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Improving the Measurement, Reporting and Assessment of Federally Performed Science and Technology

Demonstrating Results for Canadians

Final Report

Canada

Improving the Measurement, Reporting and Assessment of Federally Performed Science and Technology

Demonstrating Results for Canadians

Final Report

Policy Research Initiative

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PRI Project
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Executive Summary

In its Science and Technology (S&T) Strategy, the Government of Canada committed to increase accountability to Canadians by improving the federal government's ability to measure and report on the impact of S&T expenditures. Better measurement and reporting would provide a more thorough accounting to everyone interested in how Canadians benefit from the $5 billion or so they spend on federally performed S&T each year.

The challenge for the federal government is to ensure that its S&T activities provide maximum benefits to Canadians in relation to costs, and to show Canadians that this is the case. This requires a combination of good planning, efficient operations, and the measurement and reporting of impacts.

While considerable information is already reported on federal S&T inputs and activities, and on the general objectives of individual departments and agencies, more effort is required to substantiate the relationship between S&T activities and their impacts and objectives within and across federal organizations. More transparency and accountability to Canadians requires planning, measuring, assessing, and reporting federal S&T in a more open, integrated, and detailed way to show how S&T activities, both by themselves and in combination with other federal activities, advance organization-specific and government-wide objectives and thereby contribute to the well-being of Canadians.

The federal government would improve its ability to measure and report on the impact of S&T expenditures, increase its accountability to Canadians, and better support policy development, implementation, evaluation, and research by acting in nine areas.

1. Capture key objectives fully.

- Current policies require that all federal program activities be associated with one and only one strategic outcome. As a result, it can be difficult for departments and agencies to associate some S&T activities with all of their key objectives.

- Policies and practices could be revisited so that the impacts of S&T activities are more easily reported in terms of all of their key objectives.

2. Capture connections that cross departments and agencies.

- It can be difficult for departments and agencies to show how specific S&T activities support activities in other departments and agencies.

- More government-wide reporting at a level of detail sufficient for demonstrating the relationship among specific activities, objectives, and impacts across departments and agencies would be useful.

3. Capture relationships across activities.

- S&T activities are sometimes combined with other government functions to support policy development and implementation.

- In such cases, it can be useful to assess S&T activities in combination with the related activities. Where this is impractical, it would be useful to focus the assessment of S&T activities on their efficiency and effectiveness in supporting the related activities.

4. Report more detailed and integrated information on planning and performance.

- Compared to leading practices in Canada and abroad, impact information on federally-performed S&T tends to be reported at a high level of aggregation. Moreover, reporting on specific activities rarely connects plans with impacts.

- There would be merit in departments and agencies making all S&T expenditures explicit in reporting documents, and to collecting and making generally available planning and related performance information about S&T at the project level, where feasible and affordable.

5. Involve externally-funded researchers.

- While detailed information is available on the activities of external researchers funded by the federal government, little information is provided systematically on the impacts of this research.

- It would be useful to have externally funded researchers report impacts as a matter of course.

6. Involve the consumers of research.

- Departments and agencies would benefit from consulting with expected beneficiaries when exploring intended impacts before S&T is undertaken, and from involving these and other beneficiaries when assessing impacts after the activities have been completed.

7. Invest more in assessment.

- With some notable exceptions, little assessment is carried out on how federal S&T impacts Canadians. Consideration could be given on a regular basis to identifying priority issues or activities that would benefit from greater attention.

8. Support assessments with data.

- Measurement, reporting, and assessment all depend fundamentally on the quantity, quality and relevance of available data. It would be useful to address

S&T impact assessment needs when considering data development priorities. An initial step could be for Statistics Canada and interested federal science-based departments and agencies to collaborate on preparing a proposal for increasing the amount of available data.

9. Keep guidance up-to-date.

- Useful guidance is available from various sources in several formats. It would be helpful to synthesize this material and make it more readily available, possibly as part of the development of a broader community of practice for evaluation, performance measurement, and regulatory impact assessment.

Over the longer term, policy researchers could usefully explore two questions.

1. How to secure benefits and promote information sharing?

2. What are the objectives of government S&T?

As further explained and substantiated in the main part of the report, implementing actions along the preceding lines would enable the federal government to better demonstrate the difference federal S&T makes to the lives of Canadians, and to thereby increase the accountability of the federal government and the effectiveness of government activities.

Treasury Board Secretariat officials have indicated their willingness to work with the S&T community and other central agencies to explore ways to facilitate horizontal S&T reporting leading to more consistent aggregated information regarding results-based management of S&T, drawing on experiences from other horizontal reporting initiatives. This is a welcome initiative that would advance the actions identified in this report.

Introduction

The Science and Technology Strategy announced in May 2007 stated that the Government of Canada would increase accountability to Canadians by improving the federal government's ability to measure and report on the impact of science and technology (S&T) expenditures. The Strategy also called for greater sophistication in measuring the impacts of S&T investments.

This is the final report of a horizontal policy research project that predates the Strategy and which is also a part of the implementation plan for the Strategy. The project drew implications from recent research, the experience of practitioners, and original analysis to suggest how the impact of S&T performed by the federal government can be better measured and reported, and thereby potentially enhanced over time. The project explored what information is and could be collected about federally performed S&T, and how that information is and could be made available. This report summarizes the evidence accumulated during the project and explores the potential implications of this evidence.

Preliminary project findings were tested with experts located both inside and outside the federal government. All issues raised by reviewers and by the project steering committee were explored and addressed based on the available evidence.

Federal policy makers responsible for developing and implementing the policies and practices that define how departments and agencies measure and report on the impacts of federally performed S&T are the primary audience for this report.

Why this is Important

As noted in the S&T Strategy, improving measurement and reporting on the impacts of federal S&T would increase the accountability of the government to Canadians. It would also enhance transparency, as called for in other key federal government documents.[1] Better data collection, measurement, and reporting would also facilitate better policy and operational decision making.[2] This would help direct inputs with the objective of maximizing benefits in relation to costs. It would also facilitate effective policy research in which success is driven, in large part, by the quantity and quality of available information.

Better data collection, measurement, and reporting would provide a more thorough accounting to everyone interested in how Canadians benefit from the $5 billion or so they spend on federally performed S&T each year (Statistics Canada, 2008a). It would also respond to recent calls by policy researchers for more comprehensive reporting on federally performed S&T (Doern and Kinder, 2007). Better reporting would also allow federal scientists to demonstrate the relationship between their activities and positive results for Canadians, which would help identify and build on successes, and maintain and secure additional resources for effective and efficient S&T activities.

The many existing forums that review federal expenditures demonstrate the demand for measurement and reporting. The program activities of federal departments and agencies are subject to up to 13 different reviews. While most of these do not focus on S&T, they do apply to this area of activity (Federal S&T Strategy Implementation Working Group, 2008).[3] Yet despite the many forums, none reports very detailed information on a regular basis about the impacts of federal S&T.

The ongoing challenge for the federal government is to deliver and demonstrate results for Canadians; the aim of the project and this report is to explore and suggest how the connection between federal S&T and the well-being of Canadians can be better demonstrated and strengthened. The overall goal is to improve measurement, reporting, and assessment to demonstrate accountability more clearly to Canadians for federally performed S&T and better support policy development, implementation, evaluation, and review.

Definitions of Terms used

This section provides a glossary of key concepts used throughout the report. It is included here because interpretation of the analysis and potential actions that follow depend on the meaning of these key terms.

Impacts encompass all of the direct and indirect consequences of activities. Impacts include *outputs*, which are the direct products or services stemming from activities; *final outcomes*, which are their consequences on individuals; and *intermediate outcomes*,[4] which are intermediaries between outputs and final outcomes. Intermediate outcomes are located somewhere between the federal government and Canadians, and often involve linkages with other organizations.

Publications and patents are examples of outputs. New goods and services and consensus standards (e.g., relating to energy efficiency) are examples of intermediate outcomes. Higher incomes, lower accident rates, and a cleaner environment are examples of final outcomes.[5]

An *activity* is an operation or work process internal to an organization that uses inputs to produce outputs.

Inputs in the form of people, land, buildings, machinery and equipment, and operating funds are allocated to activities.

Compared to outcomes, outputs are more readily measurable, but are also less indicative of benefits provided to citizens. By definition, S&T activities lead directly to outputs that are intended to realize intermediate outcomes that eventually, and final outcomes that immediately, affect individuals.

Strategic outcomes are long-term, enduring benefits to Canadians that stem from a department or agency's mandate. They represent the difference a department or agency intends to make for Canadians (TBS, 2009a). They are similar to o*bjectives*, which are the aims of activities, and to planned results.

Measurement involves recording the dimensions, capacity, extent, or amount of something; *reporting* involves describing the relationship among objectives, inputs, activities, outputs, and outcomes; while *assessing* involves exploring and explaining the relationship among these.

Performance measurement is the process and systems of selection, development, and ongoing use of performance measures to guide decision making.

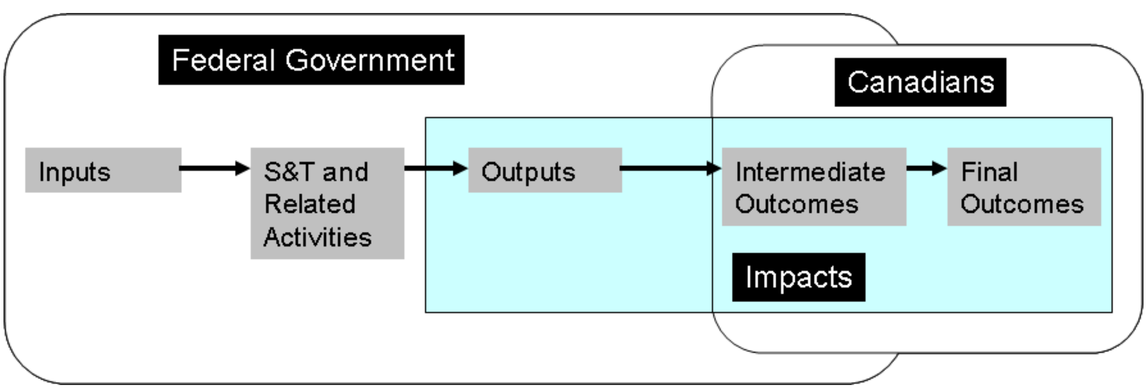
A *project* is an activity or series of activities that has a beginning and an end (TBS, 2007a). Under the *Policy on the Management of Projects* (TBS, 2007a), a project is required to produce defined outputs and realize specific outcomes in support of a public policy objective, within a clear schedule and resource plan.

A *program* is a plan under which action is taken toward a goal. In comparison to projects, programs do not necessarily have end points, and they tend to be broader. Multiple projects can constitute a program, but programs are not always made up of projects.[6]

Under TBS Management Resources and Results Structure (MRRS) guidelines, a program is a group of related resource inputs and activities that are managed to meet specific needs and achieve intended results, and that are treated as a budgetary unit (TBS, 2009a).

Figure 1 illustrates the relationship among many of the preceding terms, as well as the relationship between the federal government and Canadians.

