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Science and Technology for the New Century

A Federal Strategy

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Canada

Science and Technology for the New Century

A Federal Strategy

March 1996

For further information, contact:

Andrei Sulzenko
Executive Director, S&T Review
Industry Canada
235 Queen Street
OTTAWA, Ont.
K1A 0H5
Tel.: (613) 954-8911
Fax: (613) 957-1990

Additional copies of this report are available from:

Distribution Services
Industry Canada
Room 205D, West Tower
235 Queen Street
OTTAWA, Ont.
K1A 0H5
Tel.: (613) 947-7466
Fax: (613) 954-6436

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1. Introduction

Science and technology (S&T) play a critical role in the health and well-being of Canadians and in the country's ability to generate sustainable employment and economic growth. That is why the government, which came into office in the fall of 1993 with an agenda for jobs and growth, announced a fundamental review of our investment in science and technology in its first budget.

The Science and Technology Review was launched in June 1994, with consultations in communities across Canada. Five regional conferences were held, culminating in a national forum in Ottawa. More than 3000 Canadians offered their views and advice during the public process. Results of the consultations are summarized in the Annex.

Federal departments and agencies carried out a parallel internal review of S&T policies and programs. The Prime Minister also asked the National Advisory Board on Science and Technology (NABST) to undertake an independent assessment of federal S&T policies.

Science and Technology for the New Century completes the review by setting out the government's policy response. It reflects the views offered by Canadians during the nationwide consultations. It responds to recommendations made in NABST's June 1995 report *Healthy, Wealthy and Wise*. It incorporates the major conclusions of the government's own internal review of its S&T activities. It responds to the 1994 report of the Auditor General of Canada, which examined the overall management of federal S&T. And it follows through on the challenges posed by the measures taken in Program Review and announced in the budget process, to get government right and bring down Canada's burdensome debt and deficit.

Science and Technology for the New Century recognizes that the world's advanced economies are undergoing a fundamental transformation to knowledge-based industries. Canadians must respond with policies, programs, institutions and partnerships that will maximize our economic opportunities and sustain our social fabric. For its part, the federal government must re-evaluate not only where it spends its S&T resources, but also how to spend more effectively and efficiently. This paper starts with an accounting of S&T priorities — overall and by a number of major science-based departments and agencies — and then outlines a strategic approach to the development of federal S&T policies and programs. Separate chapters take up the major themes in this approach.

- Chapter 2 discusses the need to focus on establishing partnerships and networks — an innovation system that enhances the ability of Canadians to share knowledge and information. This is key to improved economic performance.
- Chapter 3 recognizes the connections between the goals of job creation with economic growth, quality of life and advancement of knowledge, and the need to pursue all three in an integrated and mutually reinforcing way.
- Chapter 4 points out that a shift in emphasis in the role of the federal government to become a partner to business, academic institutions, other governments and voluntary organizations will stimulate increased S&T activity.

- Chapter 5 addresses squarely the need for better governance of the federal S&T effort. At the highest level, this means strengthening the role of our elected representatives — in the Cabinet and Parliament — and new ways of cooperating with the private sector and other partners. The government will create new institutions to improve advice, decision making and coordination. As well, it will introduce a new approach to managing the federal S&T effort in order to increase the accountability of departments and agencies to the government, to Parliament and, ultimately, to Canadians.
- Chapter 6 sets out a common set of principles to further improve the management of our S&T effort in federal departments and agencies. These guidelines give operational reality to the general policy themes and provide more specific policy directions. They reflect the advice received from many participants during the S&T Review.

- Chapter 7 concludes that our success ultimately depends on the dedicated collaboration of Canadians in the national innovation system. A genuine partnership is needed among all players in the economy to make sure that Canada's overall S&T effort matches our domestic and global challenges, and maintains our place as the world's best country in which to live in the new century.

Science and Technology for the New Century

fulfils the government's commitment to put in place a federal strategy with "real priorities, real direction, and a real review of results."

In accordance with this broad new S&T policy, all major federal departments and agencies engaged in the S&T enterprise have prepared action plans detailing how they are putting it into effect. They present the results already achieved and their future plans to strengthen the Canadian innovation system.

2. Adapting to a Changing World

The United Nations has repeatedly recognized Canada as the best place in the world to live. Our country is unsurpassed in its quality of life, magnificent geography, tolerance and sharing.

Canadians did not get there by accident. We are good at many things: highly efficient natural resource development, world-class telecommunications, a health care system that is the envy of many nations.

We have a long history of resourcefulness in adapting to the challenges of a northern climate, vast distances, and regional and cultural diversity. A proud legacy of achievements in science and technology demonstrates our ability to innovate.

Canadian scientists and engineers have earned the respect of the international community. Despite our relatively small population, 22 researchers who were born or educated in Canada or who worked here have won Nobel prizes. Many Canadian inventors and entrepreneurs have demonstrated a remarkable ability to harness the benefits of science and technology to develop new products and processes.

