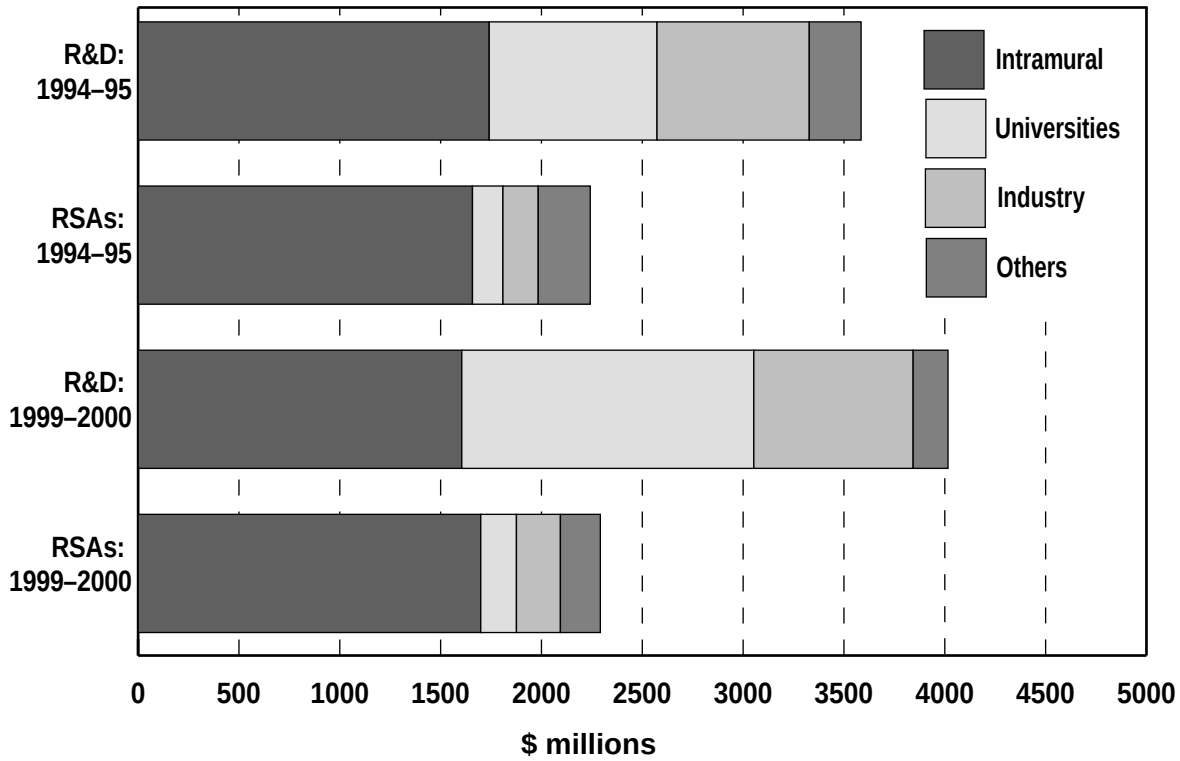


Source: Statistics Canada.

R&D, however, is only one portion of the S&T activities funded by the federal government. Over the last decade, about 40 percent of the federal funds were directed toward related scientific activities (RSAs) such as data collection, information services, and economic and feasibility studies. These underpin the government's ability to provide essential public services such as weather forecasts, etc. Unlike the R&D component, more than half of which is now performed external to the federal government (extramurally), the RSAs are conducted mainly within the federal scientific establishment.

According to a recently released Statistics Canada report, the federal government will spend an estimated $6.3 billion on S&T activities in the 1999–2000 fiscal year. Of this amount, $4 billion will be on R&D and the remaining $2.3 billion on RSAs (see Figure 2, p. 31). The universities, industry and other extramural sectors will perform $2.4 billion (about 60 percent) of the total R&D and $592 million (16 percent) of the RSAs. The federal scientific establishment will conduct $3.3 billion in S&T activities, $1.6 billion in R&D and $1.7 billion in RSAs. Whereas federal support for both university and industry R&D is larger than in 1994–95, intramural R&D spending will have decreased by more than $100 million, which is a 13-percent decrease in purchasing power.