Figure 1. The Relationship between Inputs and Final Outcomes

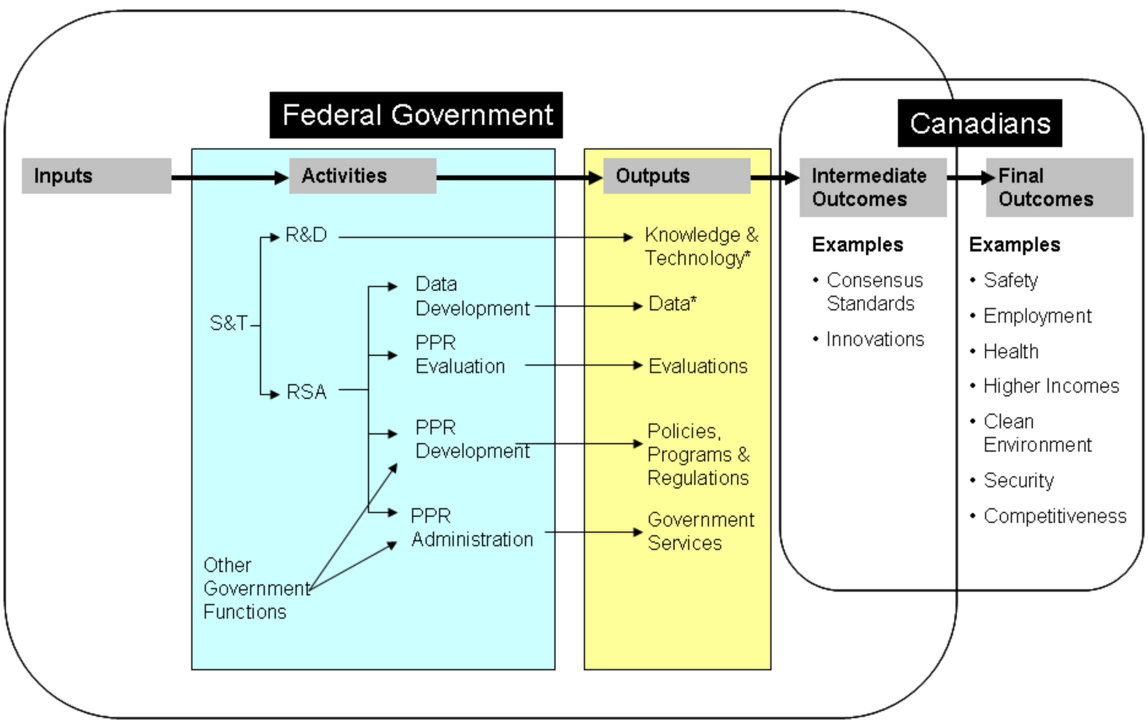


Purpose of the Report

This document identifies potential actions that could be adopted to increase transparency and accountability to Canadians by better measuring and reporting on S&T impacts. The challenge for the federal government is to ensure that each of its S&T activities provides maximum benefits to Canadians in relation to costs, and to show Canadians that this is the case. This requires a combination of good planning, efficient operations, and the measurement and reporting of impacts.

Figure 2 builds on Figure 1 to illustrate how federal S&T impacts Canadians, directly, and in concert with other federal activities, by influencing the development, administration, and evaluation of policies, programs, and regulations. The figure presents a theory of the role of federal S&T.

Figure 2. The Role of Federal S&T

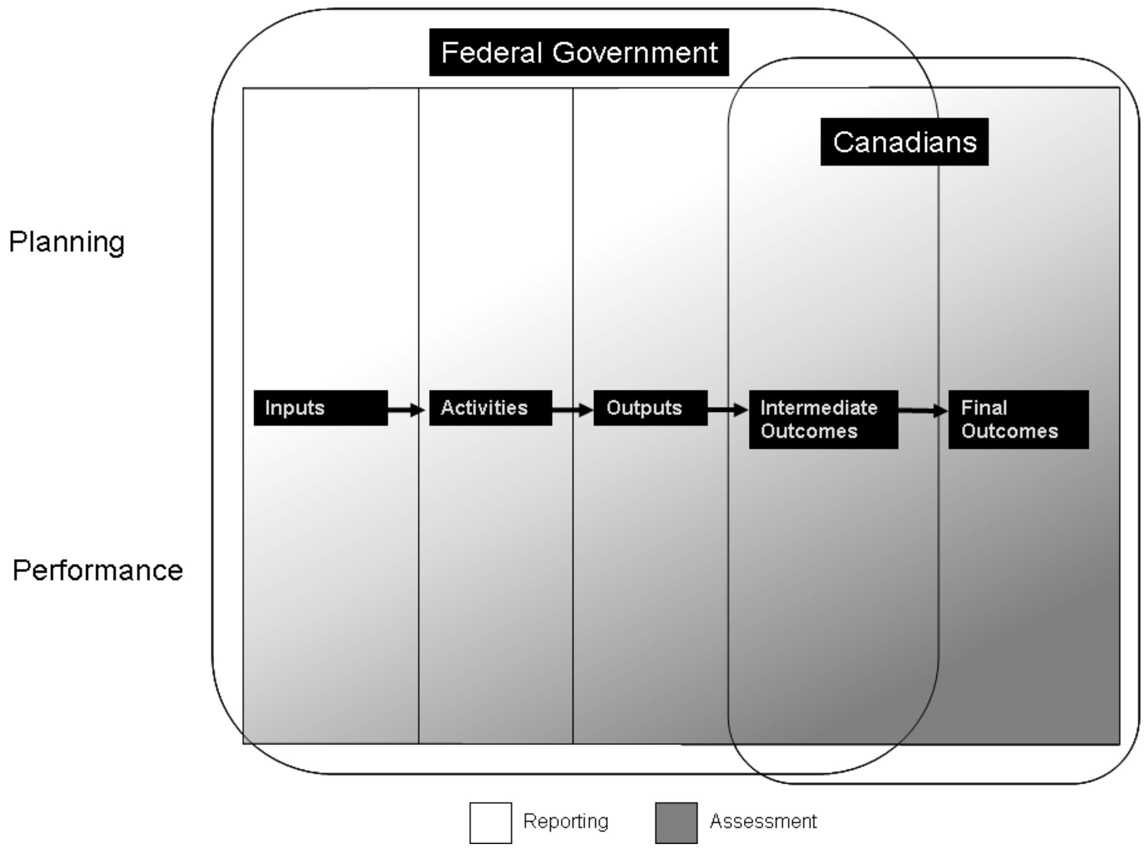


Notes: PPR = Policy, Program and Regulatory
RSA = Related Scientific Activities
* Data, knowledge, and technology can be inputs to policy, program and regulatory evaluation, development, and administration, as well as to R&D.

Figure 2 shows that intermediate outcomes are, by definition, the link between the federal government and Canadians. The outputs of federal S&T are used by the federal government and other organizations in ways that aim to and do improve the lives of citizens. An implication is that an understanding of the links between these outputs and other organizations, including organizations that perform S&T, is often needed to demonstrate the results of federally performed S&T.

Figure 3 also builds on Figure 1 by illustrating how integrated planning and performance and integrated reporting and assessment can demonstrate the relationship between inputs and impacts on Canadians.

Figure 3. The Relationship between Inputs and Final Outcomes



By definition, *reporting* involves describing the relationship among objectives, inputs, activities, outputs, and outcomes; while *assessing* requires exploring and explaining the relationship among these.

Figure 3 suggests that reporting alone is generally sufficient for describing inputs, activities, and planning, while the assessment of performance information is needed to address outcomes. The figure also suggests that integrated planning and performance and integrated reporting and assessment are needed to relate inputs to final outcomes, and thereby demonstrate results for Canadians.

There are two approaches to performance measurement. One involves identifying, measuring, and reporting final outcome indicators, while the other uses a combination of reporting and assessment to demonstrate links among all of objectives, inputs, activities, outputs, and outcomes. Considerable evidence as described later in the report indicates that, in general, the latter is the more realistic and effective approach.

The challenge for the federal government is to fill the space between inputs and final outcomes through a combination of related planning, assessment, and performance-reporting activities. The potential actions identified in this report are options available to the federal government to help fill this void.

Current Situation

Departments and agencies report their plans and performance annually to Parliament based on an MRRS approved by the Treasury Board, which is a committee of ministers.

A given MRRS consists of strategic outcomes; a program activity architecture (PAA), which is an inventory of programs linked to the strategic outcomes; and a performance measurement framework, which is an objective basis for collecting information related to the intended results of a department and its programs, and which consists of information on planned and actual inputs and impacts and a governance structure that demonstrates who is accountable for programs (TBS, 2010, 2006). The PAA provides the framework by which planned resource allocations are linked to activities at all levels and against which financial results are reported (TBS, 2009a, 2006). It has a maximum of three levels below strategic outcomes. Each program activity – the highest level program in the PAA, which is reported on and displayed to the public in estimates documents and public accounts – can be linked to only one strategic outcome (TBS, 2009a).

Reports on plans and priorities (RPPs) are expenditure plans tabled annually in Parliament in which departments and agencies outline their strategic outcomes, program activities, plans and priorities, performance measurement plans, and expected results for the following three-year period. So, for example, the reports tabled in March 2009 are for the three fiscal years 2009-10 through 2011-12.

After the end of every fiscal year, each department and agency reports back to Parliament through a departmental performance report (DPR) on its performance in delivering on plans, addressing priorities, and achieving expected results that were outlined in its RPP for that fiscal year. For example, the DPRs for fiscal 2008-09 were tabled in November 2009. The RPP and DPR are based on the department or agency's MRRS.

The Federal S&T Map of Outcomes and Activities describes federally performed S&T activities, the outcomes those activities support, and the relationship between the activities and the outcomes. It describes the work of the federal S&T community not in terms of departmental mandates, but by area of S&T. The Map has been validated to make sure its content aligns with S&T activities in departmental PAAs. It constitutes a high-level, cross-departmental program activity architecture for federal S&T as a whole. The Map identifies a mission statement, several mission-critical outcomes, and from 17 to 27 activity areas in each of five domains (economy, energy, environment, health, and security and defence) (Walker, 2008). Box 1 provides further detail on the Map and its applications.

Box 1 - Federal Science and Technology Map

The Integration Board Federal Science and Technology (S&T) Map of Outcomes and Activities is a snapshot of federally performed and federally led S&T. It provides a holistic view of where federal S&T supports opportunity and growth for Canada and where it helps mitigate risks to Canadians.

The Map categorizes federal S&T into five domains: economy, energy, environment, health, and security and defence. Each domain consists of a set of themes that cluster the S&T activities the federal government undertakes. These activities deliver on the mission-critical outcomes of the domain. Each theme is then broken down into a set of portfolios that describe the activities being undertaken.

Why it is Useful

The Federal S&T Map has been validated to make sure its content aligns with S&T activities in departmental PAAs. It describes the work of the federal S&T community, not by departmental mandate, but by area of S&T. This allows linkages to be made between departments. In a sense, it is a horizontal PAA for S&T activities performed and led by science-based departments and agencies.