Canada has benefited enormously from a rich heritage of natural resources. While these resources continue to be important, we must recognize that our economy is undergoing a major transformation, unlike any since the Industrial Revolution. Steam power was the technological catalyst for that revolution. Today, knowledge and information — their applications and technologies — are at the root of the economic and societal shift now under way. This transformation affects economic and social activities from forestry and mining to high-technology manufacturing, sophisticated business services, and health and resource management. It also has profound impacts on how we learn and play, and how we care for each other.

All advanced economies face similar structural change. In this globalized environment, classical economic theory, where every nation had a comparative advantage based on different natural endowments, no longer adequately explains reality. With the increasingly free flow of capital and technology worldwide, the advanced economies now compete head-to-head for investment in and production and export of many of the same goods and services — not only among themselves, but increasingly with the emerging economies of newly industrialized countries.

IMPROVING OUR PERFORMANCE

What separates success from failure in this new environment is the ability of a nation's people to develop innovative new products, processes and services, and underpin their economic progress by improving their quality of life.

As individual Canadians, we and our children must therefore develop the skills and knowledge required to see us through this economic transformation. From 1984 to 1994, there was a net gain of more than 800 000 new jobs in Canada for those with advanced post-secondary education, while there was a net loss of almost 1.4 million jobs for Canadians with high school training or less. Although high-knowledge industries account for only about a third of total employment, they have contributed more to recent job growth in Canada than all other industries combined.

The ability of Canadians, especially our youth, to acquire the skills necessary to understand science and technology, contribute to their further development, and make best use of them to meet economic and social goals will be instrumental in maintaining this country as the best place to live.

We have some way to go. A recent study by Statistics Canada found that two of the top three factors accounting for the success of fast-growing small firms — the economy's job generators — are their research and development performance and their ability to adopt new technologies. But it is well-documented that, by international standards, Canada's S&T effort has considerable room for improvement, particularly in the development, adoption and commercialization of technology.

In the World Economic Forum's 1995 review of the 48 national economies surveyed, Canada ranks only eighteenth in science and technology. This "innovation gap," as it has been characterized by the Organisation for Economic Co-operation and Development (OECD), has been a significant contributing factor to our poor productivity performance over the past two decades — an average increase of only 0.3 percent per year from 1974 to 1993. Poor productivity has in turn depressed real income growth and promoted high government deficits. Had we maintained productivity growth at the 2 percent a year rate of the fifties and sixties, some half a million more Canadians would be working today, incomes would be ahead by almost \$10 000 per person and the federal budget would be in balance.

BUILDING THE CANADIAN INNOVATION SYSTEM

The federal government is a major contributor to Canada's overall effort in science and technology. It accounts for over a quarter of the country's total investment in research and development. The S&T Review has been instrumental in stimulating a debate on the role of the federal government, and on its directions and priorities. The government recognizes the

deficiencies of its traditional emphasis on public funding of research and development. We must go beyond that. The federal government must respond to the challenges of the knowledge-based economy by becoming a more effective partner in the innovation system. This means new goals, directions and initiatives.

We must build the institutions, partnerships and networks needed to link individual skills and talents. At the heart of our ability as a nation to meet these challenges lies the creation of a more effective, integrated innovation system, which recognizes the interdependence and interconnections between wealth and job creation, quality of life and advancement of knowledge.

What matters most is the exchange of knowledge and information; cooperation among governments, business and universities; and the forging of partnerships for mutual benefit. These relationships do not just happen. They thrive in countries that understand the process and act to strengthen them in an innovation system.

Canada has many innovative institutions. Thousands of firms conduct research and development. As well, our universities and colleges, more than 100 federal government laboratories, some 90 provincial laboratories, dozens of consortia involving universities and industry, and tens of thousands of entrepreneurs are engaged in Canada's S&T enterprise. Banks and other financial institutions are beginning to recognize and serve the needs of knowledge-based industries for start-up, venture and other types of patient capital. Canadian firms and labs are partners in thousands of strategic alliances with international counterparts, penetrating foreign markets and seizing technological and strategic opportunities. Taken together, Canada's knowledge-producing organizations form an impressive mosaic.

Innovation is as much regional and local as it is national. A climate for innovation is created by the leadership and drive of clusters of firms in an industry, along with the financial institutions serving them; responsive education and training institutions; local research bodies; boards of trade; municipal, territorial and provincial governments; entrepreneurs; and many others.

Canada's challenge is to put our knowledge to work to create an effective and resilient innovation system that maximizes the synergies from activities performed at all levels and across all sectors and regions. This is critically important for a mid-sized country like Canada, which has more limited resources than its major trading partners, but equivalent competitive challenges. But our size should be no obstacle; smaller economies than ours have succeeded in creating innovation systems that work well for them.