Figure 2: Federal S&T and R&D Expenditures by Major Performers, 1994–95 and 1999–2000



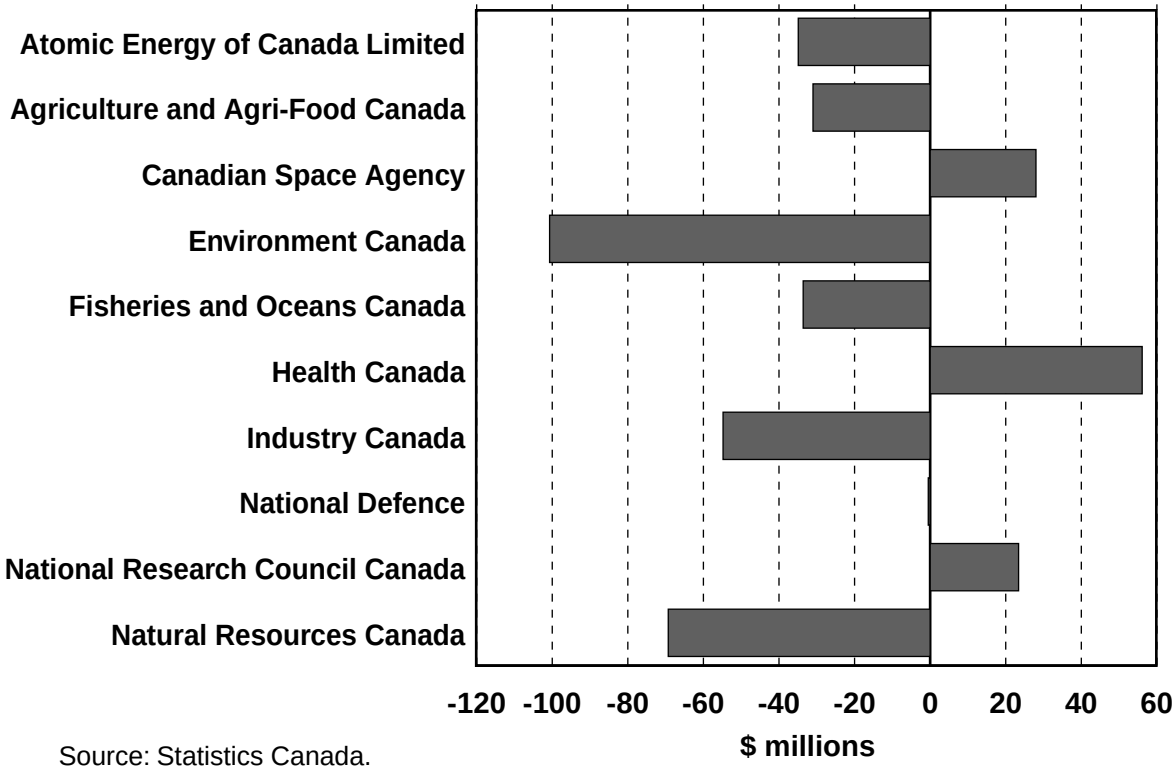
Source: Statistics Canada.

The federal intramural S&T program has two other components, one in the natural sciences and engineering and the other in the social sciences and humanities (SSH). The latter consists almost entirely of RSAs. Major programs in this area include those of Statistics Canada and the National Library. Programs in the SSH provide important services and undoubtedly make significant contributions to the well-being of Canadians. However, since the major programs of this genre have been excluded from the study of federal S&T facilities, no further attention will be devoted to the federal intramural SSH component. Similarly, in what follows, the focus will be on those departments and agencies whose facilities are the subject of the present review.

