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# THE FUTURE OF SCIENCE AND TECHNOLOGY AT NATURAL RESOURCES CANADA

Prepared by

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## Deputy Minister's Message

I am pleased to present this report on “The Future of Science and Technology at Natural Resources Canada” (NRCan). This in-depth analysis was undertaken to develop recommendations about the future vision, organization and delivery of science and technology (S&T) in the department.

Canada's national innovation system continues to evolve. S&T-related policy issues are becoming increasingly more complex and the need for knowledge to support decision-making continues to grow. At the federal level, major investments in research and research institutions are giving the Department new opportunities for innovative partnerships. At the same time, budget and other considerations are requiring us to more tightly define our S&T priorities.

NRCan's S&T work remains critical to the sustainable development of Canada's natural resources and a fundamental part of our mandate. At the same time, as one of the largest science-based federal departments, NRCan's S&T plays a role in overall Government of Canada priorities.

This study represents an important first step towards the refocusing of NRCan S&T in response to the evolving national innovation system. We have already begun to implement some of its recommendations.

NRCan will continue to be a leader in federal S&T, building on the Government of Canada's commitment to strengthening government science — for the Canada we want, for ourselves and for future generations.



George Anderson

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## Executive Summary

The Study on the Future of Science and Technology at Natural Resources Canada (the “NRCan S&T Futures Study”) was initiated in September 2001 at the request of the Deputy Minister. The purpose of the study was to provide the Deputy Minister and the Departmental Management Committee with analysis and recommendations concerning the future vision, organization, and delivery of S&T at NRCan. The study methodology included group discussions with scientists and science managers from across the department; laboratory tours of NRCan facilities across the country; the evaluation of different models of S&T program delivery; and analysis of trends in the evolution of federal S&T and NRCan’s S&T resource base. In parallel with this, the Corporate Services Sector undertook a series of resource demand analysis pilots on S&T programs, in partnership with the sectors. Finally, a related study on the views of external clients and partners on NRCan’s S&T activities and future directions was undertaken, and is available on request.

This summary report describes the purpose and methodology of the study, summarizes the key observations that emerged over the course of the study, and provides background information on several issues of concern. Information compiled in support of the study is contained in a set of appendices, which are available on request. The report concludes with a series of recommended actions that could be initiated or implemented within the next two years.

The NRCan S&T Futures Study was primarily focused on addressing issues internal to the department, in the context of broader trends and challenges facing government S&T organizations. Discussions with scientists and science managers, coupled with the review of different models of NRCan S&T delivery, has revealed significant issues for consideration. While the perspectives shared by scientists and science managers were by no means homogeneous, consensus emerged around certain themes and observations, which are presented in this report. Many of these observations were also raised in the interviews with external clients and partners.

With respect to the financial situation, each of NRCan’s four S&T sectors absorbed large reductions in their A-Base resources in the mid-1990s, seriously impacting their S&T program budgets and the availability of capital needed to renew and maintain the department’s aging S&T infrastructure. However, there are wide differences across S&T program areas with respect to their present degree of

dependence on external (non A-Base) sources of funding; the state of capital assets (buildings and scientific equipment), and the current or projected gaps in their S&T workforce expertise.

With respect to S&T delivery options, the study revealed that many examples of highly creative delivery models and arrangements have evolved within the department to respond to financial pressures as well as new opportunities within Canada and internationally. However, there was only limited awareness across the department of the innovative delivery models already in place. In large measure, the delivery models and arrangements were designed to meet the particular circumstances of individual S&T programs or sectors, within sectoral contexts and frameworks as opposed to a broader departmental context. As such, one issue that emerged during the study was the lack of clarity, at the S&T project and program level, regarding their alignment with and contributions to the broader strategic priorities and policy needs of the department and the government.

Another key theme to emerge was the role of NRCan S&T within the national system of innovation, including R&D and related science activities performed, funded and managed by NRCan. Studies undertaken by the Conference Board of Canada have emphasized the particularly critical role of government S&T to the natural resource sectors, a factor that was highlighted by many of the external clients and partners interviewed for the study. While the study did not seek to investigate this broader issue, it arose as an important consideration.

This report and recommendations are presented as the start of a process of dialogue and renewal in NRCan, rather than an end in itself. Moving forward will require potentially difficult choices on the department’s S&T roles and activities, as well as its approaches to S&T delivery (including those involving external research performers). Some S&T delivery models already employed within NRCan could be more broadly applied, and there is a need to better coordinate S&T program delivery across sectors on horizontal themes. Moreover, NRCan faces major internal challenges with respect to its S&T infrastructure and the need to ensure coordination and harmonization with the department’s S&T workforce. Faced with renewal of both its S&T infrastructure and personnel, the timing is right for NRCan to reassess its core S&T roles and responsibilities, and to make strategic choices with respect to how it will deliver its

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S&T roles and responsibilities in the coming years. By working together as a department, NRCan can achieve a higher level of excellence and relevance in delivering and managing its S&T resources.

A draft report on the study's main observations, conclusions and recommendations was provided to the Deputy Minister and Departmental Management Committee (DMC) in June 2002. The report has been revised to reflect these discussions and subsequent comments by the Deputy Minister, DMC members and the Science and Technology Coordinating Committee (STCC).

The report recommends a series of follow-up actions in response to the main observations and conclusions stemming from the study. The proposed time frame for implementing or initiating the recommended actions is Fall 2002 – Summer 2004. Short-term (i.e., 2002-2003) recommendations include improving departmental level S&T information; continued analysis of NRCan's S&T infrastructure (capital facilities and equipment, human resources) at the program level; increasing synergies between sectors in terms of sharing facilities and equipment (particularly on the Booth Street Campus) as well as with external partners; and piloting horizontal S&T networks within NRCan, focussed on cross-cutting policy issues. Finally, it is proposed that STCC support the implementation of the recommendations.

## Introduction

The use of science and technology (S&T) to support the sustainable development of Canada's natural resources and foster knowledge of the state of Canada's landmass is central to NRCan's mandate and ability to support government priorities. There are many varied interpretations of what constitutes S&T activities. For the purposes of this report, S&T includes two main activities:

- Scientific research and experimental development (R&D); and
- Related science activities (RSA) such as data collection, information services, monitoring, and mapping.