We must take a more deliberate approach to building the Canadian innovation system, by understanding how it functions, playing on its strengths and reducing its weaknesses, engaging all the participants, and getting the federal government's role right. This will be a cornerstone of the federal government's strategy in building a more innovative economy.

3. Setting Goals

The bedrock of a federal science and technology strategy must be a coherent set of national goals to which our S&T resources should be directed.

The government, acknowledging its responsibility as a major participant in Canada's innovation system, has examined today's challenges and those of the coming century and arrived at three related goals for building a strong, forward-looking, dynamic Canadian innovation system: sustainable job creation and economic growth, improved quality of life, and advancement of knowledge.

SUSTAINABLE JOB CREATION AND ECONOMIC GROWTH

Although Canada has made major contributions in many areas of scientific knowledge, we have been slow to apply and commercialize this knowledge and slow to put it to work for our social and economic benefit. The government, recognizing industry's leading role, will help develop partnerships between the public and private sectors that are exemplary by global standards.

The goal: to ensure that Canada is among the best in the world in applying and commercializing S&T for sustainable job creation and economic growth.

IMPROVED QUALITY OF LIFE

We must continually build on our efforts to use science and technology for the well-being of Canadians.

The goal: to ensure that Canada applies S&T to improve the quality of life for our citizens through the creation of fulfilling jobs and through the most effective social, environmental and health care programs in the world.

ADVANCEMENT OF KNOWLEDGE

Canada has been a significant contributor to scientific and technological advances.

The goal: to create in Canada world centres of excellence in scientific discovery; to build a broad base of scientific enquiry; to foster Canadian participation in all major fields of science and technology; and to ensure that new knowledge can be acquired and disseminated widely, from Canadian sources and from around the world.

DYNAMIC INTERPLAY

The S&T Review has demonstrated the pervasiveness, potential and importance of science and technology to achieving sustainable job creation and growth, a high quality of life and the advancement of knowledge. The strategic framework developed by NABST in its recent report, *Healthy, Wealthy and Wise*, incorporated this model and it was the model around which the S&T consultations were structured. NABST pointed out that we must not only set clear goals in each of these areas, but also recognize and learn from the dynamic interplay among them. The government endorses this approach.

These goals cannot be isolated from one another. Economic growth has strong links to advances in scientific and technological knowledge, but it is also determined by social advances that improve the quality of life and create a resourceful work force. A sound social environment is a precondition for creative individuals and communities to build a more innovative Canadian economy for jobs and growth. Research, both basic and applied, provides a continuous, renewable source of skills, ideas, technologies and policies, which help create further innovations, thereby contributing to both economic growth and social well-being.

4. Establishing Priorities

At the best of times, setting priorities is a difficult process, for it means carrying out some activities at the expense of others which also have merit. Priority setting is particularly difficult for governments today in Canada as they deal with the burdens of budget deficits and cumulative debt loads.

NEW AND REALLOCATED FUNDING

For the federal government, despite the clear need to continue tackling fiscal problems, S&T remain a priority. This is illustrated by the examples that follow of S&T programs and projects supported by new or reallocated funds.

- The Long-Term Space Plan focuses on meeting Canadian needs and spurring economic growth and employment.
- CANARIE (the Canadian Network for the Advancement of Research, Industry and Education) accelerates construction of the Information Highway.
- The Canadian Technology Network will help small businesses gain access to leading-edge technologies.
- SchoolNet is linking Canada's public schools, libraries, colleges and universities to the Information Highway.
- The Health Intelligence Network, a recent Health Canada initiative, is strengthening Canada's national surveillance and disease-monitoring capacity.
- The Medical Research Council's partnership with the Pharmaceutical Manufacturer's Association of Canada in the MRC-PMAC Health Program is stimulating health research with a high ratio of private sector investment.

- The Tri-University Meson Facility (TRIUMF), Canada's largest particle physics laboratory, offers a unique, world-class research facility to the Canadian and international research communities and ensures that Canadian scientists have access to international particle physics research.
- Western Economic Diversification Canada's Biotechnology Partnerships program engages financial institutions in improving access to capital for small businesses in emerging industries.
- PRECARN (Pre-Competitive Applied Research Network), a not-for-profit industrial consortium, is involved in collaborative, pre-competitive R&D on intelligent systems.
- Agriculture and Agri-food Canada's Matching Investment Initiative co-funds projects with industry to ensure that research priorities are met and technology is transferred.

PRIORITIES IN PROGRAM REVIEW

As part of its effort to cut the deficit, achieve a more sustainable fiscal position and free national savings for more productive investment, the government carried out a major review of roles and priorities in its Program Review. Program spending was reduced in virtually all areas of government.