Expenditures on intramural S&T in the natural sciences and engineering are expected to amount to $2.3 billion in this fiscal year, down about $200 million since 1994–95. This represents a 7-percent decrease in current dollars and a 12-percent loss after adjusting for inflation. Most of the reduction was made in R&D expenditures. Whereas these accounted for 67 percent of the S&T total in 1994–95, 83 percent of the reduction came from the R&D component. Expenditure reduction was also not uniform across departments and agencies (see Figure 3, p.32). Some, such as Health Canada,

the Canadian Space Agency (CSA) and the National Research Council Canada (NRC), have actually experienced growth in their intramural spending. Environment Canada, on the other hand, has seen its intramural spending decrease by $100 million (21 percent); Natural Resources Canada (NRCan) by $69 million (18 percent); Industry Canada by $54 million (28 percent); Fisheries and Oceans Canada by $34 million (15 percent); and Agriculture and Agri-Food Canada by $31 million (9 percent). On the personnel side, NRCan has lost 22 percent of its S&T complement and Environment Canada, 19 percent.

Figure 3: Change between 1994–95 and 1999–2000, in funds for the major federal intramural S&T programs



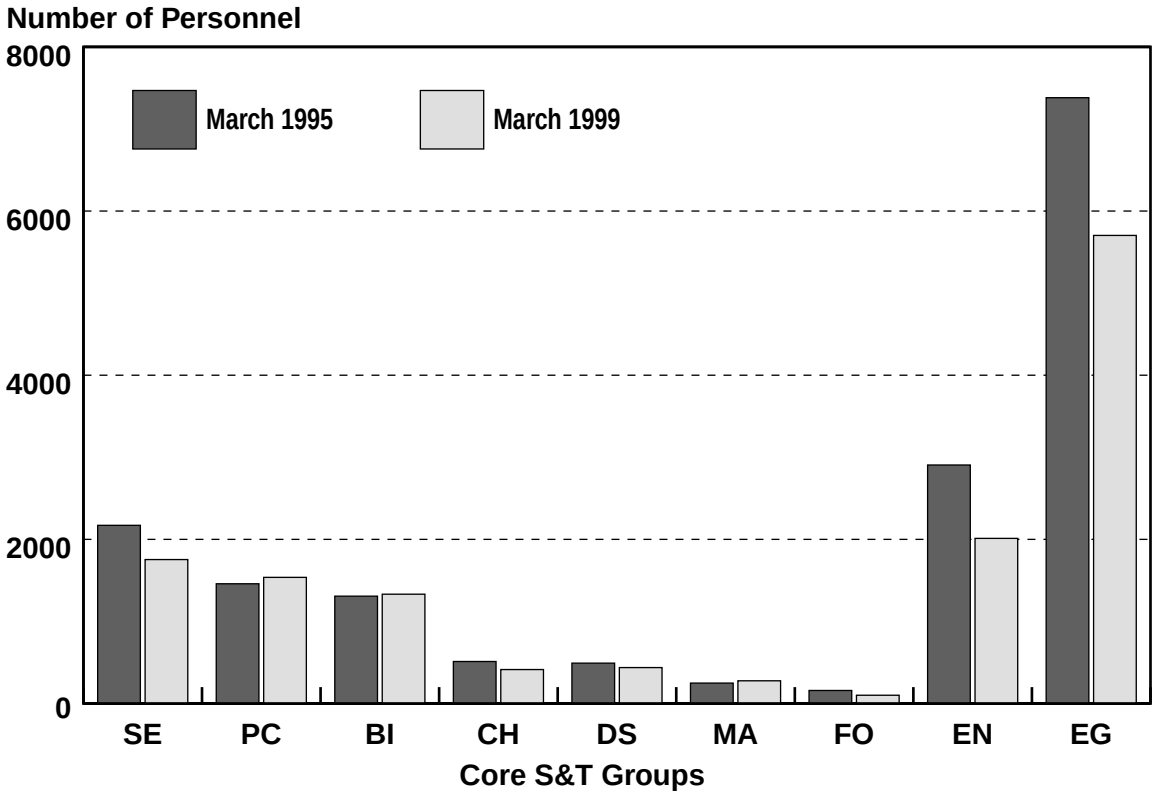
Source: Statistics Canada.