According to *Investing in Excellence 1996-2001*, the latest annual federal report on S&T, R&D is "work performed to increase or enhance knowledge in order to create or improve applications of S&T". RSA is defined as, "activities to reinforce the findings of R&D by disseminating and applying S&T knowledge. Data collection, testing, scientific and technical services, and museum services are examples of RSAs".

NRCan is one of the largest federal science-based departments and agencies (SBDAs) with expenditures on S&T representing over 60% of its total annual expenditures. In terms of total S&T expenditures (i.e., R&D + RSA), NRCan is the seventh largest federal science-based department and agency (SBDA).

In recent years, NRCan has fallen in its ranking relative to other departments with respect to annual S&T expenditures. This is the combined result of large reductions in the department's A-base resources and the emergence of new S&T organizations, such as the CIHR. New S&T funding to NRCan in recent years has been "special purpose" funding for sunseting initiatives addressing specific issues, rather than core departmental (A-base) programs. Recent data by Statistics Canada on the changes between 1995-96 to 2000-01 in real S&T expenditures by twenty-six federal agencies and departments indicates that NRCan had the largest decrease in S&T A-Base funding. However, other major SBDAs also experienced large reductions in their levels of S&T expenditure over this period, including Environment Canada and Agriculture and Agri-Food Canada. In common with NRCan, they face many of the challenges and changing circumstances influencing federal S&T.

NRCan is a complex organization, which relies on S&T knowledge and information to achieve a wide variety of objectives. The department's S&T includes both external

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and in-house S&T delivered primarily, but not wholly, through its four S&T sectors – each of which has its own strategic planning and management structure, client base and research priorities.

S&T is seen as integral to NRCan's mandate and to addressing government priorities. Not surprisingly, the variety and breadth of NRCan's S&T reflects the breadth of this mandate. The department's S&T covers highly heterogeneous subject matter, including the provision of information to Canadians, policy and regulation in support of several federal acts; promoting technological innovation and competitiveness in Canada's resource-based industries, and international negotiations and cooperation on global science issues. In addition, NRCan S&T programs are found along the full spectrum of the innovation continuum, including basic research, national monitoring and database development, scientific data and information dissemination, pre-competitive R&D, and new technology deployment.

Traditionally, the department has been foremost a performer of S&T, while providing funding to external organizations in the form of research grants and contributions for targeted purposes. In relative terms, funding for "extramural" S&T remains below 20% of the department's overall S&T spending. However, the approach to the conduct and delivery of S&T has significantly changed across all NRCan S&T sectors. Of particular note is the increasingly limited amount of NRCan S&T that is performed outside of a partnership or cooperative research arrangements with others.

### ***S&T Policy Context***

The S&T policy context within which NRCan operates has rapidly evolved over the past decade. The pace of change has been such that NRCan has experienced difficulty in developing department-wide S&T management responses. Several factors are contributing to the need for NRCan, as a department, to review its S&T roles and priorities and possibly re-focus its internal S&T activities. These factors include:

- The national innovation system is undergoing a major evolution. The federal government is making significant new investments in university research, through increased funding to the granting councils and the creation of several new S&T funding institutions, e.g., the Canada Foundation for Innovation, the Foundation for Sustainable Development Technology in Canada, Genome Canada and the Canadian Foundation for

Climate and Atmospheric Sciences. These new investments and institutions have created new opportunities for NRCan to develop synergies with university and industrial partners, by exploring and entering into alternative S&T delivery partnerships

- NRCan's current portfolio of S&T facilities and equipment is becoming increasingly unreliable and costly to operate and maintain.
- NRCan faces significant challenges with respect to its S&T workforce. Demographics analysis suggests that NRCan will lose a significant portion of its S&T workforce over the next 5-10 years, with a commensurate loss of corporate knowledge. This is anticipated to be a period marked by significant competition for highly qualified personnel.
- Despite the fact that the department's budgetary resources were significantly affected by government downsizing in the 1990's, NRCan has attempted to retain S&T efforts in a wide range of traditional areas of S&T activity, with the result of highly stretched S&T program budgets and personnel. Although the department has made concerted efforts over the years to make the case for increased core resources for its S&T programs, these have had limited success.
- Extensive discussions have taken place at the level of senior federal officials on new approaches for the management and delivery of federal S&T. These include the possibilities for rationalizing existing S&T programs across federal departments, and developing new horizontal S&T initiatives, such as federal S&T networks combining the efforts of federal, university and private sector institutions.
- External advisors, notably the federal Council of Science and Technology Advisors (CSTA), have also stressed the need for federal S&T organizations to re-evaluate their S&T roles and responsibilities in order to ensure the alignment of their S&T activities with departmental mandates, linkages with other organizations in the national innovation system and the excellence of federally performed S&T.
- Central agencies have expressed concerns about the apparent inability of federal SBDA's to set S&T priorities and re-allocate resources from low to high priority areas of activity, as well as their inability to rationalize S&T activities in areas of overlapping

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mandates and to form effective S&T partnerships with other institutions in the national innovation system.

Other federal science-performing departments in Canada, as well as government S&T departments in other countries face similar challenges. In 1995, the United States (US) Congress eliminated the US Bureau of Mines, a federal science agency with a \$140M budget whose work focused primarily on environmental geology and mine safety. In the same session, Congress came within a few votes of eliminating the US Geological Survey a long-established federal S&T organization with a budget of over \$850M and a staff of over 10,000.<sup>1</sup> The USGS was saved by the interventions of other government departments, who articulated the relevance of USGS S&T activities where they could not.

More recently, in August 2001 the US Office of Management and Budget (OMB) announced a plan to develop criteria for federally funded S&T programs, including those in academia. The OMB has criticized the handling of these funds by government departments and that the ultimate goals of projects funded by federal research are not always clear. As part of the US President's Management Agenda, the OMB recommendations call for objective investment criteria covering federally funded S&T projects to assess past and future S&T performance. The US Department of Energy (DOE), which spent more than 40% of its 2001 budget on S&T, is serving as a pilot for this initiative.

Significant changes have recently been initiated within some Canadian federal S&T organizations. Agriculture and Agri-food Canada is currently undertaking a major internal re-organization of departmental S&T activities to increase S&T integration with policy development and program delivery. The National Research Council has pursued a successful strategy of S&T visioning, budgetary reallocations to new areas of priority, and greater community-based delivery of S&T activities through the development of technology clusters. Environment Canada has developed departmental business line tables to manage its S&T activities in a matrix fashion and is experimenting with different S&T delivery mechanisms, such as the creation of government-university research networks, co-location at universities and privatisation.