Since S&T are essential to so many programs and activities, the reduction or elimination of programs and activities has affected their supporting S&T. At the same time, the advice received during the consultations in the S&T Review was critical to decision making on S&T spending priorities for individual departments and agencies.

Although Program Review will result in a reduction in S&T expenditures, the federal government maintains a major commitment to S&T: \$5.5 billion in 1995-96. The government also provides considerable indirect S&T assistance to the private sector through the Scientific Research and Experimental Development tax credit. This assistance amounted to over \$1 billion in 1992, the most recent year for which information is available.

Departmental and agency action plans present detailed information on the S&T priorities for the major science-based departments and agencies. The plans also describe the internal innovations and external partnerships departments and agencies have developed to carry out their mandates and deliver essential programs and services to Canadians. A number of examples follow.

■ **Environment Canada.** The department will employ new technologies and automation to meet Canadians' needs for basic weather and other environmental information at lower cost. These technologies are the result of the department's R&D investments over many years. Advanced numerical models of the atmosphere use data from all over the world to make weather predictions up to five days and beyond. The department also uses artificial intelligence technologies to produce routine forecasts, freeing forecasters to concentrate on severe weather warnings and other difficult weather situations. Environment Canada is using the most advanced technologies in the world to make sure Canadians receive essential basic services in support of public safety.

■ **Fisheries and Oceans.** The government is consolidating authority for most oceans policies in Fisheries and Oceans (F&O), to help foster innovation, economic growth and job creation in the oceans sector. It is realigning F&O science activities to focus on core businesses: conservation of marine and anadromous (ocean fish such as salmon that ascend rivers to spawn) fishery resources; marine environment and fish habitat protection; and safe navigation. Multidisciplinary interregional teams will deliver a greater share of the science program in a new project-based management system. Opportunities to deliver programs through partnerships with fishers, universities, the oceans industry and other organizations are being maximized.

■ **Health Canada.** The department is working with the provinces to explore the potential for a Health Research Agenda for Canada. All Canadian jurisdictions recognize the importance of a sound evidence base to guide health policies and programs, and to guide the allocation of resources between health care and population-health strategies. There are opportunities to collaborate on the identification of research needs and priorities, and to improve the ways in which policy-relevant health services research and population health research are communicated and used.

Health Canada is also working with the Medical Research Council and other federal agencies on strategies to expand the evidence base on the outcomes of health affecting interventions. The department is also undertaking a strategic reorientation of its intramural and extramural S&T programs.

- **Industry Canada.** The department will concentrate on establishing an efficient, competitive and fair marketplace, one driven by informed and demanding consumers, and one in which businesses can seize opportunities at home and abroad and apply advances in S&T. Departmental efforts will centre on three related lines of business: micro-economic policy, marketplace rules and services, and industry sectoral development. S&T are central to all three lines of business.
- **The National Research Council.** The NRC has undertaken a complete realignment of its research portfolio to focus on five technology groups: biotechnologies, construction, information and telecommunications, manufacturing and infrastructure (including measurement standards, engineering research and science facilities). NRC's research institutes, in conjunction with its Industrial Research Assistance Program and the Canada Institute for Scientific and Technical Information, will adopt a more integrated approach to support innovation — one that achieves an overall national impact through a focus on regional and community-based innovation.
- **Natural Resources Canada.** The priorities of the department are the sustainable development of Canada's natural resources and the international competitiveness of associated industrial sectors. The department was recently reorganized to link science and technology more closely with policy and programs in its business lines of energy, forestry, minerals and metals, and the land mass. This realignment ensures that policy will be informed by science and that science will be guided by policy priorities. Natural Resources Canada will continue to work in partnership with the

public and private sectors, universities, other countries and international organizations to encourage scientific cooperation and technology development and transfer to meet its sustainable development and international competitiveness objectives.

These examples of departmental and agency priorities illustrate the substantial re-engineering and refocusing of federal S&T activities resulting from Program Review. The S&T Review not only assisted this process, but also helped identify the key issues common to all departments and agencies as the government moved to implement these priorities.

FOCUS ON CORE ACTIVITIES

With smaller budgets, it is now more important than ever to invest our resources strategically, so that Canadians can obtain the maximum economic, social and scientific returns. This means both focusing on core activities and finding more efficient and effective ways to deliver them.

Delivery will be improved within government and between government and the private and not-for-profit sectors through the strategic use of partnership arrangements. These partnerships will often lead to federal support, which will stimulate complementary participation in the latter sectors. And this will result in not only more activity but also better decision making up front and better results downstream.

Partnerships with the provinces and territories, and those struck internally among federal departments and agencies, will reduce overlap and make initiatives complement and reinforce one another.

The federal government's core S&T activities are:

- funding and performing scientific research to support the mandates of departments and agencies;
- supporting research in universities, colleges, hospitals and other non-governmental research institutions and Networks of Centres of Excellence; and
- supporting private sector research and development.