The Map identifies areas for potential collaboration between departments, as well as with other pillars of the innovation system. The Map offers to the federal S&T community an opportunity to speak with a more unified voice about its activities, providing a basis for highlighting synergies and gaps within the community, and for improving networks within the Canadian innovation system. It is an invitation to dialogue – with the rest of the federal S&T community, with its partners, and with its stakeholders.

In some cases, there may appear to be overlap across domains, themes, and portfolios. This occurs where similar S&T activities are described in multiple places, because they contribute to different outcomes. This apparent overlap serves as a reminder of the interconnections between S&T activities, and of the reason federal S&T efforts require active co-ordination.

How it might be Implemented more Broadly

The Federal S&T Map is being used to look at federal S&T activities in oceans science. The *Oceans Act*, which was brought into force in 1997, provides the basis for governance and regulatory responsibilities for many federal departments. The Oceans Science Map is a means of articulating to central agencies, officials, and the public, the extent of federal activities in oceans science and its impact, the role of the federal government in oceans science, and the degree of interconnectivity between activities in different federal departments. It is also a means for creating a visual map of federal activities in oceans science to serve as the basis of discussion with academia and the private sector. This work was started by the Department of Fisheries and Oceans to support its deputy minister, and the work of other departments and agencies is now being incorporated. The final document will give a cross-government perspective on the S&T activities in oceans science.

The Federal S&T Map can support many applications. It can be used as a tool or methodology to create a map of any horizontal or crosscutting issue to highlight linkages between departments and determine gaps and areas of overlap (e.g., oceans science, nanotechnology). The Map can also be used as the basis for an inventory of federal activities and the associated resources, which include a skilled and talented federal S&T work force, a modern and functional science infrastructure, strong partnerships and linkages, and innovative policies and practices. In addition, the Map can provide an overview of federal S&T and its outcomes. This overview can be used as a framework for measuring the impact of federal S&T.

Three documents approved by the Treasury Board provide the framework for evaluation within the federal government.[7] The *Policy on Evaluation* defines evaluation as "the systematic collection and analysis of evidence on the outcomes of programs to make judgments about their relevance, performance and alternative ways to deliver them or to achieve the same results" (TBS, 2009b). As illustrated by the definition, the documents recognize the two-way relationship between evaluation and performance measurement.[8]

On an annual basis, Statistics Canada surveys federal departments and agencies that either perform S&T activities or have a budgetary allocation to fund S&T on the expenditures and personnel dedicated to S&T. Information is collected by activity, performer, region, funder, and socio-economic objective in two surveys: one covers the natural sciences and the other covers the social sciences[9] (Statistics Canada, 2008b and 2008c). The surveys collect data on:

- expenditures on R&D for multiple categories;
- expenditures on related scientific activities (RSAs) (scientific data collection, information services, special services and studies, education support, administration of extramural programs, and capital expenditures);
- personnel for multiple categories; and
- expenditures on R&D and RSA for the following socio-economic objectives:
    - exploration and exploitation of the Earth
    - infrastructure and general planning of land use (separately for transport, telecommunication, and other)
    - control and care of the environment
    - protection and improvement of human health
    - production, distribution and rational utilization of energy
    - agricultural production and technology (separately for agriculture, fishing, and forestry)
    - industrial production and technology
    - social structures and relationships
    - exploration and exploitation of space
    - non-oriented research
    - other civil research
    - defence

Statistics Canada also reports annual data on intellectual property management activities of the federal government as a whole.

As demonstrated by Anderson (2008) and described in more detail below, data from the Statistics Canada surveys of innovation can be used to explore the impacts of federal

S&T. These surveys of firms have been carried out every three or four years since 1996. (The industries covered vary from survey to survey.)

The following examples of good practices adopted by federal departments and agencies are described in text boxes throughout this report:

- granting council searchable databases of investments in research and training;
- Communications Research Centre Canada publications and patents;
- planning with peer review at Agriculture and Agri-Food Canada (AAFC);
- National Research Council's (NRC's) S&T socio-economic impact measurement framework;
- Natural Resources Canada's (NRCan's) annual S&T report;
- Environment Canada's S&T into Action studies and R&D performance reports; and
- The Federal S&T Map developed by the Assistant Deputy Minister (ADM) S&T Integration Board.

These examples are illustrative of good federal practices, rather than exhaustive. They illustrate some of the ways in which departments and agencies already meet the challenge identified by the federal government in 2007.

A Vision for Measuring and Reporting on Federally Performed Science and Technology

Transparency and accountability require planning, measuring, assessing, and reporting in an open, integrated, and detailed way to show how resources are invested in S&T activities that individually and in combination with other federal activities advance organization-specific and government-wide objectives and contribute to the well-being of Canadians. Measurement and reporting, planning, and assessment processes should work together to allow Canadians to see how the money they invest in S&T through the federal government benefits them directly and indirectly. This would result in greater understanding of the role and accomplishments of federal S&T, and more open, better informed and, ultimately, more efficient and effective policy, program, and regulatory development, administration, and evaluation. Subject to the cost of doing so, everyone would benefit from having access to more information that demonstrates how federally performed S&T generates results for Canadians.

This section identifies and explores issues and potential actions the federal government could adopt to realize this vision.

1. Capture Key Objectives fully

Issue

It can be difficult to associate S&T activities with all their key objectives.

Analysis

It is difficult to report impacts and be accountable if key reporting documents don't establish clear linkages between S&T activities and their objectives. While some activities have multiple objectives, under MRRS guidelines, program activities are each tied directly or indirectly to only one strategic outcome. As a result, it can be difficult to portray some of the relationships illustrated in Figure 2.

Initiatives meant to both protect the environment and promote the commercialization of new environmental technologies provide an example of S&T activities with multiple objectives. In such cases, it is difficult to portray fully the contribution that S&T makes to realizing public policy objectives.

That programs sometimes advance more than one objective is recognized implicitly in the definition of "program" provided in the MRRS guidelines, which deploy the plural term "intended results" (TBS, 2009a).

Accounting for each S&T activity in terms of a single strategic outcome may encourage departments and agencies to focus each activity narrowly on the goal associated with it, to the possible detriment of seeking to maximize all positive impacts in relation to all costs for all activities. Related observations from TBS can be found in Box 2.

Box 2 - Observations from Treasury Board Secretariat

Strategic outcomes are high-level outcomes that a group of programs fitting under the same general theme within a department or agency aim to achieve. It is well understood and recognized that attribution at the strategic outcome level is not required to be one hundred percent.

A program can have more than one expected result, as long as the group of expected results is captured by the strategic outcome associated with the program, and as long as the expected results are within the scope and reach of the resources and activities of the program.

A strategic outcome can encompass several areas that S&T activities contribute to within a department. For example, the NRC has a strategic outcome that reads: "Advancements in innovative technologies and increased innovation capacity in targeted Canadian industries and national priority areas."[10] This strategic outcome covers several aspects of S&T programming, including increased innovation, commercialization, and addressing government priorities.

The expected results and associated strategic outcome of a given program are expected to speak to the mandate of the program within the department or agency in question. There are different ways of exploring the facilitation of horizontal S&T reporting, which can include drawing on other existing horizontal reporting initiatives, and possibly making use of other government-wide reporting mechanisms.

Potential Actions

Policies and practices could be revised so S&T activities are measured and reported against all their key objectives. One approach would be to examine and further explore the Policy on MRRS, and the utilization of its existing elements, to allow for a robust way of linking S&T activities to their outcomes. Applicable policies could have departments and agencies identify explicitly all the key objectives of the activities presented in estimates documents, or departments and agencies could take steps on their own to report on the relationship between activities and key objectives.

2. Capture Connections that cross Departments and Agencies

Issue

It can be difficult for departments and agencies to show how specific S&T activities support activities in other departments and agencies.

Analysis

The MRRS requires that program activities be tied to higher-order program activities and strategic outcomes only within individual departments and agencies. Lower-level programs must be tied to higher-order program activities, which then tie to strategic outcomes. This makes it difficult to show how S&T activities in one department or agency sometimes support other activities in other organizations. Doern and Kinder (2007) offered the significant example of health risk assessments prepared by Health Canada that support regulatory compliance activities carried out by the Canadian Food Inspection Agency (CFIA).

The Federal S&T Map of Outcomes and Activities can capture activities that cross departmental and agency borders, but it provides only a loose connection between S&T activities and the policy, program, and regulatory development and administration that those activities support. Accounting for S&T activities alone, even across departments and agencies, makes it difficult to show how those activities sometimes support other government functions.

Potential Actions

Facilitate reporting on the relationship among S&T activities and their impacts across departments and agencies. This could be further examined by exploring the existing Policy on MRRS, and related guidance, to determine how to facilitate horizontal reporting. More use of government-wide reporting at a level of detail sufficient for demonstrating the relationship among specific activities, objectives, and impacts across departments and agencies would be useful.

3. Capture Relationships across Activities

Issue

Science and technology managers can be held accountable for impacts beyond their control.

Analysis

Globerman (2009) noted that it is difficult to isolate the impacts of government S&T on the environment and sustainability, since other government tools, particularly regulation, influence practices that, in turn, affect the environment, so the impacts of the related S&T activities are mediated by other government functions.

More generally, Figure 2 illustrates that S&T activities are sometimes combined with other government functions to support the development, administration, or evaluation of policies, programs, or regulations.

The fact that S&T activities sometimes work in concert with related activities means accountability for impacts is sometimes shared between S&T and other managers. For example, the sole function of S&T might be to inform decision making, such as with monitoring and surveillance that helps the government prepare for and respond to a health risk. In cases where S&T supports decision making by others, the actual results flowing from the S&T activities (i.e., their direct impacts on Canadians) can be beyond the control of S&T managers, it would not be reasonable to hold these managers accountable for the results. In these cases, measurement and reporting approaches that focus more narrowly on the efficiency and accuracy of the S&T activity, or which align all related activities with all their key impacts, would be more appropriate.

Potential Action

Assess the impacts of S&T activities in light of their relationship to other activities. In some cases, this may require considering the impacts and costs of all related S&T and other activities. In other instances, it may require limiting the assessment of S&T activities to their efficiency and effectiveness.

4. Report more Detailed and Integrated Information on Planning and Performance

Issue

Compared to leading practices in Canada and abroad, impact information on federally performed S&T tends to be reported at a high level of aggregation. Moreover, reporting on specific activities rarely connects plans with impacts.

Analysis

At least 13 existing forums examine federal expenditures (Federal S&T Strategy Implementation Working Group, 2008). Many of these rely on information prepared on an ad hoc basis. The results are not always shared broadly, and the various forums do not necessarily inform one another.

The reporting units used to generate performance information (i.e., the collections of federally performed S&T activities for which performance information is systematically provided) tend to be large. For example, the information provided on federally performed S&T in RPPs and DPRs supplemented by the Web sites of science-based departments and agencies provides nothing close to the level of detail included in the federal granting council databases described in Box 3 (PRI, 2009).

