BUILDING MOMENTUM

A REPORT ON FEDERAL SCIENCE AND TECHNOLOGY — 1998

Government of Canada
Gouvernement du Canada

Canada

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As we face the new millennium, it is more apparent than ever that we are living through a time of transition. The knowledge revolution is creating dramatic changes in our society. Science, research and technology are becoming vitally important to every sector of our economy and field of endeavour, as well as to every Canadian. Although, historically we have depended on our vast natural resources to generate wealth and maintain our standard of living, our future success will, increasingly, depend on knowledge — a resource that is less tangible, but virtually unlimited.

In recognition of this reality, in 1996 the Government of Canada announced its strategy, *Science and Technology for the New Century*. The strategy provides direction to federal departments and agencies and sets out the elements of a federal governance system for their science and technology (S&T) activities.

With this framework in place, the government moved forward with strategic investments in knowledge and innovation. Last year's *Minding our Future*, the first report on the implementation of the S&T strategy, highlighted many of these investments. This year's report demonstrates how momentum is continuing to build towards reaching the strategy's goals.

The 1999 budget clearly demonstrates the government's new framework for innovation, with significant new investments of $1.8 billion in science and technology. With $390 million over three years going to health-related research, including the innovative Canadian Institutes of Health Research, increases in funding for the Canada Foundation for Innovation ($200 million), the granting councils ($90 million over three years), and the Networks of Centres of Excellence program ($90 million over three years), as well as increased funding to federal departments performing research and development, this framework will continue our push for the creation of knowledge, its dissemination, and its ultimate application for the benefit of Canadians.

The 1999 budget builds on similar investments in innovation over the past three years. For example, in 1998, the period covered by this second report, the government:

- provided $34 million in increased funding to the Industrial Research Assistance Program of the National Research Council to provide greater support to Canadian small business in adopting new technologies and developing new products and processes for commercial markets;
- increased financial support to the three granting councils — the Natural Sciences and Engineering Research Council, the Medical Research Council, and the Social Sciences and Humanities Research Council — to provide research grants, scholarships and fellowships for advanced research and graduate students, and to expand partnerships between university researchers and the private sector (a total of $120 million in new funding was provided to the councils in 1998-99, to be increased to $150 million by 2000-01); and

- provided $55 million to the Canadian Network for the Advancement of Research, Industry and Education (CANARIE) to support the development of high-speed communications networks.

Although some observers have expressed concern about slow progress and a lack of coordination in the implementation of the federal strategy, this report demonstrates both the impact of the strategy on federal S&T and the significant progress that is being made.

Clear progress has been made in building a stronger, better-coordinated federal S&T effort, and it is apparent that momentum is continuing to build on furthering the strategy's goals of sustainable job creation, improved quality of life and the advancement of knowledge. Across the government, federal departments and agencies have focussed their S&T efforts and are achieving significant results.

In order to make the most of our S&T investment, the federal government is also increasingly collaborating with a wide variety of stakeholders. Research, development and the advancement of the knowledge-based economy depend on cooperative links and partnerships with all sectors.

Progress is also being made by the Advisory Council on Science and Technology in focussing attention on issues that are vital to Canada's future — critical skills needs and the commercialization of university research. Both of these issues are crucial to maintaining and improving our nation's position at the forefront of the knowledge society. With the formation of the Council of Science and Technology Advisors, we also have valuable external input on the management of federal S&T.

To be able to compete successfully in the global marketplace, firms must continually innovate. This is essential not only for high-tech companies, but for all sectors. The creation of new technologies and the development of new products and production processes require people who have leading-edge research skills, people who know how to put new technology to work, and a modern, sophisticated infrastructure.

Canada has the potential to become a world leader in science, research and development. As a nation, we can make this vision a reality by continuing our investment in science and technology and by achieving our goal of becoming the world's most connected country. If we work together, we can take advantage of the economic and social benefits of the Information Highway and the knowledge revolution, building a stronger Canada that will compete effectively in the new global economy. In so doing we can secure our future — for this generation and the next.

John Manley
Minister of Industry

Message from the Secretary of State (Science, Research and Development)

Canada has built a society and economy that make our country one of the best places in the world in which to live. Science, research and development have a critical role to play in ensuring both economic growth and enhanced quality of life. Canada is well positioned to benefit from the ongoing transition to a knowledge-based economy. Indeed, the World Economic Forum has ranked Canada as having the strongest technological potential of all the G7 countries. We lead the G7 in terms of home computer, cable and telephone use, and we have the highest level of post-secondary education in the world.

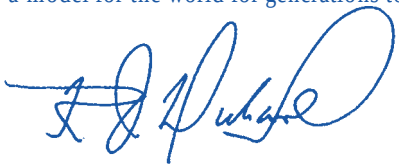
Our challenge as a country is to ensure that all Canadians have the skills to benefit from the knowledge-based economy, and to apply science and technology to all aspects of our industrial growth. We must continue to respond to this global transformation by developing policies, programs and partnerships that will assist us in working with Canadians to meet their needs.

The 1996 science and technology strategy systematically coordinates the many elements of federal S&T policy and establishes concrete goals and guiding principles. The strategy recognizes S&T's vital role in terms of protecting the health and well-being of Canadians, generating sustainable employment and creating economic growth. It points to the importance of partnerships and networks as a means of ensuring that we get the most value from our investment in S&T.

This report highlights the wide-ranging and innovative initiatives that federal departments and agencies have undertaken to implement the strategy. It also illustrates how they are creating new ways of doing business in order to better address the increasingly complex and multifaceted S&T issues the government is facing. Departments and agencies are collaborating more than ever on key issues that cut across departmental and agency boundaries.

This horizontal approach is the focus of the Council of Science and Technology Advisors, which was created in May 1998. The council, which comprises 22 members from the private sector advisory bodies to government's science-based departments and agencies, will advise the government on internal, crosscutting S&T issues that require strategic attention.

Over the past 130 years, Canadians have worked together to create a society and an economy that are envied around the world. Our challenge — and our opportunity — is to build on that momentum, to ensure that our country remains a model for the world for generations to come.



Ron J. Duhamel
Secretary of State (Science, Research and Development)

Guide to Acronyms

The following acronyms are used throughout this report:

AAFC	Agriculture and Agri-Food Canada
ACST	Advisory Council on Science and Technology
AECL	Atomic Energy of Canada Limited
CFIA	Canadian Food Inspection Agency
CSA	Canadian Space Agency
CSTA	Council of Science and Technology Advisors
DFO	Department of Fisheries and Oceans
DIAND	Department of Indian Affairs and Northern Development
DND	Department of National Defence
FPTT	Federal Partners in Technology Transfer
MRC	Medical Research Council of Canada
NCEs	Networks of Centres of Excellence
NRC	National Research Council Canada
NRCan	Natural Resources Canada
NSERC	Natural Sciences and Engineering Research Council of Canada
OECD	Organisation for Economic Co-operation and Development
SSHRC	Social Sciences and Humanities Research Council of Canada
TPC	Technology Partnerships Canada

Several abbreviations also appear regularly throughout the text:

R&D	Research and development
RSAs	Related scientific activities
S&T	Science and technology
SMEs	Small and medium-sized enterprises

Executive Summary

During the 1980s, Canada, like other industrialized countries, experienced rapid growth in gross expenditures on research and development (GERD). However, during the early 1990s, this worldwide growth began slowing down as a result of the recession and efforts by governments to reduce spending. Canada's GERD continued to grow at a healthy rate during the recession, fuelled largely by private sector investment. Federal expenditure on research and development (R&D) during this time period did not keep pace with the growth in business enterprise spending, however, and instead remained at a relatively constant level. This has meant that the federal share of national R&D has decreased from 33 percent in 1981 to an estimated 22 percent in 1998, a share that is much closer to the international norm.

Federal Investment in Science and Technology

The federal government employs scientists and engineers in every major population centre, and these researchers make a significant contribution to the generation of new knowledge. After researchers in universities and hospitals, federal scientists and engineers are Canada's largest contributors to international scientific and technical literature.

Moreover, a recent federal survey of commercialization activities in 10 of the larger science-based departments and agencies illustrates the role the federal government is playing in developing and successfully transferring technology to industry. In 1997-98, this group filed 233 patent applications and received 130 new patents. In addition, 398 new licences were signed, more than 80 percent of which were with Canadian firms. The 10 departments also reported spinning off some 20 companies in 1997-98.

The federal government also supports R&D to be undertaken by universities and business enterprises. In 1998, 41 percent of the government's total expenditures on science and technology (S&T) were on these extramural programs. Federal expenditures on university R&D increased by 11 percent, which restored university R&D funding to approximately the same level as that of 1993-94. Spending on industrial R&D increased by about 18 percent.

Improving Economic Health and Social Well-being

Last year's report, *Minding Our Future*, focussed on two key themes: innovation and people. This report highlights how these themes have been addressed within the context of the goals set out in the federal science and technology strategy, *Science and Technology for the New Century*. The three goals are to enhance the quality of life for Canadians, advance knowledge in a wide range of fields, and help promote sustainable job creation and economic growth.

Innovation Thrust of Recent Federal Budgets

"Over the past several years, we have put in place a new framework for innovation — a strategy that we have implemented step by step in each of our budgets. That strategy has three parts — the creation of knowledge, the dissemination and sharing of knowledge and the application of knowledge — its commercialization, getting ideas out into the market. This budget takes further action in each of those three areas."

– Finance Minister Paul Martin, 1999 budget speech.

In the 1997 budget, the government provided $800 million to create the Canada Foundation for Innovation to strengthen research infrastructure at universities, colleges, research hospitals and not-for-profit research institutions in the areas of health, environment, science and engineering.

In 1998-99, the government increased financial support to the three granting councils — the Natural Sciences and Engineering Research Council, the Medical Research Council, and the Social Sciences and Humanities Research Council — to provide research grants, scholarships and fellowships for advanced research and graduate students. By 2000-01, the granting councils will have received more than $400 million in additional resources and their budgets will be at their highest level ever.

Over the past year, federal departments and agencies have continued to apply innovative approaches to using S&T in fulfilling their mandates. They have worked to improve Canadians' quality of life through a variety of initiatives, which range from using a remote-sensing satellite to help respond to and monitor natural disasters, to undertaking research to diversify the aquaculture industry, to developing analytical methods for the detection of allergens such as peanut or egg protein in foods.

Innovation also characterizes the approaches that have been used by the federal government to advance knowledge. Departments and agencies are working together in new ways to ensure that key issues are addressed. To undertake research in areas of vital importance to Canada, the federal government is also strengthening its partnerships with universities and industry. The Networks of Centres of Excellence program, which teams up academic institutions, government laboratories, and private sector research facilities across Canada to provide critical mass for important research projects, has proven to be very effective and continues to produce world-class research, highly skilled graduates and dynamic spin-off firms.

The government is also stepping up efforts to ensure that commercial benefits can be reaped by the private sector from the ideas generated by both federal and university research. It is continuing to work to support the private sector and increase Canada's international competitiveness by ensuring that regulatory systems are well designed and scientifically sound. The government is also working to bring to Canada foreign technology that could significantly benefit Canadian industry and contribute to the creation of jobs.

The past year also saw a focus on people. For example, to help improve Canadians' quality of life, researchers from the natural and social sciences collaborated to produce the first-ever *Canada's Physical Activity Guide to Healthy Active Living*. Released in the fall of 1998, the guide provides Canadians with the information needed to make wise choices about their health. It is expected to become as influential a reference guide as *Canada's Food Guide to Healthy Eating*.

Through initiatives such as the Canada Foundation for Innovation and the Networks of Centres of Excellence, the government is working to help ensure that the best and brightest up-and-coming researchers are attracted to work in Canada. This is especially important because Canada's supply of young scientists and engineers is not keeping pace with the rate of retirement at Canadian universities.

The government is also seeking to better its understanding of the dynamics of the emerging knowledge-based economy. While recent college and university graduates report difficulties finding jobs in their fields, businesses are indicating that they cannot find and retain the highly skilled workers they need. Consequently, in the spring of 1998, the government undertook a series of consultations with leaders from industry, academia, labour and other stakeholders. Priorities were identified and a range of projects was initiated to respond to them.

Innovation Thrusts of the 1999 Budget

- *Canada Foundation for Innovation*
  $200 million to help meet the demand for research infrastructure in the areas of health, the environment, science and engineering.
- *Natural Sciences and Engineering Research Council (NSERC)*
  $75 million over three years to build on Canada's support for basic research and advanced studies funded by NSERC.
- *Social Sciences and Humanities Research Council*
  $15 million in additional funding over three years for new research in the social sciences and humanities.
- *National Research Council*
  $16 million in 1998-99 to invest in leading-edge equipment, plus $15 million over three years in support of national and regional research objectives.
- *Biotechnology Research and Development*
  $55 million over three years for biotechnology research and development by federal science-based departments and agencies.
- *Canadian Institutes of Health Research*
  A total of $240 million, beginning in 2000-01, to support an innovative approach to health research. In addition, a total of $150 million over three years, beginning in 1999-2000, to the three granting councils, the National Research Council and Health Canada for health-related research.
- *GeoConnections*
  $60 million over five years to make available comprehensive and integrated data about Canada's geography, environment, people and resources through the Information Highway.
- *Networks of Centres of Excellence*
  $90 million over three years to support partnerships among world-class researchers and the private sector across Canada.
- *Technology Partnerships Canada (TPC)*
  $150 million over three years to help keep Canada at the forefront of technological innovation. TPC makes strategic investments with companies to commercialize innovative products and processes.
- *Business Development Bank of Canada (BDC)*
  A $50 million equity injection to help the BDC expand financing for small and medium-sized knowledge-based and export-oriented businesses.
- *Canadian Space Agency (CSA)*
  $430 million over three years, and ongoing stable funding of $300 million annually thereafter, for the CSA to make strategic investments in space projects, science and technology.

A Coordinated Approach to S&T

The 1996 S&T strategy highlighted the need for new mechanisms and institutions for the governance of science and technology. In addition, it noted that the government needed to find ways to profit from the advice of the country's best-qualified advisors from the public and private sectors.

Toward this end, the Prime Minister's Advisory Council on Science and Technology (ACST) has established expert panels to address some key S&T issues. The Council of Science and Technology Advisors (CSTA) has also been created to integrate the various external advisory bodies used by science-based government departments to obtain expert advice. By more closely linking the ideas and expertise of government, business, finance and academia, both the ACST expert panels and the CSTA are helping to create a cooperative and coordinated approach to federal S&T.

Because biotechnology is an important component of Canada's knowledge-based economy, in August 1998, the government announced the renewal of the Canadian Biotechnology Strategy. Seven departments came together to develop a common vision and approach to crosscutting biotechnology issues. The result of their efforts is a more comprehensive, integrated strategy that emphasizes developing biotechnology as an important economic engine, within the context of social and ethical considerations.

Growth in federal policy research capability has been fostered by the work of the Policy Research Initiative, which began in 1996. The ongoing efforts of the interdepartmental research networks established under this initiative have focussed on key issues in Canadian society that are most likely to create future challenges.

Over the past year, two new challenges have emerged as priority issues for the federal government's S&T activities. These are to address global climate change and develop ways to strengthen the science-policy interface.

Global Climate Change

In April 1998, the federal, provincial and territorial ministers of energy and environment met in Toronto to consider how to implement the 1997 Kyoto Protocol on greenhouse gas emissions. They emerged from the meeting expressing a strong commitment to addressing climate change. A corresponding and important S&T priority is to contribute to a comprehensive understanding of global climate change and how to mitigate it. Federal centres and laboratories are developing new technologies to help reduce emissions in most relevant sectors (e.g., transportation and community energy). Federal S&T is also focussing on developing a suitable knowledge base for wise decision making.

The Important Link Between Science and Policy

Science is increasingly becoming a prominent factor in government decision making. Policies on the economy, regulatory systems and social welfare, to name a few, are influenced more than ever by science. It is therefore critical to ensure that the government has access to the highest quality scientific information on which to base its decisions. In addition, the implications and limitations of that science must also be clearly understood by decision makers. The interface between science and policy is becoming increasingly important, given the ramifications it can have, both for the well-being of Canadians and for the Canadian economy.

Over the coming year, departments and agencies will work to ensure they have the S&T capacity, both in-house and external, to provide the highest-quality science-based advice. They will also be implementing best practices for the conduct, management and use of science in the federal government. In order to ensure a highly effective process for providing scientific advice, departments and agencies are seeking input from the Council of Science and Technology Advisors. Ultimately, these activities aim to ensure a strong interface between science and policy — one which will play a pivotal role in helping shape Canada's future as we move into the new millennium.

1.0 New Challenges, New Ways of Doing Business

In December 1997, the federal government issued its first comprehensive report on federal science and technology (S&T), *Minding Our Future*. The report highlighted the early stages of the implementation of the federal science and technology strategy, *Science and Technology for the New Century: A Federal Strategy*, which was released in March 1996. The strategy outlines how federal science and technology activities further the goals of improved quality of life, advancement of knowledge, and economic growth and job creation. This report documents the building momentum of the S&T strategy. It also seeks to illustrate how federal science and technology have contributed both to the development of Canada as one of the world's leading economies and to a quality of life that remains the envy of the world.

In *Minding Our Future*, the government recognized two key themes: innovation and people. Indeed, the challenges in these two areas are the driving force behind a significant amount of federal S&T activity. The theme of innovation — reaping the benefits of good ideas — pointed to a broad need to seek out better ways of meeting the challenges and opportunities facing the government and the nation. This report details how innovative approaches on the part of government are contributing to the realization of the strategy goals. "People" has been another area of significant focus over the past year. This report outlines not only how the government is responding to its own people challenges, but also how its actions are helping to meet the challenges facing the nation in ensuring that Canada will have the leading-edge work force it needs as we move into the 21st century.

In the S&T strategy, the government announced its plan for situating and transforming the federal S&T effort in the context of the new knowledge-based economy. The strategy contained broad goals and a set of principles to guide departments in its implementation. As the strategy was being developed, the government was also undergoing a comprehensive Program Review, aimed at refocussing resources on core federal responsibilities to help reduce the federal deficit. Program Review had a significant impact on federal science-based departments and agencies, with some of them cutting budgets and human resource allocations by more than 30%. These cuts were spread over a number of years, and in some departments the full impact of the cuts is only now being felt.

The streamlining of government operations flowing out of Program Review has resulted in both facility closures and staff layoffs. Moreover, the implementation of the S&T strategy and the impact of the global, knowledge-based economy, and its tremendous advances in technology, have forced federal science-based departments and agencies to seek out new ways of doing business. As a result, the government's involvement has developed into a dynamic partnership with all stakeholders.

The demands placed on federal S&T have therefore expanded and diversified. In some sectors, the federal government remains as the major player in developing the fundamental research base. In others, it owns and operates major facilities and equipment that are used by a wide range of stakeholders. Certain departments and agencies have a mandate for industrial research assistance and strategic analysis.

Science and Technology for the New Century — A Federal Strategy, March 1996

Goals:

- Improved quality of life
- Advancement of knowledge
- Sustainable job creation and economic growth.

Principles:

- Increasing the effectiveness of federally supported research
- Capturing the benefits of partnership
- Emphasizing preventive approaches and sustainable development
- Positioning Canada competitively within emerging international regulatory standards and intellectual property regimes
- Building information networks, the infrastructure of the knowledge economy
- Extending science and technology linkages internationally
- Promoting a stronger science culture.

Others serve primarily to protect the environment or maintain and improve public health through regulation. Still others are responsible for the sustainable development of Canada's natural resources. Government departments and agencies also have important responsibilities for funding university research, developing enabling technologies, and levelling the international playing field in important technology and industrial areas, such as aerospace and defence, that are dominated by support from governments. The federal S&T effort also includes a wide range of activities carried out in the social sciences: research into understanding the knowledge-based economy and its impacts on people, society and the way we work; examination of the drivers of economic growth; population health and health systems; and so on. It is important to note that federal S&T includes not only natural and social science research, but also a host of related scientific activities (RSAs) — such as environmental monitoring, weather forecasting, statistical research and analysis, and premarket reviews of drugs — that contribute directly to both economic growth and improved quality of life for Canadians.

In many cases, individual departments that traditionally applied one set of policy and program instruments now use a much wider set of instruments, reflecting a different way of doing business in the knowledge-based economy. This trend is well illustrated in the area of university research. Since World War II, the federal government has been the major supporter of university research. The rationale was that university research would not only train the bright minds of the future, but also form the base of knowledge upon which the government's applied research and the private sector's technology and product development could build. More recently, it has been recognized that the university role is much more complex, and that this linear model is not the best description of the innovation process. Federal support for university research is still critical. However, with the increasing importance of linkages among the players in the innovation system, support for university research now includes not only research grants, but also programs to encourage interuniversity networking and university-industry linkages. Implicit in this expanded program base is the need for people within government to have a broader experience and knowledge base. This pattern of expanded and changing roles, and evolving human resource requirements, is repeated across the federal system.

Other departments and agencies have developed new approaches to delivering services to Canadians and undertaken a fundamental rethinking of how they can deliver on their departmental mandates and missions. This has resulted in a restructuring and reorientation of activities, aimed at modernizing approaches that date back to a different time, world situation, and technological and policy environment. The rethinking of delivery mechanisms also has important implications for the S&T effort in most departments and agencies. Research needs have always been changing, as scientific advancement is inevitable. Now, however, new knowledge and technologies are allowing for entirely new fields of research to open up.

Moreover, some fields where the federal government has significant expertise are becoming less relevant, or less feasible, to governments in a global, knowledge-based economy. In a time of government spending restraint, it is no longer possible to keep all research programs in place just because they do world-class work.

Difficult choices between competing priorities have to be made. Departments are finding that some research functions could be more appropriately carried out in the private sector, as recommended in the S&T strategy. Other research functions of course remain within the government purview. In fact some, such as those related to product safety approvals, are often duplicated by governments around the world. Thus, there are potential gains in efficiency and safety to be realized from cooperation with similar government agencies in other countries. Federal agencies are exploring ways to maintain Canada's high standards of protection and gain efficiency by contributing to, and drawing on, the international body of research. These are only some of the many new approaches being explored by departments and agencies to deliver on their mandates.

A key challenge in these sorts of activities is changing the culture within departments. In some areas, these culture shifts are dramatic — from performing research to assessing the quality of research performed elsewhere. In many cases, these new tasks require different skills and talents from the ones they replace. Departments, still trying to identify and adapt to new roles, are also faced with the daunting task of creating a work force with the skills of the future without losing the expertise built up over decades of research.

The past year has seen a number of high-profile issues that have brought federal S&T into the media spotlight and opened new debates about the roles and responsibilities of the federal S&T system. Criticisms from current and former government scientists have raised questions about the openness and independence of the scientific advisory process in such diverse areas as fisheries management and drug approvals. Justice Krever's report on Canada's blood system raised questions about when, and with what level of evidence, governments should act in the face of potential problems. The Kyoto agreement on climate change spurred new funding for federal S&T, but raised challenges for the federal S&T system in terms of cross-government coordination, working with stakeholders, and fostering federal–provincial and international cooperation.

The federal government has responded to these challenges in accordance with the principles of the strategy. Fisheries stock assessment and management are now being carried out in an open and transparent way, involving both academic scientists and fishermen. A new blood collection system is being put in place that is committed to applying the best available technology to ensure the safety of Canada's blood supply and its users. The three granting councils — Medical Research Council of Canada (MRC), Natural Sciences and Engineering Research Council of Canada (NSERC), Social Sciences and Humanities Research Council of Canada (SSHRC) — have issued the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans*, making Canada the first country to produce a comprehensive ethical policy statement for research involving humans in all academic disciplines. A best practices initiative for the conduct, management and use of science in government is also being established. The issue of drug testing and approvals remains contentious in some eyes, but this process is being re-examined with broad participation from all stakeholders.

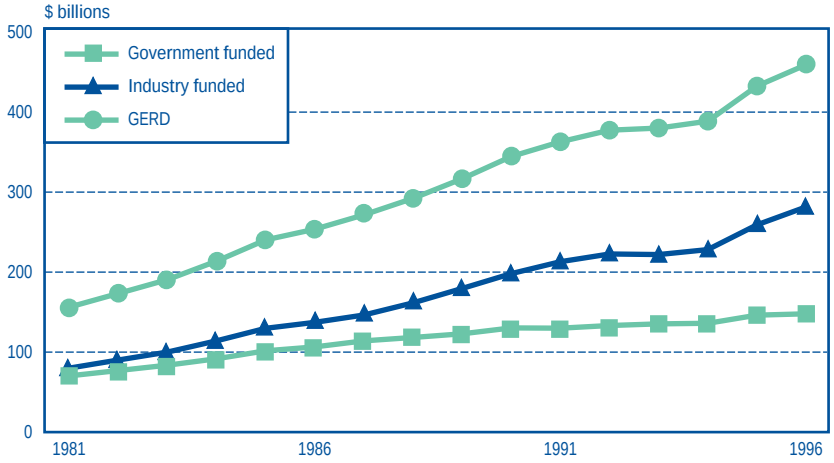
The following chapters

- provide an overview of the federal investment in science and technology and show how this investment fits into the national effort;
- highlight how the government's performance in addressing the innovation and people challenges is advancing the strategy's goals of quality of life, advancement of knowledge, and sustainable job creation and economic growth;
- demonstrate a number of key successes in dealing with important horizontal S&T management issues;
- highlight a number of the central policy challenges that will face the federal S&T effort in the near future; and
- point to the work initiated across government to better understand and respond to these challenges.

2.0 Federal Investment in Science and Technology

The effects of the recession and the expenditure reduction strategies adopted by various governments have combined to dampen the explosive growth in gross expenditure on research and development (GERD) that took place in Organisation for Economic Co-operation and Development (OECD) countries during the 1980s. Between 1981 and 1990, research and development (R&D) expenditure in the OECD as a whole grew at an average annual rate of 9.2%, and more than doubled from $156 billion to $345 billion. This growth slowed to 2.3% per annum over the period from 1991 to 1994. But, whereas industrial spending has since recovered, the growth in government funding is still relatively weak (*see Figure 1*). Between 1991 and 1996, for example, industry-financed R&D increased at an average annual rate of 5.7%, compared with a 2.6% per annum growth in government funding. Moreover, the share of government discretionary expenditure devoted to R&D is on the decline in all G7 countries, except Japan.

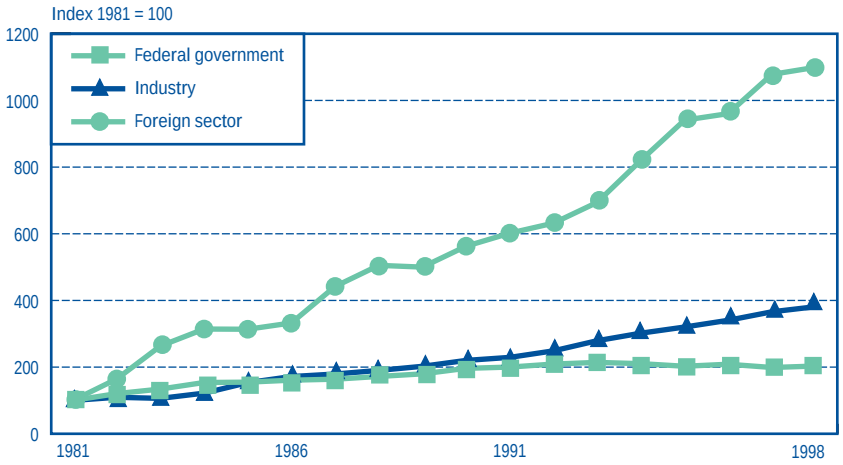
Figure 1: R&D Expenditure in OECD Countries by Source of Funds, 1981 to 1996



Source: OECD Main S&T Indicators, 1998/1

Here in Canada, gross domestic expenditures on research and development also increased rapidly during the 1980s. But, unlike in most OECD countries, GERD continued to grow at a healthy rate throughout the recession. As a percentage of gross domestic product (GDP), GERD increased in Canada from 1.43% of GDP in 1990 to 1.57% in 1994, whereas for the OECD as a whole it decreased from its peak of 2.36% in 1990 to 2.12% in 1994. As elsewhere, growth was largely fuelled by private sector investment (*see Figure 2*). The business enterprise sector increased its funding by 109% between 1981 and 1990 and almost doubled it again during the period from 1990 to 1998.