In addition to these traditional activities, the government will increasingly emphasize a new role: that of information analyst, knowledge disseminator and network builder — critical elements in the successful evolution of the Canadian innovation system.

FUNDING AND PERFORMING SCIENTIFIC RESEARCH

One of the government's principal roles in science and technology is to undertake research and other scientific activities that produce a "public good." The federal government will focus on doing well what it should do. This includes research and development that:

- lead to optimum public policy;
- the private sector would not likely carry out on its own; or
- are carried out in partnership with the private sector and the academic community.

Sound science is central to sound policy development and decision making. For example, regulatory responsibilities in drug licensing, food inspection, fisheries conservation and environmental protection rely on the effective use of

S&T in testing, assessing risks, anticipating and avoiding threats to health and safety, and mitigating damage. Regardless of who ultimately implements these policies, S&T increasingly determine their substance, scope and methods of application.

Economic success often depends on social as well as technical considerations. Along with the health sciences, the social sciences have a large role in the design and delivery of programs aimed at improving Canadians' quality of life. In critical areas such as health care and social well-being, the results of social science research can be brought to bear on improving program effectiveness and reducing program costs. Applied social research is needed to improve government programs that help people enter the labour market and contribute to better health, and to determine the most cost-effective way to deliver these programs. Research is also needed to ensure a sustainable health care system. Furthermore, the social sciences are uniquely competent to advance our understanding of innovation itself. Job creation, high performance workplaces, the impacts of emerging information technologies, international competitiveness, and the needs and structure of Canada's innovation system — all are vital issues for research and analysis by the social sciences.

Strong collaboration between the federal government and the provinces and territories, as well as with the private sector, is important in carrying out many research activities. The federal government will encourage opportunities for the private sector to take on a greater role. Some S&T activities once carried out exclusively by the federal government because of insufficient private sector capacity are now being conducted as public-private collaborations or are being

transferred fully to the private sector, reflecting the growing S&T capability of private firms. For example:

- In Agriculture and Agri-Food Canada's Matching Investment Initiative, the department matches private sector investment in joint research projects dollar-for-dollar. This initiative is expected to stimulate an incremental \$35 million from private sector participants into industry-relevant agricultural research.
- Aquaculture is an area where Canadian industry is building the capacity to assume some of the related scientific activities formerly undertaken by the government. As well, in the fisheries, co-management and partnership arrangements are being developed with First Nations authorities, licence holders and other community groups to develop conservation and harvesting plans; deliver science and other programs; and manage capacity, licensing and compliance.

SUPPORTING RESEARCH IN UNIVERSITIES AND COLLEGES, NETWORKS OF CENTRES OF EXCELLENCE AND OTHER NON-GOVERNMENTAL RESEARCH INSTITUTIONS

Although the provinces are responsible for education and its funding, the federal government has a continuing involvement in post-secondary education, through its support of:

- the Canada Student Loans Program, which provides students with financial assistance for post-secondary education;
- the post-secondary education of Indian and Inuit students; and

- the granting councils, which provide research grants and scholarships for researchers and trainees in universities, hospitals and other non-governmental research institutes.

Research and the training of graduate and post-graduate students in post-secondary and other institutions continue to receive substantial public support because they provide a broad public benefit. Research based in universities and institutes generates new discoveries essential to Canadian innovation, and ensures our ability to adopt and adapt technologies developed elsewhere in the world.

Program Review resulted in some reductions to the federal government's research granting councils. The government is, however, developing innovative partnerships with the private sector as a means of sustaining support for researchers. For example:

- The Canadian Medical Discoveries Fund, inspired by the Medical Research Council of Canada, is a collaborative venture designed to build on medical discoveries by investing in early-stage companies with the potential to become industry leaders. Canadians benefit from increased investment opportunities, new businesses in Canada, knowledge-intensive jobs, and increased research and research training opportunities.
- The Natural Sciences and Engineering Research Council of Canada (NSERC) has negotiated a memorandum of understanding with a management group in the science and engineering sector to create an investment fund aimed at applying knowledge developed in university laboratories with NSERC support, and to enhance the transfer of technology to

Canadian industry. The fund's primary objective is to invest in the science and engineering sector, with an emphasis on businesses engaged in early-stage commercialization of research or product development.

- The Networks of Centres of Excellence program is a unique initiative that puts Canada at the leading edge of multidisciplinary targeted research based on nationwide collaboration among universities, industries and government. Administered by the three federal granting councils in collaboration with Industry Canada, the Networks of Centres of Excellence program represents an innovative approach to R&D. It is designed to accelerate the transfer of technology to the private sector, develop Canada's economy and improve the quality of life of Canadians. New networks focused on advanced materials technologies, the environment, health and technology-based learning were recently announced, complementing the 10 other networks located across Canada.
- The Social Sciences and Humanities Research Council in partnership with Citizenship and Immigration Canada, Health Canada, Canadian Heritage, Status of Women Canada, and the Canadian Mortgage and Housing Corporation have launched Immigration and the Metropolis: Centres of Excellence for Research on Immigration and Integration. This initiative is designed to develop a better understanding of immigration and how it transforms countries, cities, communities and individuals. Up to three research centres across Canada will be funded to promote, coordinate, conduct and communicate Canadian research on immigration and integration.