According to the Treasury Board Secretariat's publication, *Employment Statistics for the Federal Public Service*, in March 1995 the federal government had 2171 personnel in the Scientific Research (SE) group; 1459 in the Physical Sciences (PC); 1308 in the Biological Sciences (BI); 512 in Chemistry (CH); 492 in the Defence Scientific Service (DS); 249 in Mathematics (MA); 159 in Forestry (FO); and 2906 in Engineering and Land Survey (EN). In the Technical category, 7381 personnel were in the Engineering and Scientific Support group (EG) (see Figure 4, p.33). These numbers do not include those employed by the "separate employers" such as the NRC and Atomic Energy of Canada Limited, nor do they include military personnel. Unfortunately, the Statistics Canada

data on S&T personnel does not permit us to determine how many members of the core groups were actually engaged in S&T activities, but, with the exception of the EN and EG groups, it seems reasonable to assume that most of them were. By March 1999, this core S&T group of 16 637 had been reduced by 18 percent to 13 568, as compared to a 10-percent decrease in the overall Scientific and Professional category.

A substantial portion of the 10-percent decrease was due to the devolution of responsibilities to provincial government and privatization, with a resulting removal of personnel from the Treasury Board management regime.

Figure 4: Employment in the "core" S&T groups, March 1995 and March 1999



Source: Treasury Board of Canada Secretariat.

Legend

SE: Scientific Research
PC: Physical Sciences
BI: Biological Sciences
CH: Chemistry
DS: Defence Scientific Service
MA: Mathematics
FO: Forestry
EN: Engineering and Land Survey
EG: Engineering and Scientific Support

Level-of-effort Trends Against Key Activities

To address our mandate, we needed information on current roles being performed by federal laboratories. Statistics Canada data only provided information to the departmental level, since the collection of data by facility had been discontinued several years ago. An early task for the Council was to identify a set of key activities that represented the range of S&T activities performed by federal facilities. With the cooperation of federal science-based departments and agencies, we developed the following list, which we believe spans most of the activities carried out in federal labs:

- support regulatory and policy-making activities;
- support development and management of standards;
- support public health, safety, environmental and defence needs;
- support industry research and testing needs;
- promote economic and social development;
- understand and respond to new S&T developments;
- support the advancement of knowledge;
- support public outreach and communications; and
- other (administrative functions).

In this initiative, we elected to focus on activities carried out in federal S&T facilities, understanding that a significant part of overall federal S&T performed within government is undertaken outside those facilities (i.e. science assessment, data collection, monitoring, many regulatory approvals). Notably, this definition does not include significant parts of what is normally referred to as “federal intramural S&T.” This distinction is relevant to the determination of the overall federal S&T capacity, but is less so in looking at the roles of the government in performing S&T.

Departments and agencies were then asked to provide data on their S&T facilities based on this set of activities. While acknowledging that the list of activities was representative of the S&T functions in their facilities, departments and agencies indicated that data were not normally collected on this basis and cautioned that the data they were providing should not be considered definitive. Data were collected for three years: 1994–95 (before the government’s Program Review) and the two most recent full years,