Figure 2: Growth in Major Sources of Funds for Canadian R&D, 1981 to 1998

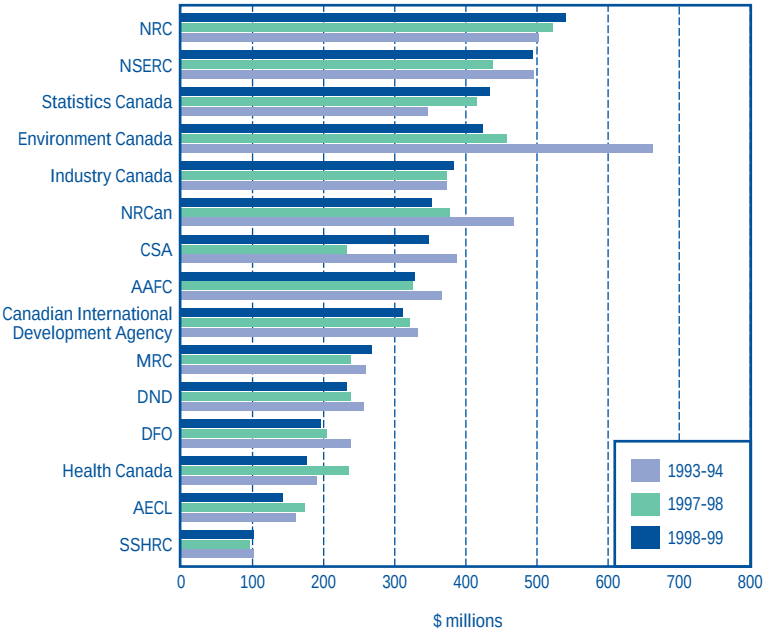


Source: Statistics Canada, October 1998

Meanwhile, the foreign sector, mainly parents or subsidiaries of Canadian firms, a small, but increasingly significant part of the total, increased its spending by 463% during the first and by 95% during the second of these two periods. Federal R&D expenditure, on the other hand, kept pace with the growth in business enterprise spending during the 1980s, but has since remained relatively constant at around $3 billion. Consequently, the federal share of national R&D expenditure decreased from 33% in 1981 to an estimated 22% in 1998, a share that is much closer to the international norm. However, Canada still ranks close to the lowest among the G7, just ahead of Italy.

Federal departments and agencies will spend an estimated $5.5 billion on scientific and technological activities during the fiscal year ending March 31, 1999. This is slightly more than in the previous year but still well below the historic high of $6 billion in 1993-94. This year's growth in current dollar terms is due almost entirely to major increases in funding for the Canadian Space Agency (CSA) ($115 million, which is a result of a year-to-year cash flow adjustment, with no actual increases to the base funding of the agency) and the granting councils ($93 million). Balancing off these increases are reductions of between 4% and 25% in expenditures by the Department of Fisheries and Oceans (DFO), Environment Canada, Natural Resources Canada (NRCan), Atomic Energy of Canada Limited (AECL), and Health Canada. For most of the other major funders, expenditures are to remain relatively stable or increase only slightly (*see Figure 3*).

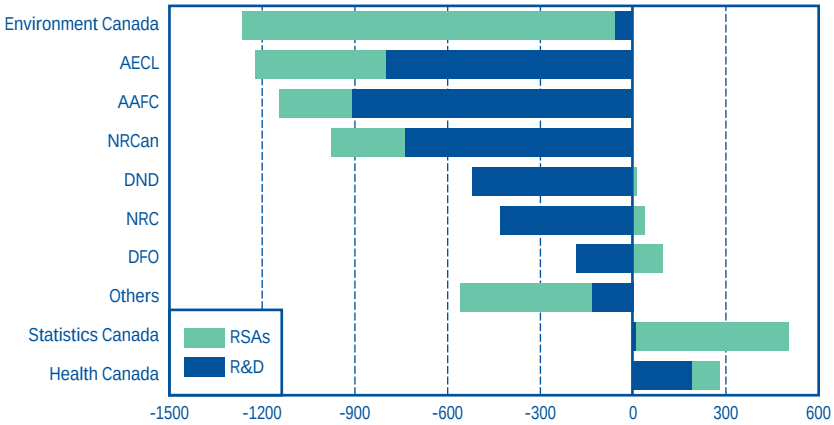
Figure 3: Federal S&T Expenditure by Major Funders, 1993-94, 1997-98 and 1998-99



Source: Statistics Canada, July 1998

Over the longer period, the departments most affected are those with mandates in the resource and environment sectors. Of the 15 largest federal S&T funders, two, Environment Canada and NRCan, have had their expenditures reduced by more than one quarter since 1993-94. DFO has decreased its S&T spending by 18%, AECL by 11% and Agriculture and Agri-Food Canada (AAFC) by 10%. These expenditure cuts have been accompanied by large reductions in the size of their S&T work force (*see Figure 4*). Between 1993-94 and 1998-99, the five departments and agencies named above have decreased their S&T personnel pool by 4700 person-years or more than one quarter. Together they account for 88% of the overall reduction in the federal S&T work force.

Figure 4: Change in Size of the Federal S&T Work Force Between 1993-94 and 1998-99



Source: Statistics Canada

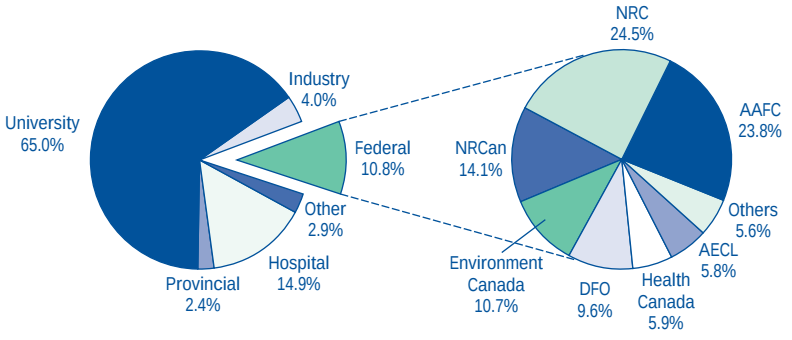
2.1 Knowledge Generation

In addition to serving as independent, reliable and timely sources of scientific and technical advice on matters relating to government policies, programs, procurement, standards and regulation, federal scientists and engineers are engaged in providing specialized services to the general public, and in developing and transferring technologies to Canadian industry. The knowledge created in the discharge of these duties is disseminated in a number of ways, including conference presentations, workshops and the publication of contract reports. An important means of disseminating this scientific knowledge is publication. After researchers in universities and hospitals, federal scientists and engineers are Canada's largest contributors to international scientific and technical literature (*see Figure 5*). In 1995, for example, they published 3376 papers, notes and reviews in the world's most prestigious journals and periodicals. This is roughly equivalent to one tenth of all S&T papers having at least one Canadian author.

Federal scientists and engineers published in all of the major research disciplines and in almost every one of their subfields. They were particularly active in the disciplines of biology and earth and space, where they authored more than one third of all Canadian publications. In subfields such as agriculture and food science, environmental science, meteorology and atmospheric science, and oceanography and limnology, federal researchers accounted for almost one half of the Canadian papers. And in dairy and animal science, entomology, nuclear technology, marine biology and hydrobiology, and analytical chemistry, they authored approximately one third.

In all provinces other than Ontario, Quebec and British Columbia, the federal government is the largest producer of scientific publications, after the university sector. In these three provinces, the hospital sector occupies second place. The federal share of provincial totals ranges from a high of 25% in Prince Edward Island to a low of 5.8% in Quebec. The federal government employs scientists and engineers in every major Canadian population centre; in some of these communities, its employees are the major generators of new knowledge. In the National Capital Region, for example, federal researchers are sole author or co-authors on more

Figure 5: Federal Government's Contribution to Canada's Scientific and Technical Literature in the Natural Sciences and Engineering, 1995



Source: Statistics Canada

than half of all papers. Bibliometric data also show that federal scientists and engineers are engaged in a relatively large number of collaborative efforts both among themselves and with partners in the university and industry sectors, provincial governments, and internationally.

About 90% of their papers are collaborative efforts. Nearly 60% of the papers are written with another author or authors from outside the federal government and another 32% result from collaborative efforts with other federal public servants. About three quarters of the intersectoral collaborative efforts are with the university sector and 8% are with industry. In spite of this relatively low overall percentage with industry, in provinces such as Nova Scotia, Newfoundland and Prince Edward Island, the federal government is industry's leading partner. The overall high level of collaborative effort may be the result of factors such as recent government policies that encourage closer liaison between the various components of the national system of innovation, the increasing cost and complexity of research, shrinking research budgets, and the increasingly multidisciplinary nature of research. Future work on trend analysis and international comparisons may shed some light on the relative importance of these factors.

2.2 Commercialization

A recent study by Narin, Hamilton and Olivastro ("The Increasing Linkage between U.S. Technology and Public Science," Research Policy 26, No. 3, December 1997, pp. 317-30) shows that innovation, as proxied by patents, is increasingly linked to the research conducted in public institutions such as universities and government labs. According to an OECD study ("Science, Technology and Industry Outlook, 1998"), the links between publicly supported research and industry are particularly strong in Canada, Denmark, the United Kingdom and the United States, and relatively weak in Germany, Japan and Korea.

Canada's federal labs have a long history of involvement in the development and successful transfer of technology to industry. Indeed, this was one of the major motivations behind the establishment of many of these institutions. At last count, technologies developed at two of these institutions, the National Research Council Canada (NRC) and the Communications Research Centre, had given rise to 114 spin-off companies with about 11 600 employees and with 1996 sales of around $2 billion. Other departments have also made important contributions. Some have contributed much to the continued viability of traditional industry sectors and some have even spawned entirely new Canadian industries. Canada's geomatics sector, for example, which now has a worldwide reputation, provides approximately 20 500 jobs and has annual sales in excess of $2 billion, owes part of its success to the expertise developed at Energy, Mines and Resources, the predecessor department to Natural Resources Canada.

According to a recent federal survey of commercialization activities in 10 of the larger science-based departments and agencies, in 1997-98, this group filed 233 patent applications and received 130 new patents, which brought the number

of patents in force to 1950. The Department of National Defence (DND) had the largest patent portfolio, about 40% of the total, followed by the NRC with about 33%, and the Communications Research Centre at around 10% of the total. The 10 departments recorded 355 disclosures, with almost half arising from intramural R&D and 40% from collaborative research.

However, it is important to note that, in both the above and what follows, the totals quoted in this text may not necessarily present a complete picture of the activities of the 10 departments and agencies. Some departments were unable to provide complete responses. Some had to omit certain questions altogether, while others could not provide the details requested. It is also important to note that opportunities for developing and exploiting technology are not evenly shared among departments, since the technological opportunities presented to a department are to a large measure determined by factors that are mandate-related. The NRC, for example, with its responsibility to assist in strengthening the technology base in Canadian industry, is faced with a much richer opportunity set than departments such as Environment Canada, whose mandate is primarily one of stewardship.

The 10 departments reported signing 398 new licences, bringing the total number of active licences to 1112 and generating total royalties of some $7 million. More than 80% of these licences were with Canadian firms, and about half were non-exclusive. Foreign licences, however, accounted for about one third of the revenue stream. The top two revenue generators were AAFC and the NRC, which together earned about 70% of the total. AAFC, the Communications Research Centre, DND, NRCan and the NRC, had the most active licences, each having more than 100. The vast majority (70%) of the licensed technology was the product of in-house R&D. Only rarely was it the result of collaborative or contracted-out R&D. During 1997-98, the departments contracted out S&T activities for $241 million; about three quarters of this amount went to the business sector. The departments also received contracts worth $141 million. Not surprisingly, in-house technology development was also a major source of revenue, although it was not as dominant an income earner as it was a source. The 10 departments also reported spinning off some 20 companies in 1997-98.

The statistics for the 10 departments and agencies are quite similar to those derived from the survey of commercialization activities in the higher education sector. According to the preliminary results for 74 universities and colleges, 379 patent applications were filed last year and 143 patents were received, bringing the number of patents in force to 1252. The universities and colleges signed 195 new licences, which brought the total of active licences up to 672. Reported royalties amounted to $15.6 million, approximately one third of which was from Canadian and two thirds from foreign sources. During the year, the institutions entered into 5081 research contracts valued at $288 million. About two fifths of the dollar value came from contracts with the private sector, one quarter from provincial governments and one fifth from the federal government. Of the 312 spin-off companies that were listed, 37 have been incorporated since 1997.

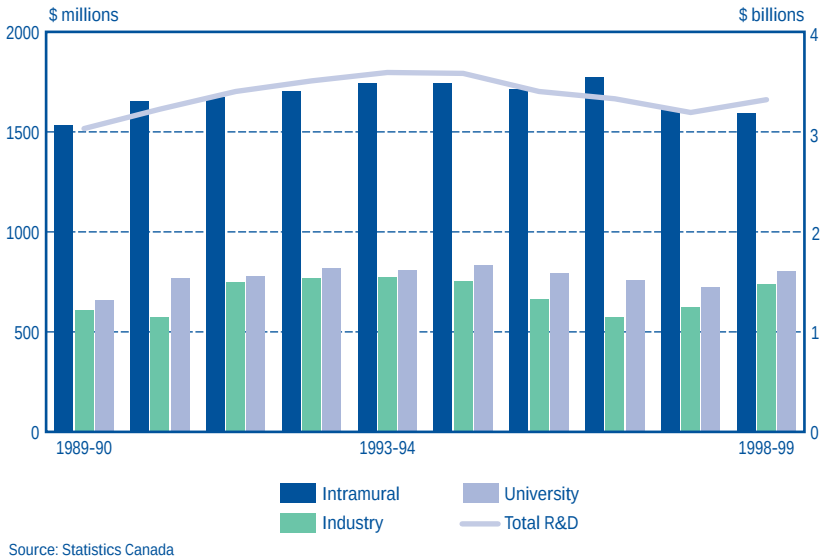
The federal survey of intellectual property management was the first of what may become a regular feature and, as is common with first efforts, revealed some areas requiring improvements. First, there is a need to develop better measurement of commercialization activities. Second, there is the need for the larger science-based departments and agencies to centralize record keeping regarding their collaborative efforts and their production and exploitation of intellectual property.

2.3 Extramural Science and Technology Program

In 1998-99, the federal government will spend an estimated $2245 million, 41% of the total S&T expenditures, on its extramural programs. This is $128 million or about 6% more than in the previous year. The university sector will receive $937 million, up 8% over last year; and the business enterprise sector, $943 million, an increase of 11%. Unlike the intramural program, where S&T expenditures are almost equally divided between support for R&D and for RSAs, funding for these two sectors is directed mainly to R&D. Of the $937 million that Canadian universities will receive, $802 million (85%) will be for R&D. In the industrial sector, funding for R&D will be $738 million (78%). Federal expenditures on university R&D will increase by $78 million (11%) and on industrial R&D by $115 million (18%). This will restore university R&D funding to approximately the same level as in 1993-94 (*see Figure 6*).

After the business sector, the federal government is the largest domestic source of funds for industrial research and development. Approximately half of these federal funds is normally awarded as grants or contributions and the remainder through R&D contracts. Two departments/agencies, Industry Canada and the CSA, usually

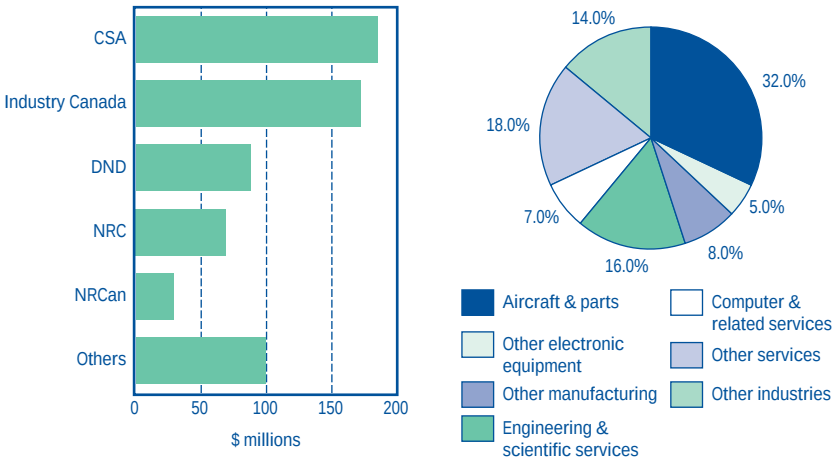
Figure 6: Federal R&D Expenditures by Major Performance Sectors, 1989-90 to 1998-99



Source: Statistics Canada

dominate the list of funders: the first, in terms of grants and contributions; and the second, on the contracts side. They both have large programs whose major component is in the aircraft and parts industry. It is therefore not surprising that this sector is the largest recipient of federal industrial R&D payments. In 1995-96, the most recent year for which data at the firm level is currently available, 32% of the payments were to the aircraft and parts industry, 16% to engineering and scientific services, and 8% to other manufacturing industries (*see Figure 7*). This is quite similar to the distribution in the two preceding years. Interestingly, the payments were about equally divided between manufacturing and services, 45% and 41%, respectively. This distribution is an indication of the growing importance of the service sector as an R&D performer.

Figure 7: Federal R&D Payments by Major Sources of Funds and for Selected Industries, 1995-96



Source: Statistics Canada

For 1995-96, departments and agencies reported R&D payments to industry amounting to $642 million, $329 million of which was for contracts and $313 million for grants and contributions. Of the more than 2000 funding recipients, the top firm received 19% of the total; the top five, 35%; and the top twenty, 51%. Contract funds were even more highly concentrated, with the top firm receiving 36% of the awards; the top five, 50%; and the top twenty, 66%. This high concentration among firms is reflected in the geographic distribution of the payments. Firms in Montréal received 28% of the total payments: 22% went to companies based in Toronto and 15% to those in the National Capital Region. Whereas the aircraft and parts industry was the primary income gainer in Montréal and Toronto, firms in the service sector accounted for most of the National Capital Region's share of federal industrial R&D payments.

The booklet *Science and Technology Data — 1998* provides more statistics on S&T investments, trends in federal and national expenditures, and some performance measures. This information is also available on *Strategis*, Industry Canada's business information Web site (**http://strategis.ic.gc.ca/S-Tinfo**).

3.0 Getting Value for Our Investment

The federal government has an important role in maintaining the strength of Canada's innovation system. By both performing and supporting S&T activities, the federal government makes a strong contribution to Canada's economic health and social well-being. However, the task of measuring this contribution, and attributing outcomes to specific spending, often proves difficult. Governments around the world are tackling the issue of measurement. Canada is making significant progress on its own, as well as drawing on the experience of other countries. However, comprehensive measurement frameworks for innovation are not yet in place.

Minding Our Future summarized federal government spending on S&T and provided examples of activities that resulted from that spending. At that time, the government noted that more rigorous processes for the measurement of performance and outcomes were being developed in response to the S&T strategy. These processes are not yet completely evolved, but in this report we are able to provide more concrete information on the results of federal involvement in the innovation system.

In *Minding Our Future*, the government identified two key challenges: innovation and people. Indeed, these challenges represented the driving force behind a significant portion of federal S&T activity over the past year. "Innovation" was interpreted in a broad sense: reaping the benefits of good ideas. The highlights in this report focus on numerous innovative approaches taken by the federal government to using S&T in fulfilling its mandates. "People" was also interpreted in a broad sense: examining not only the need for a skilled work force for the 21st century, but also the process of adapting to the demands of a knowledge-based economy. Revitalizing the federal S&T work force and improving the supply of workers for the private sector remain significant focal points for activity across the government. Some of the contributions of this activity to the fulfilment of the S&T strategy's goals are highlighted in the following sections.

The three goals set out in the federal strategy — enhancing quality of life, advancement of knowledge, and sustainable job creation and economic growth — represent a full spectrum of government S&T activities. However, none of these goals are exclusively federal responsibilities. Depending on the nature of the issue, its state of development and the relative capabilities of the other players, the federal government is a funder, performer, leader, facilitator or only an interested observer of the S&T activities needed to support the Canadian society and economy. The following examples illustrate performance across the government. For more information on specific departmental performance, consult the Annexes and the departmental performance reports.

3.1 Innovation

Minding Our Future highlighted four innovation-based challenges, and progress has clearly been made on all of them.

- **Making Canada the most connected nation in the world.** The "connectedness agenda" remains a priority for the government. The 1998 federal budget saw new funding of $205 million over three years to expand SchoolNet and the Community Access Program. Through these programs, the federal government will work with provinces and the private sector to put computers in more classrooms and to create 5000 Internet access sites in urban neighbourhoods, in addition to the 5000 sites already being established in rural Canada. These funds also established the Voluntary Sector Network Support Program — a program to enhance the capacity of voluntary organizations — by providing access to computer equipment, the Internet, new information technologies, network supports and training. In addition, the government provided $55 million this year to the Canadian Network for the Advancement of Research, Industry and Education (CANARIE) to support the development of high-speed networks.
- **Encouraging innovation in addressing Canada's challenges for the future.** Departments and agencies are exploring a wide range of new ways of delivering services to Canadians. For example, in developing the Sixth Report of the National Biotechnology Advisory Committee, *Leading in the Next Millennium*, Industry Canada teamed 14 university students with the chief executive officers (CEOs) of biotechnology companies to do background research for the report that has since been hailed as a blueprint for a new Canadian government strategy for biotechnology. This creative approach gave the students a rare opportunity to work with government officials, private sector CEOs and prominent Canadian academics.
- **Turning knowledge into jobs, commercial products and services.** This theme is a prominent part of the mandate of the Advisory Council on Science and Technology (ACST). In December 1997, the ACST made a series of recommendations. In response, approval was given for the creation of an ACST Expert Panel on the Commercialization of University Research. The panel will report on options to maximize social and economic returns to Canada from investments in university research. A major source of new ideas and highly qualified personnel, university research is a key feature of a knowledge-based economy and society. It contributes significantly to improving Canadians' standard of living.
- **Innovating to achieve national and international social, health and environmental goals.** The memorandum of understanding (MOU) among the four natural resource departments, expanded to include Health Canada, on science and technology for sustainable development was signed while the S&T strategy was under development. In the intervening years, the MOU has proven to be a valuable tool for the horizontal management of a key S&T file: sustainable development. The main strength of the MOU is its ability to bring signatory departments together to address issues of common concern that are either current or

beginning to emerge. The original working groups have produced substantial reports (**http://rn4nr.nrcan.gc.ca/**), forged partnerships among the four departments and built bridges with other departments. With the success of this approach, other new working groups have been added to deal with a broad range of science and science management issues. The value of the MOU can also be seen through links to other federal initiatives such as biotechnology, Northern science, the implementation of the federal S&T strategy, and increased mobility of staff under the Framework for the Human Resources Management of the Federal Science and Technology Community.

Another example is the additional $34 million provided annually to the Industrial Research Assistance Program to help small and medium-sized businesses to foster strategic innovation and to implement state-of-the-art technologies and approaches for using energy, water and natural resources more efficiently and for preventing pollution.

Minding Our Future's broad interpretation of innovation makes it clear that this challenge is not government-driven, but is one shared by all Canadians. While a relatively significant part of the government's S&T efforts have been directed towards its own innovative activity, much of the overall federal effort has been directed at creating a business climate and scientific infrastructure that encourages and rewards innovation outside of government.

3.1.1 Enhancing Quality of Life Through Innovation

A key message of the S&T strategy was the dynamic interplay between the goals of economic growth, advancement of knowledge and quality of life. This is well illustrated in the S&T activities and outputs of most federal departments and agencies, which often have multiple benefits to the nation. An excellent example is RADARSAT-1, a project led by the CSA involving the private sector, several of the provinces and the United States. The RADARSAT program builds on technologies and experience developed through decades of federal R&D. The sophisticated remote sensing satellite, carrying synthetic aperture radar, was launched in November 1995 and will operate for about six years. It covers most of Canada every 72 hours; the Arctic, every 24 hours. NRCan has worked with RADARSAT end users, industry and academia to develop applications for RADARSAT data in a variety of disciplines, including geology, forestry, agriculture, oceans, ice and hydrology. This development uses NRCan's remote-sensing expertise with the requirements of end users and industry, the related expertise from other departments, and the expertise within universities to address some of the long-term scientific requirements. This has placed Canadian industry at the forefront of the use of remotely sensed data in general, and RADARSAT data in particular.

Tracking Natural Disasters

The flooding of the Saguenay region in 1996 and the Red River in 1997 are good examples of how RADARSAT can provide useful data to help manage natural disasters. RADARSAT data helped monitor the 1997 record-breaking Red River flood. Interpretation of the flood images allowed Canadian and American authorities to track the advance of the flood from the United States into Canada, and to assist Canadian Forces personnel in their flood relief efforts. Together with NRCan's systematic geoscience mapping and sampling, RADARSAT images will be a valuable tool in analysing the history of flooding in these regions to refine the flood prediction models for the Red River system. In collaboration with NRCan and private industry, the CSA has produced a CD-ROM that chronicles the 1997 Red River Valley flood and the critical role RADARSAT played in monitoring and responding to the disaster.

The RADARSAT program also contributes to the advancement of knowledge about Canada's land mass and resources through the Canadian Earth Observation Network. As well, RADARSAT generates economic benefits, both through efficiencies in the federal system (for example, it is estimated that RADARSAT is saving the Canadian Ice Service more than $6 million per year in data acquisition costs) and through the worldwide marketing of data (RADARSAT International has captured 12% of the world remote-sensing market).

Innovative activities in federal departments also contribute to enhanced quality of life by helping to address environmental issues facing industry. Through the use of federal research capabilities, it is possible to identify key problems and then develop and demonstrate solutions. By drawing together research capabilities from government facilities, universities and the private sector, the federal government helps to ensure that the best technologies are identified early and implemented by industry to the benefit of the environment. For example, results from NRCan's Aquatic Effects Technology Evaluation (AETE) program are currently being used by government and industry in the design of an environmental effects monitoring program for Canadian mines. AETE, a government-industry initiative involving Environment Canada, DFO and the Department of Indian Affairs and Northern Development (DIAND), seven provincial governments and the Mining Association of Canada, was completed in December 1998. AETE evaluated the cost-effectiveness of environmental monitoring technologies available to the Canadian mining industry to assess its impacts on the aquatic environment.

Federal government S&T activities can help industries to diversify their activities so as to minimize negative impacts on the environment and maximize the return to Canadians. For example, DFO is participating in collaborative research on culturing wild species to help diversify the aquaculture industry. To support this, research conducted at St. Andrews Biological Station has provided the knowledge base and techniques used to facilitate halibut culture. These innovations have led to a partnership with Maritime Mariculture Inc. on a scale-up pilot project for the commercialization of halibut culture. The pilot project is based at the Huntsman Marine Laboratory in St. Andrews, New Brunswick. The purpose is to refine grow-out techniques, especially for the difficult larval stage, and further assess the economic feasibility.

Innovations in service delivery can also lead to improved environmental quality and quality of life for Canadians. One example is the air quality prediction program. This Environment Canada initiative responds to the department's Clean Air strategy, which states that "every Canadian has the right to know about the quality of air that they are breathing." To meet the needs of Canadians, the New Brunswick Weather Centre produces daily forecasts of ground level ozone. The enhanced availability of air quality information and forecasts enables the general public to take an informed decision about their health and environment and to better plan their daily activities. This is presently the only program of its type available in Canada.

Environmental Management Strategies

A partnership has been established between AAFC, the provincial governments and the hog industry to develop a national strategy that will address the environmental challenges confronting the industry. Extensive consultations with producers and provincial government representatives resulted in the identification of the most pressing environmental issues: odour and water quality. AAFC has developed and will continue to modify an environmental management strategy that focusses on research and development, technology transfer, information and support tools for the hog industry. The goal of the strategy is to provide hog producers with information that will allow them to expand their market while addressing environmental concerns. AAFC will use the Hog Environmental Management Strategy as a model that can be applied broadly to the livestock industry in the future.

Implementing Sustainable Forestry

Forestry companies operating in British Columbia are implementing major changes to their forestry practices, based on the results of collaborative research carried out under the Montane Alternative Silviculture Systems (MASS) project. Through the MASS project, NRCan and MacMillan Bloedel Ltd., Canada's largest producer of forest products, have been developing ecological and economical alternatives to clearcutting, together with such partners as the Forest Engineering Research Institute of Canada (FERIC), the University of British Columbia, the University of Victoria and the British Columbia Ministry of Forests. The multidisciplinary project has led to new prescriptions for forest renewal and the preservation of wildlife habitat, aesthetics and biodiversity in coastal montane forests. In June 1998 MacMillan Bloedel announced it will phase out clearcutting in all of its B.C. operations within five years. The knowledge gained through MASS will be essential in meeting this target.

Canadians generally feel confident in the safety and high quality of the food they eat. This confidence arises from a strong presence of the federal government in the food inspection system. The Government of Canada has consolidated all federally mandated food inspection and quarantine services into a single food inspection agency. The Canadian Food Inspection Agency (CFIA) began operations in April 1997 and reports to Parliament through the Minister of Agriculture and Agri-Food.

The consolidation into a single agency enhances the delivery of inspection and quarantine services previously provided by AAFC, Health Canada, Industry Canada and DFO. All inspection services related to food safety, economic fraud, trade-related requirements, and animal and plant health programs are provided by the CFIA. The responsibilities for food safety policy, standard setting, risk assessment, analytical testing research and audit have been strengthened and remain with Health Canada.

The CFIA has its own scientific capabilities, but is also able to draw on the resources of other federal agencies. For example, through a memorandum of understanding, the CFIA and AAFC have agreed to cooperatively apply S&T to address challenges in the agri-food sector. Of particular note, AAFC will cooperate with the CFIA in providing research and diagnostic/control support on quarantinable animal and plant diseases, and for food-related concerns of significance to the CFIA. AAFC ensures that scientific, technical and management support and advice are provided to manage emergency situations. While the CFIA has primary responsibility, AAFC agrees to make available at short notice its research and testing facilities, as well as expert advice in crisis situations. The CFIA also has a memorandum of understanding with NRCan for collaboration on research, monitoring and inspection activities to address the growing threat to Canada's forests posed by the entry of "exotic" or non indigenous forest pests. This issue is emerging as an important national and international concern.