Within NRCan, there have been some significant shifts in S&T management at the level of individual S&T sectors.

- The Earth Sciences Sector (ESS) has initiated a process to develop an issues-based ESS Science Strategy, focussed on achieving specific outputs and outcomes addressing identified government priorities. This Strategy has established a new management process for ESS's S&T programs in both the Geological Survey of Canada and Geomatics Canada.
- The Canadian Forest Service (CFS) has organized the science programs of its Forestry Research Centres into five nationally managed forest S&T networks, each of which is led by a different centre.
- The Minerals and Metals Sector (MMS) has expended significant efforts to develop new models of research partnership and collaboration with Canadian universities. It has worked with Canadian universities to propose a Major Facilities Access Grant to the Natural Sciences and Engineering Council of Canada (NSERC) in the area of materials technology. This effort is proposed as the basis for a broader Materials Innovation Cooperative (MIC), which would be a national consortium partnership between NRCan's Material Technology Branch and nodes, established at Canadian universities.
- The Energy Sector (ES) has made the development of energy research networks a focus of its activity. The three ES Energy Technology Centres, located in Devon (Alberta) Varennes (Quebec) and Bells Corners (Ontario) have each become hubs for specific energy research partnerships, such as the Canadian Oilsands Network for Research and Development (CONRAD). Integrating science and policy objectives is another major management focus within the ES.

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<sup>1</sup> Froedman, R. 2000. Science and the public self. *Technology in Society*. 22: 341-352. As Froedman noted, "Congressional critics questioned the need for such agencies on several grounds. First they were dubious about the relevance of the research being done. Second, they asked whether private companies could more easily handle those aspects of the work that were relevant. And third, questions were raised regarding the objectivity of the research: were agency scientists promoting their own values in the guise of objective research?"



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## Purpose and Approach

In September 2001 the Deputy Minister of NRCan asked the department's Chief S&T Advisor (Dr. Yvan Hardy, Assistant Deputy Minister of the Canadian Forest Service) to carry out a study in partnership with Bruce Holden (Assistant Deputy Minister, Corporate Services Sector) that would outline options for innovative delivery of S&T at NRCan. The purpose of the study was to provide the Deputy Minister and Departmental Management Committee (DMC) with analysis and options concerning the future vision, organization and delivery of S&T at NRCan that would meet the department's core S&T responsibilities, while maximizing opportunities for S&T alliances and partnerships.

The study involved analyses and reviews of:

- current trends in S&T delivery within Canada, including federal policy directions for S&T investment and delivery;
- the S&T roles and responsibilities of NRCan;
- innovative S&T delivery mechanisms in NRCan and other federal SBDAs;
- new opportunities for NRCan to fulfill selected S&T roles and responsibilities through alternative delivery mechanisms; and
- options and opportunities for long-term transformation of S&T delivery in NRCan, through alternative approaches or partnerships.

The NRCan Departmental Management Committee (DMC) approved the Terms of Reference for the NRCan S&T Futures Study on October 31, 2001. Progress updates were provided to the departmental Science and Technology Coordinating Committee (STCC), the Minister's Advisory Council on Science and Technology (MACST) and sector S&T Advisory Boards. A reference group of NRCan scientists drawn from the four S&T sectors met several times over the course of the study to provide input to the main observations and conclusions of the report. Ongoing secretariat support for the S&T Futures study was provided by the Corporate Policy and Portfolio Coordination Branch, and for the resource demand analysis pilots by the Financial Management Branch of the Corporate Services Sector.

The study components included:

- Internal interviews and analysis of current NRCan S&T roles and responsibilities. Site visits and group interviews (with scientists and science managers) were conducted at seventeen NRCan facilities by the Chief

S&T Advisor, with the support of the Director General of NRCan's Financial Management Branch. These discussions focussed on varied issues, including: the current range of NRCan's S&T activities; future opportunities for alternative delivery of NRCan's S&T; new approaches to improve S&T integration with partners; current limitations associated with NRCan's S&T resources and capital assets; and the types of mechanisms or flexibilities needed by NRCan scientists to deliver S&T in innovative ways.

- Analysis of the main issues and considerations related to S&T delivery at NRCan, including: drivers of change; major areas of NRCan S&T delivery; NRCan's present range of S&T activities (legislated requirements and areas of flexibility), and analysis of S&T delivery challenges, such as capital rust-out and personnel requirements
- Compilation of case study examples of innovative federal S&T delivery models, both within NRCan and within other federal government departments and agencies.
- Interviews with external partners and stakeholders, including other federal departments and agencies, the granting councils, universities, the private sector and non-government organizations. These interviews, conducted by a consultant, focussed on opportunities, barriers, and challenges to more effective and innovative delivery of S&T by NRCan, as well as possible approaches or incentives, which might be pursued in the future. A key focus of the interviews was to assess the willingness of partners to work with NRCan in the formation of new and mutually beneficial S&T delivery approaches.
- The identification of key issues requiring attention by the department and of recommended actions for consideration by the Deputy Minister and Departmental Management Committee.

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## Main Observations

Observations reflected both challenges and new opportunities for the department, emerged from the study. Although the internal discussions tended to focus more on immediate operational concerns, rather than longer-term issues and future directions for S&T at NRCan, there was a surprising degree of consensus regarding the challenges facing the department. External perspectives, summarized in the consultant's report, show a high degree of consistency with many of these themes and issues that were raised internally. The central observations are broadly summarized as follows:

- NRCan has many outstanding S&T programs, scientists, and models of S&T delivery. The diversity of S&T programs at NRCan, however, mitigates against the application of a one-size-fits-all approach to S&T delivery within the department. The diversity of S&T delivery approaches within NRCan speaks to both the complexity of the department's S&T, as well as its scope. Some approaches, however, could be expanded to form the basis of new NRCan-wide S&T models where applicable and efficient.
- NRCan supports an extremely diverse range of S&T activities, covering the entire spectrum of R&D and key areas of related science activities (RSA). Sector-specific S&T responsibilities and management approaches at NRCan are well established and most are undergoing productive evolution to better link S&T activity with policy priorities and to address emerging government issues. On the other hand, NRCan has relatively weak department-wide approaches to S&T management information and tracking systems. This has led to poor understanding and identification of S&T initiatives, equipment, facilities, and skill-sets that cut across sectors, and missed internal opportunities for rationalization, leveraging and teamwork. There are significant opportunities for the development of operational and functional S&T teams and/or networks within NRCan, extending to external partners, but there are no designated processes to manage S&T issues horizontally.
- As a department, NRCan lacks a departmental profile, vision, and direction for its S&T. Although its S&T is delivered by long-established, recognized organizations such as the Geological Survey of Canada (GSC), the Canadian Forest Service (CFS) and Canada Centre for Mineral and Energy Technology (CANMET), there is little departmental profile or recognition of NRCan's S&T roles, strengths or contributions.
- There is strong internal support for NRCan's S&T efforts to become increasingly more issues-based and top-down management directed, but in a manner that allows for bottom up scientific input and foresight. The perspectives of end-users and partners need to be included in S&T priority setting. Stronger linkages and communications are needed between sector S&T programs and policy and program priorities at the departmental and government level.
- NRCan will face significant difficulties in maintaining its S&T capacity without instituting changes in the delivery and organization of its current S&T program activities. The department's available capital resources are insufficient to maintain, let alone renew, the department's current S&T facilities and equipment base. Pending retirements of scientific staff will create major recruitment challenges, which will be exacerbated by the increasing competition for highly qualified personnel. As a department, NRCan has not identified the S&T "core competencies" that it currently needs or would like to develop in the future. NRCan needs to examine its S&T roles and relationships with other organizations, beyond that of simply being an S&T performer. This effort would answer the question posed by the Council of Science and Technology Advisors (CSTA), "S&T for what"?
- All of NRCan's science sectors absorbed large reductions in their budgetary resources in the 1990s, which severely constrained O&M and salary budgets and the availability of capital needed to renew and maintain the department's S&T infrastructure. There are, however, wide differences across S&T program areas with respect to their reliance on external sources of funding and the state of their S&T capital assets and workforce requirements. One of the key responses to a declining S&T resource base has been the development of many innovative S&T partnership and delivery models by NRCan project and program managers. In many cases, however, there is limited knowledge or awareness across the department of these new delivery models.
- NRCan has made strong commitments to S&T partnerships and collaboration, but the department currently lacks adequate financial and management flexibility to support S&T project and program managers in initiating or committing to emerging S&T partnership opportunities. In many areas, setting

targets for revenue generation by S&T programs may serve more as a barrier than an incentive to managers in developing or attracting interest in alternative delivery arrangements with external parties. Many NRCCan S&T project and program managers have difficulty determining where to provide leadership in cooperative research initiatives, or even when to be a participant. In short, the department lacks an overarching strategic framework to guide the necessary S&T program planning and decision-making.

## Key Issues Requiring Attention

### *Defining NRCCan's S&T Mandate*

There is a general consensus that NRCCan must become more focused in terms of defining its S&T activities. An outstanding question is whether such an approach should continue to be done along sectoral lines or at the departmental level. A clear message was that a common set of objectives, which could help direct NRCCan's S&T efforts, would be welcomed by NRCCan's S&T personnel. This would provide a degree of direction from senior management, and would best be developed through a participatory process involving management and staff. The National Research Council (NRC) of Canada is often cited as a federal S&T organization that has dedicated significant time and effort in recent years in defining its S&T vision and mandate. This approach has had positive effects, both internally and externally. The NRC effort has been a highly participatory process, with strong leadership from the President that has helped the NRC to establish clear S&T priorities and strategies for the future.

NRCCan is engaged in wide-ranging S&T activities. Several scientists questioned whether the spectrum of activities was too wide; others referred to the department as "trying to be everything to everybody". Many of those involved in the group discussions indicated that the department must clearly identify those areas where no one else would produce the needed knowledge and information (i.e., niche areas), and those areas where the S&T could be delivered by external performers (e.g. provinces, other federal departments, academia or industry).

*"We need to better understand what the government wants to get from its science efforts. The department cannot be all things to all people."*

*"We should determine areas where no-one else will produce needed knowledge. Determining these niche areas should include assessments of what should be done inside government and what should be done by external parties."*

*"We have to be prudent about chasing dollars and focus on key areas aligned with mandate. The ideal situation is bottom-up ingenuity coupled with top-down management guidance on priorities aligned to mandate. The department's mandate is currently too broad - and is becoming increasingly broader. We need to make the mandate clearer, and put the appropriate resources into meeting the core mandate."*

*"There is a need for a dialogue to direct where we are going, both from an S&T and policy perspective. We need to get policy and S&T directions working together. We need to have a better idea of where S&T fits within the broader priorities of the sector and the department."*

Selected quotes from NRCCan scientists

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There was a general consensus on the need for NRCan to determine core S&T roles. A related view was that NRCan's S&T activities are trying to serve too broad a range of government and external clients. It was proposed that NRCan foster an internal discussion on the roles that it should play within the national innovation system, including those that only NRCan can do or that it is specifically mandated to do.

One option would be for NRCan to re-profile or phase out some S&T activities, in order to free up some program resources for other NRCan S&T programs or to fund new S&T partnership initiatives. There was a clear consensus on the need for NRCan to create an internal environment that enhances the ability to deliver S&T programs and activities.

#### ***Availability and Comparability of Information Concerning NRCan S&T Activities***

While NRCan S&T activities and programs can be described in detail, particularly at the sector level, a key issue identified in the course of the study was the lack of information at the departmental level on the relative efforts of NRCan in support of different types of S&T (e.g., basic and applied research, technology development and demonstration, monitoring and data integration, etc). With the exception of the NRCan sector estimates of aggregate S&T expenditures and personnel submitted to the annual Statistics Canada survey of federal S&T activity, there is no department-wide information specific to S&T activities. Information on departmental and sectoral activities is maintained in relation to the department's five corporate goals that are used in the annual expenditure planning and "main estimates" processes, but does not break out S&T activities specifically. There are no standardized descriptions of different S&T roles and activities (even at the level of R&D vs. RSA), leading to comparability problems in evaluating S&T activities or resources within and across sectors.

#### ***NRCan as a Knowledge Integrator/Disseminator***

Considerable NRCan S&T resources are devoted to gathering data and converting it to information and knowledge. New initiatives such as GeoConnections, the National Atlas online, and the Georgia Basin Digital Library were also cited as positive new models for making S&T data, information and knowledge more available to the public and decision-makers.