SUPPORTING PRIVATE SECTOR RESEARCH AND TECHNOLOGY DEVELOPMENT

Over the years, the federal government has had various programs to promote increased R&D activity in the private sector. These programs include general support through the tax system, support for industry-led consortia in pre-competitive research, and firm-specific technology development assistance for high-risk commercialization.

One example of the government's strategic approach to support for innovation is the National Research Council's Industrial Research Assistance Program (IRAP). Through partnership with organizations across Canada, IRAP has created a national network of technology advisors to help Canadian companies in their own communities acquire, develop and exploit technology from across Canada and around the world.

IRAP has consistently received the highest praise from industry. In fact, IRAP won the Ernest C. Manning Award for Excellence, one of the most prestigious awards for business excellence in Canada. IRAP provides technical advice to over 10 000 companies per year and, where necessary, financial support for R&D activities. The program is delivered coast-to-coast through a network of 260 Industrial Technology Advisors and involves 130 members representing provincial research organizations, research centres, universities and colleges, and industrial associations. Through IRAP, some 9000 jobs are created in the private sector each year. Other examples of substantive federal activity in support of technology development are found in the companion action plans of the science-based departments and agencies.

In response to Program Review, the 1995 budget terminated many business subsidy programs. But this does not mean the end of direct support for private sector R&D activity. What it does mean is a new approach in how such support will be provided.

A key gap exists in the government's plan for technology development, one that must be addressed to create secure, sustainable jobs and economic growth. Canada needs a forward-looking, risk-sharing instrument — an investment fund — to develop partnerships with the private sector in achieving technological excellence. And this must involve a major national program with the capability of reinforcing regional technological strengths.

The development of many technologies is a high-risk, high-cost venture. The scale of effort and investment required often exceeds the capacity of many Canadian firms, which are relatively small by global standards. Also, firms are often reluctant to invest in technologies because they cannot reap enough of the benefits that result. In some sectors, they are reluctant to do the work in Canada because other nations offer high levels of public support.

The federal government recognizes that it has a legitimate role to level the playing field and, by doing so, to share both the risks and benefits in those strategic industries in which we choose to compete.

Canada requires an effective, market-driven tool to stimulate the development and commercialization of technologies. Therefore, the government will introduce a new investment program to stimulate increased private sector investment in high technology product and process development in globally competitive, footloose and high-growth industries. Technology Partnerships Canada will be designed to share risk with private sector participants, gain royalties

from successful projects and reinvest these repayments to help support new initiatives. The best advice available in the public and private sectors will be sought to ensure that sectors and technologies essential to Canada's economic growth are targeted, for example, toward aerospace and defence, environmental and enabling technologies, and industries converting from military to civilian production.

PROVIDING INFORMATION AND ANALYSIS AND BUILDING NETWORKS

The timely flow of information and the ability to understand and manage this information are among the critical determinants of innovative capacity. The federal government is uniquely positioned to promote and build the information networks that link Canadians to each other, and to foster international connections.

As the Information Highway Advisory Council (IHAC) put it in its recent report, *Connection, Community, Content: The Challenge of the Information Highway*, "Canada's Information Highway will be key to improving Canada's competitive position. It is essential for a successful transition to an economy in which jobs and wealth are based on the creation, movement and application of knowledge."

The Information Highway will affect all aspects of Canada's innovation system. With its far-reaching implications for the provision of government services, the growth of new industries, Canadian culture, networking, intergovernmental cooperation and job creation, this national communications infrastructure is the platform for Canada's innovation system. One of our country's central projects for the future is to transform today's networks into a fully integrated system so that Canadians, their communities, and their places of work, research and study can interact

with and add value to each other using audio, video and multimedia services.

But simply “being digital” is not enough. Knowledge-intensive content is needed. The federal government, through its array of activities, has much S&T-related information that it can share with Canadians, using the Information Highway along with other mechanisms of dissemination. The government also has a comparative advantage in analyzing this information and making it available to Canadians as a public good so that they can use it to make informed decisions, whether on investment and production, health, safety, sustainable development, lifelong learning or promoting a science culture. Indeed, IHAC’s recent report urged the government to make active use of the Information Highway to improve public access to information and government services.