Health Canada's and the CFIA's food programs are active participants in the Canadian Food Inspection System (CFIS) and have identified the CFIS as an important vehicle for the harmonization of food safety standards across all levels of government. The CFIS is a multisectoral initiative charged with implementing nationally harmonized food standards and developing a common food legislative base. This initiative is very broad in scope, covering food production to retail and aspects of both food safety and trade.

In some cases, innovation requires merely taking a new approach to a problem. In the case of the Northern Contaminants Program (NCP), this new approach meant drawing the federal effort together and involving those who were most affected in the research planning process. The NCP was established in 1991, in response to concerns over contaminants in northern traditionally harvested foods. The program is assessing the risk to northern ecosystems and human health from the long-range transport of persistent contaminants into the Arctic. The program's key objective is "to reduce and, wherever possible, eliminate contaminants in traditionally harvested foods, while providing information that assists informed decision making by individuals and communities in their food use."

Better Information for Personal Decision Making

The country's first smog forecast, launched in southern New Brunswick during the summer of 1997, provided one-stop shopping for air quality information. The project was implemented as a permanent program for parts of southern New Brunswick in the spring of 1998. Through the improved understanding of ground level ozone behaviour and expanded monitoring network, the program will be expanded in 1999 to include the entire province of New Brunswick. It is anticipated that similar programs will be made available in other provinces in the future. The forecast allowed individuals to take expected smog levels into account when planning outdoor activities. The project was a partnership among the New Brunswick departments of Environment, and Health and Community Services, as well as the Lung Association, the Saint John Citizens Coalition for Clean Air, the Saint John Air Resource Management Area Committee and Environment Canada's Atlantic Region.

Federal Research for Public Safety

Health Canada's Food Program developed analytical methods for the detection of allergens, such as peanut or egg proteins, in foods. In response to consumer complaints investigated by the CFIA, the methods were used to identify these allergens in unlabelled products. The technology was transferred to the CFIA for use to identify other "contaminated" foods, resulting in product recalls at the retail level.

The parasite *Cyclospora* has received widespread attention by health officials and the media (for example, the recent case involving contaminated fresh berries). The program has developed a method for the detection of *Cyclospora* in food in only two minutes, which will greatly increase the number of samples that can be analysed during an investigation.

DIAND manages the overall program and coordinates its activities nationally and internationally in partnership with the five northern Aboriginal organizations, the two territorial governments, the province of Quebec and the federal departments of Environment Canada, DFO and Health Canada. The northern Aboriginal organizations, which consist of the Déné Nation, the Métis Nation, the Council for Yukon First Nations, the Inuit Tapirisat of Canada and the Inuit Circumpolar Conference, contribute significantly to the overall program through their representation in project review teams and the NCP management committee, chaired by DIAND. They have a direct decision-making role in all aspects of program delivery, including funding decisions and future directions. The Aboriginal organizations lead on the conduct of communications, education and community-based strategies in the North. A baseline monitoring program for levels of contaminants in humans is currently nearing completion in the Northwest Territories, and the need for further studies to determine if there may be effects associated with current human tissue burdens will be determined through consultation with communities, Aboriginal organizations and health researchers. Research continues in Canada and around the world to investigate the possible effects of contaminants. Health effects currently under investigation include infant neurological development, immune systems impairment and hormonal changes.

Other innovative approaches to improving quality of life focus on developing synergies between a number of federal programs. While there has always been cooperation between departments and agencies, the S&T strategy has provided the impetus to make more efficient use of these partnerships.

A case in point is the Sustainable Communities initiative, which was launched by NRCan to bring rural, Aboriginal and urban communities closer to the decision-making processes that affect them. The project makes use of information technology and the accessibility of relevant scientific knowledge. The initiative acknowledges that most communities wish to pursue a goal of sustainable development, i.e., to achieve the best possible balance between economic, environmental, health and social considerations that affect them. The first project in Mayo, Yukon, was planned in collaboration with First Nations and Mayo Village.

Not all federal S&T is research, and not all innovation occurs in laboratories. A key role of the federal government is to ensure the maintenance of a national infrastructure for science and technology. This infrastructure includes information. The federal government is in a unique position to facilitate the integration of information from diverse sources into national information resources that can be applied for the benefit of Canadians.

One example is the Canadian Health Infostructure. Health Canada is in the second year of a three-year health information systems initiative. Three initiatives stem from the Government of Canada's 1997 budget decision to provide funds to begin the development of a national strategy for a Canadian Health Infostructure. Health Canada is involved in the following:

- In collaboration with the provinces and other stakeholders, it is developing and testing key elements and systems of a public health surveillance network at local, national and international levels.

International Leadership on Pollution Control

Under the Northern Contaminants Program, Canada has taken a leadership role at the international level to demand controls on persistent organic pollutants (POPs). This year, European and North American countries signed protocols for control of POPs and heavy metals under the United Nations Economic Commission for Europe's Convention on Long-range Transboundary Air Pollution. Negotiations began in June for worldwide control of these substances under the United Nations Environment Programme.

Sustainable Communities

There are three elements to this initiative: 1) identifying community needs; 2) facilitating the acquisition of locally relevant data by the community using the Information Highway; and 3) making it possible for non-specialist community people to easily access and handle the data to extract and present results of interest. The initiative is based on a partnership of NRCan with interested federal government departments, notably Industry Canada's Community Access Program, Health Canada, Statistics Canada, Environment Canada, AAFC and DIAND, as well as provincial/territorial and local governments.

- It is implementing the initial version of a Health Information System in First Nations communities across the country. This system was initially developed in partnership with First Nations.
- In partnership with key non-governmental organizations, it is developing the capability and implementing a Web-enabled call centre to provide health information to consumers.

This will lead to enhanced access to better quality and more timely health information and services for First Nations, public health professionals and Canadians in general.

3.1.2 Advancement of Knowledge Through Innovation

The federal government has a significant presence in the advancement of knowledge in Canada. It is the major funder of university research through the granting councils. Science and technology activities carried out by federal departments and agencies also help to advance knowledge in a wide range of fields. There are numerous examples of how exploratory and directed research in federal labs have provided the knowledge base on which new products, processes and even industries have been based. Innovations in government programs and operations have played an equally important role in advancing the knowledge base on which Canada's economic and social well-being are based.

For example, the Networks of Centres of Excellence (NCE) program draws together universities from across the country with industrial partners to do research in areas of particular importance to Canada. These "virtual" centres of excellence use modern-day electronic technology, in addition to meetings and conferences, to create a critical mass of expertise to examine key scientific challenges. Departments are also looking at sharing facilities, to make the most efficient use of their investments. Various organizations share locations and facilities, often in conjunction with universities and other research institutes.

Consortia represent an excellent mechanism to pool expertise and knowledge and to advance the frontiers of knowledge much faster than could be accomplished by any one of the consortium members individually. Consortia are not just groupings of organizations with similar interests; they must be driven by mutual needs and complementary capabilities. Federal participation in consortia with universities and the private sector offers more "bang for the buck," and creates the critical mass needed to tackle key research questions that face entire industry sectors.

Innovative arrangements between federal departments and agencies are also ensuring that key issues that are important, but not necessarily priorities, do not fall between the cracks. For example, the Canadian Museum of Nature (CMN) is a partner in renewing the Federal Biosystematics Partnership (FBP). The FBP is a cooperative effort between the AAFC, Environment Canada, NRCan, the CMN, and DFO, and was formed to ensure that the importance of systematics research

Clusters at the AAFC

Clusters are pools of knowledge and expertise that result when specialized research facilities (federal, provincial, university and private labs) are concentrated in one particular area. These clusters then become incubation centres for innovation through partnerships and information exchange. To achieve the above-noted benefits, a strengthened team of AAFC's molecular biologists is now working at the research centre in Saskatoon, Saskatchewan, a city with an international reputation in agri-food biotechnology. Also, researchers in the department's food program have recently been relocated to Guelph, Ontario, where they are working in proximity to the university, Health Canada's food lab and the food industry. A major advantage of clustering is the ability to share resources with research partners to maximize R&D dollars in the agri-food sector. In Guelph, for example, AAFC's staff are working in the provincial lab building.

in Canada is recognized, emphasized and supported. Among other activities concerning biology and particularly systematics, the FBP has cooperated in sending representatives to the OECD Mega-science Forum within the Working Group on Biological Informatics. This working group is especially important in addressing the global scale issues on the conservation of biodiversity and ultimately the ecological services that are so important to the health of this planet.

Combining programs from different departments and agencies in innovative ways allows individual organizations to meet their own objectives while supporting initiatives that are beyond the scope of their individual programs. For example, the cooperation between NSERC and NRCan on the LITHOPROBE project has allowed NSERC-supported scientists to work on a major, cross-Canada project, and has allowed NRCan to expand its geological study of Canada far beyond the scope it could afford from departmental resources. LITHOPROBE is a major national research project that combines multidisciplinary earth science studies of the Canadian landmass and surrounding offshore margins. Canada's vast geographic expanse and its diverse geological history provide an exceptional opportunity to investigate the evolution of the northern North American continent over geological time from 4 billion years ago to the present.

Federal S&T can often draw on a broader range of expertise and international contacts than can most individual firms in Canada. By mobilizing these resources, the federal government is able to develop a knowledge base upon which entire sectors of the economy or society can draw.

For example, NRCan and Japanese scientists joined forces in 1997 in a major research partnership to develop and test new exploration technologies for gas hydrates. Gas hydrates incorporate natural gas into a solid ice-like structure under conditions of cold temperature and high pressure. They occur beneath permafrost and in offshore sediments overlain by deep water. Although little studied in nature, they represent a huge potential energy source, a significant hazard to conventional exploration drilling, and a possible source of greenhouse gases during global warming. To acquire geoscience and engineering information about the natural distribution and properties of gas hydrates in an Arctic setting, a team that included the U.S. Geological Survey and a variety of Canadian, Japanese, and American companies drilled the first gas hydrate research well in the Arctic in February 1998, and collected the first Arctic gas hydrate samples ever recovered below permafrost. Innovative, on-site laboratory testing characterized hydrate concentrations and the physical properties of the enclosing sediments.

Another example where the federal government can be a logical mechanism for undertaking large-scale S&T projects is in the field of earth observation. Under the earth observation programs jointly managed by the CSA and NRCan, the first

Collaborations to Advance Knowledge

LITHOPROBE was renewed for another five years, to complete the highly successful national geoscience research program started in 1984 to understand the nature and evolution of Canada's landmass and offshore regions in three dimensions and through time. This will enable the final two transects to be completed (Yellowknife to the Yukon coast, and Northern Ontario). This will also allow the synthesis of the remarkable new understanding of how the Canadian landmass has grown over the past 4 billion years. Recently, LITHOPROBE's Slave-Northern Cordillera Lithospheric Evolution (SNORCLE) Transect has produced the world's most spectacular images of the Precambrian crust and upper mantle, with fundamental implications for Precambrian plate tectonics and the tectonic history of the diamond-bearing continental root beneath Slave Geological Province. Results from the Peace River Arch Industry Seismic Experiment were released, providing new insight into fault history associated with hydrocarbon emplacement and tectonic evolution of the crust that hosts recent diamond discoveries in the Buffalo Head Hills of northern Alberta.

Canada on the World Stage

On April 28 and 29, 1998, Sudbury, Ontario, hosted a world premiere in the history of science, not only nationally but also internationally. The world's most advanced neutrino observatory was officially inaugurated in this Northern Ontario mining town, and a slew of prominent guests attended to mark the occasion. The world-renowned British physicist Stephen Hawking was there, as well as two Canadian Nobel Prize recipients, Drs. Bertram Brockhouse and Richard Taylor. The federal government contributed $47 million towards the construction of the Sudbury Neutrino Observatory.

version of the Canadian Earth Observation Network has provided on-line access to earth observation data. Applications for satellite were successfully transferred to users and include land cover mapping, large area digital elevation model generation, information products for agri-business and mineral exploration, environmental impact assessment, forestry, and mobile technical offices.

Another key role of federal S&T is to provide a bridge between the varied efforts across Canada. In some cases this means developing, or helping to develop, technical standards that facilitate the integration of information from diverse sources. In other cases, it means doing some of the fundamental research to allow these standards to be developed. The Defence Research Establishment Valcartier and Defence Geomatics played an important role in the development of the Open Geospatial Datastore Interface (OGDI), a key technical component of the GeoConnections initiative. The OGDI project is an open systems development that solves many of the difficulties related to geospatial data interoperability across system, data type and data format integration issues. OGDI harnesses the power of the Internet, using an open Web-based architecture to provide access to data both locally and over any TCP/IP network, and is expected to reduce some of the barriers to growth in the geographic information systems industry.

In a number of key sectors, the federal government has the explicit responsibility for the management of natural resources. Fisheries is one of these areas. Results of research by DFO are used by other levels of government, universities and private firms. For example, DFO's Marine and Environmental Data Service supplied on-line ocean data to over 300 clients from Canadian industry, academia and international organizations. The stock status reports, the scientific basis for resource conservation, are available to Canadians on DFO's Science Web page.

In the global, knowledge-based economy and society, Canada benefits from scientific progress from around the world. At the same time, it can draw on this global experience much more effectively if it contributes to the global scientific effort. In this context, Environment Canada has pushed further the development and application of its Global Climate Models to provide insight into the behaviour of the climate system in the future. Environment Canada has state-of-the-art models that are used by the Intergovernmental Panel on Climate Change (IPCC). Most of the development has involved partners through the Climate Research Network (CRN) of the Atmospheric Environment Service. A recent evaluation of the CRN documents how Environment Canada has increased the effectiveness of its climate change work as a result of this partnership. The results are being made available electronically, both through the Environment Canada Web site, and through an IPCC data distribution centre. NRCan continues to play a major role in international scientific research on

Government-Industry Partnerships for Sectoral Development

In 1995, two oil sands operators and NRCan recognized R&D investment as essential for the continued economic growth of the oil sands industry. They established a consortium to develop and evaluate more effective and energy-efficient technologies for the production of pipeline specification bitumen, while reducing emissions. The dry, solids-free bitumen product is a superior feedstock for upgrading and refining. This consortium represents an innovative approach to doing business. It is the first time that an NRCan-industry partnership has designed, constructed and operated a research facility at an NRCan energy-related site. The $1.5 million froth/emulsion treatment pilot plant was operational by the fall of 1995. Three additional industrial partners have since joined the consortium. In early 1997 the facility was expanded to meet new requirements of the industrial partners. All consortium costs are equally shared by members. The NRCan pilot plant results were an integral part of Shell Canada's design of its $1.3 billion, 150 000 barrels per day oil sands extraction plant near Fort McMurray, Alta.

Cancer Research

In February 1998 the Steering Committee on Clinical Practice Guidelines for the Care and Treatment of Breast Cancer, which operates under the aegis of the Canadian Breast Cancer Initiative, released 10 clinical practice guidelines. The guidelines were developed on the basis of scientific evidence, or — where evidence was not conclusive — on the basis of expert opinion. The steering committee and review of the guidelines involved over 200 persons from across the country, including family physicians, nurses, surgical/medical/radiation oncologists, breast cancer survivors, national and provincial cancer agencies, as well as national health professional educational bodies.

carbon budget modelling and the role of forests as a source and "sink" of atmospheric carbon. In August 1998 a first workshop in a series was held. Other workshops will take place in Canada, Russia, Sweden and the United States, leading to an international conference in Canada in 2000 on "The Role of Boreal Forests and Forestry in the Global Carbon Budget." The goal is to develop the first comprehensive carbon budget of the circumpolar boreal forest zone.

3.1.3 Sustainable Job Creation and Economic Growth Through Innovation

Many observers use a fairly narrow definition of innovation, focussed on making money from the exploitation of a good idea. In general, this is not a role of the federal government. It is the private sector that should be creating the wealth by which Canada can continue to prosper. However, a notable characteristic of the Canadian economy is our apparent weakness in commercialization: we are not profiting from our ideas. Many good ideas arise from research and other S&T activities within federal departments and agencies, and even more arise from research in universities supported by the granting councils. However, since many government departments and agencies do not have a mandate to commercialize these ideas, more focus is needed on transferring the technologies to those who can turn them into profitable products, processes and services. The Federal Partners in Technology Transfer (FPTT) has met the growing need and demand in government for a forum to deal with issues related to technology transfer and commercialization. FPTT includes 14 departments and agencies,[1] led by the NRC. Over the past year, FPTT has provided a forum for the right people to talk to each other about successful initiatives, domestic and international model practices, upcoming events, and common concerns. As a result, individual departments and agencies have saved both time and money, and become more effective in their technology- and knowledge-transfer activities.

AAFC's Matching Investment Initiative (MII) is an innovative way to assist industry in meeting its research needs, and draw private sector investment to support the department's research capability. The MII has been a major success since it was launched about three years ago. Investments, which have consistently shown annual growth, are expected to inject more than $70 million worth of public-private funds in new R&D into the economy by the end of the century. Companies and organizations partnering with the department under the MII represent a broad cross-section of the Canadian agri-food industry, including small and medium-sized enterprises, multinational corporations, producer groups, and consortia of private firms.

The government can be an important source of knowledge, which can have significant benefits in both economic growth and improved quality of life, when applied to policy and regulations. Indeed, well-designed, scientifically sound regulatory systems can increase the international competitiveness of Canadian products by

Network of Defence S&T Partners

In the past year, the effectiveness of defence S&T has been markedly enhanced through the creation of the Network of Defence S&T Partners. Led by the Chief, R&D, the network comprises representatives from the entire spectrum of DND S&T. The network has led to greater coordination of the S&T effort within DND and will allow for more effective S&T advice to senior decision makers in the department. For example, the Defence R&D Branch and the Network of Defence S&T Partners are playing a leading role in defining the Canadian response to the revolution in military affairs, which will support senior defence decision makers as they chart a course into the 21st century. On an operational level, the department can expect to achieve cost-savings in the acquisition process as well as in operational training through the network's extensive evaluation of DND's use of and expertise in modelling and simulation (M&S). This effort will lead to harmonized recommendations to the department for the optimal exploitation of these M&S capabilities.

1. Agriculture and Agri-Food Canada, Atomic Energy of Canada Limited, the Canadian Food Inspection Agency, the Canadian Space Agency, the Communications Research Centre, the Department of Fisheries and Oceans, the Department of National Defence, Environment Canada, Health Canada, Industry Canada, the Medical Research Council of Canada, the National Research Council Canada, Natural Resources Canada, and the Natural Sciences and Engineering Research Council of Canada.

ensuring high quality and establishing a high international reputation. For example, two recent case studies demonstrated that Environment Canada's scientific knowledge makes a substantial contribution to sustainable development. These independent studies were done to assess the socio-economic impacts of Environment Canada's research supporting Canada's pulp and paper regulations and control of ozone-depleting substances. The studies examined Environment Canada's unique contribution to the global scientific knowledge base and found that benefits have been considerable for Canadians.

With respect to the research supporting pulp and paper regulations, the case study concluded that, for an investment of about $13 million in federal research on the pulping process since 1988-89, the impact on Canada's gross domestic product, as a best estimate, was about $546 million. Environment Canada's research was ground-breaking and helped to protect Canada's access to foreign markets. Also, if the department had regulated on the basis of existing scientific knowledge (mainly from Swedish research), industry would have needlessly incurred higher costs to comply with an inappropriate regulation.

Environment Canada's research on stratospheric ozone not only enabled Canada to have a significant impact on the Montréal Protocol but also led to the development of the UV index, the first of this type of advisory, which enables people to protect themselves from increased ultraviolet rays. The ultimate results of this research include reduced incidence of skin cancer and fewer environmental impacts that would reduce fishery and agricultural productivity. The cost-benefit analysis carried out showed that, as a best estimate, the $108 million invested in the department's stratospheric ozone research since 1975-76 had an impact of about $432 million on Canada's gross domestic product.

The NRC is one of the few federal agencies with a mandate for industrial support and assistance. For example, it's Biotechnology Group currently has a combined portfolio of 107 collaborative agreements with partners across Canada, including 73 industry partners, 20 universities and 13 other federal and provincial government departments. Last year, the group created four new spin-off companies, and generated one licence and 15 patents. Twenty-eight firms used incubation facilities within the group's institutes, and 13 products and processes were commercialized. The NRC's Manufacturing Technologies Group has a portfolio of 346 research contracts with 255 clients, an increase of 13% from 1996-97. In 1997-98, the group generated 11 patents and 11 licences. During the year, the NRC Entrepreneurship Program entered into 42 new licensing agreements. The royalties collected from licences in 1997-98 doubled from the previous year, totalling over $2 million. In 1997-98, six new firms were spun off by NRC researchers, bringing the two-year total to 10.

In order to better use the international pool of knowledge on science and technology, science-based departments and agencies in the federal government have been consulted on their views for developing an international science and technology

Technology Transfer — Rewarding Success

The first FPTT Awards marked an important milestone in both FPTT's history and endeavours by the federal government and the private sector to successfully exploit technology developed in or by federal laboratories. These were distributed at a banquet held in conjunction with the successful FPTT Workshop on Evaluating Technology for Commercial Exploitation, which attracted more than 150 participants from across the country.
The two events attracted 15 sponsors.

Award Winners:

- Agriculture and Agri-Food Canada/Hedley Technologies Inc.
- Communications Research Centre/Innovative Fibres Inc.
- Department of Fisheries and Oceans/Focal Technologies Inc.
- Department of National Defence/CDL Systems
- Department of National Defence/Hemosol Inc.
- National Research Council Canada/Iogen Corporation
- Natural Resources Canada/Chemex Laboratories

For details, see **http://www.nrc.ca/fptt/index.html**

Technology Roadmaps

Industry Canada continues to facilitate Canadian industry's capacity to develop and commercialize technology through its Technology Roadmaps initiative. Technology roadmapping is a research and development planning and management exercise involving groups of firms in a given sector. These industry participants identify critical technologies required to meet future market demands (Phase I), leading to the formation and implementation of various partnerships and consortia to develop and commercialize these technologies (Phase II).

Since its inception three years ago, this initiative has led to seven industry-led Technology Roadmaps exercises on a pilot basis. At present, three Technology Roadmaps teams are involved in Phase I: Electrical Power, Medical Imaging and Metal Casting. Four teams are involved in Phase II: Aerospace and Defence, Forest Operations, Geomatics and Wood-based Panel Products. For details, visit **http://strategis.ic.gc.ca/sc_indps/trm/engdoc/homepage.html**

framework. This framework would facilitate federal coordination in the area of international S&T. The science-based departments' and agencies' views have been consolidated, and more focussed consultations are under way to clarify areas of consensus. An analysis will then be provided for the Assistant Deputy Minister Committee on Science and Technology to coordinate the next steps.

The important role that the federal S&T effort can play in access to foreign markets and to leading-edge products and processes should not be underestimated. With global pressures for the harmonization of regulations, Canadians demand assurances that their traditional high standards will not be diminished. Significant research is conducted by (or for) federal organizations such as Health Canada, the NRC and the Standards Council of Canada, to support the development of mutual recognition agreements (MRAs) with other countries. MRAs increase efficiency and effectiveness by reducing duplication, and ensure the availability of products in a more timely manner and at a potentially lower cost. They facilitate the development of new export markets for Canadian therapeutic products and simplify trade by reducing barriers without compromising Canadian standards. MRAs also enable Canadian regulators to allocate resources to products imported from countries that lack appropriate standards and foster increased Canadian-European regulatory cooperation.

NRCan's involvement in the adaptation of South African hydraulic drill technology for Canadian conditions is another example of the important role of the federal S&T effort in bringing to Canada foreign technology that could significantly benefit Canadian industry and contribute to the creation of jobs. The CANDRILL water-powered rock drill is being developed under a consortium agreement involving NRCan, Hydro-Québec, the SOREDEM group of Quebec mining companies, and Novatek of Johannesburg, South Africa. Work to date indicates that, compared with compressed air drills, the CANDRILL will offer double the penetration rates, reduced vibration, fewer dust and oil mist emissions, and improved energy efficiency. The new drill will be manufactured in Canada for the North and South American markets, where sales may exceed 2000 drills a year.

The widely increased availability of digital information is shaping our economy and society, both expanding the bounds of what is possible and changing who is able to control and profit from the information. This has created opportunities for innovative firms in many fields. It has also forced governments to find innovative ways to process and package this information to benefit Canadians. An example is GeoConnections, a collaborative effort to provide a range of geographic information to Canadians.

In a number of high profile, high technology-intensive fields, governments around the world support their domestic industries. The defence and aerospace fields are prime examples. In these fields, the government can have an important role in terms of levelling the playing field. Technology Partnerships Canada (TPC),

International Agreements, National Benefits

The MRA agreement for the medical devices sector establishes mutual recognition of each country's ability to assess products to the standards of the other country. Specific categories of medical devices that are not included in the agreement are in vitro diagnostic devices, breast implants, devices containing drugs, and devices incorporating tissues of human or animal origin. The agreements have been negotiated without compromising Canada's high standards of health and safety. According to the Department of Foreign Affairs and International Trade, it is estimated that the MRA could eliminate 50% of the product testing and certification costs that exporters currently bear to meet Environment Canada's regulatory requirements. The MRA could also facilitate the development of new export markets for Canadian therapeutic products.

Consolidated Information Sources

GeoConnections, the activity to build the Canadian Geospatial Data Infrastructure, championed by NRCan, is a coordinated effort across the federal, provincial and territorial governments, industry and academia to develop the geographic lane on the Information Highway. It will provide Canadians everywhere with on-line access to geographic information for a variety of applications such as resource and environmental management, community planning, emergency response planning, and transportation modelling. The geomatics industry has stated that developing GeoConnections is the most important thing Canada can do to support its growth. GeoConnections will foster a projected 10% industry growth per year, potentially creating 16 000 new jobs over the next five years.

a key outcome of the S&T strategy, has a mandate to support the enabling technologies upon which Canada will build its future, as well as to support commercialization efforts in sectors where foreign governments are providing support. As of March 31, 1998, TPC had approved 66 projects in aerospace and defence industries, environmental technologies, and enabling technologies. These projects will result in multi-year research and development investments of $588 million by TPC. TPC's investments will leverage an additional estimated $2.4 billion in research and development and downstream investments by private sector partners. Projections by private sector partners indicate that these investments will generate some $67.8 billion in sales. It is estimated that nearly 14 500 jobs will be created or maintained directly and indirectly through these projects.

Governments around the world are the keepers of a vast resource of technology: their patent data bases. These data bases are considerable stores of information on technological developments and innovations, and can be the starting point for new innovations. Seeking to make Canada's patent information more accessible, and thus more useful to Canadian firms and innovators, Industry Canada's Canadian Intellectual Property Office recently placed its massive patent data base on the Internet. The data base includes detailed information and drawings of more than 1.3 million patents and patent applications that have been filed over the past 80 years. The new on-line data base was developed with a private sector partner.

Encouraging the commercialization of university research has been a government priority for a number of years. It has driven the creation of university-industry programs under the granting councils, and is a key objective of the NCEs. It also propelled the creation in 1998 of an expert panel by the ACST, which will provide the government an external perspective on how to maximize the results from this important federal investment.

3.2 People: Investing in the Leading-edge Work Force of the 21st Century

A large and growing body of evidence supports the proposition that a nation's economic prospects and the quality of life of its citizens are critically dependent on the knowledge and skills of its people. A literate, highly skilled and innovative work force is the key to success in a world that is being rapidly transformed by information technology. Hence, governments the world over are re-examining their support to education and training systems with a view to improving access and making these systems more responsive to the demands of an ever-changing labour market.

Canadians of all ages and both genders are acutely aware of the increasing social and economic benefits to be derived from the pursuit of higher education. Full-time enrolment in colleges and universities is at an all-time high and, in today's university graduating classes, the women outnumber the men. Over the past 20 years or so, the number of adults returning to full-time studies has more than tripled. Most

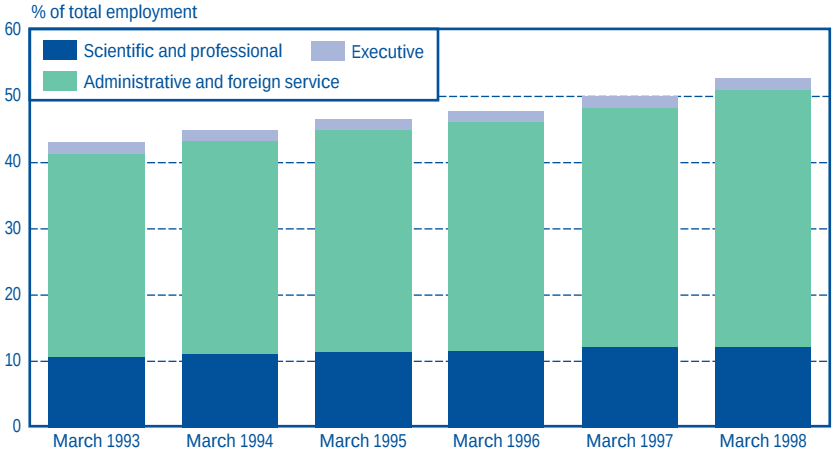
of these returnees are going back for job-related reasons. In response to these trends, the federal government's 1998 budget contained a package of measures — some new, others building on existing programs — to provide Canadians with greater access to the knowledge and skills needed to acquire better jobs.