Box 3 - Granting Council Searchable Databases of Investments in Research and Training

For many years, the federal agencies responsible for the support of research and advanced training in post-secondary institutions and hospitals (Canadian Institutes of Health Research/CIHR, Natural Sciences and Engineering Research Council/NSERC, Social Sciences and Humanities Research Council/SSHRC, and the Canada Foundation for Innovation/CFI) have maintained, on their Web sites, searchable databases of their investments.

These databases include information on each grant and scholarship/fellowship awarded by the agency, such as the name of the recipient, institution, the program under which the award was made, and the title and annual amount awarded. Searches can be conducted for specific areas of research, disciplines, themes, or areas of application. Keyword searches are also possible.

The search engines also allow for the generation of reports compiling statistics on awards by institution, area of research, etc. The NSERC search engine has started including summaries of each award and, in the future, the CIHR database will contain information about the outputs and outcomes of funded research.

For some programs, such as the Canada Research Chairs and NSERC's Industrial Research Chairs, more specific databases provide a profile of the researcher, including a summary of the research, contact information, and partners.

These databases can be invaluable resources for those looking for an expert in a specific area. They can help link Canadian academic researchers with private or public sector organizations looking for expertise, to apply research advances, or to hire students. They can also link researchers with Canadian or foreign colleagues looking to collaborate, or with journalists needing help with stories on various topics. The databases can also be used by employers looking to hire graduates in specific disciplines.

The databases are important reference tools for policy makers to assess research capacity and intensity in various areas and to locate clusters of strength.

CIHR Funded Research Database

Canadian Research Information System (covers several health research organizations)

NSERC Awards Search Engine

NSERC Chairholders Database

SSHRC Awards Search Engine

Canada Research Chairs Database

A review of the coverage of a recently constructed database of S&T programs suggests it is difficult to identify federal S&T activities using estimates documents and supplementary information sources. Output, outcome, and project-level indicators are rarely used (PRI, 2009).[11]

The explicit coverage of S&T in MRRSs varies from low (e.g., Environment Canada) to high (e.g., Department of Fisheries and Oceans) across departments and agencies, presumably due to independent decisions regarding how to portray the relationship between program activities and strategic outcomes. While this variability may make sense from the point of view of individual departments and agencies, it also constitutes a significant barrier to increasing the transparency of, and accountability for, federal S&T.

The two Statistics Canada federal S&T surveys provide a detailed categorization of S&T by department and agency designed to fully capture both the spending and personnel devoted to S&T. Given the categories and definitions employed, and the fact that information is collected annually by department and agency, the surveys provide detailed data on the inputs and activities of federally performed S&T. Further indicator development work would be required for the federal S&T surveys to be applied to measure the impacts of federal S&T expenditures and activities.

The Potential of Project-Level Approaches

The usefulness of project-level reporting, even without information on final outcomes, is illustrated by an entry from a 2005 report on technology transfer by the US Department of Commerce. The report described how a government agency worked with commercial fishers for three years to develop a new way to catch fish while greatly reducing interaction with threatened marine turtles. This impact information is insufficient for demonstrating net present value to the satisfaction of everyone, but it connects an activity to an intermediate outcome and an objective, thereby providing information on the impacts of S&T likely to prove useful to a variety of audiences.

Much can often be said about the usefulness of an individual output (such as a publication) in the context of the objectives of a particular project and the efforts made before and after the activity to relate the output to the needs of those who might benefit from making use of it. Information of this sort is likely to be more meaningful and useful than reporting that, for example, a given program of research generated X publications, Y patents, and Z requests for information.

The relationship among objectives, activities, and impacts depends on the details. Reporting more disaggregated and related information about plans and performance would allow for demonstrating impacts without necessarily spending a lot of money on assessment or final outcome measurement which, as explored later in this report, can be both difficult and expensive. Of course, it is important to ensure that project-level information is collected and assessed objectively.

Administrative data in the form of project files sometimes provide readily available information relating to costs, objectives, anticipated outcomes, and impacts (Management Solutions Inc., 2008). Reporting more disaggregated information on plans and performance using existing project-based files would address impacts without requiring potentially extensive and costly assessment.

Rostum et al., (2001) identified project-oriented priority setting as a best practice in government S&T management, while providing examples of project-based approaches from Environment Canada's National Water Research Institute, Health Canada, the Energy Sector and CANMET from NRCan, AAFC's Saskatoon Research Centre, the Alberta Research Centre, and *Le centre de recherche industrielle du Québec*. So, for example, the Saskatoon Research Centre tracks information on each ongoing study, and can thereby make research investment decisions at the project level. AAFC scientists prepare annual reports on some projects. The project-based information assembled by these and likely other organizations appears to be an underexploited resource for more detailed and transparent measurement and reporting that in some cases would connect planning to performance. Box 3 from the granting councils and Box 4 from the Communications Research Centre Canada illustrate how project-level information can be provided. In both cases, detailed useful information is publicly available.

Box 4 - Communications Research Centre Canada Publications and Patents

As a federal laboratory under the Department of Industry dedicated to basic and applied research and development across the very broad field of communications, the CRC strives to provide quantifiable outputs that are beneficial to both its internal Government of Canada clients and its external industry clients.

Frequently, the key outputs of CRC research are publications that stem from the four research branches: Satellite Communications and Radio Propagation, Terrestrial Wireless Systems, Broadband Network Technologies, and Broadcast Technology.

Before scientific information can be published, it must be approved by the responsible vice-president. The CRC publishes to meet the following objectives:

- disseminate technical information useful to the scientific community and to industry;
- gain recognition for CRC researchers; and
- serve as a marketing tool for attracting private sector interest to CRC technologies and services.

To reach these objectives and provide maximum visibility, CRC publications are distributed as widely as possible. However, the CRC is careful not to publish prematurely any sensitive information that should be protected through patent applications or as trade secrets. Without proper protection, the intellectual property value would be diminished and lose its attractiveness to the private sector. To this end, the CRC protects 10 to 12 new inventions each year, and maintains a portfolio of about 220 patents, which are available for and actively licensed to industry. These patents are made available as business opportunities on the CRC Web site.

Reports and Technical Notes
CRC Reports are peer-reviewed, serially numbered internal documents that usually report on the completion of a project task or study. The reports are sometimes distributed to the public. CRC Technical Notes are similar to CRC Reports, but report tentative or interim data that may be published if there is value in doing so before project completion. These documents are posted on the CRC Web site for public review.

Publications in the Open Literature
This includes proceedings of conferences sponsored by the CRC, papers published in scientific and trade journals, and papers presented at conferences, seminars, or other forums that are subsequently published in a formal conference document. These documents are formal publications in the public domain.

While costly in some cases, project-based reporting would provide a useful level of detail for all those who make use of federal S&T, while increasing federal transparency and accountability. Project-level information might be rolled up to prepare DPRs and respond to the federal S&T surveys. Key reporting documents could provide pointers to project-level information sources for those wanting more detail.

A complementary approach to project-level reporting is assessing impacts at the aggregate level which, in some contexts, can be both affordable and highly informative. Box 5 provides an illustration from the NRC of how data collected at the aggregate level can help in assessing the impacts of programs using econometric methods. As explored in more detail below, the results of such assessments make a valuable contribution to performance reports.

Box 5 - National Research Council Canada's Science and Technology Socio-Economic Impact Measurement Framework

The NRC has developed an innovative impact measurement framework to quantify the socio-economic impacts of its programs, national initiatives, and R&D activities. It was designed, developed, and tested over a three-year period. The framework can be applied to measure quantitatively the economic return on investment to taxpayers as well as the overall contributions to productivity growth, wealth creation, and innovation in Canada.

The three main design imperatives of the measurement framework are:

- objectivity, transparency, repeatability;
- accepted methods, models, and guidelines; and
- multiple/converging lines of evidence.

The framework is designed to work in tandem with NRC's Delta Project, which ensures that NRC planning and performance targets are established and measured by using a balanced score card approach, as well as a business planning and performance data framework.

The impact measurement framework ensures that the goals and targets of the NRC's national strategy are established and measured. As such, it serves as an input to various Treasury Board submissions, including those related to strategic review, the PAA, and the MRRS. Meeting Treasury Board requirements increasingly requires quantitative impact measures and targets.

Quantitative Analysis Methods and Results
The NRC impact measurement framework consists of the following main components:

- inclusion of both macro-economic and client level (micro) impacts;
- four main analytical methods: econometrics, cost-benefit, input/output, and risk/sensitivity;
- modelling of eight separate R&D activities;

- 15 impact metrics, including productivity, R&D capacity, output/GDP, wealth creation, knowledge creation, and innovation;
- 14 key economic sectors;
- comparison of impacts to both clients and non-clients, with data on 20,000 clients and non-clients;
- 10 years of NRC operational data; and
- 30 databases and datasets, including 25 Statistics Canada and other external sources.

The framework and methodology were successfully piloted in 2007 as part of the Industrial Research Assistance Program (NRC-IRAP) Impact Evaluation. The evaluation concluded that the program, over a five-year period, provided a return on investment to taxpayers in the range of $2.3 billion to $6.5 billion, or from four to twelve times the cost of the program. The NRC-IRAP Impact Evaluation also provided evidence that the program contributed directly to increasing the sales and decreasing the costs of the Canadian small and medium enterprises that NRC-IRAP supported by providing funding and services. These wealth effects were a key component to estimating the return on investment to taxpayers, and were included due to the framework's ability to measure program "attribution" rates.

The full results of implementing the NRC impact measurement framework are described in the NRC-IRAP Impact Evaluation Report.[12]

The framework's methodology has been reviewed by international and national experts, and adjustments have been made based on their comments.

The Importance of Linkages

The exploration of how outputs can be and are translated into outcomes can be useful both before and after research takes place. A priori, this process can increase the likelihood of beneficial results and suggest how to measure, report on, and assess impacts. After the research has been conducted, the same process can help to communicate S&T findings to those who might benefit from applying them, and also to determine the scope of assessments so they can examine all the key impacts. Box 6 provides an illustration from Environment Canada of how this can be useful after the research is conducted.

Box 6 - Environment Canada's Science and Technology into Action Studies and Research and Development Performance Report

Science and Technology into Action to Benefit Canadians is a series of studies illustrating the impacts of Environment Canada's S&T on Canadian society. Each study details the particular benefits stemming from a given S&T activity in terms of its economic, environmental, health, social, regulatory, policy, or other impacts. Each study is presented in a three-page, fold-out format, with information in four concise sections: the problem, seeking a solution through S&T, how new knowledge was translated into action, and benefits to Canadians.

Not only does this series measure and communicate the benefits of federal science in concrete, readily understood examples, through careful targeting and dissemination to potential users, it also contributes to an increased value for money spent on S&T, as new knowledge is taken up and applied by other sectors, levels of government, resource managers, environmental professionals, and the environmental policy community.

The series of studies stems from an earlier series that focused on Environment Canada's water science and technology. The Science and Technology into Action to Benefit Canadians series is available at <http://ec.gc.ca/scitech/default.asp?lang=En&n=4B40916E-1>.