In many respects, NRCan is a mature information and knowledge management organization. It gathers information, organizes, synthesizes and interprets it, and makes the results public, often through scientific and technical reports and peer-reviewed publications. The department also has multiple information dissemination units. But the extent of knowledge integration and dissemination activities, and the formal mechanisms for planning and conducting these activities, are highly variable across the department. No central source of NRCan S&T information exists, and inadequate corporate effort is devoted to developing strategic S&T communications and information dissemination. Finally, it was noted that the S&T promotion and reward system within NRCan, particularly for S&T personnel, while recognizing new information production, is not designed to specifically accommodate knowledge coordination, integration or dissemination functions.

Several participants in the study indicated that federal departments, including NRCan, are not dedicating sufficient resources to S&T communications, or to linking S&T information with knowledge users. The "Science in the Centers" outreach model was cited as an approach that could be pursued widely by the department.

#### ***Linking S&T with Policy and Program Priorities of NRCan***

An issue that was often raised in the course of the study was that additional steps need to be taken to increase the attention given to linkages between individual S&T program areas and the policy and program directions of the department. While S&T policy and program objectives are explicitly linked at the sectoral level, there was recognition that these linkages were not occurring at a departmental level.

Many NRCan scientists expressed frustration with the notion that their S&T efforts continue to be isolated from the policy directions and activities of the department. Moreover, differences in perceptions of NRCan's core functions and the role of S&T within the department have led to confusion and uncertainty with respect to how S&T should link with policy and program functions. Many scientists within the department view the department as an S&T organization, whose primary function is to produce excellent research and scientific data in support of the natural resources sector. An alternative notion is that NRCan is primarily a policy and program delivery department, and that NRCan's S&T activity should be limited to playing a supporting role for these functions.

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The department has taken steps to improve the integration between S&T, policy and program functions. For example, the Energy Sector has explicitly linked S&T and policy objectives in the performance accountability accords of all its S&T managers. Nevertheless, scientists within the department still feel that they are dissociated from the policy development processes and decision-making concerning the policy directions of the department.

### *The Unsustainability of Current S&T Assets*

Like other federal S&T departments, NRCan faces significant challenges with respect to its S&T workforce and infrastructure. The Long-term Capital Plan, prepared in 2001, underlined that the department's asset base has been significantly under-funded. This is attributed, in part, to the restrictive conditions on the transfer of building assets following the Neilsen Review (1985/86 to 1986/87) and, in part, to the government's Program Review and implementation (1994/95 to 1996/97), when NRCan was a "most-affected" department.

While there have been some limited capital infusions, from time to time, the re-basing of capital and operating budgets has not taken place. At present, capital disbursements fall short of the levels required to sustain the NRCan's asset base. Under-funding has led to a situation where a larger proportion of assets are near, or are at, the end of their useful lives, with implications for reliability, safety and operational cost-effectiveness.

For two years, the Real Property Environment and Security Branch has been developing and implementing a Real Property Management Framework to manage NRCan's portfolio of S&T facilities. The Branch recently completed a portfolio-wide assessment of the conditions of its major assets and their capacity to respond to current and emerging issues facing the department. The Branch studies have identified a number of inter-connected challenges and opportunities, which will require departmental consideration and decision. As part of a formal response to the Treasury Board Secretariat, the Financial Management Branch of the Corporate Services Sector initiated a series of pilot studies of specific program areas, the resource demand analysis pilots, to assess integrated options for renewal of S&T infrastructure, human resources, and equipment.

In the discussions with NRCan S&T staff, strong opinions were expressed within several sections of the department that NRCan's internal complement of S&T facilities and

equipment is handcuffing the department. In some program areas, considerable revenue generation is required simply to sustain an S&T infrastructure that is capital- and salary-deficient. Suggestions were made that NRCan should seek to reduce its dependence on internally owned S&T facilities and equipment, and focus more resources on co-location options and rationalization of work (with other departments, universities, and/or industry research organizations). The Energy Sector Buildings Energies Group, within the Energy Technology Branch, offers an example of an alternative approach: The Group does not maintain any laboratories or S&T assets, but seeks to establish cooperative arrangements with other labs, such as NRC labs, on a program or project basis. The Group functions somewhere between providing a laboratory role and a program implementation/funding role.

Numerous S&T staff said that NRCan's current policies and targeted approaches with respect to revenue generation and cost recovery had too great an influence on S&T priorities in certain parts of the organization. This perspective was also presented in a recent study conducted for NRCan by the Carleton Research Unit on Innovation, Science and the Environment (CRUISE). For example, the CRUISE study concluded that, in certain NRCan S&T units, up to 80 percent of total S&T staff time went to revenue-earning projects, with the remaining 20 percent spent on other core S&T activities, generally of a longer term nature. The study noted the growing conundrum on how to secure a better balance between "public good" S&T, without any clearly identifiable client groups, and S&T in support of specific users or commercial applications.

The CRUISE study found that raising revenue is still seen as a good disciplining process (when tied to other management tools, such as project evaluations and impact assessments), but that relying on revenue generation to meet S&T budget requirements could undermine the longer-term, public good focus of the department.<sup>2</sup> Scientists argued that revenue generation or cost recovery should be a strategic mechanism employed by the department only once priorities are set, rather than a survival mechanism, as is currently the case for some S&T program areas.

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<sup>2</sup> See Doern, B. 2002. The CANMET Mining and Mineral Sciences Laboratories (MMSL): Key Features of Institutional Change. Paper Prepared for Natural Resources Canada. CRUISE.

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## S&T Delivery Models

NRCan S&T project and program managers have developed many varied innovative S&T delivery options. A long-standing model of horizontal federal S&T coordination is the Program on Energy Research and Development (PERD), which serves to mobilize the collective capacity of no less than twelve federal departments and agencies in the area of energy R&D. The Lithoprobe project, supported by the Geological Survey of Canada, is a highly successful research network involving more than 800 scientists from universities across Canada in earth sciences.

There is no shortage of new ideas coming from within NRCan for innovative S&T delivery. For example, the proposed Materials Innovation Cooperative (MIC) would establish a national government-university-industry research consortium to provide leading-edge Canadian facilities for materials design, production and assessment in support of the transportation, construction and energy industries. If implemented, it would include a national research centre and a series of regional nodes, probably located on university campuses. The CANMET Materials Technology Laboratory would be transformed to function as the national centre that would be made accessible to researchers in universities, industry, and other federal institutes. Major new S&T delivery models, however, do face the challenge of securing departmental and ministerial support (including policy and financial support).