This set of measures, the Canadian Opportunities Strategy, takes action on the following seven fronts by:

- providing more than 100 000 students with Canada Millennium Scholarships, averaging $3000 a year, and Canada Study Grants to as many as 25 000 students who are in financial need and have children or other dependants;
- increasing assistance by $405 million over three years for advanced research and for graduate students through increased funding for the three granting councils;
- helping graduates manage their student loans by providing tax relief on interest payments on student loans, and through improvements to the Canada Student Loans Program;
- helping Canadians upgrade their skills throughout their working lives by allowing tax-free withdrawals from their registered retirement savings plans, and by extending the education tax credit and the child care expense deduction to part-time students;
- ensuring that families can better save for their children's future education by providing stronger incentives through a new Canada Education Savings Grant — a grant of 20% on the first $2000 of contributions made each year to registered education savings plans;
- supporting youth employment by more than doubling funding for youth at risk who lack basic education and job skills, and by providing employers with an employment insurance premium holiday for additional young Canadians hired in 1999 and 2000; and
- increasing funding for SchoolNet, the Community Access Program, and CANARIE to help bring the benefits of information technology into more classrooms and communities across Canada.

The trends evident in the private sector labour force are also reflected in the federal public service employment statistics. Coincident with downsizing, there has been a gradual change in the occupational profile of the federal public service, with the emphasis shifting toward jobs held by knowledge-based workers (*see Figure 8*). As of March 31, 1998, 52.7% of federal employees occupied positions in the executive, scientific and professional, and administrative and foreign service categories, compared with 43.0% on March 31, 1993. The strong growth in the administrative and foreign service category is almost entirely due to a 34% increase in the size of the computer systems administration group. Other groups showing a sizeable increase include economics, sociology and statistics; mathematics; and physical sciences, which are all within the scientific and professional category. Moreover, growth in these groups occurred during a period when overall public service employment was decreasing by 22.2%.

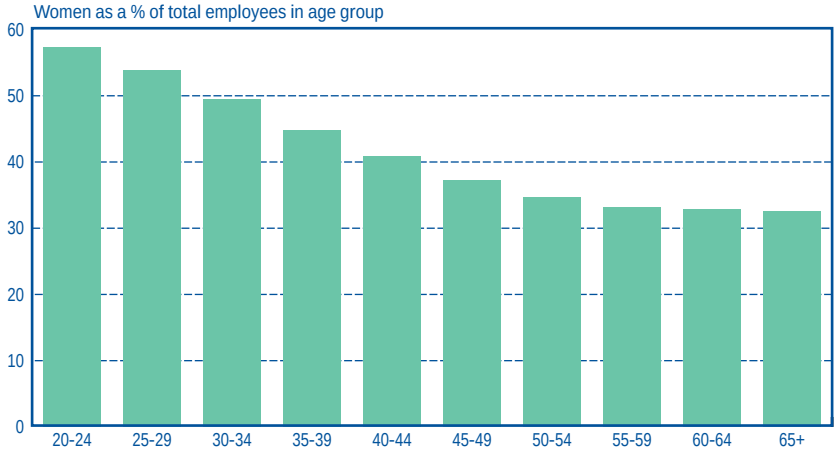
Figure 8: Changes in the Professional Composition of the Public Service, 1993 to 1998



Source: Treasury Board Secretariat

With downsizing, there has also been an increase in the proportion of knowledge-based positions occupied by women. As of March 31, 1998, women occupied 46.8% of the positions in the executive, scientific and professional, and administrative and foreign service categories, up from 41.4% in March 1993. More than 48% of the women in the public service now work in one of these three professional categories. Within the scientific and professional category, almost one third of the jobs are today performed by women, compared with about 29% in 1993. This trend is likely to continue, since not only are there more women than men graduating from universities, but the women presently in the public service are also younger on average than their male counterparts. Of the employees in the under-30 age group, 53.8% are women (*see Figure 9*). This is five percentage points higher than in 1993.

Figure 9: Employment in the Scientific and Professional Category by Gender and Age Group, March 1998



Source: Treasury Board Secretariat, "Employment Statistics for the Federal Public Service."

3.2.1 People: Enhancing Quality of Life

The people of Canada enjoy a high quality of life: the United Nations has once again identified Canada as the best place in the world to live. More importantly, however, those same people — Canadians — are in large part responsible for creating and maintaining that quality of life. It is therefore important that the federal government continue to invest in people and their skills, especially since most of the opportunities presented by the knowledge-based economy and society require higher levels of skill and knowledge. Thus, the Millennium Scholarship Foundation, with a $2.5 billion endowment, has as its basic objective to improve the accessibility of post-secondary education to all Canadians in order to maximize their potential to participate in the Canadian and global, knowledge-based economy.

The federal government needs a strong, highly motivated work force. Revitalizing this work force has been an even higher government priority since the release of the S&T strategy in 1996. The Framework for the Human Resources Management of S&T is a model for collectively developing solutions to human resource issues, which is now being used as a model across the federal government. Through a community of common interests, involving departments and agencies, central agencies, employees, and bargaining agents, it is helping to prepare the federal S&T work force to meet the challenges of the future.

The framework is managed so as to maximize its ability to deliver on the demands of the Canadian people, and is continuously renewed to remain up to constantly evolving challenges. In the past year, the community-wide consultations and planning have turned into concrete results. Most notably, an S&T Managers' Forum held in December 1998 brought together federal government managers from across Canada. The forum led to new appreciation of the shared challenges facing federal S&T and a renewed commitment to delivering the highest calibre of science and technology to support the protection of the environment, as well as human health and safety, and government policy making. As well, the results of pilot projects in areas such as training, staffing flexibilities, information exchange and career development are now being assessed and put into action across the government. Implementation of these approaches across the government will help the federal S&T work force remain both forward-looking and responsive to changing needs.

Work to improve Canadians' quality of life often brings together the natural and social sciences to provide Canadians with the information they need to make wise choices. For example, the first-ever *Canada's Physical Activity Guide to Healthy Active Living*, released in the fall of 1998, is a distillation of the best current Canadian scientific opinion on physical activity and health. The guide is a joint project of Health Canada's Fitness and Active Living Unit and the Canadian Society of Exercise Physiology. A panel of internationally recognized Canadian scientists (exercise physiologists and social psychologists) led a peer-reviewed process to reach consensus on guidelines for the amount and type of activity needed to benefit health, and the most effective design of social marketing messages. As it represents state-of-the-art science and social marketing, the guide is expected to become a reference guide as influential as *Canada's Food Guide to Healthy Eating*.

Priorities for the Management of the Federal S&T Community

- Implementation of the universal classification standard (UCS) for the S&T community.
- Review of promotion criteria for incumbent-based science positions (especially RES, DS), in light of changing work requirements and implementation of the UCS.
- Development of core competencies for science managers and a science managers training program.
- Preparation of work force demographic analyses and proposals for recruitment of the S&T community, with special reference to diversity and equity issues (women, Aboriginal peoples, people with disabilities, visible minorities).
- Inclusion of technologists' and technicians' concerns in the discussion and resolution of S&T issues, so that the S&T community is represented in its entirety.
- Establishment of internal and external communications mechanisms for the S&T community.

One of the most important roles of federal S&T is to inform policy and decision making. As a result of population analysis of health issues and health determinants, Health Canada has developed an extensive focus on childhood and youth health, well-being and development. Since investments in healthy child development can result in decreased costs and demands on the health care, social services, education and justice systems in the future, Health Canada is carefully evaluating the major community-based programs and analysing the data available from major population-based health studies for further information on key risk factors and successful intervention strategies.

3.2.2 People: Advancement of Knowledge

Knowledge has some unique properties when examined from an economic viewpoint. As a factor of production, it is re-usable without losing its value, although its value may diminish with wide distribution. It can be applied in many different contexts, creating new value each time. Not all knowledge can be stored in a quantifiable form, since much of it is in the form of tacit knowledge or know-how. Because they either carry this knowledge or apply it, people are the key link in translating knowledge into tangible benefits to society. Thus, by focussing on the people part of the equation, governments are able both to advance knowledge and to ensure that it has an ultimately positive return.

From a demographic standpoint, Canada's aging population is a concern. This is a problem Canada shares with many industrialized nations. Recent data from the Association of Universities and Colleges of Canada indicate that, in Canadian universities, a growing proportion of researchers are nearing retirement age. This trend is also mirrored in studies of the demographics of the federal S&T work force. However, for a number of reasons, the supply of young scientists and engineers is not keeping pace with the rate of retirement. This is leading to fears that the nation's S&T capabilities will decline in the future, when they will be needed more than ever. To reverse this trend, the federal government is seeking to address the underlying factors by improving opportunities for young researchers and ensuring that the national S&T apparatus remains vibrant, in order to attract and retain the best and brightest minds.

The NCE program is an excellent example of how the federal government is supporting the advancement of knowledge while generating other benefits to Canadians. The NCEs draw together academic and private sector researchers from institutions across Canada to tackle leading-edge research. In 1997-98, the 14 NCEs involved more than 742 university network researchers, 54 universities, 456 companies, 336 other organizations across Canada, and 94 foreign partners. In addition to state-of-the-art research, the networks provide employment and valuable training experience to some 3262 highly qualified people (industry associates, federal and provincial agencies, hospitals, research associates, postdoctoral fellows, technical staff, graduate students, and summer/undergraduate students). The active involvement of Canadian industry provides stimulating training environments and

NCEs Funded in 1997-98

- NeuroScience Network
- Canadian Bacterial Diseases Network
- Canadian Genetic Diseases Network
- Canadian Institute for Telecommunications Research
- Concrete Canada
- Health Evidence Application and Linkage Network
- Institute for Robotics and Intelligent Systems
- Intelligent Sensing for Innovative Structures
- Respiratory Health Network of Centres of Excellence (Inspiraplex)
- Mechanical Wood-Pulps Network
- Micronet — Microelectronic Devices, Circuits and Systems
- Protein Engineering Network of Centres of Excellence
- Sustainable Forest Management Network of Centres of Excellence
- TeleLearning Network of Centres of Excellence

employment opportunities. Of the postdoctoral fellows and students who graduate and leave the networks, the majority are hired by industry (56.45%), universities (31.36%) or government (5.39%). Since the beginning of the NCE program, the networks' entrepreneurial thrust has resulted in the creation of 59 spin-off companies.

The SSHRC is planning to launch the Community University Research Alliances, an innovative model to develop knowledge and expertise geared to community development through innovative alliances between universities and local and regional action groups. These innovation centres are designed to mobilize researchers and students at universities to develop knowledge and transfer mechanisms around priority issues such as youth, violence, sustainable development, health care restructuring and local governance. In a pilot phase, the program will allow the establishment of up to 16 innovation centres that will focus on developing knowledge, expertise and innovative transfer mechanisms to contribute to the development of communities across the country.

The important role performed by universities, colleges, hospitals and other not-for-profit research institutions can be diminished without the appropriate infrastructure. Research equipment in many of these institutions is aging and often not able to address the needs of leading-edge research and teaching. This was the reason behind the creation of the Canada Foundation for Innovation (CFI). In October 1998, the CFI announced awards totalling $21.6 million to help strengthen the capability for world-class research and technology development at 35 Canadian universities and research institutions. These investments enable more than 550 researchers in institutions across the country to have access to the advanced equipment and facilities they need to undertake leading-edge research. Under its New Opportunities fund, the CFI recently announced an investment of $36 million to help launch the careers of more than 400 new faculty members in 26 universities across the country. The funds will be used to provide the new university researchers with the equipment and installations needed to address important problems in the areas of health, science, engineering and the environment. For projects under $350 000, the CFI approved an investment of $7.8 million for 67 infrastructure projects at 26 institutions. These awards will help strengthen the research infrastructure in the institutions' priority areas. For projects over $350 000 and regional/national facilities, 14 institutions will receive funding for 16 projects, totalling $8.1 million.

Programs such as the CFI, through their cost sharing of funding, leverage significant investment by the private sector. In other cases, however, government initiatives attract private sector funding simply through their potential for positive impacts on Canadian society. Microsoft CEO Bill Gates recently donated $1 million to Industry Canada's Grassroots, a SchoolNet initiative intended to encourage Canadian K-12 teachers and students to develop on-line learning projects. Industry Canada hopes to obtain $15 million from the private sector over the next three years, which the federal government will match. Some 20 000 projects are expected to be spawned by 5 million students as a result of this program.

The Canadian Genetic Diseases Network (CGDN) Centre

The CGDN isolated two genes associated with Alzheimer's disease that led to a strategic alliance among three partners — Schering Canada/ Schering Plough, the University of Toronto, and Toronto's Hospital for Sick Children — and the largest university intellectual property licensing deal in the history of Canada. Other work involved the development of a molecular diagnostic test for childhood eye disease that could save the Canadian health care system up to 70% of the cost of conventional surgery. Neurovir Inc., a CGDN spin-off company, will begin clinical trials in 1998 with a proprietary treatment for brain cancer. With CGDN's strong presence in the research community and world-recognized contributions to genetics, the future of Canada in this area looks promising.

3.2.3 People: Sustainable Job Creation and Economic Growth

As the knowledge-based economy and society have become a reality around the world, governments have shifted the focus of their activities. With continued pressure for the reduction of government spending and the globalization of economic activity, governments have decreased their direct funding to businesses. Instead, governments are seeking to become key sources of information and intelligence. They are using the power of information technology to reach out to users from all walks of life and with a wide range of needs.

Industry Canada's *Strategis* Web site, launched in 1996, has quickly become the largest and most successful source of business information of its type in the world. *Strategis* provides information for and about the people who create economic growth in Canada — businesspeople and entrepreneurs. *Strategis*' National Expertise Index provides access to more than 15 000 Canadian researchers in university and government labs that can assist Canadian firms with cutting-edge research, technologies and expertise to promote innovation-based growth and profitability. *Strategis* also provides the Opportunity Match service to link the research and technology available for licence or exploitation to firms that have problems to solve or new markets they wish to exploit. Several of *Strategis*' novel information products also support innovation in Canada. Commercialization efforts of Canada's smaller firms and entrepreneurs are supported through the Commercialization Toolbox — a novel, Internet-based product that provides how-to guides, checklists, templates and an extensive data base of commercialization experts in government and the private sector.

Federal government researchers have a long history of inventions that have made significant contributions to the Canadian economy and society. For the past 25 years, the Government of Canada has had an award program to encourage the disclosure of inventions made by public servants. In 1973, the federal government enacted the *Public Servants Inventions Act* to cover inventions made by public servants where ownership was vested in Her Majesty. Under this act, inventors may receive cash payments of up to 35% of the royalties received by the Crown for the invention.

The federal government plays a key role in recognizing and thus encouraging the entrepreneurs who create jobs and economic growth in Canada. The government provides support for the National Quality Institute, which administers the Canadian Awards for Excellence to deserving individuals or organizations in the public or private sector — in government, business, health care or education.

Canadian industrial and business sectors are continually adapting to maintain their competitive edge in the international, knowledge-based marketplace. The sectors that are now driving Canada's economic growth and job creation are knowledge-intensive. Demand for highly skilled workers is growing, but many sectors are experiencing difficulties in finding and retaining such workers. At the same time, however, some of Canada's recent graduates from universities and colleges are finding it difficult to find jobs in the fields for which they have trained. The difficulties reported by both business and graduates need to be understood and addressed.

Matching Technology Needs with Employment Opportunities

The First Jobs in Science and Technology Program (FJST) was announced in March 1997, targeting small and medium-sized enterprises (SMEs) and having the dual objectives of helping SMEs to enhance their competitive positions through technological adaptation and developing a work force of science and technology professionals with entrepreneurial skills. The FJST program has created 311 jobs for recent post-secondary graduates with Western Economic Diversification Canada funding of $11.5 million as of October 31, 1998.

Strengthening our understanding of the skills challenges facing the nation and finding solutions is a key concern of the federal government. To understand better the dynamics at play and the nature and scope of the human resource problems faced by Canadian employers, the Secretary of State (Science, Research and Development) undertook, in spring 1998, a series of consultations with leaders from industry, academia, labour, national sector councils, granting councils and the federal government. The first message was that these challenges are global, not national. The following key priorities were identified:

- to correct/eliminate skills shortages;
- to attract skilled workers from abroad;
- to retain skilled workers;
- to attract youth to specialized fields; and
- to upgrade skills.

Responding to the messages heard by the Secretary of State, the federal government has taken action on a number of fronts. For example, the federal government is addressing the challenge of attracting skilled workers from abroad in three ways: through the software development worker pilot project, upcoming reforms to Canada's *Immigration Act*, and the spousal employment authorization pilot.

The federal government has a responsibility to address the "big picture" in areas such as economic growth and social development. For this reason, it supports broad programs in social science research of importance to the nation as a whole. For example, in March 1998, the 11 science and economic organizations of the Industry Portfolio participated in a workshop entitled "Building Local Capabilities for Innovation." As a result of this workshop, the Portfolio established a work plan that focusses on local community innovation. One key project in this work plan involves SSHRC, the NRC and NSERC, which have invested $600 000 over three years to create the Innovation Systems Research Network. This national network of researchers will examine the link between innovation and development in various regions of the country. The three-year pilot project will support university-based research on technological change, economic development, and the systems that affect how innovations — such as new or improved services, products, management methods or production techniques — are applied in society. The new knowledge produced by this research should help policy makers better understand how science, technology and economic policy affects economic development.

Federal S&T activities also support the goals and economic aspirations of Canada's Aboriginal peoples. For example, NRCan delivers the First Nations Forestry Program in partnership with DIAND. The program aims to enhance economic opportunities in the forest sector for First Nations people and to increase their capacity to sustainably manage their reserve forests. In March 1998 the program completed a highly successful second year of operation. More than 200 proposals received $5.5 million in program funding, with an additional $14 million in support from First Nations and other partners. Examples of projects include a joint venture between the Ditidaht First Nation and British Columbia Forest Products Ltd., leading to the construction of a First Nation sawmill; an initiative with the Berens

Reducing Barriers to Immigration

The Software Development Worker Pilot Project was developed by the Software Human Resource Council, in conjunction with Citizenship and Immigration Canada (CIC), Human Resources Development Canada (HRDC), and Industry Canada, largely in response to critical shortages of software development workers. This pilot was launched to test "fast track" validation for specific senior software development workers. An evaluation, published on November 30, 1998, confirmed the success of the pilot and the program has been extended. CIC and HRDC are currently reviewing the evaluation of the pilot with a view to incorporating successful practices into new immigration policies. The Software Development Worker Pilot Project, which began in May 1997, has attracted more than 500 software developers from countries such as India and Russia. With an estimated shortage of about 20 000 software workers in Canada, the program is popular because it streamlines the hiring process.

River First Nation in Manitoba to conduct log home building courses for First Nations people on their reserve, which has led to permanent employment in this sector; and the establishment of a forest nursery by the Makwa Development Corporation of the Algonquins of Golden Lake.

3.3 Taking Control of Horizontal Issues

3.3.1 Science and Technology Advisory Structure, Progress and Outputs

The 1996 S&T strategy advised on the need for new institutions and mechanisms to be created for the governance of science and technology. A key concern was how to address the numerous and increasingly complex S&T issues the government was facing. The government required governance infrastructures incorporating consultation and advice from the best-qualified advisors in the country, whether from the public or private sectors.

In the past year, the government undertook initiatives to profit from this external advice. Flowing from recommendations made by the ACST, authorization has been given to establish expert panels on specific S&T issues. To maintain and improve Canada's position at the forefront of the knowledge society, the ACST formed expert panels to address issues at the core of this challenge: the development of skills needed for the knowledge society, and the commercialization of university research. The deliberations of the panels are to be completed within a year, at which time reports from the panels will be made public.

Futhermore, the ACST was given approval to appoint a Deputy Chair for the council in December 1998. The Deputy Chair will help the ACST chart its ongoing work plan, manage the expert panels process, and provide a focal point for the council's interaction with other advisory bodies and with the scientific and business communities in Canada and around the world.

The government has also tapped expert external advice through another means. Heeding the S&T strategy's call for greater reliance on expert external advice, most science-based departments and agencies created external advisory bodies. To better integrate this diverse external advice received by ministers and agencies, the government established the Council of Science and Technology Advisors (CSTA).

Chaired by the Secretary of State (Science, Research and Development), the CSTA complements the work of the ACST. Although both deliver external advice to the government, their priorities differ. ACST members will continue to focus on transforming S&T into economic growth and employment, while CSTA members will advise the government on internal, crosscutting S&T issues. The first two tasks for CSTA members are to examine the roles of the federal government in the performance of S&T and its ability to fulfil these roles, and to develop a set of guidelines for the use of scientific advice in government decision making.

The use of expert panels and the creation of the CSTA advance the government agenda of a cooperative and coordinated approach, more closely linking the ideas and expertise of government, business, finance and academia.

This governance structure, set out in the S&T strategy, also ensures close contact between the various S&T policy advisory bodies and excellent complementarity between their agendas. The Secretary of State (Science, Research and Development) is the Vice Chair of the ACST and the Chair of the CSTA. As well, the Deputy Chair of the ACST sits as an ex-officio member of the CSTA. The CSTA is also linked to the internal Assistant Deputy Minister Committee on Science and Technology (S&T ADMs), as one of the co-chairs of S&T ADMs is an ex-officio member of the CSTA. This network of linkages between the various S&T advisory committees, and the fact that the secretariats for all three bodies are located within the same sector at Industry Canada, have resulted in significant cross-fertilization of ideas.

3.3.2 Renewal of the Canadian Biotechnology Strategy

Biotechnology is an important component of Canada's knowledge-based economy. In the 1997 Speech from the Throne, the federal government acknowledged it as an important sector for future jobs and economic growth. On August 6, 1998, the government announced the renewal of the Canadian Biotechnology Strategy (CBS), which replaces the 1983 National Biotechnology Strategy. A cornerstone of the renewed strategy is the balanced approach to develop biotechnology as an important economic engine within the context of social and ethical considerations.

The strategy follows extensive, broad-based consultations with key stakeholders and the public. Altogether, more than 5000 individuals participated in a variety of activities, including three sets of consultations in the spring of 1998. The first set of consultations involved multi-stakeholder roundtable consultations in five cities across Canada concerning the strategy's policy framework, the advisory committee, and public information and participation. The second set of consultations focussed on matters pertinent to Canada's main biotechnology sectors: health, agriculture and agri-food, environment, aquaculture, forestry, mining and energy, and biotechnology R&D. The third set examined the strategic priorities for biotechnology R&D, including basic/fundamental R&D, regulatory/stewardship R&D, and innovative/wealth-generating R&D. As the government was seeking advice through roundtable and sectoral consultations on R&D, it also sought input from the general public through means such as its Web site and public opinion research. Consultations during the renewal process also included the provinces to ensure that their views were reflected in the final strategy.

Central to the strategy is the creation of the Canadian Biotechnology Advisory Committee. This independent, expert panel will advise a team of seven key ministers on the ethical, social, economic, scientific, regulatory, environmental and health aspects of biotechnology. It will advise on policy directions but will not arbitrate regulatory decisions. A key element of the strategy will also give Canadians an

ongoing forum to voice their views and participate in an open and transparent dialogue on biotechnology issues. To that end, the strategy will facilitate Canadians' access to accurate, understandable information regarding biotechnology, its application and its regulation.

The strategy also sets out a policy framework consisting of a vision, guiding principles and goals that reflect biotechnology's importance as a key contributor to quality of life and economic growth in Canada. The framework contains 10 themes for concerted action over the coming months to implement the strategy's goals in partnership with the provinces and territories, industry, academia, consumers, environmental groups, and other interested parties.

A team of seven ministers, coordinated by the Honourable John Manley, Minister of Industry, will oversee the strategy and address issues that cut across the mandates of various federal departments and agencies. The seven federal ministers are those whose portfolios touch on biotechnology matters: Industry, Agriculture and Agri-Food, Health, Environment, Fisheries and Oceans, Natural Resources, and International Trade.

One of the immediate priorities to be addressed is the commitment to the Canadian regulatory framework for products of biotechnology, which provides the necessary safeguards to protect health, safety and the environment. The regulatory system is a crucial intermediary between product R&D and ensuring that safe and effective products are offered on the Canadian marketplace. The Canadian regulatory system for products of biotechnology is often highlighted as one of the best in the world, and has been viewed as a model system by a number of countries and international organizations. However, the effectiveness of this system is at risk. Recent scientific advances have focussed research into new, and increasingly complex, biotechnology products and applications. In particular, these advances mean that there will be an imminent acceleration of new products into the Canadian regulatory system. The Canadian Food Inspection Agency, as the regulator of plants developed through biotechnology in Canada, is expecting to see substantial increases in crop species and product types, and a resultant increase in workload.

What made the renewal of the Canadian Biotechnology Strategy so unique was the coming together of seven departments, with different mandates and priorities, to work on developing a common vision and approach to crosscutting biotechnology issues. As a result, the renewed strategy is more comprehensive and integrated. The new horizontal management structure to implement the strategy is also unique, headed by a team of seven federal ministers, supported by a similar coordinating structure at the deputy minister and assistant deputy minister level. This new approach and structure is a clear indication of the government's intent to position Canada strategically to take advantage of opportunities in the global economy, while improving the quality of life of Canadians in a socially and ethically responsible manner.

3.3.3 Strengthening the Government's Policy Capacity

The federal government provides significant support for policy-related research and studies in universities, aimed at expanding the knowledge base upon which policy is formulated. However, while supporting university research in these areas is important, the federal government also needs to strengthen its own policy capacity to ensure that it is able to deal with longer-term strategic and horizontal issues. To address this need, the Policy Research Initiative (PRI) was launched in July 1996. The objective of the PRI is to build a solid foundation of horizontal research upon which future public policy decisions can be based. The initiative brings together more than 30 federal departments and agencies.

In Phase I of the initiative, departments identified key pressure points in Canadian society that are most likely to create future policy challenges. They assessed the current state of knowledge and pinpointed research gaps that need to be filled in order to support policy development. Many of these gaps require or will influence the direction of federal S&T. Phase II saw the establishment of four inter-departmental research networks: Growth, Human Development, Social Cohesion, and Global Challenges and Opportunities. In addition, a working group on the knowledge-based economy and society, with representation from each of the networks, is examining adjustment and transition issues facing Canada. The ongoing efforts of the networks and the knowledge-based economy and society are helping to enrich the quality of policy research. Key PRI reports that have emerged thus far include *Growth, Human Development and Social Cohesion* and *Canada 2005 — Global Challenges and Opportunities*. The initiative has fostered growth in the federal policy research capability through networking and conferences, including Policy Research: Creating Linkages, in October 1998.

4.0 Emerging Policy Challenges

In order to serve Canadians efficiently, the federal science and technology network needs not only to respond to current challenges, but also to be proactive in identifying issues that will affect the government's future progress toward its goals of improved quality of life, advancement of knowledge, and economic growth and job creation. This report focusses on how the government has been responding to two challenges that have become prominent since the release of the S&T strategy: innovation and people. Over the past year, a number of new challenges have also arisen, two of which are highlighted here: global climate change and strengthening the science-policy interface. Canada's signing of the Kyoto Protocol on greenhouse gas emissions has focussed attention on how federal science and technology activities can best contribute to an understanding of, and help to mitigate, global climate change. Another point of focus is the impact of global climate change on Canada's economy, society and environment and its effective management through S&T activities. As Canada moves into the new millennium, it is essential that its policy formulation processes keep up with the changes that come with the shift to a global, knowledge-based economy and society. Moreover, recent public and media attention to the role of science in government policy formulation and decision making has indicated an erosion in public confidence in these processes. Restoring this confidence will be a priority for the future.

4.1 Global Climate Change

4.1.1 Context and Problem

Climate affects our daily lives in many ways. Most physical and biological processes, and even human health and safety, are climate-dependent. Over time, Canadians as a society have developed policies that make assumptions about the normalcy of climatic conditions. In this context, the most essential assumptions are that our weather varies within a range of "normals" and that we have a reasonable estimate of the probability of extreme events: in effect, we have adapted to our local climatic conditions. The extent to which our policy implements (i.e., national codes and local regulations) are linked to climate is truly impressive, but this is not generally recognized by the Canadian public at large. In some countries of the world, because of population pressures, economics and historical developments, there is ample evidence to suggest that some regions may already be poorly adapted to current climatic conditions, let alone somewhat different future conditions.

"Our actions today will decide the kind of world we pass on in the next century. That is why the need to act on climate change is so pressing. Global warming is happening. And greenhouse gas emissions are a major cause — on that much we agree."

– The Right Honourable Jean Chrétien, Prime Minister of Canada, November 6, 1997.

The atmosphere has the capability of insulating the Earth's surface from heat loss, through a process popularly known as the greenhouse effect. Caused by a number of trace gases in the atmosphere, the greenhouse effect keeps the Earth's surface some 33°C warmer than if these gases were absent. It is therefore critical to life as we know it on this planet. Since about 1800, atmospheric concentrations of carbon dioxide, methane and nitrous oxide have risen by 30%, 145% and 15%, respectively, and now exceed any past levels at least over the past 200 000 years. These increases are linked to human activities, primarily the combustion of fossil fuels for energy and the clearing of forests. Over the same period, global temperatures have risen by 0.6°C.