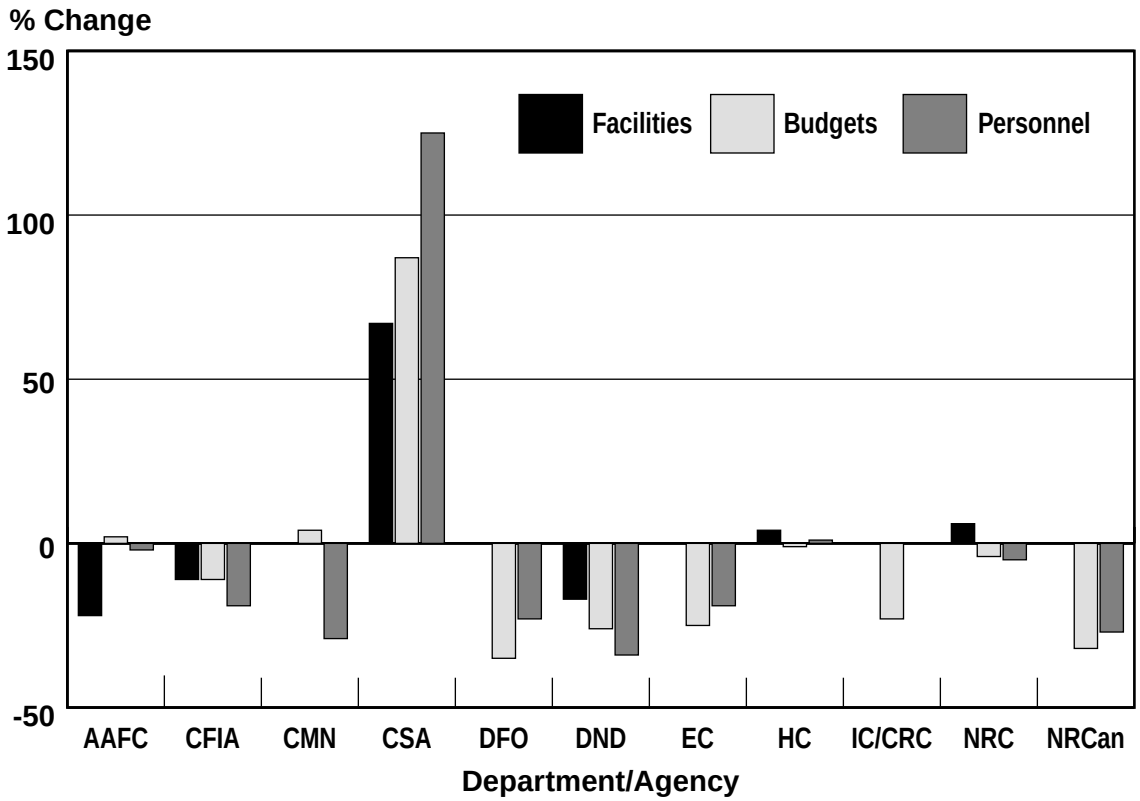
1997–98 and 1998–99. Reporting included total facility spending and personnel, along with a percentage "level of effort" against each of the above activities. Departments and agencies provided information on 122 distinct S&T facilities, ranging in size from one employee and an $80 000-per-year budget to over 400 employees and budgets of over $40 million.

Resource Trends

The data provided by departments and agencies represented $1203 million of spending in 1998–99 (down 17 percent from 1994–95) and 12 182 workers (down 15 percent from 1994–95). Spending on R&D consumed approximately 72 percent of total facility budgets in 1998–99, up slightly from the pre-Program Review period. Spending on RSAs was approximately 12.7 percent of the total over both periods. "Other" spending, such as administration and the management of facilities, consumed the remaining resources. While spending on both R&D and RSAs declined, the cuts to R&D were less than those to RSAs (-16 percent compared to -19 percent). In terms of employment, R&D personnel showed a slight gain (+0.6 percent), while RSA personnel declined by 16 percent.