The large number of S&T delivery models currently used within the department speaks to the breadth of S&T within NRCan. Generally, the S&T delivery has tended to be customized to the situation and type of S&T activity or objective. While no one single approach can be universally applied by the department, there are opportunities to evolve departmental S&T delivery approaches, such as for research consortia, privatization or outsourcing, and co-location with universities and other departments. NRCan could also consider some near term options to respond to internal program pressures or real property considerations. It was suggested on numerous occasions that NRCan's industrial-oriented technology development programs could benefit from greater integration with National Research Council programs, creation of industry-led research consortia (similar to the national forest research institutes), university-based research consortia with NRCan financial support, or creation of Special Operating Agencies. The Energy Sector currently contracts out a significant portion of its S&T needs to meet sector program and policy priorities.

Many scientists pointed out that approaches such as co-location with other organizations have already evolved in some regional operations (e.g., co-location of the Geological Survey of Canada offices with the Department of Fisheries and Oceans facilities in Sydney, BC, and Dartmouth, NS). Scientists felt that more co-location of NRCan with other departments or with universities is an option worthy of greater emphasis by the department, but no specific groups were suggested. The issue of further decentralizing NRCan's S&T activities in order to connect more directly with Canadians arose in the course of the study. Although a significant proportion of NRCan's S&T facilities are located outside of Ottawa, there is a pervasive view that the department is largely an "Ottawa organization".

*"The ideal model would be university-government-industry collaboration. Instead there is competition because of our cost recovery policies. We need a new science policy for NRCan that encourages more students, more post-docs, less competition, more collaboration".*

*"There would be value in separating government labs from the main part of the department, like Defence Research Canada. This would reduce the focus on administration, and increase the focus on doing research. The NRC has a similar advantage, it is focussed on S&T, not administration and overhead related to issues management".*

*"There are many actors involved in (forest) research now, there is much more partnering and networking, but we still have to find mechanisms for coordinating the national (forest) research effort in Canada. It is important to determine areas where we should lead, and others where it is sufficient to participate in some way".*

*"The evolving role of institutions is key. We need an adaptable framework. We need to break down corporate barriers across organizations. There are too many overlapping mandates. There is also an opportunity to identify international spheres for focus".*

Selected quotes from NRCan scientists

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The choice of S&T delivery options open to the department must be driven by several considerations, including whether NRCan involvement necessitates internally performed S&T, or whether a funding or coordinating role would be more effective. Several scientists spoke to the need to direct more attention to NRCan roles as facilitator, coordinator, integrator and communicator of information. Performing these roles would require maintaining internal S&T capacity, but moving beyond simply being a performer of S&T. Rather than focus primarily on the collection and publication of information, it was suggested that the department give greater attention to reducing fragmentation between diverse producers of knowledge and data – play a knowledge management and integrator function, and facilitator of knowledge production.

### ***S&T Partnerships and Networks***

Scientists and science managers across the department agree that S&T partnerships are of strategic importance to NRCan's future. There was a sense at the working level that NRCan should establish S&T delivery via partnerships as a core element of NRCan's vision and operations. Numerous suggestions concerned the need for NRCan to create greater internal financial flexibilities and other mechanisms that would support these efforts. These would include mechanisms to enable senior scientists and program managers to ascertain the level of executive (and Ministerial) support, especially in the early stages of developing new S&T partnerships, which would also help to open doors with academic institutions and other federal (and provincial) research funding organizations. As NRCan sector partnerships usually arise from the initiative of working researchers and their managers, there often comes a period when concrete expressions of high-level support from within the department are needed to move emerging partnerships forward.

Currently, there is no clear route within NRCan for the review and approval of proposed new S&T partnership initiatives, especially those that would cut across NRCan sectors and may require special departmental resource commitments. Similarly, once sectors have made a commitment to a major partnership, the involvement of senior level management may be needed in seeking new federal resources or reallocating resources within the department, and in securing the participation of other federal departments and agencies. One solution would be to develop and implement a more structured mechanism for senior level review and endorsement of S&T partnership proposals from within the department.

Greater S&T partnerships within NRCan (i.e., across sectors) must also be realized. NRCan scientists and program managers indicated limited awareness of related S&T activities in other S&T sectors or program areas, and their concern with institutional barriers to greater collaboration. The study did identify examples of S&T-based networks and teams that are emerging, at the working level, within the department. The informal "Nano-club", for example, is bringing together staff from across all S&T sectors to identify S&T activities that could be of strategic importance to NRCan in the area of nanotechnologies. Many NRCan scientists indicated support for the development of cross-sectoral teams or networks that could either be oriented towards common policy problems (e.g., climate change) or based on new S&T spheres (e.g. nanotechnology, biotechnology, space technology). NRCan would need to establish internal agreement and incentives for scientists and program managers to act on opportunities for greater cross sector S&T coordination.

It was also suggested that departmental teams could help identify opportunities for rationalization, such as with respect to laboratory facilities in the National Capital Region. There was strong support for creating a departmental Laboratory Coordinating Committee similar to that used by Environment Canada, to improve NRCan laboratory rationalization and the identification of departmental priorities for new S&T capital investment. A number of functional areas that could benefit from greater internal collaboration were suggested, including: Inorganic chemical analysis; sample preparation; electron microscopy; microbeam characterization; spectroscopy; and high-end computer modeling.

Many scientists recognized the growing importance of sectoral or national S&T networks as a mechanism for facilitating partnerships. NRCan sectors have significant experience in developing and participating in such networks and flagship initiatives. The Earth Sciences Sector, for example, is a key participant in the Metals and the Environment Research Network, as well as the lead organization within the new Canadian Climate Impacts and Adaptation Research Network. The S&T programs of the Canadian Forest Service are conducted through five networks linking the forestry research centres. A key issue for consideration is whether NRCan should formalize its approach to developing or participating in larger-scale S&T networks, which would involve combining NRCan resources with those of others (at both regional and national scales).