Scientists at international meetings in the late 1980s began raising concerns about the potential for future large climatic changes if the rate of greenhouse gas emissions continued to increase. Estimates by the Intergovernmental Panel on Climate Change suggest that a 1°C to 3.5°C, or more, warming of the Earth's mean annual temperature is possible over the next century. To put these numbers into perspective the difference in global mean annual temperatures between a full ice age — covering most of Canada, the northern United States and northern Europe with ice a kilometre or more thick — and the current climate is approximately 5°C. Against this background, the projected changes in mean global temperature must be considered large. At the regional level, the projected changes may be much higher.

4.1.2 Initial and Ongoing Policy Responses to Scientific Findings

In response to scientific findings, at the Earth Summit in Rio de Janeiro in June 1992, Canada signed the Framework Convention on Climate Change. Along with other industrialized nations, we identified a goal of stabilizing greenhouse gas emissions at 1990 levels by 2000. Subsequent negotiations led to the adoption in 1997 of the Kyoto Protocol, which calls on developed countries to reduce their collective emissions of greenhouse gases by 5.2% by the period between 2008 and 2012. Canada's reduction target is 6%, a challenging figure considering that by 1997 we were exceeding the 1990 level by more than 10%.

In April 1998, the federal, provincial and territorial ministers of energy and environment met in Toronto and approved a process to examine the impacts, cost and benefits of implementing the Kyoto Protocol as well as the various options open to Canada for implementing the protocol. They agreed that Canada must do its part to address climate change. They decided to move forward on key issues, in which S&T figures prominently.

4.1.3 Issues and Research Needs

Ultimately, global climate change research and policy actions are being driven by the desire to limit the potential negative impacts of climate change. There are two basic options for dealing with climate change: 1) to reduce the magnitude and rate of the climate change through mitigative actions, i.e., reducing atmospheric

Kyoto Anniversary: A Year of Action

One year after the negotiation of the Kyoto Protocol, the federal government has undertaken a number of actions to help Canada meet its commitment to reduce greenhouse gas emissions.

Domestically, actions include:

- the introduction of the Federal Action Program on Climate Change: Leading the Way Forward, which commits the federal government to surpass the goals of stabilization and reduce its emissions by 20% by 2005 (for more information on the federal response see **http://www.climatechange.gc.ca**);
- the establishment of 15 "Issue Tables," where 450 experts are working to identify options so that all sectors of our economy and all regions of our country can make their contributions to achieving reductions in greenhouse gas emissions;
- the development of a national implementation strategy to meet our Kyoto target of minus 6%; and
- the introduction of the $150 million Climate Change Action Fund.

The government has also undertaken actions on the international front, including the following:

- hosting a forum for ministers from developed and developing countries on how to make use of the flexibility measures through the Kyoto Protocol's Clean Development Mechanism;
- sponsoring regional workshops in Latin America and Africa on flexibility measures; and
- working to develop the Buenos Aires Plan of Action that commits countries to have in place international rules and mechanisms necessary to implement the protocol by the end of 2000.

concentrations of greenhouse gases that are causing climate change; and 2) to develop adaptive strategies that will reduce and/or take advantage of the impacts that climate change will have. Underlying both of these actions is the need for suitable S&T. Because climate change is such a complex issue, we must further our understanding of all aspects of the climate system, its drivers and environmental responses, so that we can more fully consider the impacts of potential climate changes on human health, or the economy and society as a whole. Our knowledge is incomplete.

Mitigation: Although the overall goal must be to reduce global, not just national, emissions, each country must do its best at home. In Canada, a number of federal programs promote energy efficiency and renewable energy, while a voluntary registry program contributes to the reduction of greenhouse gas emissions. The eventual solution will have a high technological component, and for this we must rely on S&T. Federal centres and laboratories are developing new technologies to help reduce emissions in most major user sectors (e.g., transportation and community energy). As well, research is being undertaken that may allow us to effectively sequester carbon dioxide in geological deposits (e.g., coal fields, oil reservoirs), forests (tree plantations and managed forests) and agricultural soils. The latter two options in particular are actively being discussed internationally at the Framework Convention on Climate Change meetings, and national positions are being developed. Federal S&T activities are being redirected to provide the answers Canadian negotiators and policy makers need.

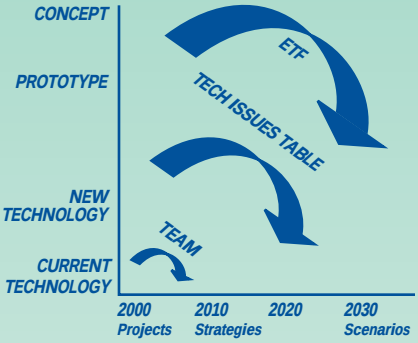
Adaptation: While reducing the rate at which future climate will change through mitigative actions is a critical factor in reducing and slowing its effects on ecosystems and society and economy, totally avoiding climate change is not possible. Both the magnitude of the changes in atmospheric concentrations of greenhouse gases to date, and the practical difficulty of achieving and maintaining the more than 50% reduction in emissions required to stabilize atmospheric concentrations at current levels, suggest that some climate change in future decades is unavoidable. Hence, in addition to efforts aimed at reducing greenhouse gas emissions, we must prepare to adapt and adjust to the impact of ongoing climate change. Such anticipatory adaptation will help society capitalize on the potential benefits that climate change may bring and avoid many of the undesirable effects. This is particularly true in the case where the lifetime or implications of a decision or investment is sufficiently long that climate change can make a difference. An excellent example of such anticipatory action is the consideration of a potential one-metre rise in sea level in the design of the recently completed bridge to Prince Edward Island.

Critical questions remain and a refocussing of current federal government research programs in the relevant fields is under way.

Advancing Technologies to Reduce Greenhouse Gases

The overall federal government's response to climate change is being coordinated by a committee lead by the deputy ministers of NRCan and Environment Canada. There are three (short-, medium- and long-term) technology elements of the committee's work program. Respectively, these elements are:

Focus of Three Initiatives



- **Technology for Early Action Measures (TEAM)** — a government joint action program involving NRCan, Environment Canada, Industry Canada, Transport Canada and the private sector, that is part of the Climate Change Action Fund. Over the next three years, TEAM will implement projects involving the immediate deployment of advanced technologies to reduce greenhouse gas emissions.
- **The Technology Issues Table** — a component of the process to develop the National Implementation Strategy. The table is mandated to develop options designed to accelerate the development and commercialization of greenhouse gas mitigation technologies and to enhance the capabilities and opportunities for Canadian companies in domestic and international markets.
- **The Energy Technology Future (ETF)** — an investigative and exploratory research initiative, led by NRCan, addressing altering the fundamental relationship between economic growth and increasing greenhouse gas emissions. ETF will look beyond the existing technology pool to develop a set of scenarios of energy service demands, innovative technology options and fuel sources that will contribute substantively to reducing greenhouse gas emissions three to five decades in the future.

4.1.4 Summary

We are currently investing in the furthering of our scientific understanding of climate change and in developing a suitable knowledge base for wise and prudent decision making to enable us 1) to develop public policy for the reduction of greenhouse gas emissions, and 2) to identify and implement the most appropriate portfolio of response strategies, including those required to adapt to climate impacts. These efforts are central to developing a national implementation strategy to deal with climate change and its impacts and to allow Canada to meet its international commitments and obligations.

Climate change is an international issue precisely because it has both global causes and global consequences. Mitigative actions are a global priority in order to reduce the rate of climate change so that adaptive measures can in fact work. Adaptation will be an ongoing process that will help make the transition to new climates much less traumatic.

4.2 Strengthening the Science-Policy Interface

Much of the federal S&T network has been established to inform policy making and regulation. Although this network has evolved to meet changing needs and policy considerations, the need to adapt to change has never been stronger. Our vastly expanded knowledge about the world around us allows us to identify, through science and technology, where new policy may be needed. The immense power of modern science and technology provides the capability to inform policy and decision making to an unprecedented extent. Moreover, the range of issues upon which governments look to science for advice is expanding. Science and technology not only inform governments on issues relating to the security and safety of both people and the environment, but are also key to policy development to strengthen the economy (e.g., innovation policy) and define better approaches to delivering government services (e.g., efficiency gains).

Science is becoming a more prominent factor in government decision making. It is therefore increasingly important that the processes by which science is translated into policy are both rigorous and transparent. These processes must be based on high-quality science, and must ensure that both the implications and limitations of that science are clearly understood by decision makers. If this science-policy interface breaks down, the negative impacts on public confidence and the economy can be significant.

Canada's science-based, policy-making system has been in the spotlight recently, with respect to issues as diverse as Atlantic cod stocks, the safety of the blood supply, gasoline additives, and the use of hormones to increase milk supply in cattle. Canada is not alone, however. Norway has also faced similar challenges with its cod stocks; France and Japan have had HIV contamination concerns about their blood supplies; and the United Kingdom is still dealing with mad cow disease. The fact that many countries share similar problems is a clear indication of the growing complexity of issues facing governments, and the increasing role that science and technology are playing in government decision making.

Around the world, there is an apparent erosion of public confidence in the ability of governments to develop policies and regulations to protect the safety and health of their citizens and environments. To restore this confidence, governments must demonstrate that decisions are based on high-quality research, and carried out in accordance with established scientific traditions of careful empirical research, peer review and exposure to professional criticism. They must also demonstrate that codes of ethics have been followed, and that open and transparent decision-making processes, which include consultation with stakeholders and the public, have been followed. Without such processes, governments face both a political cost, through a loss of public trust, and a financial one, through increased economic, societal and liability costs.

To strengthen the science-policy interface, the government must have access to the highest quality scientific information on which to base its decisions. The federal government's support for research in universities helps to ensure a strong base of scientific knowledge in Canada. Moreover, through its support for participation in international scientific projects, the government also facilitates access to the leading edge of science worldwide.

In addition to access to scientific knowledge, the government needs specific capabilities in-house. These are necessary to carry out research that is not available from outside sources, or that cannot be obtained quickly enough to ensure a timely response to emerging issues, as well as to understand and interpret findings for the purposes of policy development. The government must have the ability to direct or conduct research that specifically relates to the decisions it must make. By carrying out this research in-house, the government is able to ensure that the advice it receives is independent, of high quality, and obtained at a cost consistent with the benefits that will accrue to Canadians.

Questions have been raised recently about the in-house S&T capacity of the federal government in the wake of Program Review and the changing requirements imposed by the knowledge-based economy. In terms of human resources, many highly trained federal researchers have left the government, and a significant proportion of their colleagues are nearing retirement age. Funding and opportunities for young scientists entering the government are not what they were 30 years ago. In addition, the changing role of science and technology in the federal government is creating a need for people with new skill sets. In terms of research programs, Program Review helped departments to focus their activities and to identify other options for getting the information they needed. However, with the requirements for science shifting more rapidly than ever, departments may need more room to manoeuvre to meet the needs. Furthermore, the federal government's research equipment and facilities are aging. For the most part, the government's research equipment and facilities are unique in Canada, represent a resource for all Canadian S&T, and have made strong contributions to Canada's scientific knowledge base and economic development. However, it may be time to evaluate if, and how well, they will be able to address the needs of the future.

Another challenge in strengthening the science-policy interface is to ensure that departments have effective processes and the human resource capacity to receive and use the scientific information. This is not only a question of communication, but also of ensuring that a system is in place to seek out scientific advice when appropriate, consider the full range of scientific views, and give the scientific advice an appropriate weighting (alongside legal, economic and social advice), in formulating a final decision.

One of the most difficult aspects of science-based decision making is dealing with incomplete information. While decision makers like yes-or-no answers, science and scientists are more comfortable offering probabilities and estimates. It is of utmost importance that the nature of the uncertainties involved in scientific advice are communicated clearly and that recognition is given to minority opinions and alternative outcomes. In some cases, science cannot offer any data at all, but can only suggest that there may be a problem. In these cases, the question is: Do we take action or do we wait until we have more data? Accordingly, scientific advice should reflect a range of possible outcomes, coupled with their probabilities. Canada's experience with the safety of the blood supply has pushed government departments towards the side of action, erring on the side of caution, but this approach can be costly. Even when decisions are made erring on the side of caution, totally unexpected factors can come into play. This can result in a perfectly "good," science-based decision turning out to be "wrong." Although no system will ever be perfect in this regard, the government is striving to establish a system whereby the best possible scientific advice is used to formulate the best possible policy for the benefit of Canadians. Whatever the outcome, an open, transparent process will ensure that everyone knows what scientific information led to the decision, and why the government made the choice that it did.

To be effective, governments must make choices and achieve balances. Some of these choices may involve redistributing income within the economy, while others may result in social benefits at an economic cost. Still other choices may involve determining which beneficial option can be implemented more cost-effectively. Science influences economic policy decisions, regulatory options, social policy — a much broader spectrum than in the past. In addition, the globalization of economies and of science and technology has, to an unprecedented degree, linked domestic science-based decision making to decisions made in other countries. In a global, knowledge-based economy, standing still means falling behind. Governments must be proactive regarding the continual advances made in science and technology, and their application in policy development, around the world.

Ultimately, most science-based decisions require some form of risk management, in other words, balancing a risk to the health and safety of Canadians and their environment against the potential economic and social costs of a given action. No activity is without risk; we undertake risk even walking across the street or driving to work. The idea of "acceptable risk" is unpopular with some people but, of necessity, it forms the basis of all decision making. Making this concept work for governments

and their citizens, however, requires a strong, consistently applied framework. It also requires an open and inclusive process that builds confidence in the resulting decisions. Expert scientific input should be a given, but this alone is not sufficient. This input must be presented openly, exposed to review by other experts, and made available to those interested in the factors leading to the final decision. The advice must also be presented clearly so it can be placed in context with other considerations.

Over the coming year, departments and agencies, individually and across the government, will be working to ensure that they have the S&T capacity (both in-house and external) to provide the highest quality of science-based advice to the decision-making process. They will also be implementing best practices for the conduct, management and use of science in the federal government. As well, they have sought the advice of the CSTA on how to ensure the quality and integrity of the scientific advice process. Together, these activities will help to ensure a strong science-policy interface as Canada moves into the new millennium.

5.0 Conclusion

Minding Our Future was the federal government's first report on its science and technology effort. It demonstrated that the government was committed to the implementation of its S&T strategy and was working toward integrating the strategy's principles into all of its S&T activities. This report clearly indicates that momentum is building behind the strategy. While federal science-based departments and agencies have been challenged by Program Review, and have had to make difficult choices, they have responded by taking innovative approaches that ensure a high-quality S&T effort that will continue to support the strategy's goals of quality of life, advancement of knowledge, and sustainable job creation and economic growth.

The federal S&T effort and its institutions have a long record of responsiveness and adaptability to the needs of the Canadian society, environment and economy. This tradition is continuing in the increasingly complex knowledge-based economy and society. Significant progress has been made in addressing the two themes from *Minding Our Future* — innovation and people. Undoubtedly, work on these themes will continue and new emphasis will be placed on the themes highlighted in this report. And, no doubt, the federal S&T system will continue to renew itself to deal with these themes and contribute to a better quality of life and higher standard of living for all Canadians.

Annexes — Highlights of Departmental and Agency Performance

Individual Ministers set priorities and direct their S&T activities in order to deliver on their departmental missions. The following material provides highlights of individual department/agency S&T, illustrating how these activities support the strategy's goals.

AGRICULTURE AND AGRI-FOOD CANADA

Mandate

Agriculture and Agri-Food Canada (AAFC) promotes the development, adaptation and competitiveness of the Canadian agriculture and agri-food sector which generates one tenth of our gross domestic product and employs almost 1.9 million people. A key objective of the department's Research Branch is to improve the long-term competitiveness of the sector through the development and transfer of innovative technologies. The branch's core competencies are aimed at controlling threats to the safety of crops and to human and environmental health for the public good and adding value to products for competitive advantage.

How does AAFC use S&T to deliver on its mandate?

Each of AAFC's 18 research branch centres has a specialized and strategic research focus of national importance. Their expertise reflects the type of industry in the agro-ecological region in their location. The centres do not work in isolation, but operate as nodes in a sophisticated and flexible network of scientific expertise at a number of sites that can link to each other and bring a range of resources to bear on a problem.

Research Facilities

- Atlantic Cool Climate Crop Research Centre (St. John's, NFLD): Crop production on mineral and peat soils under cool climate conditions.
- Crops and Livestock Research Centre (Charlottetown, P.E.I.): Programs include cereal and forage crops, potatoes, soil management and conservation, and swine nutrition.
- Atlantic Food and Horticulture Research Centre (Kentville, N.S.): New cultivars and technologies for horticultural crops; programs include post-harvest storage and processing, and nutrition and management of poultry.
- Potato Research Centre (Fredericton, N.B.): New cultivars and technologies for potatoes; programs include potato gene resources, pest management, and soil and water conservation.
- Soils and Crops Research and Development Centre (Sainte-Foy, Que.): New cultivars and production methods for forage crops as well as soil and water conservation, grain production, and wheat improvement.
- Dairy and Swine Research and Development Centre (Lennoxville, Que.): Animal production with a focus on dairy cattle and swine, as well as sheep and beef cattle.
- Horticulture Research and Development Centre (St-Jean-sur-Richelieu, Que.): Environmentally sustainable production of vegetables, fruits and ornamentals.
- Food Research and Development Centre (Saint-Hyacinthe, Que.): Food processing of animal and crop products; work also includes non-food products and processes.
- Eastern Cereal and Oilseed Research Centre (Ottawa, Ont.): Grains and oilseeds for eastern Canada, including corn, wheat, barley, oats and soybeans. Work in land evaluations, pest diagnostics, and national collections of plants, fungi and insects.
- Southern Crop Protection and Food Research Centre (London, Ont.): Alternative protection technologies for tree fruits, vegetables, field crops, and ornamentals and alternative crop development and soil and water quality.
- Greenhouse and Processing Crops Research Centre (Harrow, Ont.): Greenhouse and processing crops; programs include vegetables, oilseeds, and protein seed crops, soil management and germplasm preservation.
- Cereal Research Centre (Winnipeg, Man.): Wheat and oats for the prairies; programs include grain storage technology, cereal disease screening and alternative crops, as well as flax, field peas and germplasm preservation for alternative crops and woody ornamentals.
- Brandon Research Centre (Brandon, Man.): Sustainable management systems for selected soils, barley breeding, livestock and pasture management, and manure management.
- Saskatoon Research Centre (Saskatoon, Sask.): Long-term crop research focussing on biotechnology and chemistry; programs include oilseeds, forages, crop protection, crop processing and germplasm preservation for oats, barley, oilseeds, prosomillet, and forages.

- Semiarid Prairie Agricultural Research Centre (Swift Current, Sask.): Dryland farming systems; programs include land resource conservation, cereals, forages and field crops.
- Lethbridge Research Centre (Lethbridge, Alta.): Beef production and quality technology; programs include sustainable production systems for cultivated and range land.
- Lacombe Research Centre (Lacombe, Alta.): Meat processing, quality, safety and preservation, as well as breeding and crop production for parkland and northwestern Canada.
- Pacific Agri-Food Research Centre (Summerland, B.C.): Horticultural and field crop production, processing of plant products and biology of plant pathogens; programs include tree fruits, greenhouse vegetables and special crops, as well as soil resource conservation and poultry production.

Major S&T achievements in 1997-98

Research and Return on Investment (ROI)

Studies are undertaken to measure the costs, benefits and returns from public research related to the agriculture and agri-food sector. In terms of preventing crop loss and increasing crop yields, university and federal economists have concluded that research on potatoes returned $10 for every dollar invested (28% ROI); wheat returned $10 for every dollar invested (ROI 34%) and swine returned $6.40 for every dollar invested (53.7% ROI). The 1997-98 study on swine showed a net benefit of $590 million.

Environmental Sustainability and Improved Productivity

Following a serious wheat midge problem on the prairies, AAFC researchers at the Saskatoon Research Centre developed a biological control system that reduces midge numbers by 30% to 80%. The program rests on the development of a wheat midge forecast map that allows farmers to concentrate on prevention, rather than relying on chemical control. Not only does the biocontrol system improve farm productivity, but it also improves the long-term health of the land.

Keeping nitrates from washing into the Great Lakes is a serious concern. AAFC scientists devised a method to keep nitrates in the soil, where they are beneficial as plant food. A simple modification to existing tile drainage systems turns the land into a giant holding tank for water that would otherwise carry nutrients off to the lakes. The technology helps reduce nitrate loss by up to 50%, while increasing crop yields.

Partnership and Communications

AAFC's Matching Investment Initiative (MII) has been a major success since its launch three years ago. Through MII, the department matches industry investment in innovative projects ranging from the development of new soybean cultivars for soy milk to creating flavour enhancers for yeast. Investments, which have consistently shown annual growth, are projected to reach $70 million annually by 2000. Some 800 industry/government projects were undertaken in 1997-98.

The department has increasingly improved its accessibility by developing electronic resources to assist its clients. The Research Branch Web site contains a wide variety of information, including the 1997-98 Directory of Research. This directory helps clients and potential clients access information in order to explore collaborative opportunities. The directory presents each of the 18 research centres in the following areas: staff contacts, mandate, resources, main achievements and publications. It also includes information on branch headquarters.

AAFC is also actively involved in working with other departments to share information and resources and cooperate in the areas of shared research interests, including participating as a member of the five natural resource departments, one of the seven key departments delivering the Canadian Biotechnology Strategy, and one of 14 departments and agencies working with the federal Climate Change Secretariat.

Future strategic directions in S&T

To help ensure delivery on the research projects under way in the Research Branch, several important initiatives are being undertaken over the next three years that maintain or build the research capacity of the department. Under three categories, specific outcomes have been developed, which include performance targets and measurement strategies. Expected key results include innovation, sustainable resource use, and integrated policies and decision making.

Innovation

- offer services and technologies that conserve soil, water, air quality and genetic resources;
- increase collaborative research between industry and the department; and

- introduce
  - stress-resistant crop varieties and new crop protection and production systems,
  - new animal production and protection systems, and
  - new value-added food and non-food products and processes.

Sustainable Resource Use

- assess/manage land and water capabilities for sustainable use;
- increase knowledge and adoption of innovative resource-based information into agriculture and agri-food systems; and
- increase the contribution of the sector to international environmental committees.

Integrated Policies and Decision Making

- implement an environmentally sound agri-food policy framework; and
- provide information to support environmentally sustainable agri-food decision making.

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ATLANTIC CANADA OPPORTUNITIES AGENCY

Mandate

The Atlantic Canada Opportunities Agency (ACOA) derives its mandate from Part I of the *Government Organization Act, Atlantic Canada 1987*. The Act provides ACOA with a broad mandate for economic development in Atlantic Canada to help increase employment opportunities and earned income for Atlantic Canadians.

To fulfil its mandate, ACOA pursues two distinct goals:

- to ensure that a wide variety of business development tools and resources serve the diverse needs of the region's emerging and existing entrepreneurs; and
- to ensure that all economic development programs and activities in Atlantic Canada are coordinated and designed to improve the climate for business growth generally.

How does ACOA use S&T to deliver on its mandate?

ACOA's mandate, objectives, priorities and services are in keeping with the priority the federal government places on equipping Canada for adaptation to the global, knowledge-based economy. The enhancement of technology development and innovation are crucial to the achievement of this goal. ACOA places a high priority on innovation and technology as tools through which to advance regional and community economic development in Atlantic Canada. ACOA's innovation efforts therefore focus on helping SMEs increase their productivity, diversity and revenues — generated from technology development and commercialization, and diffusion. ACOA and its partners do this in several ways, including:

- providing project-specific financing and advisory support for SMEs, and infrastructure support for research;
- supporting alliances for technology development and commercialization;
- undertaking technology initiatives with partners; and
- facilitating innovation in strategic sectors, such as aquaculture, ocean industries/marine technology, biomedical industries, food processing, geomatics, space and information technology.

Through the innovation element of its Business Development Program, ACOA delivers conditionally repayable financing for firms engaged in innovation activities. For fiscal year 1997-98, 47 projects were approved under innovation, for a total commitment of $9.96 million in authorized assistance. In addition,

ACOA's COOPERATION Program provides for joint establishment and funding, with the Atlantic provinces, of broadly based regional development agreements. These agreements provide for collaborative federal-provincial investments in strategic areas of the economy through the funding of technology development projects and initiatives.

Major S&T achievements in 1997-98

During the past year, there have been many excellent examples of how ACOA has helped strengthen the capacity of the Atlantic region to develop, commercialize and diffuse technology in order to promote the region's competitiveness in global markets.

ACOA's support of international and domestic partnerships for technology development and commercialization, including research-private sector partnerships and alliances between private sector firms, has been instrumental in this regard. For instance:

- Canada-Israel Industrial Research and Development Foundation (CIIRDF): At the international level, ACOA's agreement with CIIRDF and the NRC, has resulted in several high-tech companies in Atlantic Canada forming partnerships with Israeli high-tech firms to develop and commercialize their products. Atlantic region firms have shown a high rate of interest in CIIRDF, accounting for 44% of all Canadian firms seeking partnerships in 1997-98.
- Domestically, ACOA has undertaken a number of innovative projects with the provinces under its COOPERATION Program. In New Brunswick, for example, collaboration with the Department of Education led to the establishment of New Brunswick's Virtual Campus, which facilitates the development of New Brunswick-based training content on the World Wide Web. This initiative provides for the identification, management and distribution of clinical health opportunities, and supports an information technology alliance.
- Knowledge-based industries in Nova Scotia: Alliances and partnerships formed with the private sector have boosted the development of the information technology sector in this province to the point where the sector contributes over $3 billion annually to the provinces's economy and employs 15 000 people directly, plus 7000 indirectly through 300 companies. COOPERATION Agreement support was instrumental in establishing the Telecom Applications Research Alliance (TARA), which is now attracting members from other provinces, given its capacity to support the development of telecom-based services and products.
- Improving Community Access to Technology: ACOA has been involved in projects to help people gain access to and understand the use of modern technologies for some time. Two projects under the COOPERATION Program are: STEM~Net (Science, Technology, Education, Mathematics Network) in Newfoundland, and STANet (Science and Technology Awareness Network) in Nova Scotia. STEM~Net is a school-based province-wide Internet server with the dual purpose of being an on-line resource for both school and college teachers. A partnership with Cable Atlantic brings the Internet to more than 175 schools in Newfoundland. STANet links organizations with an interest in promoting science and technology, and provides information on information technology activities with the goal of fostering a science and technology culture in Nova Scotia. STANet won the prestigious Michael Smith award for Science Promotion in 1997 and has been recognized by the Conference Board of Canada's Excellence in Business-Education Partnerships.
- Prince Edward Island's Knowledge Economy Partnership (KEP): This alliance of federal and provincial governments, the University of P.E.I., Holland College and the private sector began in 1997. KEP will establish the first province-wide broadband network in Canada as a new way to build business capacity. ACOA chairs KEP, which includes a funding program to encourage private sector development of knowledge-based enterprises. Partners committed $1 million to KEP in its first year of operation (1997-98).
- The Genesis Centre: ACOA's partnership with the private sector, Memorial University, and the province of Newfoundland was instrumental in the establishment of this centre. Located at Memorial University, the centre functions as a support network for knowledge-based businesses and entrepreneurs to create growth enterprises through access to marketing, finance and management expertise of world-class mentors and consultants. Companies are provided with the tools to develop comprehensive business plans and management expertise capable of attracting venture capital to support the growth of technology-based enterprises.
- Facilitating Innovation in Strategic Sectors: ACOA focussed its innovation activities on sectors showing the greatest growth potential and offering opportunities for SMEs in the region (e.g., information technologies, ocean industries, aquaculture, biotechnology, space). In the case of space, for example, ACOA continued to work collaboratively with the CSA and Atlantic

provinces to secure development contracts for firms in the region in order to develop and "grow" their technological capabilities/expertise in this sector. By successfully advocating the Atlantic industry's access to major federal contracts, ACOA has applied its industrial regional benefits mandate to support the development of the high-tech capacity of Atlantic Canada in the space sector. The current participation of some 50 companies and individuals in national and international contracts attests to this capacity.

Future strategic directions in S&T

Strengthening Atlantic Canada's capacity for innovation and technology development and the region's innovation performance overall will remain a priority for ACOA. Its strategy will focus on the following:

- strengthening the networking between key players in the region's innovation system by using its unique mandate and role as facilitator/catalyst to offer region-specific business development tools and resources designed to support linkages between innovation stakeholders;
- targeting assistance to firms in traditional sectors to upgrade their technology and work force to remain competitive in an increasingly competitive global economy;
- working with the many partners to engage more SMEs in innovation and improve the region's research infrastructure; and
- fully understanding and addressing the challenges and opportunities associated with the knowledge-based economy.

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CANADA ECONOMIC DEVELOPMENT FOR QUEBEC REGIONS

Mandate

Canada Economic Development for Quebec Regions (CED) is mandated to promote the economic development of the regions of Quebec. Within the government, it has a key role in Quebec among federal players involved in the economic development of Canada's regions. CED works proactively in partnership with a number of federal departments and organizations whose activities have an impact on the economic development of the regions of Quebec. As a member of the Industry Portfolio, CED actively supports national priorities, particularly in the areas of science and technology, foreign trade, investment, youth entrepreneurship and rural development, thus contributing to management of the Canadian economic and social union.