Report on Environment Canada's Research and Development Performance
Environment Canada has developed a suite of performance measures for its R&D activities that is accessible in an online report. These measures are based on the four core principles of federal S&T (alignment, linkages, excellence, and enabling environment) that were identified by the federal government in the 2005 document, *In the Service of Canadians: A Framework for Federal Science and Technology* (Interdepartmental Working Group, 2005).

As a science-based department, Environment Canada relies on its strong science and technology capacity to deliver on its mandate. Performance assessment helps the Department maintain and strengthen its science capacity; the Science Plan commits to developing measures for the Department's science and technology. The report is also part of Environment Canada's response to the federal S&T strategy.

The report is the first phase of an ongoing project to improve the Department's ability to measure and report on its S&T activities. The focus of this first phase is on R&D measurement using readily accessible indicators. The next phase will involve developing performance measures for related science activities (RSA).

Measuring Environment Canada's Research and Development Performance

Key to the relationship between outputs and outcomes are linkages between the federal government and other organizations, since there are often intermediaries between federal S&T and its effects on individuals. For example, federal researchers affect Canadians indirectly when intermediaries like industrial associations, consultants, and individual companies make use of their publications (outputs) to improve the goods, services, and information these intermediaries provide to citizens (Anderson, 2008).

Measuring and reporting on the outcomes of federal S&T activities is facilitated by examining how other organizations make use of outputs. Linkages with other organizations play a key role in translating the objectives of government S&T into final outcomes. Anderson (2008) showed that the innovative companies most strongly linked to publicly funded research organizations were significantly more likely to indicate that their innovations had a highly important impact on improving health and safety, reducing environmental impacts, meeting regulatory requirements, reducing materials or energy per unit output, and improving the quality of jobs.

Lag Times

Globerman (2009) observed that, as a practical matter, improvements in social welfare ultimately draw on cumulative increases in scientific and technical knowledge, including knowledge that may have had no obvious application for many years after it was discovered or created. Rank and Williams (2009) observed that challenges arising in socio-economic impact analysis can include technical problems related to the time lag between research and impacts, and the difficulty of assessing the importance of complementary inputs. Associating final outcomes with specific activities is difficult because new knowledge is cumulative and impacts can occur long after activities take place.

A recent review of empirical research on R&D lag times, summarized in Box 7, indicates that the time between activities and final outcomes can indeed be long. The review suggests that a time period of 10 years or more may be appropriate when assessing the impacts of S&T.

Box 7 - Research and Development Lag Times[13]

Summary of Reported Findings

A fair amount of empirical research has explored the time between when R&D is conducted and when it has impacts on society. This research suggests the following time lines.

- It takes about one year, on average, from the end of an in-house R&D project to when the results of the project are applied within the firm.
- It usually takes in the range of from two to eight years for businesses to apply academic research to produce goods and services that are sold in the marketplace although, in some cases, this lag can be several decades.
- Spillovers from first adopters to other sectors can take an additional five to ten years.
- The average lag time between major innovations being introduced in other countries and their adoption in Canada varied between six and ten years across industrial sectors (based on data from the 1960s and '70s).
- Pharmaceuticals stands out as an area with particularly long lag times: it takes about 15 years, on average, to develop and introduce a new drug.
- It can take as long as 30 years for academic research to be fully reflected in the economy.
- The average time lag between public R&D spending on medical research and measureable health benefits is 17 years.
- While most university licences stop providing revenue within five years, those that have broader social impacts can take in the range of 15 years to reach their full potential.
- Lag times tend to be shorter for applied science and engineering than for basic research.

Observations

While none of the findings speaks directly to the impacts of federally performed S&T, overall they suggest that the time between this activity and these impacts is likely to be quite long.

Given that research is often exploratory in nature, not all research endeavours will result in benefits for society. Moreover, discovering that impacts have yet to be realized does not mean that none will be forthcoming. Research can have commercial or non-commercial impacts decades after it has been completed.

Future policy research on the underlying causes of lag times might explore some or all of the following possible factors:

- the need for subsequent R&D based on initial results;
- the need for multiple lines of R&D before their combined results can be applied;
- the need for refinement through prototype development and testing;
- the readiness of manufacturers and service providers to introduce new products or make use of new technologies;

- regulatory, financing, publication, or other operational barriers that may need to be overcome;
- the willingness of consumers to try new products and services; and
- the need for intermediaries to understand the results and implications of R&D findings.

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Box 8 provides an example of a particularly long lag time and a complex licensing process from the Communications Research Centre Canada (CRC).

Box 8 - From Discovery to Application in Optical Communications

It can take years before research results in success. In 1978, the Communications Research Centre's Dr. Ken Hill made a breakthrough discovery of photosensitivity within an optical fibre core. Developing the capability to photo-imprint gratings in optical fibre required further experimentation throughout the 1980s before an emerging technology known as fibre Bragg gratings (FBGs) could be introduced in prototype products, protected by a family of related patents.

The worldwide telecommunications boom occurred in the 1990s and FBGs were introduced into the marketplace in 1995. Large telecommunications companies began using FBGs as a solution for increasing telecommunications network efficiency. The CRC in partnership with another laboratory in the United States combined patents to cover the FBG manufacturing process. Since 1995, the portfolio has been licensed worldwide to more than 50 companies.

Canadian companies have benefited from access to the new technology at a preferential licensing price, and a strong optical industry niche developed in Canada to exploit the technology. Fifteen years after its market introduction, the FBG portfolio continues to generate substantial royalty revenues for CRC, while six Canadian companies are market leaders in the manufacture and sale of FBGs worldwide. In addition to telecom applications, the FBG technology has found a strong niche in engineering use for strain gauges and stress sensors.

The photosensitivity phenomenon, discovered at CRC back in the late 1970s, has been recognized by the Institute of Electrical and Electronics Engineers as one of the top four milestone developments in optical communications, alongside the invention of the laser, optical fibre, and the optical amplifier.

The Complexity of Impact Assessment

Anticipating and measuring the impacts of research can be very difficult. Actual outputs are likely to differ from planned outputs; actual intermediate outcomes are more likely to differ from planned intermediate outcomes; and actual final outcomes are even more likely to differ from intended final outcomes. Measuring and reporting systems need to allow for these divergences.

Outcome indicators are not always available when performance reports need to be prepared. Take the case of innovation. Reporting on an extensive appraisal of innovation indicators led by the OECD, Colecchia (2007) observed that, with the exception of indicators from innovation surveys of the kind analyzed by Anderson (2008), the available range of innovation indicators is almost entirely limited to inputs, activities, and intermediate indicators that measure *invention*, or the *disclosure* component of the innovation process, such as patents and bibliometrics. That is, available innovation indicators are almost all activity or output indicators, despite the considerable investments made throughout the world to investigate and measure innovation.

The conclusions of detailed assessments aren't always available either, given the cost and time involved in conducting them. This is illustrated by Rank and Williams' (2009) observation that top-down methods that aim to estimate net benefits are rarely appropriate for smaller initiatives, because the cost is generally prohibitive. Rank and Williams (2009) also noted the complexity involved in attributing impacts to particular S&T activities. If the goal is to attribute impacts transparently to activities, performance reports may need to present information primarily in terms of outputs and the conclusions of whatever relevant assessments (reviews, evaluations, and audits) that have been conducted, rather than in terms of outcome indicators.

Rank and Williams (2009) described and examined the application of various methods for assessing S&T impacts, identifying the following as effective practices.

- Partial benefit-cost methods aggregate the benefits of the highest impact cases and compare the result to the cost of the initiative as a whole. They work well for identifying lower-bound, net-benefit estimates.
- Top-down methods based on econometric or similar approaches can assess the net-benefits of major initiatives, where there is adequate data for the key variables (including controls).
- Case studies are especially good at illuminating how and why a program has achieved its impacts.
- The evaluation of S&T is a "craft" in which well-qualified analysts can usefully be provided with considerable scope to apply customized approaches to fit the particular situation.

For *reporting* purposes, outputs can be preferable to outcomes because they tend to be more readily observable, measurable, and attributable to the activities. When combined with information about objectives, plans, and the conclusions of applicable assessments, this can be the most cost-effective way to report on impacts.

Public reporting in RPPs and DPRs is based on expected results and the performance indicators and targets/milestones that programs aim to achieve and measuring aims to demonstrate. The outputs and activities associated with the delivery of the programs (and supporting lower-level programs) are often used to support and inform the performance story at the reporting level.

The Important Link between Planning and Reporting

Actual activities and the resources allocated to them are best related to impacts and objectives through an integrated system of planning and reporting. So, for example, reporting might focus on plans, outputs, and steps taken to transmit outputs to those who could benefit from applying them, along with the conclusions of more detailed reviews, evaluations, and audits of the activities that provide information on outcomes, to the extent that such analyses are available or affordable.

Planning processes could usefully explore the relationship between the objectives (which are similar to planned results, and to strategic outcomes as defined in the MRRS guidelines) of planned S&T activities and their expected outputs, and outcomes, as well as planned program evaluations, reviews, and audits. Doing so would strengthen the relationship between planning and performance reporting, and between inputs, activities, outputs, outcomes, and objectives. More generally, it would help to realize and demonstrate results for Canadians.

A 2007 report by the Australian Government Productivity Commission on public support for science and innovation proposed factoring performance measurement into the initial design of programs. Impacts are also considered explicitly during the planning stage in some jurisdictions. For example:

- The US National Science Foundation, an independent federal agency that funds basic research, assesses proposals based on intellectual merit and their expected broader impacts.

- A priority-setting exercise known as the Science Investment Process at the Australian Commonwealth Scientific and Industrial Research Organisation, the country's national science agency, is based on, among other things, an analysis of potential impacts. The Organisation allows user groups to participate in developing its overall research strategy and priority-setting process to improve the use of its research and align its activities with the needs of users.

An information product prepared by Environment Canada (2007) illustrated how impacts can be considered during planning. The document described the role a particular S&T activity (developing an index) played in addressing a problem. While it is likely difficult to demonstrate the specific outcomes associated with developing the index, it is comparatively easy to show how that particular S&T activity played a useful role by addressing an important problem. Describing the relationship between the activity and the problem (which is related to the activity's objective) and reporting in terms of the activity's outputs (i.e., the index) connects the activity to its objective. This may not be sufficient information to assess fully the benefits in relation to costs, but by providing the information, the S&T activity becomes more transparent; important if incomplete information is presented on the value of the S&T.

The 2007 report from the Australian Government Productivity Commission identified questions that can usefully be posed when developing and managing S&T.

- Do governance structures and processes consistently specify objectives and desired outputs?
- Do they factor performance measurement into initial design and follow through?
- Is there independence and transparency of assessment?

Posing and addressing questions along these lines would help both to connect inputs and activities with final outcomes and to demonstrate these connections.

The potential actions in this and the following two sub-sections aim to make better connections between inputs and final outcomes by better integrating planning, performance, and reporting to provide more detailed and useful information about federal S&T. The three following sub-sections (7, 8 and 9) address assessment. Collectively, these six sub-sections apply the model presented in Figure 3, with the broad goal of better demonstrating results for Canadians.