As a major step forward, the Government Online project is under way. It is aimed at improving public service through increased use of electronic messaging for communications and other services within government, and between governments and their clients. On another front, Statistics Canada and the Social Sciences and Humanities Research Council are heading a five-year pilot project to make federal data more widely available to researchers. Yet another initiative is aimed at assisting firms to keep pace

with economic and technological developments. Strategis, an Internet product developed by Industry Canada, will contain the most extensive information for Canadian business ever compiled in one site.

Information technologies present great opportunities for the health sector to enhance its research and service delivery capacities and to reduce the cost of Canada’s approximately \$70 billion per year health system. Building on the emerging information infrastructure, a national health information network could help improve the provision of health services and medical expertise to remote communities; assist the flow of research results and information; more effectively manage patient services among hospital, community and home-based programs; expand public health surveillance capacity; and disseminate information on health promotion and disease prevention.

The development of information networks, products and related policies is key to our ability to learn about, adopt and adapt leading-edge technologies and improve our innovative capacity. They take time, effort and resources to develop, but they will have a great long-term payoff for a relatively modest investment. The process is already well under way, and is a priority in the government’s S&T effort.

5. Creating New Institutions and Mechanisms for Governance

Institutions matter. The institutions that guide and carry out science and technology, and the way they are arranged and function together, can either encourage or impede invention and the exchange of ideas. Innovations in a country's S&T infrastructure can be as important as the innovations in science, engineering and technology themselves.

Other G-7 nations have well-established S&T governance infrastructures linking government, business, finance and academic institutions. Developing such an infrastructure is particularly important for a mid-sized country like Canada. We must be able to work more proficiently to compete in the global marketplace. This means taking a cooperative, coordinated and strongly networked approach to make the best use of our limited resources.

ADVICE

Advances in S&T are occurring so rapidly, and they carry such potential for systemic economic and social change, that the government must be able to consult with the best-qualified advisors in the country from the scientific community,

industry, finance and economics. The government needs regular, direct access to these advisors to help identify emerging issues and priorities and to obtain their views on proposed new policy directions.

The National Advisory Board on Science and Technology provided the government with important and influential outside expertise, including most recently its report *Healthy, Wealthy and Wise*. The government will build on the board's experience and success by reconstituting a new senior advisory body.

Accordingly, the government will establish the Advisory Council on Science and Technology. The Council will assume some of the former NABST functions and provide strategic advice on a range of S&T issues. Council members will be formally appointed by and report to the Prime Minister. The Minister of Industry will lead the government's regular interface with the Council. Members will represent the spectrum of Canada's economy, and will come from the forefront of Canadian innovators in S&T and other relevant fields. They will bring to bear their expertise and insights on translating science and technology into economic growth, jobs and social well-being.

The government believes that NABST's more public functions, those related to mobilizing the broader scientific community and influencing Canadians' attitudes toward S&T, would be best served by institutions at arm's length from government.

Canada's innovation system has many dynamic actors. At the federal level, there are research councils and laboratories, granting councils, policy and program branches, and government-funded centres of excellence. Provincial governments, universities, hospital research units and other publicly funded research institutions are essential elements as well. Many major firms also perform research and development, particularly in the telecommunications, pharmaceutical, aerospace, energy, minerals, and forest products sectors.

The government will replace NABST with an Advisory Council on Science and Technology. The council will be composed of eminent Canadians who are leaders in their fields. It will meet with the Economic Development Policy Committee of Cabinet to review the nation's performance in S&T, identify emerging issues and advise on a forward-looking agenda.

Our innovation system is maturing to a point where the public would benefit from a broader, more inclusive dialogue among the many players in that system. The government will support actions taken in this direction.

DECISION MAKING

For the federal government to be a more effective partner in the innovation system, it must get its own house in order. It has received a number of suggestions for changing the structures and processes of federal S&T decision making. For example, NABST suggested the need for improved coordination: “a strong and expert system of governance, implemented at the Cabinet level.” Other proposals made in the public consultations favoured more centralized control of S&T policies and strategies.

A centralized structure would be a more visible symbol of the priority the government attaches to S&T. It would also resemble the arrangements in some other OECD countries, where the S&T policy function is situated close to the executive branch of government.

On the other hand, consolidating responsibility in a central structure creates the risk of separating S&T from the core roles, responsibilities and activities of federal departments and agencies. More important, under our parliamentary system of government, ministers must retain the capacity to direct their departments’ efforts and resources, including their S&T resources, and be accountable for the results.

The government has concluded that it should strike a balance. Achieving greater coherence while preserving flexibility, responsiveness and ministerial accountability requires a more rigorous collective review of priorities and greater coordination of activities.