Major S&T achievements in 1997-98

To strengthen the competitive position of SMEs, CED's technology development efforts are channelled mainly into initiatives leading to the marketing of innovation. In addition, CED supplements the industrial research support provided for SMEs by the NRC under the Industrial Research Assistance Program, thus supporting technology prototyping and demonstration initiatives. To this end, CED has signed a partnership agreement with Environment Canada to ensure that the department's environmental technology specialists are involved in assisting firms wishing to carry out environmental technology demonstration projects. In addition, CED promotes the Technology Partnerships Canada program, supports the NRC in delivering the program to Quebec SMEs and makes innovative SMEs aware of other available Industry Portfolio programs.

Under the Innovation, Research and Development component of its IDEA-SME Program, CED has granted contributions totalling more than $50 million since April 1, 1995. These contributions were awarded essentially to SMEs for projects related mainly to the marketing, in Canada and abroad, of new products resulting from R&D.

CED is also continuing to consolidate the Quebec-wide technology incubator network established to promote the emergence of innovative enterprises and technology transfer from research centres.

CED has developed financial partnerships with five financial institutions in Quebec, in order to facilitate the funding of projects related to research and development, innovation and market development in technology firms. The financial institutions make an envelope of $150 million available for knowledge-based and new economy firms. In addition to providing support for participating SMEs, CED shares the financial risk with its partner institutions by providing reserves to cover possible loss.

CED also promotes the start-up of technology enterprises and contributes to the support of strategic projects that foster the emergence of technology SMEs. It is from this standpoint that CED, together with its partner, the Québec/Chaudière-Appalaches Technoregion GATIQ, created a $10-million reserve to develop the "Technoregion" concept. The goal of this initiative is to increase diversification and consolidate the economic base of an area that has a pool of about 100 research centres and laboratories in the metropolitan Québec City region and a flourishing entrepreneurial spirit in the Chaudière-Appalachian region. Since the creation of this initiative, CED has granted contributions of more than $3.5 million to carry out technological projects generating investment in the order of $20 million.

In addition, CED is continuing its financial support for the Operation SME program established by the *Ordre des ingénieurs du Québec*. This initiative is intended to encourage enterprises to make the shift to technology by promoting the placement of engineers in Quebec SMEs. Under Operation SME, experienced advisors identify opportunities for the development of technology and suggest the hiring of a qualified engineer suited to the automation, computer-aided design, digital control or assisted design needs of SMEs.

The establishment of a fast prototyping centre at the *École Polytechnique de Montréal* is a strategic project in which CED participated with other partners, including the NRC and the *Centre de haute technologie de Jonquière*. This project, to which CED and the Quebec government each contributed $1.5 million, involves the creation of a network of partners and a service and technology adaptation centre in the fields of fast prototyping, 3D digitization and retro-engineering for manufacturing firms using metals or plastics. This centre works with SMEs to increase the productivity and performance of the manufacturing industry, especially in terms of subcontracting in the key product design sector.

In the same vein, CED is also supporting the efforts of the *Institut d'ingénierie simultanée Inc.*, a non-profit organization whose mission is to enhance the skills of manufacturing firms in the area of product design and development.

CED has also helped to improve technological facilities by providing partial funding ($5 million) for expansion of the Biotechnology Research Institute (BRI). Expansion of the institute responds to the needs of biotechnology firms, which want to rent facilities close to the BRI and receive R&D support from its staff.

Future strategic directions in S&T

In order to strengthen the competitive position of target SMEs, CED's technology development efforts will continue to be directed mainly toward initiatives leading to the marketing of innovation.

In addition, CED will continue to facilitate access to relevant networks, such as the Canadian Technology Network, which provide suitable technical support.

CED will also pursue its efforts to consolidate the Quebec-wide network of technology incubators in order to promote the emergence of innovative enterprises and technology transfer from research centres.

The financial partnerships with five Quebec financial institutions will be reviewed and adjusted to ensure that these innovative funding instruments attain their full potential.

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THE CANADIAN FOOD INSPECTION AGENCY

Mandate

The Canadian Food Inspection Agency (CFIA) has the mandate to enhance the effectiveness and efficiency of federal inspection and related services for food and animal and plant health. In order to fulfil its mission, "safe foods, market access and consumer protection," the CFIA has adopted the following objectives: to contribute to a safe food supply and accurate product information; to contribute to the continuing health of animals and plants for protection of the resource base; and to facilitate trade in food, animals, plants and their products.

The CFIA is committed to delivering services in the most effective and efficient manner possible. It is headquartered in the National Capital Region, and delivers programs in all of Canada's provinces and territories through four area operations centres: Atlantic, Quebec, Ontario and Western. Some 4500 agency staff are located in 18 regional offices, 185 field offices, such as border points of entry, 408 third-party premises, such as slaughter establishments, and 22 laboratories and research facilities.

How does the CFIA use S&T to deliver on its mandate?

The focus of the CFIA food inspection program is to verify that manufacturers, importers and distributors, regulated by the CFIA, meet federal standards for safety, quality, quantity, composition, handling, identity, processing, packaging and labelling. In the case of exported food, manufacturers may be required to meet the additional requirements of the importing country. In these cases, the CFIA program verifies that these additional requirements are also met.

This regulatory function is carried out through the registration and inspection of establishments for interprovincial and international trade, and the inspection and grade-monitoring of products in registered and non-registered processing establishments, at importers' premises and in retail establishments. Working with Health Canada, other governments and regulated industries, the CFIA manages food recalls and other related enforcement actions.

The animal and plant health programs contribute to the protection of Canada's animal and plant resource base against the introduction and spread of regulated pests and diseases of significance to the economy, the environment or human health, and through the licensing of veterinary biologics. The humane transportation of animals is also regulated by the CFIA Animal Health Program.

Import activities are aimed at preventing exotic diseases and pests from becoming established in Canada. This is done through the inspection, testing and certification of horticultural, livestock, forestry, biological and other food commodities before their release into Canada. These activities are conducted at border points, seaports, airports and quarantine facilities and in the country of origin. The programs also maintain international disease intelligence activities, negotiate import health requirements with exporting countries, and conduct regional and national emergency simulation exercises.

The plant health program conducts environmental assessments for the release of plants, feed and microbial products with novel traits, such as those developed through biotechnology. It also verifies that livestock feeds and commercial fertilizers and supplements used in Canada are safe and effective and are packaged and labelled according to established standards. The program includes seed certification and the registration of varieties of field crops, and provides a form of patent by granting Plant Breeders' Rights for varieties of agricultural and horticultural crops.

The CFIA has an important mandate to negotiate technical requirements for the international movement of food, animal and plant products and the harmonization of national standards. It leads and/or provides technical assistance, as appropriate, for trade negotiations and committees and provides support for dispute settlement panels. Increasingly, trade negotiations are shifting from bilateral to multilateral fora. CFIA trade specialists work with their partners in AAFC, DFO, Health Canada and the Department of Foreign Affairs and International Trade to advance issues of common interest.

The CFIA is actively involved with international organizations for the purpose of maintaining and expanding international market access and protecting Canada's interests by reducing non-tariff trade barriers, influencing the development of international standards and encouraging the adoption of science-based sanitary and phytosanitary requirements. The CFIA participates in multilateral organizations such as the World Trade Organization, Codex Alimentarius, the North American Free Trade Agreement, the North American Plant Protection Organization, the International Plant Protection Convention of the Food and Agriculture Organization and the *Office international des épizooties*.

The CFIA provides a range of laboratory services across Canada, including technology development. Microbiology centres assess the microbiological safety of foods and respond to consumer complaints and illness. Food centres provide accurate and timely analytical services related to foods, feeds, fertilizers and seeds. Animal and plant health centres provide expertise in the areas of diagnostic testing standards, technology development and transfer, laboratory accreditation, scientific advice, and analytical capability for animal diseases and plant pests. Fish inspection laboratories provide a range of services, which include technical expertise to support the development and operation of quality management programs carried out by industry. They also carry out chemical, microbiological and physical analyses on fish and fish products.

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CANADIAN MUSEUM OF NATURE

Mandate

The mandate of the Canadian Museum of Nature (CMN) is to increase, throughout Canada and internationally, interest in, knowledge of, and appreciation and respect for the natural world by establishing, maintaining and developing for research and posterity a collection of natural history objects, with special but not exclusive reference to Canada, and by demonstrating the natural world, the knowledge derived from it and the understanding it represents.

How does the CMN use S&T to deliver on its mandate?

- The implementation of new collections data base software and a program of cataloguing the natural history collection in electronic format.
- The first steps in organizing a national collections strategy for natural history specimens.
- The ongoing development of educational programs and displays on natural science issues relevant to Canada.
- Research collaborations with universities, government agencies and other museums.
- A national consultation process to establish priority directions and actions.
- The support of collection-based research projects in systematics in the areas of biodiversity (botany, zoology), paleobiology and mineralogy, and on the conservation and management of natural history collections.

Major S&T achievements in 1997-98

- A new five-year plan based on a national consultation process (development of performance indicators under way).
- The review of its four research projects by an outside research advisory committee.
- The successful move into and opening of a new research and collection facility in Aylmer, Quebec.
- The publication of a major systematics project, the *Fescue Grasses of North America* and a negotiated contract with Yale University Press for a publication entitled *Lichens of North America*.
- The maintenance of a staff of 14 CMN research scientists, including the hiring of a new staff member, Dr. Michael Caldwell, an expert in Mesozoic reptiles.

- The publication of four issues of the popular journal, *Global Biodiversity/La Biodiversité mondiale*.
- Seventy-one scientific works, with 40 of those as refereed publications.
- The naming and description of 37 new species and three new genuses; 20 animals, seven plants, four fossils, and nine minerals from Canada and abroad. The list includes diatoms, birds, weevils, amphipods, lichens and fish.
- The provision of expertise in identifying 5381 specimens and answering 1274 inquiries from students, school teachers, researchers, consultants, government agencies and the general public.

Future strategic directions in S&T

- The formation of a research consortium of natural history facilities in Canada will be undertaken, and will contribute toward the formation of a national collections strategy. This is being done through a special interest group of the Canadian Museums Association.
- The formation of a partnership of natural history research facilities and NSERC, to encourage graduate students to study systematics, through a supplement program.
- The strengthening of the federal initiatives in systematics research through a signed memorandum of understanding between appropriate federal agencies and the CMN.
- The participation in the Canadian Biodiversity Information Initiative and the promotion of it as an activity that requires major capital backing in order to allow Canada to fully use its biodiversity information, and to share it with other countries.

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CANADIAN SPACE AGENCY

Mandate

The legislated mandate of the Canadian Space Agency (CSA), from the *Canadian Space Agency Act*, SC. 1990, c. 13, is "to promote the peaceful use and development of space, to advance the knowledge of space through science and to ensure that space science and technology provide social and economic benefits for Canadians."

The Canadian Space Agency is committed to leading the development and applications of space knowledge for the benefit of Canadians and humanity. To achieve this, the CSA:

- pursues excellence collectively;
- advocates a client-oriented attitude;
- supports employee-oriented practices and open communications;
- commits itself to both empowerment and accountability; and
- pledges to cooperate and work with partners to our mutual benefit.

How does the CSA use S&T to deliver on its mandate?

The objectives of the Canadian Space Program are to develop and apply space science and technology to meet Canadian needs, and to develop an internationally competitive space industry.

The Canadian Space Program, which is coordinated by the CSA, establishes the strategic importance of space in Canada's transition to a knowledge-based economy and to the government's social, scientific, sovereignty, industrial, security and foreign policy objectives. The CSA is responsible for coordinating all of the federal government's policies and programs in civil space-related research, science and technology, industrial development and international cooperation. Program implementation is open to industry, particularly SMEs, with a view to developing space products and services that respond to Canadian needs and to market requirements. Partnerships with Canadian industry and provinces are encouraged and sustainable industrial regional development is pursued through regional distribution targets.

The S&T plans and priorities are achieved through activities in space science, the Canadian Astronaut Program, Earth observation, space technology, satellite communications and space qualification services, as well as participation in the International Space Station. The CSA also develops relations with other world space agencies

in support of the Canadian Space Program, assists the Canadian space industry in their efforts to penetrate world markets, and manages a space awareness program in Canada.

Major S&T achievements in 1997-98

Space science at the CSA is concerned with advancing knowledge of space, the universe and the basic physical, chemical and biological processes that occur in space. The space science program at CSA provides opportunities for Canadian scientists and engineers to participate in national and international space projects. In 1997-98, the CSA secured opportunities for Canadian life sciences and microgravity research aboard NASA's space shuttles and Russia's MIR space station. Canadian astronaut Bjarni Tryggvason flew on NASA shuttle mission STS-85, and conducted a series of Canadian experiments in microgravity research. Dave Williams was assigned to the Neurolab mission on STS-90, studying the effect of microgravity on the brain and other parts of the central nervous system. This research (which cannot be conducted on earth because of gravity) has resulted in better insight into protein crystal structure, which in turn will help in the development of more effective drugs, and a better understanding of a number of medical disorders. The CSA and Canadian scientists also collaborated in international missions such as NASA's EOS, Sweden's Odin, Russia's Interball and the Japanese interplanetary mission, Planet-B. Development began on microgravity and life sciences experimental facilities for the International Space Station and an agreement was made with NASA to launch SciSat-1, a Canadian-led science satellite. Data acquired from Canadian instruments continued to improve the understanding of Earth's climate, weather and atmospheric conditions. Canadian space scientists continued their publication record of more than 100 papers annually on the results they obtained from these space projects.

One of the priority areas in space is satellite observation of the Earth. This is emerging as a major Canadian knowledge industry, using data from the Canadian RADARSAT-1 (a sophisticated remote sensing satellite carrying a synthetic aperture radar). In 1997-98, RADARSAT-1 achieved full coverage of the world's landmass, giving Canada an archive of images. RADARSAT data were increasingly used for environmental monitoring and the sustainable development of resources. It provided useful data to help manage natural disasters such as the 1997 Red River flood, where it was used to predict flood crests. RADARSAT's Antarctic mapping mission, completed in 1997-98, provided the first high-resolution snapshot radar coverage of the entire Antarctic continent. This unique data set is being analysed and will allow scientists worldwide to study the ice and to provide more insight into the effects of human activity and global warming on the icecap. The increasing commercial success of RADARSAT-1 (in 1997, it captured 12% of the world market for satellite data) resulted this year in a substantial investment by the private sector in the follow-on satellite, RADARSAT-2. This new enhanced satellite, which is now under development, builds on the S&T capacity in Canada and is expected to open new international markets and advance Canadian leadership in this business.

The space technology activities in 1997-98 pursued Canada's interests in advanced technologies for space, with investment in the development of new technologies for satellite communication, atmospheric monitoring and land management using space data. Canadian industrial infrastructure was enhanced to help adapt space technologies for terrestrial commercial applications. The CSA continued its ongoing program of technology development in industry through its contract award programs. In 1997-98, more than 200 technology development contracts were awarded, of which more than 40% went to SMEs. Thirty-five new technology transfer licences were signed with industry to commercialize CSA-owned technology. Opportunities were provided for students to develop their skills in space science and technology.

Canada is a participant in the International Space Station (ISS) program, the largest international scientific program, being jointly built by the United States, Canada, Russia, Japan and 10 European countries. As a full partner, Canadian scientists will have use of the station. In 1997-98, the CSA focussed on Canada's contributions, with the space station remote manipulator system on track for delivery to NASA. This is a sophisticated space "arm" that will be used for assembly and maintenance of the ISS. As well, development started in Canada of the space "hand," the special purpose dextrous manipulator. The first module of the ISS was successfully launched in 1998 and the station will be assembled by 2004.

Satellite communications in 1997-98 saw the beginning of the first phase of the Advanced Satellite Communications Program, in cooperation with the Communications Research Centre of Industry Canada. The new technologies being developed are aimed at

increasing the capability of satellites to provide cost-effective high-speed data communications, to bring multimedia on-demand services to all Canadians and to the international marketplace. As well, the international mobile satellite initiative is under way, and this positions Canadian industry in the fast-growing markets for mobile and personal satellite communications services.

Future strategic directions in S&T

The Canadian Space Program is a significant federal initiative that has, for more than 35 years, met national needs and helped develop a world-class space industry. Benefits derived from Canadian space activities have included advanced communication systems, robotics such as Canadarm, and the availability of Earth observation data to help monitor the environment and manage our resources. In addition, it has resulted in a high technology industry with a skilled work force.

With the current rapid advances in space technology, the opportunities for the continued development and application of space knowledge are rapidly growing. Space will become even more important for Canada. In order to realize these benefits and in the era of the global, knowledge-based economy, the CSA has developed with its stakeholders the Long-Term Space Plan III (LTSP III), to chart the future of the Canadian Space Program.

The LTSP III has five key areas:

- Earth and environment: understanding and monitoring the Earth, its environment and climate change, through the use and development of Earth observation data, including RADARSAT.
- Human presence in space: including space station, space robotics and the Canadian Astronaut Program.
- Space science: advancing knowledge through space science research in areas of strategic importance to Canada.
- Satellite communications: ensuring access for Canadians to new communication technologies and services, developing technologies for next-generation satellite services.
- Generic technologies: developing innovative technologies to meet Canadian needs and ensuring growth and competitiveness of Canadian companies.

One challenge for the CSA is that, unlike most federal departments and agencies, the CSA has no significant ongoing budget. In the past, most of its funding has been appropriated on a project basis through periodic long-term space plans approved by Cabinet (for example, the latest plan, LTSP II, was approved in 1994). The priority for the CSA is to secure approval for the Long-Term Space Plan III, within the context of a new, ongoing funding base for the agency.

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DEPARTMENT OF FISHERIES AND OCEANS

Mandate

The Department of Fisheries and Oceans (DFO), on behalf of the Government of Canada, is responsible for: policies and programs in support of Canada's economic, ecological and scientific interests in the oceans and freshwater fish habitat; the conservation and sustainable use of Canada's fisheries resources in marine and inland waters; and safe, effective and environmentally sound marine services responsive to the needs of Canadians in a global economy.

As outlined above, the department's mandate is extremely broad. It covers:

- management and protection of the marine and fisheries resources inside the 200-mile exclusive economic zone;
- management and protection of freshwater fisheries resources;
- marine safety along the world's longest coastline;
- facilitation of marine transportation;
- protection of the marine environment;
- support to other federal government institutions and objectives, as the government's civilian marine service; and
- research to support government priorities such as climate change and biodiversity.

How does DFO use S&T to deliver on its mandate?

- Providing a reliable scientific basis for fisheries resource conservation and the sustainable development of aquaculture.
- Seeking scientific understanding of ocean and coastal waters and of aquatic ecosystems.
- Transferring technology from aquaculture research projects to industry.
- Maintaining healthy and productive aquatic ecosystems.
- Improving scientific understanding of aquatic habitats.
- Effectively integrating habitat management.
- Understanding of water depths, tides, currents, water levels, and the geographic relationship between Canadian waters, adjacent waters and the Canadian landmass.
- Improving access to hydrographic information.

Major S&T achievements in 1997-98

Canada's scallop industry has access to a breakthrough technology that will help it be more efficient while conserving a valuable living marine resource. Computer-aided visualization technologies supported by data collected with multibeam sonar provide razor-sharp images of the ocean bottom that will make harvesting and resource planning much easier. The state-of-the-art ocean mapping technologies are the product of a collaboration involving the Canadian Hydrographic Service of the Department of Fisheries and Oceans, NRCan, the industrial Chair in Ocean Mapping at the University of New Brunswick, and a Newfoundland company, Nautical Data International. Obviously impressed by the quality of the images and textures produced by the new system, one captain remarked: "This is the best invention since the hook."

With the move to begin managing fisheries resources through a marine ecosystem rather than a stock-by-stock basis, there is a need for more detailed plankton measurements. A state-of-the-art optical particle counter, the product of a collaboration between a DFO scientist and a Nova Scotia company, Focal Technologies Inc., is now available to researchers. The optical particle counter meets today's needs with greater efficiency than ever before, providing more specific data than measurement taken with traditional plankton nets. The new instrument does the job quickly and automatically.

Future strategic directions in S&T

In DFO, science is used to achieve an important public policy goal: understanding how to conserve and wisely manage Canada's ocean resources for this generation and for the generations to follow. The fishery of the future must have a reliable base of scientific, traditional and local knowledge to ensure the accurate assessment of fish stocks. This knowledge base must also include a better understanding of how marine ecosystems work.

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DEPARTMENT OF NATIONAL DEFENCE

Mandate

The mission of the Department of National Defence (DND) and the Canadian Forces is to defend Canada and Canadian interests and values while contributing to international peace and security.

How does DND use S&T to deliver on its mandate?

- The provision of expert S&T knowledge facilitates and enhances the ability of senior decision makers to make informed decisions on defence policy, force generation and procurement.
- Departmental S&T contributes to the success of military operations through the provision of improved support, knowledge, protection and response to potential threats.
- By assessing technology trends, threats and opportunities, and by exploiting emerging technologies, departmental S&T enhances the preparedness of the Canadian Forces.
- The transfer of advanced technology and expertise from defence S&T contributes to the creation and maintenance of a Canadian defence industrial capability that is internationally competitive.

Major S&T achievements in 1997-98

- Advanced DND S&T played a key role in the successful search and rescue of 12 of the 15 crew of the cargo ship *Vanessa* that sank 450 miles off the shore of Newfoundland, in October 1997. Search efforts were aided for the first time by a self-locating datum marker buoy (SLDMB) that can mimic the drift characteristics of either a life raft or a human. The SLDMB was dropped by an aircraft at the last known position of the ship and relayed information that provided clues about where the crew had drifted. This allowed more tightly focussed and efficient search efforts. In addition, it relayed water temperature information that was used by a computer model to predict how long the castaways could hold out until lethal levels of hypothermia would set in. In the words of one search and rescue controller, "the model prevented us from stopping too soon."
- Scientists and graduate students at the Royal Military College Institute for the Environment successfully employed an *in situ* anaerobic bioreactor to remediate groundwater contaminated with naphthalene at Canadian Forces Base Borden. The project, performed in collaboration with the Waterloo Centre for Groundwater Research at the University of Waterloo, demonstrated the effectiveness of using this method to address a persistent organic compound dissolved in groundwater, and may lead to refined processes for dealing with similar problems elsewhere.
- DND is committed to maximizing its contribution to a healthy economy, and its participation in the Federal Partners for Technology Transfer (FPTT) has provided a means to leverage its knowledge and ability to transfer technology from its labs into the commercial sector. Evidence of DND's success is demonstrated by its receipt of two of the seven top FPTT honours in 1998. The FPTT awards recognized the successful transfer of two Defence R&D Branch technologies. The transfer of the blood substitute Hemolink™ led to the development of a new private company in Toronto, Hemosol, employing more than 70 people and capitalized at close to $80 million. The Branch's Vehicle Control Station software was transferred to CDL Systems of Calgary, which have been very successful in marketing the software and in applying it to military and non-military roles.
- The extensive countermine knowledge in DND has become an increasingly important resource in the wake of the Ottawa land mine treaty. The federal government's investment of $17 million dollars in the Centre for Mine-Action Technologies at the Defence Research Establishment Suffield near Medicine Hat, Alberta, will ensure that the global humanitarian de-mining effort will fully benefit from DND's world-class expertise in this domain. The funds will be invested in technology research to make humanitarian de-mining faster, safer and more effective. The centre will also investigate alternatives to anti-personnel land mines.

Future strategic directions in S&T

The Department of National Defence and the Canadian Forces must be able to call upon a responsive, adaptable and effective S&T network that meets client and partner needs, both long and short term, in the most effective manner possible. Accomplishing this in the face of rapid technological change and in the current fiscal environment is a significant challenge. The revolution in military affairs, for example, invites the Defence S&T community to think about how to make the most of emerging technologies, while at the same time budget constraints force DND to critically examine and prioritize what it does, how and with whom. Moreover, emerging "asymmetric" threats such as information warfare present an

additional dimension that Defence S&T must address in order to ensure that DND and the Canadian Forces can anticipate, respond to and neutralize such attacks on the military and civilian infrastructure.

To meet these challenges the strategy of the Defence S&T community is one that is proactive and forward-looking: Its strategy is to seek advice and comment from a broad cross-section of senior decision makers, both from within and outside of DND. Its strategy is to foster partnerships and networks, both within and outside of government and to leverage knowledge and resources. Finally, its strategy is to refocus and renew Defence S&T expertise through technology investment, human resources and knowledge management strategies.

The cornerstone of this strategic S&T planning is the Technology Investment Strategy (TIS) of the Defence R&D Branch. The TIS defines the technologies in which DND will invest in order to best respond to Canadian defence and security needs in the early 21st century. The strategy also sets out the R&D that will be required to exploit these technologies as well as the mechanisms for conducting the R&D.

The branch is configuring an R&D program for 2010 that will produce advances in a number of areas for the 2020 to 2025 time frame. Areas that illustrate the future of Defence S&T include sensor technology; information and knowledge management; human factors research; and S&T to respond to asymmetric threats.

For example, sensor systems with adaptable resolution coupled to systems that can perform "real-time" automated target detection, identification, tracking and engagement will be a fundamental component of any 21st century military. Without this capability, Canadian forces will not be able to defend themselves in the complex battle space of the future.

Likewise, as the world becomes more complex, it is essential that systems to manage information and knowledge be developed to process the vast amount of material that will confront DND decision makers in the 21st century. Smart information and knowledge management coupled with timely delivery will lead to reliable and simplified decision making in the complex defence environment of the future.

Meanwhile the emergence of asymmetric threats posed by information operations, chemical and biological warfare and the proliferation of ballistic missile technology requires that DND and the Canadian Forces have the ability to rapidly assess and counter these threats.

The key resource in DND and the Canadian Forces will always be people; the human factor is therefore a principal focus of the Defence S&T strategy for the future. To this end, re-configurable simulation systems for training of individuals and teams will better prepare Canadian forces, and enhance mission rehearsal. DND's effort will continue to address and expand our ability to enhance individual and collective protection, survivability and sustainability.

The investment to bring about these outcomes will be optimized by the following R&D delivery strategy:

- for technologies unique to defence, the R&D Branch will expend a significant level of in-house effort with contract support from external partners;
- for technologies with dual-use applications, but which are defence-driven, the R&D Branch will maintain a strong knowledge base and expertise through collaboration with other organizations; and
- for technologies that are driven by the civilian sector, the R&D Branch will adapt and use these technologies for defence purposes.

As part of a forward-looking strategy, the R&D Branch has also created a Technology Investment Fund (TIF) to encourage staff and external collaborators to put forward new ideas and explore new research areas. The fund provides investment in forward-looking research to kick-start activity in high risk/high pay-off areas consistent with the overall Technology Investment Strategy.

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ENVIRONMENT CANADA

Mandate

The thrust of Environment Canada's mandate is to improve the quality of life of Canadians through the preservation and enhancement of the natural environment, including water, air and soil quality, renewable resources, migratory birds and other wildlife, as well as weather forecasting and warnings. The mandate also includes addressing decisions and recommendations of the Canada-U.S. International Joint Commission, which deals with boundary waters and coordinating federal environmental policies and programs. The *Department of the Environment Act* recognizes that the Minister of the Environment has broad advocacy responsibilities to promote environmental enhancement and can cooperate with others to achieve this goal.

How does Environment Canada use S&T to deliver on its mandate?

Environment Canada's S&T is delivered through its three program activities: atmospheric environment, environmental protection and environmental conservation. S&T is conducted through the three business lines: reducing risks to human health and the environment; weather forecasts and warnings, and emergency preparedness services; and giving Canadians the tools to build a greener society. Program delivery draws on the strengths of the department's R&D base, combined with a strong regional presence.

The department's programs implement S&T across the country. In addition to studying environmental problems, it develops and implements solutions and models, and shares the results with other organizations, the private sector and the public.

Major S&T achievements in 1997-98

Climate Change

Environment Canada's most important contribution to the development of Canada's position on climate change has been its science and information on the likely effects of climate change. The Department's Canada Country Study, released in November 1997, was the first-ever national assessment of the social, biological and economic impacts of climate change. It identified how Canadians in every region of the country will be affected, how they can respond or adapt to these changes and what additional scientific research should be conducted to improve knowledge. The study is also an important contribution to international knowledge; as such it will form part of a North American chapter in a special report by the UN-led Intergovernmental Panel on Climate Change on the regional impacts of climate change. The department has pushed further the development and application of its global climate models to provide insight into the behaviour of the climate system in the future. It has state-of-the-art models that are used internationally by the Intergovernmental Panel on Climate Change. Most of the development has involved partners through the Climate Research Network of AES. Environment Canada can make a case for increasing effectiveness as a result of this partnership arrangement (as documented in a recent evaluation of the CRN). And, finally, the results are being made available electronically, both through our own Web site, and through an Intergovernmental Panel on Climate Change data distribution centre.

Clean Air

Since 1988, the Environmental Technology Centre has been developing and applying improved techniques for measuring potentially toxic air contaminants. The air quality data collected by the National Air Pollution Surveillance (NAPS) network have formed the principal ambient air exposure data base for 14 *Canadian Environmental Protection Act* priority substances list assessments. Air quality data for sulphur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3) and total suspended particulates (TSP) are measured at more than 152 stations in 55 cities in the 10 provinces and two territories. In 1997-98, 24 new instruments for the real time measurement of air particulate were installed in the field across Canada. Through the work on the NAPS network, new opportunities are being explored, as chemical methodology improves, to measure new chemicals with existing sampling programs.