Most science-based departments and agencies reported drops in their resource levels since the pre-Program Review period (see Figure 5, p.36). The CSA was a notable exception, with several new facilities and new spending coming "on-line" over that period. (The CSA grew from three to five facilities, and experienced spending increases of 87 percent and personnel increases of 125 percent). Of the 11 departments and agencies that provided data, three had reduced the number of facilities they operated (by between 11 percent and 22 percent); five had seen no change; and three, including the CSA, experienced increases in facilities of 4 to 6 percent. In terms of spending, three departments or agencies reported increases in spending of 2 to 4 percent, with the CSA receiving an 87 percent boost; the rest experienced decreases, some by as much as 35 percent. Only two departments or agencies reported increases in personnel: 1 percent for Health Canada, and 125 percent for the CSA. Other departments and agencies reported decreases as high as 29 percent.

Figure 5: Resource changes by department/agency



Source: CSTA Secretariat.

Legend

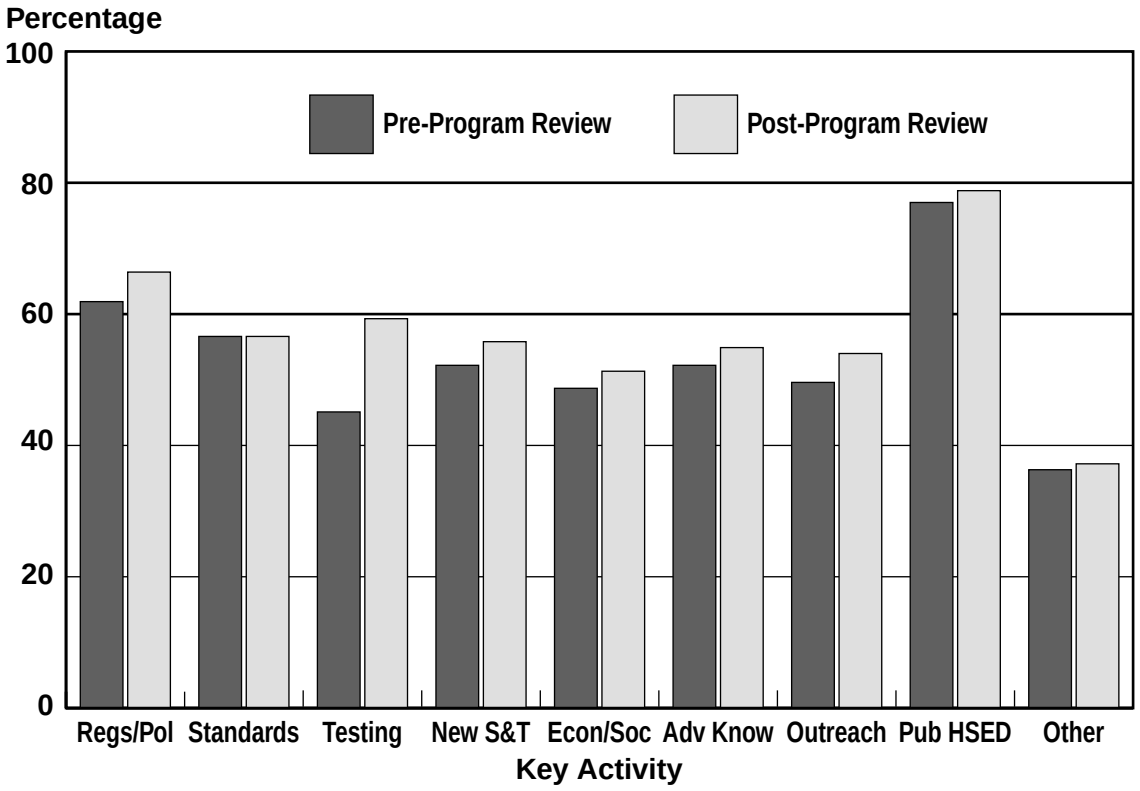
AAFC: Agriculture and Agri-Food Canada
CFIA: Canadian Food Inspection Agency
CMN: Canadian Museum of Nature
CSA: Canadian Space Agency
DFO: Department of Fisheries and Oceans Canada
DND: Department of National Defence
EC: Environment Canada
HC: Health Canada
IC/CRC: Industry Canada/Communications Research Centre
NRC: National Research Council Canada
NRCan: Natural Resources Canada

As noted above, these data are not definitive, but do indicate, with one exception, a clear reduction in resources going towards federal S&T facilities. The data presented indicate larger cuts to spending and personnel than were reported by departments and agencies as "intramural S&T" to Statistics Canada. While there are undoubtedly numerous methodological variations in the two data sets, they do suggest that within departments and agencies, facility-based S&T activities have been cut more than other S&T activities.