*“What does it mean for managing a herd of researchers – to both maintain and enhance the capacity of an organization? Organize groups of compatible multi-disciplinary teams with a focus on the problem (and don’t trivialize the problem definition stage). Not everyone works well together but there are usually efficiencies in a team approach that includes diversity, comradely and collegial, professional NOT personal discussion. We need generalists who ponder the big picture but we also need good, flexible specialists. Also don’t forget that every project needs an owner – otherwise the job won’t get done. Think big. It often takes as much effort to chase \$5000-\$10,000 as \$50000-\$100,000 or more. There is no doubt that the competitive grant system has certain advantages, but it has costs. If individuals are left to seek funds on an individual, ad hoc basis this adds to the cost and creates inefficiencies. Bureaucrats should fight the urge to distribute small sums – this can be a real cost to productivity. I have heard the story of one funding body in the U.S. that distributes \$500,000,000 a year with a staff of 10. Seek ways to deflect bureaucratic requirements. Good managers should shield their staff from as much bureaucracy as possible. Good scientists should appreciate this. Lastly, managers should provide leadership by discussing ideas and opportunities and by continually pondering research projects in the big picture – the national significance of projects at local scales.”*

Dan McKenney. 2001. Economies of scale for a national research organization: Looking for opportunities beyond the nose hairs on bears.

*Forestry Chronicle*. Vol 77, No. 5. pp. 860-865.

Some scientists suggested that NRCan should create a series of S&T networks that are oriented internally, cutting across S&T issues and activity, but that would reach outwards to link with S&T partners in universities and the private sector. They noted, however, that such an approach could require re-profiling of resources (or new resources). Several NRCan scientists drew parallels between NRCan’s internal dilemma and the challenges facing other federal departments and the federal S&T community at large.

NRCan could start by establishing a set of core S&T program areas, with committed resources, to help mobilize S&T capacity within and external to the department (e.g., PERD). One area that was suggested was the need for gathering, compiling and collating primary information and data and making it available with good metadata.

Finally, strong interest was expressed by most of the S&T staff engaged in the study in building (or re-building) S&T partnerships with universities and colleges. Currently, the Canadian Forest Service and the Earth Sciences Sector both fund university partnership research programs, through the federal granting councils, but far more is possible. To increase S&T cooperation with academic institutions, NRCan would need to implement more explicit changes, at the corporate level and within operational units, to recognize and reward efforts to develop linkages with academia. This, in turn, may call for departmental mechanisms for prioritizing S&T partnership activities in different areas. One specific suggestion was to allocate internal funds (corporate, sectoral and/or program level) to enhance collaboration with universities, including helping NRCan scientists or S&T programs in joining Canada Foundation for Innovation (CFI) applications with universities.

### ***S&T Management and Governance Systems at NRCan***

NRCan S&T management issues arose in many discussions with scientists and science managers. For example, comparisons were often made to the differences across NRCan sectors in the way that S&T is funded. Some scientists and science managers indicated that, for some S&T program budgets, A-base resources support only 5% of total costs (including salary). The remaining 95% must be raised through cost recovery, contracts, and being able to access directed funds, such as PERD. In other areas, sector A-base supplies 100% of the program budget.

While recognizing that there are limitations to horizontal S&T management within the department (since many NRCan S&T activities focus on particular needs of a particular economic sector), scientists did indicate a strong desire for NRCan to work together as a department. Working horizontally, within a vertical reporting and accountability structure, will require some new management approaches. Parts of NRCan, such as the ESS and the CFS, have been working on implementing the concepts of matrix S&T management, while retaining their divisional and branch reporting structures. Doing this at a departmental level would be a challenge for all levels of management.



There was also strong support for a policy framework at the departmental level that could help guide the department's S&T programs. Perhaps most crucially was the desire expressed by the scientists for greater stability in the department's management of S&T. The issue of stability was frequently raised, even while recognizing that significant changes may be coming in order to re-profile NRCan's S&T activities. The S&T group discussions were often marked by both positive comments and frustration.

Many scientists were concerned with their careers and sought greater certainty to assist their own personal decision-making. The recent development of a cross-sector decision-making process for the allocation of S&T capital funding was seen to represent a positive pilot project with respect to departmental S&T decision-making approaches. However, these efforts will face significant limitations in the absence of accepted departmental priorities and decisions on future NRCan S&T activity.

The study observations clearly point to the need for NRCan to rethink some of its S&T management approaches. Dimensions to be addressed could include the organization of S&T activities (including horizontal), the location of S&T activities (National Capital Region versus regionally based) and the determination of core areas for internally performed S&T. There is a need for NRCan to develop department-wide S&T management processes (and criteria) to guide which S&T activities can be outsourced, privatized, or co-delivered (e.g., co-location of infrastructure with universities or other departments).

*"There are opportunities to centralize certain types of equipment and technical support for projects. Analytical labs are a good area for amalgamation".*

*"Perhaps there should be a liaison office to help the department work with other federal departments and the funding agencies - to facilitate scientific collaborations".*

*"We currently spend too much time on the Business Plan for the lab defining outcomes and accountabilities - and not enough time on furthering research partnerships and networks. There needs to be a balance between directed and targeted research and time for scientists to be completely free to pursue blue sky research. Typically, for the latter, each scientist should have 10-20 percent free time to pursue non-directed and targeted research".*

*"There are opportunities to create a more reactive and flexible S&T organization, but this will require some change, may have to reduce the number of commitments and fixed costs. We need new flexibilities, an improved O&M situation may have to be created for scientists - perhaps we need to increase the amount of buying, and focus less on making. We can't be involved in as many areas as we currently take on".*

*"The most effective approach to S&T delivery is to focus on problem solving. Problem solving research needs to accommodate regional distinctiveness and the diversity of needs across the country".*

*"With respect to the mandate, cost recovery is a challenge. Unless cost recovery is used, the labs are not viable. Cannot compete with the private sector. Government has to be ahead of the curve-pre-competitive research. We have a clear idea of what industrial partners want, but often do not have a clear idea of what government expectations are".*

Selected quotes from NRCan scientists

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## Conclusions

A combination of factors has made a re-examination of NRCan's S&T critical at this time. Despite large reductions in sector A-Base budgets since the mid-1990s, NRCan has been striving to retain a wide range of its traditional S&T activities, while taking on new ones. The result is that program resources in many areas have become stretched to the limit. NRCan faces some difficult decisions in making strategic choices on its S&T resources, given the diversity of its S&T programs and policy responsibilities. When coupled with interdependent questions on how to renew the department's S&T workforce and its aging S&T infrastructure, these choices become even more difficult.