Potential Actions

Box 9 explores several options for how to align inputs with impacts more transparently by planning and reporting on S&T at a more detailed level and explicitly relating S&T planning to performance reporting. It concludes that there would be merit in departments and agencies making all S&T expenditures explicit in reporting documents, and to collecting and making generally available planning and related performance information about S&T at the project level, where feasible and affordable. This conclusion and the options presented in the Box could be applied to increase transparency and accountability and improve measurement and reporting on the impacts of federal S&T.

Box 9 - Options for Aligning Inputs with Impacts

How federal departments and agencies might report more fully on the objectives, inputs, activities, and impacts of federal S&T can be explored by considering two issues. The first issue is how to collect planning and performance information. Two not mutually exclusive options are:

- Conduct the federal S&T surveys in terms of the strategic outcomes identified by departments and agencies in their MRRSs. This would connect the surveys to the estimates process, and thus detailed information on S&T inputs and activities to the strategic outcomes identified by departments and agencies, which are similar to objectives, and to planned results. It might also reduce the cost of collecting information on S&T from departments and agencies, since two processes would be replaced by one. However, given that the strategic outcomes of departments and agencies have tended to change over time, the long-term usefulness of the resulting statistics could prove limited.
- Collect project-level information where feasible and affordable. Collecting performance information at the level of projects, rather than programs, could be useful, because the objectives and impacts of science activities may be best understood at the project level. Where programs are organized (or "organizable") into projects (e.g., in labs doing project work, or with programs that provide grants for projects), describing S&T activities at the project level would facilitate transparent and accountable planning and reporting by better associating objectives, activities, and inputs with impacts. It would also facilitate strategic management decisions concerning how to advance research and how to share outputs with those who would benefit from applying them.[14]

  Implementing this option would require developing and "operationalizing" a definition of an S&T project. It would also require developing an approach for ongoing activities that are not "organizable" into projects, and, in cases where project-level information is not readily available, it would be more costly than the status quo.

  It would not be necessary to present information at the project level in the annual RPPs or DPRs. Indeed, it would be unrealistic to expect this in larger science-based organizations, given the large number of projects that are underway at any given time. An approach that provided references in estimates documents to information sources organized at the project level (such as the granting council databases described in Box 3) would be more manageable.

The second issue is where to present the information. There are three options:

- RPPs and DPRs linked to more detailed information sources;
- annual planning and performance reports on S&T prepared by each science-based department and agency (boxes 10 and 6 provide examples of reports along these lines prepared by Natural Resources Canada and Environment Canada); and
- an annual government-wide horizontal planning and performance report on S&T.

The first option would not necessarily account explicitly for all federal S&T spending, unless reporting in terms of S&T was made a requirement. The key disadvantage of the second and third options is that they would be more resource intensive for some departments and agencies than the status quo, and would overlap, at least in part, with the estimates documents departments and agencies are already required to prepare each year.

While both are important, collecting and making available planning and performance information is more important than the way the information is reported, since making the information available allows anyone interested to analyze and organize it according to their needs. Improving measurement and reporting depends fundamentally on increasing the quantity and quality of the information that is made generally available. It is not otherwise possible to be more transparent and accountable.

Overall, given the aim of demonstrating results for Canadians, there would be merit in requiring departments and agencies to make all their S&T expenditures explicit in reporting documents, and in collecting and making generally available planning and performance information about S&T at the project level, where feasible and affordable.

Box 10 - Natural Resources Canada's Annual Science and Technology Report

Background
An NRCan annual S&T report was first requested in 2004 by the deputy minister. Subsequently, the April 2005 report of the Auditor General recommended that NRCan improve its research project management systems so it has better integrated information for corporate oversight. The Department is currently producing its fifth departmental S&T annual report.

Separate inputs are provided by the four S&T sectors and integrated into a single report by Science Policy Integration (SPI).

In 2005, the Department created the online S&T Information Management System (STIMS) that has since been used to collect and process data automatically and generate the NRCan S&T annual report. Now a multi-year enterprise-wide information repository, STIMS permits year-to-year comparisons and trend analysis.

The original STIMS software has been progressively upgraded to include additional functions, one of which is a mechanism to upload financial information from the Department's financial system (GFS), thereby providing more granularity for some performance indicators. The current version of the system also allows input of information at the regional and branch levels. This information can be rolled up to the sector/Department level.

Goals
The annual reports:

- inform NRCan senior managers about S&T activities in the Department and assist them in championing NRCan S&T with colleagues;
- support the making of informed strategic management and policy decisions; and
- provide an efficient source of information for internal and external reports.

Overview of the Reports and S&T Information Management System
The annual reports include graphical and tabular summaries and provide easy access to integrated information on NRCan's S&T program activities, their relevance to departmental priorities, associated costs, risks, linkages and partnerships, achievements against planned outputs, outcomes, and performance indicators.

The structure of the annual report is based on TBS guidelines for results-based management and accountability frameworks (RMAFs) and the departmental PAA. The program activity and performance information drills down to the sub-sub activity level of the PAA.

The impact of this integrated S&T information management system has spilled beyond its intended objective of producing NRCan S&T annual reports. The integration of all relevant S&T information in relation to the departmental PAA down to the sub-sub activity level has resulted in improved productivity by automating departmental input into Statistics Canada reports on S&T expenditures, intellectual property, S&T personnel, and commercialization.

Although STIMS is fully capable of reporting on both S&T and non-S&T activities (including in corporate mid-year review reports, corporate risk reports, and the departmental performance report), it is currently being used only for S&T performance reporting.

Challenges
While the information is used frequently for reporting purposes, its use in support of decision making remains limited. The information could be linked to priority-setting exercises.

There are some technical challenges involved in aligning financial information with the information requirements of the NRCan S&T annual report. Additional work on indicators might further enhance S&T performance reporting.

5. Involve Externally Funded Researchers

Issue

While detailed information is available on the activities of external researchers funded by the federal government, little information is provided systematically on the impacts of this research.

Analysis

Extensive information on funded research is accessible on granting council Web sites. However, to date this information has focused primarily on activities rather than impacts.

A recent report from the Canadian Academy of Health Sciences (2009) observed that end-of-grant reporting would address current data gaps. A comprehensive report from the Australian Government Productivity Commission (2007) proposed that research-funding organizations play a more active role in promoting access to research results, and suggested that these organizations could require, as a condition of funding, that research papers, data, and other information produced as a result of the funding be made publicly available. The Canadian Institutes of Health Research (CIHR) plans to begin providing information about the outputs and outcomes of the research it funds.

Securing the help of externally funded researchers to improve measurement and reporting on S&T impacts seems a modest request, given the extent of federal funding provided to them (currently more than $4 billion per year according to Statistics Canada, 2008a). It would be a comparatively straightforward and low-cost way to increase transparency, accountability, and the amount of information available on impacts.

Potential Action

Have externally funded researchers report impacts at the end of the funding period. Options could range from listing publications to making all research results publicly available, including any data generated by the research. The possibility of reviewing and funding proposals from externally funded researchers based, in part, on the expected results for Canadians and planned steps for realizing them as identified by researchers could also be explored.

6. Involve the Consumers of Research

Issue

Can the intended and actual users of federal S&T play a useful role in measurement and reporting?

Analysis

Diverse experts agree that, while metrics (with or without peer review), such as those provided by bibliometric studies, are useful for reporting on research quality, qualitative approaches can be useful for assessing research impacts. Research evaluation should incorporate the opinions of end users and beneficiaries (Donovan, 2007a).

Coryn et al. (2008) presented the results of a first-of-its-kind extensive comparison of the approaches used by governments in 16 countries[15] to assess research proposals. The approaches were independently assessed by expert multidisciplinary panels of evaluators and researchers. The highest ratings were received by countries that used performance and judgment-based approaches. Bulk-funding (i.e., block grants to large groups) and indicator-driven (i.e., applying algorithms using objective data) approaches were rated substantially lower. The higher-rated approaches tended to be transparent and low cost and to make use of arm's-length assessments, highlighting the importance of controlling for potential biases when feedback from users and beneficiaries is employed.

Rostum et al. (2001) observed that quantitative tools sometimes offer little information about important aspects of research programs, such as their impacts on society and the economy. They argued that the feedback of users and clients is needed to measure the quality and relevance of S&T conducted by science-based departments and agencies.

Formal stakeholder engagement during the development of its overall research strategy allows Australia's national science agency to align its activities with the needs and capacities of users and to improve the utilization of research outputs (Australia, 2007). The 2008 Australian Research Qualify Framework made use of panels consisting of academic peers and end users to consider impact statements and case studies as well as indicators (Donovan, 2007b). Validation by clients contributes to the accuracy and credibility of statements of impact (Management Solutions Inc., 2008).

Agriculture and Agri-Food Canada involves stakeholders in the development of projects, with the aim of reaching a common understanding of the research to be done and the outputs to be developed (Rostum et al., 2001). Involving the expected and actual users of outputs would increase the coverage and credibility of impact assessments. A priori, impact statements based on objective methods can facilitate examining how intended beneficiaries expect to be affected by the availability of outputs, as well as what they anticipate being able to do differently as a result. After the fact, they can help describe the actual impacts of individual activities or projects, and thereby serve as the building blocks for assessments (Management Solutions Inc., 2008). Action in this area would promote the explicit consideration of impacts during planning, as well as linkages between researchers and those who make use of their outputs.

Potential Action

Departments and agencies could consult with intended beneficiaries when exploring intended impacts ex ante, and seek feedback from actual beneficiaries when assessing impacts ex post.

7. Invest more in Assessment

Issue

Connecting inputs to outcomes usually requires assessment, which is frequently difficult and expensive.

Analysis

Literature reviews on market impacts (Mohnen, 2009), non-commercial impacts (Globerman, 2009), and assessment practices (Rank and Williams, 2009) indicated that with some notable exceptions, S&T outcome measurement and reporting, as well as evaluation, are rarely carried out, especially for longer-term, indirect, and non-market impacts, of which many are important for federally performed S&T.

Return on investment is much easier to conceptualize than to measure, assess, and report. For example, the Canadian Academy of Health Sciences (2009) observed that the science behind defining returns on investment in health research is embryonic.

One challenge is attributing specific outcomes to specific activities. It can be costly and time consuming to meet rigorous scientific standards when reporting on the relationship between inputs and final outcomes. Evaluations can examine this relationship in more detail than tracking indicators, and econometric methods can be applied to address attribution, but it can be costly and difficult to do so, and even the best work doesn't generally offer definitive findings. So, for example, in a detailed review of a sizeable literature on the market impacts of S&T investments, Mohnen (2009) reported just a few studies whose conclusions directly addressed the net present value of investments, and found that conclusions concerning how to strengthen policy research were more readily apparent than policy implications. That is, what it would be useful to know is clearer than what it would be useful to do.

It is arguably even more difficult to address non-market impacts (i.e., impacts associated with goods or services that are not traded in a market), given the lack of prices on which estimates can be directly based (Globerman, 2009). Even the best work tends to offer limited and incomplete evidence concerning the outcomes of S&T.