Trends in Activities

Departments and agencies also provided estimates of their level of effort in the key activities identified by the CSTA. To simplify reporting, these data were requested as an estimate of the percentage of the facility's total effort that each activity represented. While departments and agencies cautioned that the data were not definitive, a number of observations could be made. First, the list of key activities appeared to be a fairly comprehensive accounting of the nature of federal facilities (see Figure 6, below). This figure (i.e. the percentage of facilities indicating that they carried out that function) also indicates that all the activities have remained important to facilities since Program Review. A higher percentage of facilities reported being active in each of the categories post-Program Review, compared to the earlier period. Activities showing the greatest increases were in support of industry research and

Figure 6: Participation (% of facilities performing each activity)



Source: CSTA Secretariat.

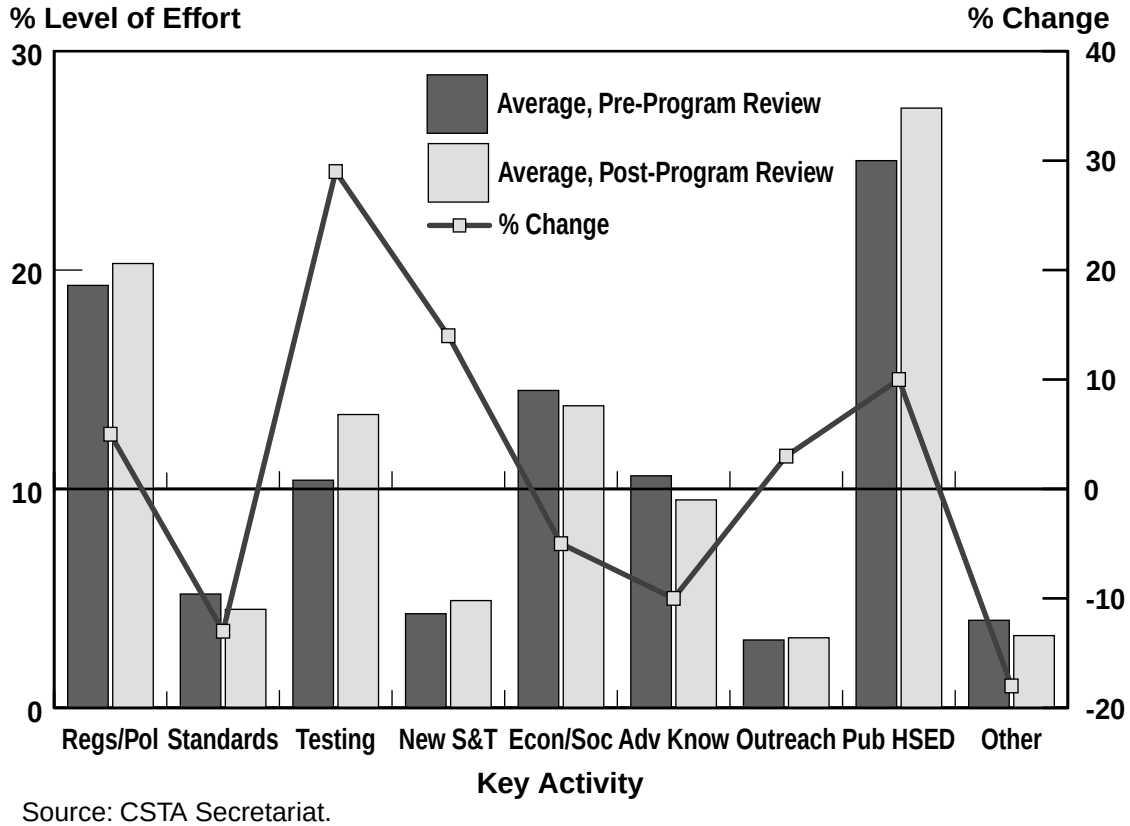
Legend

Regs/Pol: Regulatory and policy making
Standards: Standards
Testing: Industry research and testing
New S&T: New science and technology
Econ/Soc: Economic and social development
Adv Know: Advancement of knowledge
Outreach: Public outreach and communications
Pub HSED: Public health, social, economic and/or defence needs

testing needs (a 31-percent increase); public outreach and communications (up 9 percent); support for regulatory and policy-making activities and understanding and responding to new S&T developments (each up by 7 percent); and promoting economic and social development and supporting the advancement of knowledge (each up 5 percent).

The data provided by departments and agencies also provided some insight into shifts in the key activities being carried out in federal S&T facilities. Figure 7, below, indicates the magnitude of shifts in federal laboratory S&T activities since Program Review. While the shifts are small in absolute level of effort, they do indicate some changes in the priority accorded to the various activities. Major activities that are receiving increased attention include support of industry research and testing needs

Figure 7: Change in key activities



Source: CSTA Secretariat.

Legend

Regs/Pol: Regulatory and policy making
Standards: Standards
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(up 29 percent), and understanding and responding to new S&T developments (up 14 percent). Activities on the decline include supporting the development and management of standards (down 13 percent) and advancement of knowledge (down 10 percent). “Other” activities were also down by 18 percent, perhaps indicating more focusing of facilities’ activities on S&T pursuits.