Many of the factors that are driving change in NRCan's S&T are not unique to the department. Many other federal SBDA's are facing growing resource pressures due to flat or declining investment in federally-performed S&T, increasing complexity in S&T-related policy issues, and mounting demands for knowledge to support decision-making from both policymakers and the public. A factor common to all federal S&T departments is the growing recognition of the importance of a well integrated national system of innovation. A well functioning system should link to link together S&T capacities of different organizations (industry, academia, government) so that the capacity of the system is greater than the sum of its parts. Given their national presence and reach, federal SBDA's can play a key role in facilitating and enabling these linkages.

Many SBDA's are starting to recognize the importance of switching emphasis from a single-minded focus on the *performance of S&T* to an emerging model where the focus is on *ensuring the performance of, or timely access to, S&T knowledge and information* for wealth creation, policy, regulation and other federal roles. In this emerging model, SBDA's would maintain strong in-house S&T expertise and perform specific S&T activities unique to federal mandates and information needs, while nurturing the capacity, mobilization and collective performance partner institutions across the national system. Federal SBDA's would no longer rely on themselves as the predominant generators of S&T knowledge in support of federal and national policy. Indeed, the bulk of S&T might be produced outside government.

Another factor driving change in federal S&T is the growing S&T capabilities of other domestic and international institutions. Canadian university research capacity is undergoing a period of rejuvenation, thanks to new

government investments. Changes in how the government meets its requirements for S&T knowledge are also taking place as the result of growing support for new delivery models that stress partnerships, alliances and networks. Finally, demand is increasing for two different kinds of knowledge. The first is specialized knowledge of all descriptions. The degree of specialization is such that any individual organization would have trouble staying at the forefront of S&T progress. The second is integrated knowledge, of the kind that comes from the fusion of disciplines. This calls for the ability to combine and assess knowledge from many different fields and sources.

As NRCan evolves as an organization within the national innovation system, it must look to building its capacity in:

- Providing leadership;
- Identifying departmental, regional and national priority S&T themes;
- Coordinating external funding to address S&T gaps in departmental or federal S&T;
- Creating, funding and participating in research net works;
- Synthesizing metadata and providing quality control;
- Integrating S&T results into policy, services and programs; and
- Providing S&T outreach and communications.

To address its internal financial pressures, NRCan may have to look at mechanisms to better focus internally-performed S&T on core roles and priorities, and to look to flexible delivery mechanisms with external performers. The broader challenge facing the department – that of ensuring a strong, national innovation system – will require a new mix of complex skill sets and functions. The department will have to purposefully nurture S&T networking and negotiation skills, as well as management and leadership skills.

An evolution in NRCan's corporate culture is needed to support change and to seek consensus on NRCan's roles as an S&T performing organization. NRCan must become much more outward looking with respect to S&T capacity, making greater collective efforts to engage in new forms of competitive and targeted S&T with external partners. This will likely require better coordination of S&T across NRCan sectors and greater horizontal communication. Finally, internal fiscal flexibilities may need to be created to allow program managers to become more responsive to new opportunities.

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The specific challenges facing NRCan with respect to renewal of its S&T workforce and S&T infrastructure also present opportunities for the department. If approached in a strategic manner, NRCan can use S&T staff retirements as an opportunity to invest in new S&T skill sets needed for the future through recruitment and training of existing staff. To do so will require a clear assessment of S&T skills and competencies that NRCan wants to maintain, acquire and/or develop. In addressing real property and S&T capital issues, the department has a similar opportunity to pursue greater collaboration (both internally and with external partners) in new capital investments and shared use of facilities and equipment, integrated with strategic S&T human resource planning. All of these efforts will require choices and clearer direction from senior management on what S&T activities NRCan should pursue, and greater support and encouragement for S&T managers to engage in new S&T delivery opportunities in these strategic areas.

## Recommendations

The following section recommends a series of follow-up actions in response to the main observations and conclusions stemming from the study. The proposed time frame for implementing or initiating the recommended actions is Fall 2002 – Summer 2004.

### *Phase I - 2002-2003*

1. **A copy of this report should be disseminated within the department.**
2. **NRCan should develop department-level S&T management information**, linked to the NRCan information management initiative, in order to improve the availability and standardization of S&T information (R&D and RSA) at the departmental level in support of planning, reporting and decision-making processes. An initial step would be to examine the different S&T sector information systems that are in place or under development, with a view to establishing common fields and definitions for S&T program information.
3. **NRCan should continue department-wide work to better define its future S&T infrastructure (facilities and equipment) requirements and options**, including further capital demand analysis that is coordinated and harmonized with S&T human resource strategies in order to provide up-to-date information on the department's S&T capital assets and workforce. Complementing this, there is an opportunity to increase synergies between sectors in terms of sharing facilities and equipment (particularly on the Booth Street Campus) as well as with external partners. This could be facilitated through a Laboratory Coordinating Committee, which would identify innovative options for the replacement or acquisition of major capital equipment, including cross-sectoral pooling of capital resources and sharing of facilities and equipment, as well as co-investment in major capital assets with external partners.
4. **NRCan should pilot the creation of internal theme-based S&T networks** to improve coordination among sectors of S&T programs that address crosscutting policy issues. The pilot networks would explore mechanisms for greater coordination and integration of S&T program delivery across sectors, and ways to improve linkages and communications with NRCan policy and program areas and with external partners.

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5. **The Science & Technology Coordinating Committee support implementation of the S&T Futures Study recommendations**, as appropriate, based on a workplan developed by STCC and approved by DMC.

*Phase II - 2003-2004*

6. **NRCan should include an S&T visioning process**, as a central component of the broader effort to develop a new NRCan strategic plan in 2003-2004, that would position the department's S&T in the context of its mandate as well as in the context of Government priorities and the national innovation system.
7. **NRCan should establish formal departmental approaches and incentive mechanisms to support and facilitate NRCan S&T project and program managers** in initiating and participating in new S&T partnerships and cooperative delivery mechanisms where relevant to its mandate and priorities.
8. **NRCan should undertake a systematic review of the delivery options for its existing S&T programs**, including those areas that must continue to be performed in-house; those that are amenable to cooperative S&T delivery (e.g., industry- or university-led research, co-location with other departments or universities, and co-funding of external S&T), and those areas that could potentially be delivered by other institutions. This would support the identification of critical internal S&T capacity that NRCan must maintain, develop or acquire in the future, as well as the development of a national approach to major S&T areas.

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