Biotechnology

The department's Biotechnology Advancement Program supports the development and advancement of renewable, low cost, energy-efficient solutions to prevent or reduce pollution. The program focusses research and demonstration of a range of cleaning, bioremediation, phytoremediation, biosensors and production of industrial enzymes. During 1997-98 research was conducted by Enviroment Canada in partnership with the DND and Cominco at a demonstration site (Sydney Tar Ponds) to use plants for habitat restoration and the rehabilitation of sites containing heavy metals. In a large cooperative effort between Environment Canada, the Department of National Defence, the United States Environmental

Protection Agency and several other partners in Canada and the United States, demonstration work was conducted on the use of microbial techniques for the extraction and remediation of PCB-contaminated sediments.

Cumulative effects

Cumulative effects of developments remains a major challenge under the *Canadian Environmental Assessment Act*. Northern and Prairie Region is working with industry to examine the cumulative impacts of the $25 billion oil sands development industry in northern Alberta. S&T is at the heart of developing a framework and approaches to determining and applying ecosystem thresholds (indicators) and the assessment of economic development scenarios. A new collaborative initiative began in 1998 and is expected to provide strong science underpinning to long-term resource management.

Future strategic directions in S&T

New environmental issues are constantly emerging. As Environment Canada moves to implement the sustainable development agenda, a major challenge for the department is to face these new issues while continuing to deliver essential services such as weather services and enforcement activities, with reduced resources.

Environment Canada's response is to build a modern, affordable department that will be highly integrated, cohesive and streamlined. This will allow the department to discharge its ongoing responsibilities while retaining the capacity and flexibility to meet the new challenges. These changes have to be achieved within a substantially reduced fiscal framework.

In implementing these reductions, care has been taken to ensure that the remaining S&T base will be the right one to support the department in fulfilling its mandate. The federal S&T review was conducted concurrently with a review of the department's programs. This meant that the broad directions being articulated through the federal S&T review fed into the department's decisions.

As endorsed by the S&T review, the department will continue to exercise leadership in those areas of "public good" science that the federal government is best placed to deliver, where a core R&D capacity is required to support sound policy development, decision making and the implementation of programs. Environment Canada's laboratories and institutes will therefore continue to conduct research on issues such as climate change and preserving biodiversity, often in partnership nationally or internationally.

Many of the issues that the department must address in the sustainable development agenda (such as loss of species, the capacity of the environment to regenerate itself, climate change, and persistent toxic substances that accumulate in living organisms) will require ongoing investments in R&D.

S&T will also play a role in the department's increasing integration effort. In R&D, the laboratories and research institutes will be managed through the three major program activities (atmospheric environment, environmental protection and environmental conservation), but their research agenda will emphasize an integrated response to the major challenges facing the department (for example, climate change, loss of biodiversity, toxic substances and the health of ecosystems).

With an S&T management framework in place, Environment Canada now has an important tool with which to manage its departmental S&T for an effective contribution to the mandate and objectives of the department.

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HEALTH CANADA

Mandate

Health Canada and its regional offices work closely with other federal departments, provincial and territorial governments, and health stakeholders to help Canadians maintain and improve their health. The legislative mandate of Health Canada is expressed in the *Department of Health Act* and some 20 other pieces of legislation, including the *Canada Health Act* and the *Food and Drugs Act*. Responsibilities under the Acts cover areas such as: the safety of food, water, drugs, medical devices and consumer products; the sale and advertising of tobacco; the control of narcotics, pest control products and radiation-emitting devices; environmental and workplace hazards; and the application of quarantine measures. The department provides essential health services to First Nations and Inuit people and works with them as they assume responsibility for delivering the services. Other responsibilities include providing medical services to visiting dignitaries, overseeing occupational health and safety for federal workers, and supporting disaster and emergency relief operations. Health Canada provides national leadership and support in population health and well-being, and promotes good health.

How does Health Canada use S&T to deliver on its mandate?

Health-related S&T is critical to furthering the long-term sustainability of the national health system. The department uses S&T to support efficient and effective decision making in the management of risks/benefits associated with products and diseases, and in the promotion of population health, as well as to communicate evidence-based decisions. The department's activities in S&T cover mainly related scientific activities (RSAs) in natural sciences and engineering, and social sciences and humanities, with 30% of S&T resources allocated to research and development. Most of Health Canada's S&T activities are undertaken in natural sciences in the health protection area, while social science activities support mainly population health and well-being, and the promotion of good health.

Anticipating, preventing and responding to new threats from emerging and re-emerging diseases, antibiotic resistant micro-organisms, environmental and occupational hazards, consumer goods, food, water, drugs, pesticides, medical devices, and the application of new technologies, all require a strong S&T base. Research is helping to improve national diagnostic and disease outbreak investigation by pinpointing the source of the contaminants in food-borne illnesses. It is the basis for determining the causes of antimicrobial resistance. Epidemiological studies are key to understanding the relationship between health and aging. Examples of related scientific activities include monitoring drinking water for harmful micro-organisms; developing a risk-based classification system for medical devices and *in vitro* diagnostic devices; improving standards for blood, organs and tissues for transplantation; networking and collaboration with scientific experts; and participation in international scientific committees to harmonize the technical requirements for product reviews.

On the social sciences and humanities side, research is the pillar of a national research agenda on children's well-being, seniors, women, and Aboriginal health. S&T is used extensively in the area of population health. Examples include the analysis of osteoporosis risk factors in seniors, a study of the relationship between mother-infant attachment security and infants' communicative, symbolic and social-affective functioning; the social organization of inequities in health; health behaviours in school-aged children to identify key risk factors and develop successful intervention strategies. In addition, a number of RSAs, such as determining the impact of health reforms on seniors, developing a monograph on seniors and heart disease, collecting data on family violence, collaborating internationally on the development and standardization of measures of physical activities, developing clinical practice guidelines for the care and treatment of breast cancer, guide the department's policy development.

In both of the above areas, information technology is being used extensively to enhance the sharing of health knowledge and expertise through an integrated network within the context of a national strategy for a Canadian Health Infostructure.

Major S&T achievements in 1997-98

Analytical methods for the detection of allergens, such as peanut or egg proteins, were developed and used for the identification of these allergens in unlabelled food products. The technology transferred to the Canadian Food Inspection Agency resulted in product recall at the retail level. The development of a rapid (two-minute) detection method of the parasite *Cyclospora* allows the analysis of an increased number of samples during an investigation (for example, in the recent case involving contaminated fresh berries).

In therapeutics, PTP1C was identified as a powerful suppressor of human cancer cell growth and a potential target for therapeutic action. The stability of polyurethanes used in medical devices were assessed, and reliable methods to determine the corrosion resistance of metal implants were developed. Great strides were made in the safety assessment of plant-derived recombinant products that may be used for oral or mucosal immunization. Progress was made in the safety assessment of xenotransplants through the characterization of cytochrome P450 enzymes in pig liver and isolated hepatocytes. Three off-site pharmaceutical research initiatives were established through university and hospital partnerships.

In disease control, a National Asthma Control Task Force to set national objectives to control the disease was established and a National Consensus Conference on Tuberculosis as a basis for a national strategy to eliminate tuberculosis in Canada was held. Several reports were published in 1997-98, such as the *Canadian National Report on Immunization*; the *Recommendations from the Consensus Conference on Infected Health Care Workers: Risk for Transmission of Bloodborne Pathogens*; and *For the Safety of Canadian Children and Youth*, the first comprehensive document on trends, patterns and preventative measures for child injury in Canada. Other S&T highlights that involve a number of partners include managing the investigation of one of the largest salmonella outbreaks in Canadian history, and conducting a statistical survey of all mammography facilities in Canada to improve quality.

In environmental health, the 1997 *Health and Environment, Partners for Life* report examined key health risks associated with the natural environment, describes Health Canada's and other agencies' actions, and offers practical suggestions to individuals. The Office of Tobacco Control published the *Toxicity/Carcinogenecity Assessment Report on Yields of Selected Constituents by Popular Brand or Innovative Cigarettes*. This report is the culmination of a 15-year research program into the development of methods for the analysis of tobacco smoke for a number of components, including organics and heavy metals. The methods are already being used in one province and two U.S. states.

In the social sciences and humanities area, a number of programs and studies have been developed. The Canada Prenatal Nutrition Program funded projects are being analysed to provide the data needed for action in areas such as food supplementation and nutrition counselling. The 1997-98 *Health Behaviours in School-Aged Children* study, undertaken in collaboration with the World Health Organization, is the third such self-report survey of 11-, 12- and 15-year-olds. Examples of other studies include *A Systematic Review of the Literature on Socio-economic Status and Childhood Injury* and *Economic Burden of Unintentional Injury in 1995*.

Health Canada represented Canada at the G7 health informatics initiative on disease surveillance and the G8 coordinators meeting. The department worked to create a national strategy for the Canadian Health Infostructure, an integrated network encompassing elements such as hardware, applications/software, information content, standards, and so on. A pilot project to enhance surveillance capacity under the National Health Surveillance System is being developed in Alberta, and a Laboratory Data Management System for enteric diseases has been successfully piloted by the Laboratory Centre for Disease Control. A Cancer Bureau Web site to disseminate information on cancer topics, surveillance activities and statistics was established.

Future strategic directions in S&T

Four new research programs have been proposed by Health Canada under a national health research agenda: Centres of Excellence for Children's Well-Being, the Aboriginal Health Institute, the Canadian Institutes of Health Research, and the Canadian Population Health Initiative.

The Health Protection Branch (HPB) initiated in 1997 a process of transition in order to respond to the emerging challenges to public health. In-depth consultations will be carried out in several core areas including science and surveillance. The objectives of HPB transition include the following: to strengthen the science that underlies decision making in order to meet current and emerging public health risks; to improve and modernize the Canada-wide health surveillance capacity; and to review and improve the delivery of health protection programs.

The Food Program has developed a strategic framework, which clearly articulates the future role of science, particularly research. Research will refocus its emphasis to "anticipate and prevent rather than react and cure." Measurable objectives and outcomes will be identified and evaluated against criteria. Client feedback will be solicited and technology transfer strategies identified. Projects will be subjected to internal and/or external peer review.

The Therapeutic Products Program, in the pursuit of partnerships, has initiated alternative service delivery mechanisms for various program activities. Mutual recognition agreements have been and are continuing to be developed with various international

regulatory agencies to eliminate duplication in medical device regulation. The program continues to forge links with industry to ensure S&T futuristic environmental scans are accurate and timely, and to foster partnerships with universities and hospitals.

The Environmental Program's *Securing Our Future Together* recognizes Canadians' concerns about the impact of exposure to toxic substances on their health, their children's health and that of future generations, as well as the impact of these substances on the environment. A new federal initiative on toxic substances will enhance Canada's environmental and health science capacity by funding applied research on emerging health and environmental problems linked to toxic substances. Research priorities have been identified through consultations. In the planning stage is the establishment of research fellowships, the allocation of $2.5 million to in-house and extramural research projects, the enhancement and increase in the number of university and hospital partnerships, and the forging of links with industry to ensure S&T futuristic environmental scans are accurate and timely.

The Laboratory Centre for Disease Control (LCDC) is moving from a narrow focus on disease control into the wider domain of public health. It has undertaken a planning process that links priorities to output measures and is developing a business plan for the Winnipeg facility. LCDC is establishing a national risk factor surveillance system in collaboration with the provinces. Health Canada will provide surveillance information and research needed to reduce the incidence of chronic diseases and infectious diseases, and conduct global disease surveillance.

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INDUSTRY CANADA

Mandate

Industry Canada has a mandate to make Canada more competitive by fostering the growth of Canadian business, by promoting a fair and efficient marketplace for businesses and consumers, and by encouraging scientific research and technology diffusion.

How does Industry Canada use S&T to deliver on its mandate?

- Industry Canada carries out scientific research at the Communications Research Centre (CRC). CRC has a tradition of excellence in managing technical issues concerning the radio spectrum, the deployment of wireless communications and broadcast services, and the development of new technologies and knowledge for exploitation by Canadian industry. The CRC is the federal government's main research centre for communications technology R&D.
- Industry Canada also provides funding for technology development and innovation. Since 1996, innovation at the near-market end of the R&D spectrum has been supported by Technology Partnerships Canada (TPC). The program is a key element of the government's science and technology strategy and its Jobs and Growth Agenda. In partnership with the private sector, TPC invests in research, development, demonstration and market development projects of aerospace and defence industries, as well as environmental and enabling technologies. The program supports the private sector through investment rather than subsidy, sharing both risks and rewards. Within two years, TPC has become an effective government tool for closing the innovation and productivity gaps, while improving investment and trade.
- Industry Canada also promotes private sector innovation by: developing technology roadmap initiatives; developing targeted growth strategies to build knowledge-intensive sectors such as aerospace, biopharmaceuticals, biotechnology in agriculture, fisheries and forestry, environmental technologies, and information and telecommunications technologies, including new media learning solutions and telehealth; and developing sector innovation strategies to identify technology priorities and projects that will strengthen Canadian knowledge-based manufacturing, contribute to improving productivity and reduce the innovation gap.

- In Phase I of the Technology Roadmap exercises for Forest Operations in Canada and Canadian Aircraft Design, Manufacturing, and Repair and Overhaul, industry participants identified 29 and 50 critical technologies respectively. Phase II is under way for both, with participants identifying priority projects and forming consortia.
- The Minister of Industry has a horizontal policy coordination role for science and technology in the federal government. In this context, Industry Canada monitors implementation of the S&T strategy and provides secretariat support to the Advisory Council on Science and Technology (external advice to the government on Canada's science, technology and innovation challenges and opportunities) and the Council of Science and Technology Advisors (representatives of the external advisors to science-related ministers, providing advice on the management of federal S&T).
- Industry Canada develops and applies state-of-the-art information technologies for the collection and dissemination of information on science, technology and innovation opportunities (for example, through its *Strategis* Web site), as well as for the promotion of a strong science culture in Canada.

Major S&T achievements in 1997-98

- Industry Canada has launched and championed a growing number of exciting programs to help achieve the government's goal of making Canada the most connected nation in the world by the year 2000.
  - SchoolNet has linked 13 140 schools and 2180 libraries, and First Nations SchoolNet has connected 366 schools.
  - The Community Access Program (CAP) has linked 2500 communities, with projections of 4033 communities by March 31, 1999; the 1998 budget extended CAP by providing funding for an additional 5000 Internet access sites in urban centres.
  - Computers for Schools has delivered 89 812 computers to schools and provided 139 000 software packages across Canada.
  - The Prime Minister announced the Panel on Smart Communities to advise the government on how information technology can transform community economic and social development.
  - The Virtual Classroom, organized by the CRC and connecting young students from Canada and Singapore live showed APEC (Asia-Pacific Economic Cooperation) telecommunications ministers, last July, the power of the Internet for learning applications.
  - The Connecting Canadians initiative was launched, including Connecting Canadians Days, showing the benefits of the Information Highway to Canadians where they live and work across the country.
- In 1998, TPC contracted 35 projects representing a multi-year investment of $154 million, which leveraged $567 million in private sector investment in innovation.
- Industry Canada played a lead role in bringing together 22 departments and agencies to deliver a renewed Canadian Biotechnology Strategy for the Government of Canada.
- The *Automotive Competitiveness Review* was released in June, setting the stage for further collaborative work with this industry on R&D, skills, standards and regulations, and trade.
- Subsequent to providing recommendations to the Cabinet Committee on the Economic Union, the Advisory Council on Science and Technology (ACST) has established expert panels on two issues critical to Canada's success in the transition to a knowledge-based economy: skills and the commercialization of university research. A part-time, non-government Deputy Chair of the ACST has been appointed (Gilles Cloutier).
- The Council of Science and Technology Advisors (CSTA) had its inaugural meeting on September 30 and October 1. This council, made up largely of representatives from the external advisory bodies to ministers with S&T responsibilities and interests, will provide an external-to-government perspective on the management of federal S&T. Initial tasks for the CSTA include guidelines for the use of scientific advice in decision making, and the role of the federal government in performing science and technology.

Future strategic directions in S&T

Industry Canada has set two performance goals aimed at the strategic objective of improving Canada's innovation performance and the transition to a knowledge-based economy:

- to implement the federal sience and technology strategy and other science and technology initiatives; and
- to encourage and influence technological innovation.

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MEDICAL RESEARCH COUNCIL OF CANADA

Mandate

The mandate of the Medical Research Council of Canada (MRC), based on the *Medical Research Council Act*, is to promote, assist and undertake basic, applied and clinical research in Canada in the health sciences; and to advise the Minister of Health in respect of matters relating to such research as the Minister may refer to the Council.

How does the MRC use S&T to deliver on its mandate?

The MRC delivers on its mandates through a wide variety of approaches that include research grants, awards to research personnel, network and linkage development, and consultative processes that aim to: 1) provide the knowledge base required for continuing innovation in health services, health maintenance, diagnosis and treatment of illness; 2) focus a national research effort on health threats and opportunities; 3) facilitate the return of the social and economic benefits of health research to Canadians; 4) diversify and strengthen Canadian health research through partnered funding; 5) train and develop Canadian scientists with a capacity to address research questions in all areas of health; and 6) provide a national voice on health research issues.

Major S&T achievements in 1997-98

Providing Canadians with World-Class Health Research: In 1997-98 the MRC funded 2424 outstanding research proposals, down 74 from the number funded the preceding year. This project gives a sense of the nature of the S&T investment:

- At the University of British Columbia, researcher Janice Eng is determining what aspects of balance and gait problems experienced by patients with Parkinson's disease would be helped by surgery.

Promoting Research on Canadian Health Priorities: In partnership with other organizations, MRC is helping to focus research on health issues that have been identified as special threats to the health of Canadians (e.g., AIDS, breast cancer and diabetes). In 1997-98, MRC and partners earmarked $15.8 million for research in those areas to fund projects like the following:

- Frank Plummer at the University of Manitoba has been characterizing mechanisms of HIV resistance in women whose occupation exposes them to the virus. Understanding why these women do not become infected will provide clues to ways of protecting people from HIV. Dr. Plummer has isolated a gene that may be involved in resistance to the AIDS virus and is exploring the mechanisms through which it provides protection.

Supporting Research with an Impact on Health: The research breakthroughs that we see reported in the media do not reflect the extent of the research that others, in Canada and around the world, have conducted for decades in a steady piling up of small advances in knowledge. Nor do they reflect the benefits to education in science and health. But as the following example indicates, they do provide an immediate sense of the health benefits that a full research portfolio provides:

- MRC-funded researchers at the University of Calgary have discovered a gene which produces a substance that appears to tell normal cells when to stop growing. It seems be absent in most cancer cells. When the researchers exposed breast cancer cells to high levels of the gene product, cell growth was arrested.

Capturing the Economic Benefits of Health Research Discoveries: The Canadian Medical Discoveries Fund (CMDF), created in 1994 as a result of the MRC's efforts to address the shortage of venture capital for commercializing Canadian health research discoveries, has served as a vehicle for over 65 000 Canadians and organizations to invest more than $354 million in developments stemming from discoveries by our health scientists. A 1998 report indicates that, through CMDF, Canadians have invested in the start-up and early development of 30 companies and the expansion of seven more.

Training and Developing Our Most Critical Resource, Canadian Health Scientists: In 1997-98, MRC invested $17.7 million in programs directly targeted at the training of 1350 especially promising students and postdoctoral fellows. It also provided support for an estimated 5100 more who were hired as assistants on projects supported through MRC grants; the MRC invested $20.5 million in career awards for 429 of Canada's most outstanding health researchers.

Expanding Canadian Health Research Capacity Through Partnerships: In 1997-98, 7.9% of MRC funding went towards shared initiatives with over 120 partners in industry, government and not-for-profit organizations and support from continuing and new partners ensured that the total funding delivered through joint programs increased by almost $8 million. Partners have been generous with their contributions to shared health research programs over the years. The MRC's investment of $66.3 million for the period 1994 to 1997 has been complemented by a partners' investment of $190.8 million. (A ratio of MRC to partners' funding of 1:2.9.)

Providing a National Perspective on Canadian Health Research: the MRC and the other granting councils have released a joint policy on ethical principles and practices with respect to research involving people. A clear enunciation of fundamental ethical values is essential for judging what research should be done or not, and for helping society set the right course in its use of new technologies. On the international front, the MRC continues to promote linkages that will be beneficial to Canadian science, health care and business development. For example, the MRC has been participating in a series of scientific orientations with Japanese counterparts to identify productive joint research efforts.

Future strategic directions in S&T

1997-98 was to prove to be a turning point for health science. The 1998 federal budget announcements included the welcome news that the MRC funding for 1998-99 would be increased by $40 million. The MRC views this as a first step towards achieving an internationally competitive level of federal funding for health

research and a renaissance for Canadian science. What should the funding level be? The National Advisory Board on Science and Technology has indicated that the federal investment in health research in universities, hospitals and research institutes should be at least 1% of the amount that Canadians spend on health care, that is, the investment should be in the order of $766 million (1% of the $76.6 billion health care expenditure). The gap between that goal and the $267.5 million investment for 1998-99 is large, but the MRC is convinced that it must be bridged if Canada is to maintain the base of research expertise upon which innovation in our health care system depends.

Increased investment in extramural health research is essential but, in the view of the MRC, must be delivered through a system in which the funders, performers and consumers of research in every area of health have jointly developed strategic priorities and will work in concert to deliver research results to Canadians as efficiently and effectively as possible. The MRC looks forward to reporting next year on progress towards the realization of such a system, Canadian Institutes of Health Research.

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NATURAL RESOURCES CANADA

Mandate

Natural Resources Canada's vision statement is the following: "For the next century, Canada must become the world's 'smartest' natural resources developer, user and exporter: the most high-tech; the most environmentally friendly; the most socially responsible; the most productive and competitive."

Natural Resources Canada (NRCan) promotes the sustainable development and responsible use of Canada's mineral, energy and forestry resources, and develops an understanding of Canada's landmass. NRCan works with the forestry, minerals and metals, energy and earth sciences sectors to maximize economic and social benefits while safeguarding the environment and the health and safety of Canadians.

How does NRCan use S&T to deliver on its mandate?

NRCan's S&T activities are crucial in delivering on its mandate. S&T accounts for approximately 75% of the department's expenditures. *Winning in the Knowledge-based Economy* is NRCan's action plan for building on Canada's natural resource heritage. The priority areas for the action plan are creating national consensus, tackling climate change, multiplying work opportunities, increasing resource trade and investment, and spurring resource innovation. Implementation of this action plan involves significant S&T resource requirements. As such, the department is conducting an assessment of its current science capacity. "Science capacity" encompasses not only scientific research, but also related scientific activities and facilities essential to research, for example, laboratory infrastructure, technical and field support, information technology support, knowledge and technology transfer mechanisms, and business and communication functions.

Major S&T achievements in 1997-98

The *Manager's Guide to S&T Impact Assessment* and *S&T Impact Measurement Methodologies* were developed to help managers conduct impact assessments. NRCan helped launch the R&D Impact Network to promote the exchange of best practices in assessing the impact of R&D among government, industry and academia in Canada and to improve value, decision making and accountability in R&D. NRCan is also in the process of developing a performance framework that will include S&T performance indicators.

NRCan played a significant role in the interdepartmental research scientist (RES) promotion exercise under the auspices of the Criteria Working Group. Close communications between this group and NRCan's Universal Classification Standard (UCS) team allowed this working group to capture essential information at a very early stage in order to match current promotion criteria with UCS elements. NRCan has also provided support to the Treasury Board Secretariat (TBS) S&T Community Renewal Unit. NRCan was instrumental in obtaining from TBS relaxation of the RES quotas for all science-based departments.

NRCan transferred three remote-sensing applications to Canadian industry: an ocean monitoring work station to detect ships and monitor sea state; a geoscience work station (GEOANALYST) to incorporate remote-sensing with conventional geophysics and geochemistry; and a crop information system adapted for use by the Polish government. Techniques and systems were developed for integrating spatial data, remote sensing and field plot measurements with comprehensive forest data bases and landscape-design tools.

During the 1998 central-Canada ice storm, NRCan supported Canadian Forces operations with aerial photographs, more than 17 000 topographic maps and a new topographic map of the entire affected area. These maps were instrumental in helping emergency response teams and work crews provide assistance to Canadians during and after this major natural disaster.

The geoscience knowledge base of the Northwest Territories (N.W.T.) received a boost from the launch of a project to compile, in digital, geographic information system-compatible format, all available geoscience information for northern Baffin Island and Melville Peninsula. Of particular interest will be a new mineral potential analysis — the geology of the region suggests that the area could contain diamond, base metal and gold deposits. The data will be distributed on CD-ROM and via the Internet, ensuring its availability for northern communities and mineral exploration. The CD-ROM will also contain information relevant to environmental studies, education, carving stone exploration, and land-use planning. Partners include the Iqaluit-based Qikiqtaaluk Corporation, the Geological Survey of Canada and the N.W.T. government.

NRCan's new Metals in the Environment (MITE) initiative, with funding and commitments secured until 2002, responds to increasing government and industry requirements for geoscience knowledge necessary to develop national and international policies concerning metals and their release to the environment, and to formulate regulations for Canada. MITE is helping define Canada's leadership role in the sustainable use of metals. Metals in the environment are derived from natural, geological sources as well as from the activities of our modern society, from mining and manufacturing to urban living. It is important to understand trace metals in the environment as they play both positive and negative roles in biological processes: zinc and copper are bioessential, while lead and mercury can be toxic. MITE has been designed to provide a geological basis for environmental studies, defining the range of natural background metal concentrations, the mineral form and reactivity of metals, and the processes controlling their movement in the surficial environment.

Canada's Model Forest Program has been extended for an additional five years, from April 1997 to March 2002. Phase II of the program will focus on practical applications of the technologies and models for community-based sustainable forest management developed during Phase I, and on disseminating this knowledge at local, national and international levels. Contribution agreements were renewed for all 10 original model forest sites, and the network was expanded in 1998 to include an 11th model forest, the Waswanipi Cree Model Forest in the Cree territory in Quebec, focussed on sustainable forest management in keeping with Aboriginal values and traditions (**http://mf.ncr.forestry.ca**).

An advanced Internet-based geographic information system for managing forest fires, the Spatial Fire Management Information System (sFMIS), has been developed for use by Canadian fire management agencies. The technology, which integrates several software components and data bases on fire weather, prediction and control, was transferred to Saskatchewan, Alberta and B.C. for testing during the 1998 fire season. An automated national Fire Monitoring, Mapping and Modelling system currently is being developed to provide daily "real-time" satellite imagery of forest fires, which could then be linked to sFMIS.

A national network of research sites, the Forest Ecosystem Network of Sites, has been created to foster information exchange and collaboration between industry, universities and government agencies involved in sustainable forest management research. Since the initial announcement of sites in 1997, there have been several new additions. To date, the network links a total of 16 sites across Canada where innovative forestry projects are being carried out, along with ecosystem and biodiversity studies (**http://www.pfc.cfs.nrcan.gc.ca/practices/ferns**).

The CANPED™ fuel stabilization and purification process developed by NRCan under a joint R&D agreement with Par Excellence Development (PED), a Canadian firm, dramatically improves the economics of waste oil reprocessing by eliminating the problems — odour, acidity, colour and instability — associated with thermally cracked waste oil. PED has the worldwide licensing rights to the process and is focussing on business development and sub-licensing. A sub-licence has been purchased by Fuji Recycle Industry K.K. for its first waste oil to diesel fuel thermal cracking plant in Japan. PED will also be supplying a turnkey system, built and assembled in Canada. A sub-licence has also been granted to Enviro-Mining Inc. of Edmonton for a plant to be built in Germany. In addition, plans are under way by another company for the construction of a plant in Quebec.

NRCan, with the participation of 16 industry members, has completed the first version of RETScreen™, a comprehensive software package that provides a preliminary evaluation of the annual energy performance, costs and financial viability of potential renewable energy projects located anywhere in the world. The tool can be used to evaluate wind energy, small hydro, photovoltaic, solar ventilation air heating and biomass mini-district heating projects. Also included is a data base of estimated fuel costs, electricity demand and renewable energy resource availability for Canada's 300+ remote communities. RETScreen™ is intended to be used by technical and financial personnel from consulting engineering and planning firms, electric utilities, government and development agencies, financial institutions, R&D organizations, private power developers and product suppliers. It is available via the Internet at **http://cedrl.mets.nrcan.gc.ca/e/412/retscreen/retscreen_home.html**

NRCan plays a role in building public confidence related to the development of Canada's mineral resources. To determine the potential value of mineral and metal deposits, mining companies have samples tested by laboratories. However, concerns exist in the exploration and financial communities about the quality of these analyses. Following discussions with the Standards Council of Canada, NRCan has established the Proficiency Testing Program for Mineral Analysis Laboratories to give such laboratories the opportunity to get an independent assessment of their own performance. Twenty-nine Canadian and 13 non-Canadian laboratories participated in the program during the first three months of 1998.