Qualitative Information from Departments and Agencies

In addition to numeric data, departments and agencies were also asked to provide information on major scientific equipment operated at their facilities and on key resourcing issues faced by the facilities. A number of messages were apparent from the information provided:

- federal S&T facilities operate many pieces of equipment (and research laboratories) that are unique in Canada and are extensively used by many industry and university researchers;

- a significant proportion of the S&T equipment is old — past the industry standard for replacement;

- many R&D projects are at or below critical mass — further cuts to resources or the loss of personnel would mean that those capabilities would be lost;

- facilities are falling below contemporary health and safety standards;

- support equipment and research platforms (vehicles, ships, building wiring) are ageing and are not able to meet current performance needs; and

- maintaining a work force to operate this equipment and to carry out the rest of the S&T activities at the facilities is becoming a problem in a number of areas. This is a result of ageing work forces with insufficient depth in the ranks below, global shortages of highly qualified personnel in key areas (i.e. health research, veterinary medicine), lack of hiring of students and post-doctoral fellows, excessive turnover of staff due to the use of term and contract positions, non-competitive wage rates, and strict, inflexible staffing rules.

Observations from the Data

The data provided by departments and agencies provided some insight into the wide range of S&T capabilities that are resident in federal facilities. We recognize the contribution that the federal government is continuing to make to Canada’s innovation system. Moreover, we recognize that federal S&T facilities are needed to supply the high-quality, independent scientific and technical knowledge that is needed by the government to support its operations.

We are convinced that federal S&T facilities have been impacted by Program Review and general government fiscal restraint, resulting in reduced resources and a wide range of challenges to the conduct of federal S&T. In other words, we believe the S&T capacity problem is real. At the same time, however, on an individual department and agency basis, we saw only limited evidence of any shifts in activity mix or priority setting. In many departments, we saw evidence of a "business as usual" approach being squeezed by shrinking resource levels (i.e. doing the same and more with less). Relatively few facilities were closed outright; some, however, relinquished independent administration and management but remained functional.