While clearly difficult, it would be wrong to conclude that assessments can never provide useful information about outcomes, including on the relationship between benefits and costs. An example is provided by the often cited work of Mansfield and his colleagues (e.g., Mansfield, 1998) that estimated the private and social rates of return of the R&D expenditures of firms in specific areas. However, as described by Cozzarin (2006), this work, which required firm visits, in-depth interviews, and econometrics, was difficult, time consuming, and expensive. Another positive example of impact assessment is provided by the NRC's evaluation of the Industrial Research Assistance Program, as described in Box 5. The box illustrates the role that assessment can play in providing objective information on the impacts of federal S&T.

A recent review by Rank and Williams (2009), based on unpublished studies, consultations with international experts, and the considerable experience of the authors, found that many studies that assess S&T impacts funded by governments suffer from insufficient time and funding. In some cases, this may be due to contracting challenges, where studies need to be completed by a specific date. The review concluded that the considerable challenges it identified could be addressed with systematic long-term data collection, good metrics and methods, and by allocating sufficient resources to assessment.

Treasury Board Secretariat's most recent report on the health of the federal evaluation function (TBS, 2005) emphasized the importance of independent and objective reviews to ensure credible reporting, while raising concerns about the uneven quality of evaluations and the adequacy of the resources allocated to the function.

While difficult, assessment does have a key role to play in measuring and reporting impacts, as described earlier, and as illustrated in Figure 3. Action to ensure that more is done appears to be needed to improve the measurement and reporting of S&T impacts. Improving on recent practice would be facilitated by investing more in assessment and data development, and by maintaining up-to-date methodological guidance.

Potential Action

Invest more in the assessment of impacts. Consideration could be given by an existing interdepartmental body, such as the ADM S&T Integration Board or the ADM Committee on S&T, to identifying priority issues or activities that would benefit from further assessment, overseeing and sharing the results of assessments and, as explored in the remainder of this report, identifying data development priorities, offering methodological guidance, and exploring outstanding policy research questions.

8. Support Assessments with Data

Issue

Measurement, reporting, and assessment all depend fundamentally on the quantity, quality, and relevance of available data. Data forms the basis of evidence-based decision making.

Analysis

Both conducting and assessing S&T require data. By definition, this is fundamental to empirical analysis. The annual Statistics Canada survey of Industrial Consumption of Energy illustrates how data development can facilitate measurement and assessment. The survey gathers information from establishments that is used to track energy efficiency improvements, calculate carbon dioxide emissions, and inform the public about energy conservation (NRCan, 2006).

A recent report from the Canadian Academy of Health Sciences (2009) made a strong case for additional data development. The report introduced the concept of "aspirational" indicators and two types of preferred indicator characteristics: attractiveness and feasibility. The report concluded that data already being collected in Canada do not provide all the information an evaluator might want, and there is a need to prioritize from among aspirational indicators.

A variety of informed observers identified plausible candidates for future data development.

- Mohnen (2009) identified the need for firm-based longitudinal databases that provide information on the inputs (including public support), activities, and impacts of firms in the area of R&D.
- A report prepared for the Australian government identified a greater focus on measuring knowledge diffusion as a priority (Allen Consulting Group, 2005).
- An Advisory Council on Science and Technology (ACST, 1999) expert panel report proposed that Statistics Canada monitor the performance of university spinoff companies and established companies that enter into licensing deals with universities, to measure the commercial impact of research.
- Box 11, based on a review of different ways to categorize S&T (Maidment and Painter, 2009), explores the merits of revisiting the definition of related scientific activities employed in the Frascati Manual and by Statistics Canada.

Potential Action

Address S&T impact assessment needs when identifying data development priorities. An initial step could be for Statistics Canada and interested federal science-based departments and agencies to collaborate on preparing a proposal, which could seek funding for a feasibility study and one or more pilot projects for developing data useful for assessing the impacts of federal S&T.

Box 11 - Revisiting the Definition of Related Scientific Activities

The Statistics Canada federal S&T surveys for the natural and social sciences provide considerable information on related scientific activities, but the data provided by the surveys can't always be relied on to show how S&T supports other government activities. For example, the component "special services and studies" used in the social services survey encompasses investigations that provide information for planning and policy formulation as well as demonstration projects. These largely unrelated activities would be better separated.

The definitions employed in the federal S&T surveys adhere as closely as possible to the Frascati Manual[16], which provides a comprehensive and clearly defined categorization for S&T. In the manual, RSA (other than education and training) is defined in terms of the following categories: scientific and technical information services and activities, general purpose data collection, testing and standardization, feasibility studies, specialized health care, patent and licence work, policy-related studies, and routine software development.

"Testing and standardization" includes the activities of laboratories operated by public bodies and consumer organizations whose main purpose is testing and standardization. "Policy-related studies" is defined as the analysis and assessment of existing programs and operations, continuing analysis and monitoring of external phenomena, such as security, and legislative commissions of inquiry.

At least some federal S&T activities that support the development and administration of policies, programs, and regulations are covered in the Frascati Manual under parts of the categories "scientific and technical information services and activities, " "testing and standardization, " and "policy-related studies. " It is not clear whether these activities are covered entirely, or whether the total resources allocated to them are identifiable from data collected using the definitions.

Based on their detailed case studies of four federal agencies, Doern and Kinder (2007) illustrated that federal S&T activities other than R&D consist of a complex set of service-oriented and regulatory tasks that involve a combination of generating, assessing, interpreting, and explaining information, along with maintaining an up-to-date understanding of areas of expertise. While it may be technically correct to refer to them as scientific activities related to research, at least some of them appear to have little relationship to R&D, in the sense of adding to the knowledge base or using knowledge to devise new applications, which is at the basis of the Frascati Manual (and thus Statistics Canada's) definition of R&D. This may present a problem, given that, in the Frascati Manual, "the practical definitions [of the RSA components]... are intended solely to exclude [the] activities from R&D" (OECD, 2002, page 30).

Relying on definitions prepared for another purpose (i.e., to exclude the activities from R&D) to account for S&T activities other than R&D is not ideal.

Figures cited by Doern (2006) suggest that the current shortcomings of federal S&T surveys are not trivial: data provided to him by Health Canada suggest that about 55 percent of the Department's S&T personnel perform risk assessments on products and environmental risks and thereby support policy and program development and administration in a way that is not well captured by the surveys.

Revisiting the definition of related scientific activities could support better measurement and reporting on how federal S&T supports other federal activities when it does. The guidelines could be revised so that departments and agencies are better able to illustrate how S&T supports the development and administration of programs, policies, and regulations where this is the case.

Revisiting the definition of RSA might most effectively be done by working at the OECD to revisit the coverage of RSA in the Frascati Manual. An appropriate objective could be to treat the various activities currently covered by RSA more like the term "scientific and technological services" employed by the United Nations Educational, Scientific and Cultural Organization (UNESCO), rather than as activities that relate to R&D, if only because some S&T activities are unrelated to R&D.

The collection and presentation of information about government S&T could usefully be organized in terms of the following non-overlapping categories, which roughly correspond to the outputs in Figure 2.

1. Generate information (which includes monitoring environmental and other conditions).

2. Increase the stock of knowledge.

3. Develop a technology (including patent and licensing work).

4. Organize or integrate information and knowledge to support developing a policy, program, or regulation.

5. Organize or integrate information and knowledge to support administering a policy, program, or regulation.

6. Organize or integrate information and knowledge to evaluate a policy, program, or regulation.

Categories 2 and 3 (excluding "patent and licensing work") correspond to R&D as defined in the Frascati Manual, while the remaining categories (plus "patent and licensing work") are meant to capture what the Frascati Manual refers to as RSA in a way that facilitates capturing the role S&T plays within the federal government. Maidment and Painter (2009) referred to the categories as proximate objectives. Developing and deploying definitions along these lines would facilitate the development of data on S&T activities other than R&D.

9. Keep Guidance up to Date

Issue

What is the best way to maintain and share best practices and other guidance useful for assessing S&T impacts?

Analysis

There may be a case for developing and maintaining generic assessment guidelines based on work by the performance measurement, evaluation, and regulatory communities, given the extent to which assessment issues and techniques are generic across domains. For example, government S&T sometimes has results by influencing the design of regulations, so assessing S&T impacts can reduce to assessing the impacts of regulatory initiatives (Globerman, 2009).

The relationship between impact assessment and evaluation is recognized in the framework for evaluation established by the Treasury Board. Evaluation depends on and informs performance measurement.

Sources that could be drawn from to support the development of guidance for the assessment of S&T impacts include:

- policies, guidelines and practices developed in recent years by the federal regulatory community;[17]
- the federal practices described in the boxes located throughout this report;
- the effective practices identified by Rank and Williams (2009) described earlier;
- the suggestions accumulated over the course of the project presented in Box 12;
- S&T-specific evaluation tool kits, research networks, and practices from other jurisdictions;[18] and
- an existing Web site hosted by TBS for the federal evaluation community.

Potential Action

Maintain up-to-date guidelines for assessing S&T impacts, possibly as part of a broader community of practice for evaluation, performance measurement, and regulatory impact assessment.

Box 12 - Additional Suggestions for how to Assess Science and Technology Impacts

Rostum et al. (2001) identified the NRC's use of multiple lines of evidence, including peer reviews, benchmarking, socio-economic impact assessments, and surveys, as a best practice for assessing the quality and relevance of S&T.

A recent assessment from the Canadian Academy of Health Sciences (2009) suggested that the selection of indicators should be:

- focused on the objectives of the organizations that will use them;
- appropriate for the stakeholders likely to use the information;
- balanced to cover all significant areas of work performed by an organization;
- robust enough to cope with organizational changes (such as staff changes);
- integrated into management processes; and
- cost effective (balancing the benefits of the information against the costs of collection).

The Canadian Academy of Health Sciences report also offered a useful list of preferred indicator characteristics organized under two headings: attractiveness and feasibility.

Annual reports by the US Department of Commerce (2005) presented several useful output indicators (e.g., number of guest scientists and engineers, collaborative standards contributions, standard reference materials sold, and items calibrated) as well as initiatives underway for developing better metrics for program performance.

Globerman (2009) concluded that evaluations can usefully address all of the creation, diffusion, and utilization of knowledge.

Mohnen (2009) proposed that both case studies and econometric methods be applied to explore the channels, time frames, and impacts of spillovers across projects and programs.

The NRC has a comprehensive approach to peer review that is integrated with program evaluation. The reviews address the quality, relevance, and management of research programs and laboratories (Rostum et al., 2001). Box 13 describes the role that peers will play in the consideration of research proposals at AAFC.

Box 13 - Planning with Peer Review at Agriculture and Agri-Food Canada

The Planned Practice
All proposed research at AAFC will be initiated by researchers through a letter of intent (LOI) in consultation with departmental science directors who will provide suggestions and recommendations on the LOI and guide the researchers in preparing their proposals so they are aligned with AAFC priorities. Research proposals prepared by scientists will be able to address more than one of the several national science priorities. These priorities and relevant outcomes and deliverables will be posted annually under Research Proposal Review Guidelines on AAFC's Web site.