A construction material in the Confederation Bridge to Prince Edward Island saved the emission of about 30 000 tonnes of carbon dioxide. The bridge demonstrates the use of fly ash as an environmentally sound cementitious material. Fly ash, a by-product of burning coal in power plants which normally goes to landfill, replaced cement in producing much of the high-performance concrete throughout the bridge. Manufacturing cement for concrete is very energy intensive, releasing one tonne of CO_2 per tonne of cement. Cement production is the world's third largest source of CO_2 emissions. NRCan has developed the technologies for the substitution of cement in concrete by materials such as fly ash, and advised on the design and construction of the bridge. In October 1998, NRCan announced the establishment of the International Centre for Sustainable Development in the Cement and Concrete Industry. With a goal of 15% material substitution, this international market represents a potential for reduction in CO_2 emissions of 300 million tonnes annually.

Public and worker safety and security in facilities such as airports and government buildings requires accurate detection methods for explosive materials. In 1998, NRCan completed a research study under the Canada-U.S. Counter-terrorism R&D Program that shows the feasibility of manufacturing marked detonating cord as a means of improving explosives detection. A second project under the same program aims to improve the effectiveness of this technology.

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NATIONAL RESEARCH COUNCIL CANADA

Mandate

The National Research Council Canada (NRC) is a federal government departmental corporation. Its mandate, according to the *National Research Council Act*, is to undertake, assist or promote scientific and industrial research in different fields of importance to Canada; to investigate standards and methods of measurement; and to work on the standardization and certification of scientific and technical apparatus, instruments and materials used or usable by Canadian industries.

Under the *National Research Council Act*, the NRC also has the responsibility for "operating and administering any astronomical observatories established or maintained by the Government of Canada." The NRC's research and development activities include grants and contributions used to support a number of international activities.

The NRC is also mandated to provide vital scientific and technological services to the research and industrial communities. This mandate is primarily discharged through the operation of the Industrial Research Assistance Program, the Canada Institute for Scientific and Technical Information (CISTI) and the Canadian Technology Network.

The *National Research Council Act* empowers the NRC to "establish, operate and maintain a national science library" and to "publish, sell and otherwise distribute" scientific and technical information. The NRC fulfils this mandate through CISTI, providing Canadians with access to worldwide scientific, technical, medical and related information and expertise.

The NRC is responsible for primary standards of physical measurements as formally established by the *Weights and Measures Act* and the *National Research Council Act*. It has a specific mandate relating to "the investigation and determination of standards and methods of measurements including length, volume, weight, mass, capacity, time, heat, light, electricity, magnetism, and the investigation and determination of physical constants and the fundamental properties of matter."

How does the NRC use S&T to deliver on its mandate?

- The NRC's strengths in biotechnology help it serve and interact with industrial and university partners. Its five biotechnology research institutes focus on health care/pharmaceuticals, agri-food, marine biotechnology and the environment.
- The two research institutes in the NRC's Information Telecommunications and Technology Group bring together a broad range of complementary technical capabilities and equipment to help firms reduce the risks and costs of working on the next generation of communications and information technology hardware and software.
- The NRC provides R&D support to the operations of the Canadian aerospace industry in the areas of: aerodynamics; structures, materials and propulsion; flight dynamics and flight systems integration.
- Finally, the NRC provides critical support to key areas of research and technology development that underpin Canada's innovation systems.

Major S&T achievements in 1997-98

NRC's Institute for Biodiagnostics (IBD) in Winnipeg

In 1997, in partnership with Western Economic Diversification Canada and the Government of Manitoba, the NRC launched the Western Medical Technologies Strategy to bring together IBD's expertise with the talent and resources in the private sector, universities and hospitals of Western Canada. The strategy has already shown concrete results, with three new spin-off companies, incubation facilities for small businesses at IBD, and three magnetic resonance imaging demonstration sites in Western Canadian hospitals.

International Strategic Linkages

The NRC established stronger relationships through new memoranda of understanding with various Asian countries. Among these are:

- an agreement with the National Science Council of Taiwan;
- an agreement with the National Science and Technology Board of Singapore, with which the NRC now has five collaborative projects;

- agreements to establish the Canadian Technology Network in Thailand and Indonesia (with assistance from the Canadian International Development Agency).

Financing Innovation

The NRC signed agreements with the Business Development Bank of Canada and the Canadian S&T Growth Fund to help finance government spin-offs, and put in place a training program for scientists who want to create their own companies to commercialize NRC technology.

Future strategic directions in S&T

In its Vision to 2001, the NRC has taken up the challenge of contributing to Canada's technological development, competitiveness and prosperity. The vision summarizes the organization's approach to fulfilling its mandate in light of the economic and social realities facing the country now and in the coming years.

As Canada's foremost R&D agency, the NRC will be a leader in the development of an innovative, knowledge-based economy through science and engineering. This vision will be realized by:

- being dedicated to excellence in advancing the frontiers of scientific and technological knowledge in areas relevant to Canada;
- carrying out focussed research, in collaboration with industrial, university and government partners, to develop and exploit key technologies;
- providing strategic advice and national leadership to integrate key players in Canada's system of innovation; and
- taking a more aggressive, entrepreneurial approach to ensure the transfer of our knowledge and technological achievements to Canadian-based firms.

In addition, several strategic initiatives are being proposed to respond to important national S&T issues. They require new S&T investment on the part of government and its industry partners to proceed, and efforts are under way to ascertain the feasibility and timing of these new initiatives. These initiatives include:

- a national endeavour that would move Canada to the international forefront of genome science and innovation through the establishment of a new, multipartner, scientific enterprise;
- an initiative to support growth and job creation in the Canadian aerospace industry through the development of a Gas Turbine Environmental Centre in Ottawa and an Advanced Aerospace Manufacturing Technology Centre in the Montréal region;
- an initiative to connect Canadians to a vast range of scientific, technical and medical information and expertise;
- an endeavour that will provide Canadian industry, universities, Centres of Excellence and government access to a state-of-the-art optoelectronic prototyping and foundry facility; and
- a national, industry-driven, innovation partnership to foster the emergence of a viable, knowledge-based, environmentally sound fuel cell industry in Canada.

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NATURAL SCIENCES AND ENGINEERING RESEARCH COUNCIL

Mandate

Created in 1978, the Natural Sciences and Engineering Research Council (NSERC)'s legal mandate, functions, and powers are defined as follows:

> "The functions of the Council are to promote and assist research in the natural sciences and engineering, other than the health sciences; and advise the Minister in respect of such matters relating to research as the Minister may refer to the Council for its consideration." (N*atural Sciences and Engineering Research Council Act*, 1976-77, c. 24)

How does NSERC use S&T to deliver on its mandate?

NSERC fosters the discovery and application of knowledge through the support of university research and the training of scientists and engineers. It promotes the use of this knowledge to build a strong national economy and quality of life for all Canadians.

NSERC supports both basic university research through research grants and project research through partnerships of universities with industry, as well as the advanced training of highly qualified people in both areas.

NSERC is the single most important funder of R&D in the natural sciences and engineering in Canadian universities. In 1997, Canadian universities carried out $1.1 billion in R&D in the natural sciences and engineering. NSERC provided nearly one third of the total funding. The remaining funds were split among universities, provincial governments, industry and other federal departments.

Major S&T achievements in 1997-98

- University researchers produce most of Canada's natural sciences and engineering publications. Of the 15 500 university papers produced annually, roughly 80% can be attributed to NSERC-funded researchers. Furthermore, Canadian researchers in natural sciences and engineering are collaborating with international partners at an increasing rate and benefiting from the globalization of R&D. In 1996, one third of Canadian papers in this field were written with international partners.
- One of the more tangible outcomes of NSERC-funded research is the creation of a company. A survey conducted this year found that at least 108 spin-off companies have been started from results of research partially funded by NSERC over the past 20 years. They employ more than 5800 Canadians and generate more than $1.1 billion in annual sales.
- NSERC, the SSHRC and the MRC published the report of the Tri-Council Working Group on Ethical Conduct for Research Involving Humans, the first in the world to incorporate all areas of science.
- Since the beginning of NSERC's university-industry research programs, more than 1200 companies have participated, rising from less than 50 companies in 1983 to more than 500 businesses participating in 1997. On average, 100 new firms are working with NSERC every year. NSERC is well known to companies heavily involved in R&D. Forty-three of the top 50 Canadian R&D companies (as ranked by *The Globe and Mail*) have funded university research jointly with NSERC.
- Over the past 10 years, contributions from NSERC's partners, mainly industrial, have grown tremendously. From just over $23 million in 1988-89, contributions in 1997-98 reached $83 million, for a growth rate of 260% over the 10-year period. The ratio of partner contributions to NSERC funding has been steadily increasing over the past 10 years. From a low of 1.13:1 in 1988-89, this ratio now stands at 1.7:1. Put another way, for every dollar NSERC puts on the table for a university-industry research grant, our partners contribute $1.70.
- Canadian universities are increasingly using licensing to commercialize their research — revenue to Canadian universities from licensing has jumped from just under $10 million in 1991 to just below $30 million in 1996. Most of these revenues can at least be partially attributed to funding from NSERC and the MRC.
- Over NSERC's 20-year history, more than 50 000 master's and doctoral students, and young research professionals have benefited from NSERC training programs. In 1997-98, more than 9000 university students and postdoctoral fellows were supported by NSERC. Another 2700 university technicians' salaries were paid from NSERC grant funds awarded to university

researchers. In total, NSERC created more than 12 000 high-technology jobs this year in which people are learning the most advanced knowledge. Further, research spending from NSERC grants on goods and services (for example, materials, scientific equipment and travel) indirectly created or sustained roughly another 1500 jobs this year.

- Annual surveys of former holders of NSERC postgraduate scholarships show that 65% of respondents are active in R&D, using their training for one of the primary purposes of the program. The unemployment rate for respondents is estimated to be less than 2%, with 70% of them responding that their graduate training was critical to their careers. Furthermore, 96% of the respondents completed the degree (master's or doctorate) for which they received NSERC funding. A high percentage (almost 20%) of respondents were living outside the country at the time of the survey. Only half of these respondents intend to return to Canada. The two most common reasons cited for their departure from Canada were better or more job opportunities and variety of experience.
- NSERC hosted a second workshop with students and young researchers to determine the needs of Canada's next generation of researchers and how NSERC's investments and programs can be improved. This year's workshop focussed on young people making a career in industry. One main conclusion revealed that an advanced education in research is not only an education for research, but also a superb education for problem solving in all sectors of the knowledge-based economy.
- NSERC's Industrial Research Fellowships (IRF) program has contributed significantly to the number of doctoral graduates working in Canadian labs. More than 15% of Canadian industrial researchers with a PhD have been funded by NSERC through our IRF program. Seventy-five percent of former IRFs from 1980 to 1997 are still working in Canadian industries. Seven percent have gone to academic positions in Canadian universities, and a similar percentage of former IRFs have left the country.

Future strategic directions in S&T

NSERC has developed a research priority-setting mechanism, the re-allocations exercise, in which national and international experts review disciplinary submissions and identify priorities for funding. This four-year cycle re-allocations process is a form of international benchmarking appropriate for basic research. Its output is the shifting of some resources to those areas that the respective disciplines persuasively identified as the most important to Canada. The research community has identified strategic directions and set priorities that in the long term will result in more and better basic research in science and engineering in Canadian universities. The results of the second re-allocations exercise were released in 1998.

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SOCIAL SCIENCES AND HUMANITIES RESEARCH COUNCIL OF CANADA

Mandate

The Social Sciences and Humanities Research Council of Canada (SSHRC) is the government's key instrument to support university research and training in the social sciences and humanities and to chart directions for the Canadian research effort in these fields. SSHRC-supported research covers a breadth of disciplines ranging from economics, business studies, ethics, education, law, history, literature to philosophy, psychology, sociology, environmental studies, religious studies — among others. SSHRC supports basic research, targeted research on issues of national importance, the training of highly qualified personnel, and the broad dissemination of knowledge for the benefit of Canadian society. Key initiatives over the past year include the launching of SSHRC's Innovation Scenario — an action plan to maximize the contribution of SSHRC-funded research for Canadians — and new partnerships to support research and training in critical S&T areas.

How does the SSHRC use S&T to deliver on its mandate?

The entirety of SSHRC's mandate aims to sustain a strong science capacity in Canada.

Major S&T achievements in 1997-98

SSHRC is launching three new targeted research programs to build policy-relevant knowledge and expertise to respond to national challenges over the next five years:

- the challenges of a knowledge-based economy;
- social cohesion in a globalizing era; and
- the social and cultural determinants of health.

These new research areas were identified through a major consultation with the federal government, universities and a range of organizations across the country. SSHRC has concluded a range of new partnerships to strengthen research and expertise in key S&T areas.

- The Trends project — in partnership with the Policy Research Secretariat of the federal government — will generate research on eight mega-trends that will drive Canada in the next millennium (globalization, North American integration, technological change and the information revolution, the environment, demographics and ageing, value change, multiple centres of power, social differentiation). More than 20 government departments helped identify the gaps in knowledge on issues most likely to create policy challenges for Canada in the next few years. Sixty-five SSHRC-funded researchers are now working in partnership with users of research to define research agendas that will help to build the knowledge needed to develop effective policies and programs to manage change in these areas.
- Innovation Systems Research Network — in partnership with the NRC and NSERC — will promote exploration of the relationship between innovation and economic development at the local and regional levels. The network will provide a platform to build and exchange knowledge, and to chart directions for research to enhance our understanding of how innovation works, be it in the development of improved services and products, management methods or production techniques. All told, the network involves 50 leading-edge researchers and graduate students and 29 partners.
- Research and training incentives have been developed to supply the knowledge and highly qualified personnel needed in forest management (with the Canadian Forest Service) and on emerging issues relating to Canada's relationship with Asia and with Latin America (with the International Development Research Centre).
- Ongoing programs continue to provide knowledge to assist policy making in the public and private sectors and develop multidisciplinary research expertise in critical areas: managing for global competitiveness, science and technology policy in Canada, chairs in the management of technological change (SSHRC/NSERC), strategic research networks in education and training, centres of excellence on immigration issues (SSHRC/Citizenship and Immigration Canada, Health Canada, Heritage Canada, Status of Women Canada, Canadian Housing and Mortgage Corporation), and health services research (with Health Canada and MRC)
- SSHRC continued to play a key role in co-managing (with NSERC and MRC) the highly successful Networks of Centres of Excellence program. Thus far, the networks have involved more than 400 companies, close to 100 government departments and agencies, more than 40 hospitals, 50 universities and 63 other organizations.

- SSHRC is launching the Community University Research Alliances, an innovative program to develop knowledge and expertise geared to community development through innovative alliances between universities and local and regional action groups. These innovation centres are designed to mobilize researchers and students at universities to develop knowledge and transfer mechanisms around priority issues such as youth, violence, sustainable development, health care restructuring and local governance.
- The councils (SSHRC, MRC, NSERC) have released their *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans* this year. The new policy statement addresses the duties, rights and norms of those conducting research to ensure that research subjects are treated with respect and privacy and that Canadian research is conducted in a socially and scientifically responsible manner. The new Canadian guidelines are the first in the world to incorporate all areas of science.
- SSHRC has taken steps to enhance the evaluation function and to develop the capacity to measure the impact and outcomes of SSHRC support for Canadian research and training. New evaluation tools are being developed to provide a wider range of information to the council, thereby enhancing its ability to manage its programs and to undertake strategic planning more efficiently. The council continues to conduct periodic evaluations of its programs, and to participate in the Industry Portfolio's Sub-Committee on S&T Performance Measurement and Program Evaluation.

Future strategic directions in S&T

SSHRC's Innovation Scenario, launched in 1998, proposes strategic investments in research to meet three goals:

- to close important gaps in identified areas where Canada does not have the knowledge needed to develop effective policies and programs to manage change — these include globalization, social cohesion, growth and human development;
- to respond to urgent needs for strategically focussed training to prepare Canadian youth to find employment in different sectors of our knowledge-based society and economy where the humanities and social sciences are called on to play important roles;
- to further develop and maintain a strong capacity for innovation by providing greater support for fundamental research and advanced training in the human sciences.

SSHRC will also continue to push forward on its partnership strategy to promote targeted research and training in key areas of need and to foster innovative approaches to producing and sharing the knowledge generated through research.

Finally, SSHRC will enhance its knowledge brokering role and develop new mechanisms to promote awareness and use of knowledge in the social sciences and humanities.

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STATISTICS CANADA

Mandate

The mandate of Statistics Canada derives primarily from the *Statistics Act*. The Act requires the agency, under the direction of the Minister, to collect, compile, analyse and publish statistical information on the economic, social and general conditions of the country and its citizens. Statistics Canada is also mandated to provide coordination and leadership for the country's statistical system. Other federal legislation requires Statistics Canada to produce data for specific purposes.

How does Statistics Canada use S&T to deliver on its mandate?

The mission of Statistics Canada is to inform Canadians, businesses, and governments about the evolution of their society and economy and to promote a high-quality national statistical system.

The condition of a nation and its people can be assessed in many ways. Fundamental to these assessments is the availability of information on the many and diverse dimensions of the modern nation state, such as information on its population, its economy, its resources, and its social and cultural life. Under the Canadian Constitution, provision of statistics is a federal responsibility. By means of the *Statistics Act*, Parliament has designated Statistics Canada as the central agency responsible for producing such information.

The gathering of information involves a partnership with all Canadians. In this partnership, Canadians both contribute and benefit. Information is provided to Statistics Canada through surveys and access to administrative records, while Statistics Canada, after compiling and analysing this information, provides feedback through a myriad of information products.

Historically, Statistics Canada's program has been structured to provide macro-economic, micro-economic and socio-demographic statistics, and statistical information in public institutions and programs. Such information continues to be relevant. However, emerging issues prompt demands for new kinds of data, (for example, needs have been expressed for improved information on education and the transition from school to the workplace, the health of Canadians and the systems that support it, the effects of globalization, the functioning of Canada's economy, the factors affecting Canada's competitiveness in world markets, the impact of science and technology, the outcomes of government programs and the status of various subpopulations within Canadian society).

Maintaining the relevance of the Statistics Canada program by meeting such information needs will always be a primary goal for the agency. To maintain a high level of program relevance, Statistics Canada relies on two pivotal instruments. These are the advice and guidance it receives from external consultative bodies; and, the agency's rigorous planning and performance monitoring system and processes. The external consultative bodies are the National Statistics Council; professional advisory committees (including the Advisory Committee on Science and Technology Statistics); bilateral relationships with key federal departments; and the Federal-Provincial Consultative Council on Statistical Policy.

As part of ensuring the relevance of its products, the Agency co-ordinates the Data Liberation Initiative (DLI), which provides affordable access to statistical files and data bases in support of social science research and teaching. The DLI has a broader function in creating a sustainable base for public policy analysis in science and technology. The services of the DLI are described at **http://www.statcan.ca/english/Dli/dli.htm**

All of the program delivery of Statistics Canada is classified to science and technology for the purpose of the survey of federal science activities and the S&T activities are classified entirely to the social sciences. The S&T activities are divided into research and development (3% of expenditure) and related scientific activity (97% of expenditure), such as surveys and the analysis of administrative data.

As well as being the largest social science department or agency in the federal government, Statistics Canada maintains a growing program of science and technology statistics as part of the Information System for Science and Technology Project. It includes surveys of the activities of research and development, invention, innovation, technology diffusion and related human resource development, measures and analysis of linkages among actors in the S&T system, and analysis of outcomes. The program is progressing towards the analysis of the impact of S&T activity and it is guided in this by the document *Science and Technology Activities and Impacts: A Framework for a Statistical Information System 1998*.

Recent findings include the resources committed to biotechnology R&D, in industry and in the federal government, the rates of use and planned use of biotechnologies by firms, and the characteristics of firms principally engaged in biotechnology activities, as part of work in support of the development of the Canadian Biotechnology Strategy. Results on innovation in firms in key service industries were released, and there have been several measures of knowledge flows. These include the linkages between sectors

and regions measured by co-authorship of scientific papers, the commercialization of intellectual property by universities and by federal government laboratories, and the flows and distribution of skilled people working in the area of science and technology. Some of this work has been in support of the two expert panels of the federal Advisory Council on Science and Technology, on skills, and on the commercialization of intellectual property by universities.

More generally, the survey of federal science activities provides information on what the government spends on science and technology, where it spends its S&T resources (sector and region), and on what it spends its resources (socio-economic objective). A longer-term objective of this and the rest of the S&T statistics program is to show what the government gets for its S&T spending. More information can be found at **http://www.statcan.ca/english/research/scilist.htm**

Future strategic directions in S&T

Strategic planning is part of program relevance and the mechanisms for ensuring relevance where given in the previous section. In the case of statistics on science and technology, the agency has prepared *A Five-Year Strategic Plan for the Development of an Information System for Science and Technology*. The plan takes the program from its developmental stage, funded by Industry Canada since 1996, to a new level as an integral and ongoing part of the work of the agency. The funding for this strategic development is part of a $20 million-a-year package to reduce gaps in the statistical system which has been coordinated by the federal Policy Research Committee.

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TRANSPORT CANADA

Mandate

Transport Canada's mission is to develop and administer policies, regulations and services for the best possible transportation system for Canada and Canadians. Its role is to develop up-to-date, relevant transportation policies and legislation, and to maintain the highest level of safety and security possible.

How does Transport Canada use S&T to deliver on its mandate?

Transport Canada, like the transportation sector in general, depends heavily on technology. Transport policy initiatives, regulatory responsibilities and services are all affected by technological developments. To ensure the department is able to assess, advance and embrace technological change, continuing science and technology activities are essential.

The mandate for S&T in Transport Canada is to develop the scientific knowledge and technology required for effective delivery of the department's policy, safety and security and program objectives, and to help accomplish the department's mission by fostering innovation in the Canadian transportation sector.

In 1997, Transport Canada established an R&D Management Board chaired by the Assistant Deputy Minister, Safety and Security, to oversee the department's R&D activities. The Board sets priorities and approves an annual R&D plan funded by departmental and partner contributions. The R&D Serviceline in the Safety and Security Group is responsible for centralized planning and delivery of the department's technology R&D program. The Transportation Development Centre located in Montreal, Quebec is the department's centre of excellence for delivery of R&D projects in cooperation with partners in government and private industry.

Major S&T achievements in 1997-98

Transport Canada cooperates with the U.S. Department of Transportation, and the Secretariat of Communications and Transport of the United Mexican States, on S&T in the field of transportation through a Memorandum of Understanding. In January 1998, under this memorandum a set of guiding principles was adopted to harmonize the future development of standards

for dedicated short range communications (DSRC) in the three countries. DSRC uses radio frequency transponders for vehicle-to-roadside communications. Currently, the main applications are preclearing commercial vehicles at border crossings and roadside inspection sites, and collecting electronic road tolls. Harmonized standards would help to expedite the movement of goods and travellers across North America.

A flight data monitoring program for aviation took two important steps forward in 1997-98. Following an international review and subsequent revision, a flight recorder configuration standard (FRCS) became available for trial use by selected aircraft manufacturers and safety investigation authorities. An FRCS Editor, a software tool that can produce and maintain flight data in a format that complies with the standard, was also developed. Adoption of the FRCS would ensure that documentation from all aircraft is consistent, complete and available in a standard electronic format. Standardized data would greatly assist accident and incident investigations, as well as facilitating flight data monitoring.

The flight data monitoring program is supported by Transport Canada's Safety Programs, Strategy and Coordination Directorate, and Civil Aviation Directorate; the Transportation Safety Board of Canada; the National Research Council Canada; the U.S. Federal Aviation Administration; and the U.S. National Transportation Safety Board.

An aviation project to study the effects of work schedules and jet lag on pilots indicated that fatigue can affect multi-tasking performance and electrophysiological gamma activity. This means that normally easy tasks require additional effort. The findings are based on data collected in laboratory simulations and on board Department of National Defence aircraft during normal operations. In the next phase of the project, monitoring procedures will be tested on commercial airline pilots flying very long-haul flights. The ultimate aim of the work is to enable pilots to monitor their own fatigue level in flight and to provide them with effective coping strategies.

The airport security program, a long-term cooperative effort with U.S. security authorities, continued to expand. Work in 1997-98 included field trials of X-ray pattern-matching software at Pearson International Airport and enhancement of a prototype laser-based explosives detection system. A double-duty hand wand that integrates explosives detection with standard metal detection was another promising new technology under development.

In Fall 1997, an innovative marine radar detection system was put to the test off the coast of Newfoundland. The system is an innovative combination of two technologies developed in earlier R&D projects: a modular radar interface — a PC-based radar interface that can digitize and process images in real time — and an artificial intelligence-assisted tracker that greatly increases the accuracy of tracking. In three-metre seas with medium to high clutter, the system detected targets the size of a human head from two nautical miles away. Slightly larger targets were detected at a range of four nautical miles. These preliminary results indicate the system's potential for dramatically improving search and rescue operations, as well as for many other applications.

A transport of dangerous goods project culminated in a proposed draft standard for impact testing of tank containers, now under review by an International Organization for Standardization (ISO) Working Group. The project included a review of impact requirements, analyses of test approaches, and consultations with testing laboratories, manufacturers and users. ISO acceptance of a single, repeatable test would remove a current impediment to international trade by ensuring uniform safety standards.

Future strategic directions in S&T

Transport Canada will continue to address departmental and sector needs related to:

- Safety and Security — reduce risk and increase safety and security.
- Smart Transportation — increase efficiency, affordability and productivity.
- Sustainable — reduce environmental impacts, enhance competitiveness and address global climate change.
- Strategic — focus on key objectives and priorities.

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WESTERN ECONOMIC DIVERSIFICATION CANADA

Mandate

Western Economic Diversification Canada (WD) is mandated by legislation:

- to promote the development and diversification of the Western Canadian economy;
- to coordinate federal economic activities in the West; and
- to reflect Western Canadian interests in national decision making.

Science, technology and innovation enable WD to fulfil all aspects of its mandate, as well as being priority areas of the federal Jobs and Growth Agenda. Science, technology and innovation form the foundation for economic development in Western Canada.

How does WD use S&T to deliver on its mandate?

Science, technology and innovation have horizontal application which impact on all of WD's service to business through:

- the application of technology to enhance services to SMEs in WD's information services;
- the facilitation of financial support through WD's investment funds (in partnership with financial institutions), which provide debt financing to high-growth technology SMEs;
- the provision of targeted business services, including developing business plans, and export readiness services to technology SMEs; and
- partnerships with other stakeholders in providing services to technology start-ups through innovation centres.

Major S&T achievements in 1997-98

In addition to providing services to technology SMEs through its Western Business Service Network, efforts have been directed at strengthening Western Canada's innovation system through initiatives such as the following:

- WD has provided support for the start-up of innovation centres in Calgary and Edmonton, which provide assistance to technology SMEs.
- WD worked with key stakeholders such as the NRC, universities and technical institutions, the cities of Regina and Saskatoon, and the province of Saskatchewan, initially in an innovation forum, which brought together industry in information technology, biotechnology and advanced manufacturing and led to the *Blueprint for Innovation*, Saskatchewan's action plan to strengthen these technology sectors.
- The Western Medical Technologies Strategy — in partnership with the Institute of Biodiagnostics, WD, the NRC, the province of Manitoba, and the Royal Bank — focusses on commercialization of the MRI technology developed at the Institute and demonstration sites throughout Western Canada that display the technology in different applications.
- In partnership with the province of B.C., Industry Canada and the NRC, WD is collaborating to support the Fuel Cell Technology Strategy.
- WD's Canada Foundation for Innovation Support Program is directed at increasing Western participation in the Canada Foundation for Innovation (CFI). The CFI Support Program provides support to eligible institutions to prepare proposals for CFI consideration. WD will provide a maximum of 90% of direct costs up to $20 000 per proposal.
- WD has provided support to establish the Western Canadian University Technology Network, which has a mandate to accelerate the rate of technology commercialization in Western universities.
- WD has played a major role in the Canadian Light Source Synchrotron Steering Committee, in putting together the financing package which will lead to a major research facility established at the University of Saskatchewan.
- WD's First Jobs in Science and Technology provides businesses with skilled technology workers. Since April 1997, 311 jobs have been created for recent science graduates.
- Climate change initiative — WD is working to develop an action plan that will build upon the opportunities for technology development and diffusion presented through climate change commitments. The action plan will be integrated within the Industry Portfolio's approach.

Future strategic directions in S&T

In addition to addressing major issues for the West, such as climate change, the key issues for Western Canada's technology sectors over the next year include:

- increasing the rate of technology commercialization from universities and research organizations;
- increasing the capacity of SMEs to adopt new technologies;
- recruiting, retaining, and re-training skilled workers;
- strengthening the Western regional innovation systems by building and enhancing linkages between components of the innovation system (i.e., increasing the linkages between universities and SMEs); and
- increasing the competitiveness of resource-based firms through technology adoption.

To address these important issues, WD will be working with provincial, federal and other stakeholders on initiatives such as the following:

- the ADM Forum on Innovation — meetings of senior federal and provincial officials to address, in a collaborative fashion, Western Canada's innovation system, S&T infrastructure, and key issues such as climate change;
- the roll-out of the O-Vittesse Skills Retraining model throughout Western Canada;
- the participation in and strengthening of the Western Innovation Systems Research Network; and
- in conjunction with the universities, the NRC and other partners, the examination of new ways to address the issue of receptor capability.

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