The research proposal evaluation process will include a management evaluation and a peer review evaluation, which will occur concurrently. Reports from these two evaluations will be used by the Research Branch Executive Committee to make final funding decisions.

Usefulness
Science performed within AAFC is largely supported by public funds and must meet high standards. The peer-reviewed approach is a recognized and accepted standard used by most public agencies around the world, and is being used to allocate A-Base funds to AAFC scientists. The review process is an opportunity for AAFC researchers to receive up to four years of support for public good research they believe will address the national and departmental mandate priorities identified by AAFC. It is aligned with the Department's science priorities, builds on synergies, and aims to have a high impact for Canada.

A proposal will typically consist of several interrelated research activities from different investigators and/or laboratories. There is an expectation that research proposals will address the needs of a successful innovation chain and achieve progress toward their objectives to serve Canadians.

Method of Implementation
The peer review process will examine the scientific excellence of the scientists, scientific merit, originality and quality of the proposed research, and how it contributes to innovation and/or public good. It will also assess the feasibility and probability of achieving the objectives of the

proposed research and delivering results.

Peer-review panelists will be appointed as individuals for their expertise. They will be instructed to make the best recommendations on the investment of public funds in research.

The research proposal evaluation process will take into account the experience of the researcher in relation to younger scientists. Scientists will suggest external reviewers. The evaluation results against the available budget will be reviewed by the Research Branch Executive Committee, which will make a final decision to fund the proposal in whole or in part, or not at all.

The Science Bureau will oversee and administer the entire review process and will be the first point of contact for both the panel and scientist. A guideline is in place for appeals of non-funded projects to ensure that applicants are treated fairly and consistently

Outstanding Policy Research Questions

1. How to Secure Benefits and Promote Information Sharing?

A recent report from the Canadian Academy of Health Sciences (2009) noted that the results of funded health research are first evident in published research documents, which then add to the *global* pool of knowledge, implicitly raising the issue of how a comparatively small player like Canada can ensure that Canadians benefit to the maximum extent possible from the comparatively small amount of research funded and conducted here.

Guellec and Van Pottelsberghe (2001), among others, showed that, for any country, the R&D of other countries matters more than domestic R&D for productivity growth – provided the country has the capacity to absorb technology from abroad. Accordingly, countries with a strong education system for S&T like Canada may want to promote the open sharing of results. So-called “open-innovation” approaches offer considerable promise.

However, Canada’s position on open innovation should depend on the practices adopted by other jurisdictions, which may or may not be as inclined toward openness. Expressed more starkly, it is unlikely to be in the interest of Canadians to share all of their trade secrets unilaterally with the world. The optimal policy for a given jurisdiction may involve co-ordinating initiatives and policies with other jurisdictions in order to share results and benefits both ways across borders.

Consideration could usefully be given during the planning of S&T activities to how findings and other outputs will be shared, since the approach chosen can have a significant impact on the extent to which Canadians will benefit (ACST, 1999). Managing intellectual property strategically can lead to significant benefits for Canadians (Management Solutions Inc., 2008), as illustrated in Box 8, which describes how the management of intellectual property played a role in the development of a significant optical industry niche in Canada.

The Study Management System used by AAFC illustrates how benefit to Canada can be considered when planning research. Funding criteria applied under the system include the ability of Canada's organizations to convert technological progress into commercial or other returns, and Canada's ability to realize any R&D potential in a timely manner (Rostum et al., 2001).

How the federal government can continue to promote the interests of Canadians while encouraging the development of open-innovation practices is an important question that merits further policy research.

2. What are the Objectives of Government S&T?

The Challenge of Accounting for Objectives

The Canadian Academy of Health Sciences (2009) noted the relationship between objectives and impacts when it advised that indicators be focused on organizational objectives. Similarly, the Australian Government Productivity Commission (2007) proposed that outputs and intended outcomes be defined in relation to the rationales for public support.

The objectives of federal S&T are not always fully accounted for; for example, departments and agencies sometimes respond to the federal S&T surveys by reporting their expenditures in terms of the objectives of the organization as a whole, rather than the objectives of the activities that constitute the expenditures (Statistics Canada, 2005).[19] Accordingly, survey results do not always indicate fully the objectives of federal S&T activities.

Departments and agencies are required to account for all their expenditures in terms of the strategic outcomes identified in their MRRSs, but the relationship between S&T activities and the strategic outcomes is not as a rule explicit.

In some cases, broader departmental objectives reflect S&T objectives (e.g., AAFC, but not the CFIA) (Golder and Haley, 2004). The difference does not appear to be due to how much S&T the organization conducts, or its importance within the organization, but simply to how the organization decides to report its activities writ large. The objectives of S&T activities cannot be understood fully by reviewing key reporting documents.

The socio-economic objective categories used in the federal S&T surveys do not always account for the S&T-related broader organizational objectives identified by departments and agencies in key reporting documents. For example, they cannot fully account for the three strategic outcomes identified by the CIHR in the organization's 2008-09 report on plans and priorities: advances in health knowledge, people and research capacity, and knowledge translation and commercialization

Currie's (2006) observation that the available statistical information provides little help in trying to identify how much federal intramural R&D supports the objective of economic development illustrates the difficulty of fully accounting for objectives.

Future policy research could identify, examine, and compare current sets of S&T objectives from different organizations and jurisdictions. It could also explore the relationship between S&T objectives and the strategic outcomes of departments and agencies. The results could improve impact measurement and reporting by better accounting for S&T objectives and better relating S&T to general organizational objectives.

Officials from the TBS have indicated their willingness to work with the S&T community and other central agencies to explore ways to facilitate horizontal S&T reporting leading to more consistent aggregated information regarding results-based management of S&T, drawing on experiences from other horizontal reporting initiatives.

Science and Technology Objectives, Activities, and Impacts

Globerman (2009) defined non-commercial impacts in terms of public goods and explored evidence concerning impacts associated with three particular public goods: a cleaner environment, improved public health, and enhanced public safety. Globerman's approach illustrates how concepts from welfare economics can be applied to explore objectives and impacts.

Science and technology objectives could also be explored by analyzing the activities and outcomes of the Federal S&T Map. Future work on objectives could also benefit from the past examination of S&T roles by the Council of Science and Technology Advisors (1999).

Activities are located between objectives and impacts, and can usefully be identified and adjusted based on a combination of working forward from objectives (i.e., activities can be deduced from objectives), and backward from impacts (i.e., based on empirical assessment). Accordingly, future policy research on S&T objectives might help to inform priority setting as well as impact assessment.

Conclusion

The federal government committed in 2007 to increase its accountability to Canadians by improving its ability to measure and report on the impact of S&T expenditures.

This report has identified steps already taken to deliver on this commitment, as well as further steps that might better demonstrate results for Canadians. While implementing additional measures would realize benefits, they would not be without cost. Planning, measuring, reporting, and assessing S&T activities as described here would require additional investment by the federal government.

The remaining challenge for policy makers is to assess both the benefits and costs of the potential actions in greater detail and then act accordingly to maximize benefits to Canadians in relation to costs.

Expressed in terms of the definitions and concepts presented earlier, the potential actions identified in this report are the outputs of a horizontal policy research project. Whether they will make a difference will depend on whether policy makers translate them into actions that deliver results for Canadians.

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Notes

[1] For example, the 2007 Budget called for improving tracking and reporting on the impacts of research expenditures to enhance accountability and value for money. The 2005 framework for federal S&T identified the need for transparency and openness at each step of the S&T process. The Government of Canada (2006) noted in *Advantage Canada* that investments in primary research must be measured rigorously and objectively.

[2] The Auditor General noted the relationship between reporting on S&T and the quality of decisions in 1994: when he noted that the government would be limited in its ability to make sound decisions until better information exists on the results of its S&T portfolio.

[3] A 2008 report by a federal S&T strategy implementation working group identified the following forums: reports on plans and priorities, departmental performance reports, standing committee reviews, ministerial advisory committee reviews, Auditor General reviews, the Treasury Board Strategic Expenditure Review, parliamentary estimates reviews, the Treasury Board Budget Review, federal government S&T council reviews, third-party reviews (e.g., Council of Canadian Academies), results management and accountability frameworks, departmental science strategies, and ministerial budget approvals.

[4] The MRRS guidelines (TBS, 2010) identify three kinds of outcomes: immediate, intermediate, and long-term or final. For simplicity, this report uses “intermediate outcomes” to capture the first two categories, and “final outcomes” to capture the last category.

[5] These short examples are illustrative rather than definitive. Things can be more complicated. For example, goods and services and consensus standards would be considered outputs in cases where they are products or services that stem directly from the activities of a program. In the case of patents, if they are generated by the federal government directly, they would be considered outputs. If a patent was generated by a third party (e.g., a firm) funded under a federal program, it would be considered an intermediate outcome.

[6] The Project Management Institute (2004), a professional association for project managers, draws a useful distinction between projects and operations in an American national standard: operations are ongoing and repetitive, while projects are temporary and unique.

[7] The three documents are the *Policy on Evaluation* (TBS, 2009b), the *Directive on the Evaluation Function* (TBS, 2009c), and the *Standard on Evaluation for the Government of Canada* (TBS, 2009d).

[8] That is, evaluations both depend on and can inform performance measurement. See, for example, sections 6.1.10 and 7.3.1 of the *Policy on Evaluation* (TBS, 2009b).

[9] These two surveys are referred to throughout the report as “the federal S&T surveys.”

[10] NRC (2010: 2.1 NRC Strategic Outcome #1).

[11] The review was based on a listing of federal programs aimed at technology commercialization presented in a report from 2005 prepared to support the work of the Expert Panel on Commercialization (Impact Group, 2005). The report was based on a database of programs assembled by Industry Canada. An inventory of federal S&T or R&D programs that would facilitate examining this issue more generally does not exist. This source was employed because it was the most detailed inventory of S&T-related programs identified.

[12] The Executive Summary of the report is accessible. Most of the framework results are presented in section 5 of the report, entitled “Innovation Capacity.”

[13] The interest in and work on lag times of Denys Cooper, a former NRC program director, was the starting point for the analysis summarized here, and his comments improved an early draft. Two economics students from Carleton University, Bilal Nasrallah and Khalid Saheb, tracked down documents identified by Denys. Pierre Mohnen, Louise Earl, Peggy Borbey, and Shannon Townsend provided additional references and comments. All the documents were reviewed and this text was prepared by Peter Reinecke and Alan Painter from the Policy Research Initiative.

[14] The Auditor General identified this as an area in need of improved performance measurement in 2007.

[15] Unfortunately, Canada was not included in the study.

[16] The document's formal name is *Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development*. It was published by the OECD in 2002.

[17] See, for example, guidance developed by TBS to support the Cabinet Directive on Streamlining Regulation (TBS, 2007b), as well as the results of work on regulation led by the Policy Research Initiative.

[18] See OECD (2006) for a description of key initiatives.

[19] "In many cases, projects have multiple objectives and a department assigned its expenditures consistent with the stated objectives of the department" (Statistics Canada, 2005, page 66).