Therefore, to reinforce the governance of S&T at the ministerial level, the Economic Development Policy Committee of Cabinet will formally

The government will take the following measures to improve the governance of S&T at the ministerial level:

- **The Economic Development Policy Committee of Cabinet will, as part of the government’s overall planning and accountability framework, review federal S&T performance and make recommendations to Cabinet on S&T priorities.**
- **The committee’s review of S&T performance will be based on an annual report to Cabinet on science and technology activities in the federal government.**
- **The Advisory Council on S&T will provide its own views and advice as input to the committee’s review of S&T priorities.**

review federal performance of S&T and make recommendations to Cabinet on the government’s S&T priorities. Other ministers with S&T portfolios will attend committee meetings to deal with major horizontal issues, as required. The Advisory Council on Science and Technology will be called upon to provide advice to the committee in its review of S&T priorities. These measures will ensure that S&T are strongly linked to related policy issues and the broader government agenda.

MANAGEMENT

Improving top-level advisory and decision-making structures is not enough to ensure that the federal government's substantial investment in S&T will yield better results. The government recognizes that it must also put in place new institutions and mechanisms to improve management of that investment.

At its broadest level, management means improving the coordination of S&T activity among federal departments and agencies. Program Review and the S&T Review have been instrumental in accelerating reduction of overlap and duplication and rationalizing S&T activities. They have also pointed to the need to increase collaboration among departments on major crosscutting issues. This is happening. For example, the recently signed memorandum of

understanding on S&T for sustainable development among the four natural resource departments outlines how they will cooperate on S&T activities.

But the federal government can and should do more than this. There is clearly a need to put in place systematic, government-wide coordination mechanisms in which all players are represented, to create synergies and efficiencies in our overall S&T effort.

Ministers and federal departments and agencies receive advice on science, technology and innovation from an array of expert external advisory boards. To improve the management of federal S&T, the government will better integrate this diverse advice by establishing a committee of federal S&T advisory bodies. Through the Secretary of State (Science, Research and Development), the committee will use its external perspective to inform the government on S&T and innovation issues common to federal science-based departments and agencies, such as: opportunities for cooperation and multidisciplinary collaboration; cross-cutting initiatives such as polar science, enabling technologies and big science; harmonizing S&T policies and strategies across departments and agencies; and the management of S&T personnel.

The government will also adopt new measures to increase the accountability of individual departments and agencies for the management of their S&T activities. This will be undertaken within the framework of the new Expenditure Management System, which was announced by the President of the Treasury Board in February 1995. It is designed to give Canadians a more open, transparent and accountable management process.

Annual S&T reports will be part of public documents for two key audiences. First, Departmental Outlooks, together with the Main Estimates, will give parliamentary standing

The Minister of Industry, supported by the Secretary of State (Science, Research and Development), will lead the coordination of S&T policy and strategies across the federal government.

This effort will be supported by a committee composed of representatives of external advisory bodies to federal science-based departments and agencies. This committee will advise the government on approaches to horizontal, crosscutting issues in S&T.

Each science-based department and agency will prepare an S&T plan describing and integrating the approach that it will take within its overall business plan. This S&T plan will form the basis for Cabinet review of results.

As well, each federal department and agency responsible for S&T expenditures will prepare a report on its priorities, key initiatives, spending plans, management challenges and performance measures in S&T as part of its annual Departmental Outlook.

committees the information they need to review and report on federal S&T. Second, Departmental Outlooks will give the public the opportunity to examine federal S&T priorities and performance for themselves.

Together these initiatives respond substantively to the Auditor General's recommendation for a stronger role for parliamentarians and better S&T information for the public, a call also heard frequently during the S&T Review consultations, as well as greater transparency and accountability in the federal science and technology effort.

Departments and agencies are responding to the challenge. For example, Natural Resources Canada is developing a pilot project aimed at an improved S&T management framework. It will include practices and processes for greater

client focus, more effective and responsible accountability, and better S&T management.

The government acknowledges the need for greater attention to the recruitment, career development and training of its scientists and technical personnel. As well, it is clear that there are opportunities for improvement of government's research management capability to ensure the continuing excellence of federal research, a recurring theme in public consultations during

The Treasury Board, together with other S&T stakeholders, has introduced a new framework for human resources management of the federal science and technology community. To implement this framework, science-based departments, the Public Service Commission, the Professional Institute of the Public Service of Canada, and the Treasury Board Secretariat are working in partnership on new approaches to:

- **management and scientific development and training;**
- **classification;**
- **rewards, recognition and incentives;**
- **the work force and mobility; and**
- **recruitment and rejuvenation.**

Each science-based department and agency will set clear S&T targets and objectives, establish performance measurement indicators based on outputs, develop evaluation frameworks, and maintain mechanisms for external advice and review.

the S&T Review. Finally, it is important to recognize the vital role human resources play in technology transfer.

Our employees — scientists, engineers, technicians, analysts and laboratory managers — are at the heart of the government's performance of S&T. Recognizing the importance of S&T staff and the distinct challenges they face, the Treasury Board Secretariat is working with science-based departments and agencies to design and implement a human resources management strategy for the federal S&T community. This strategy is aimed at producing innovative, tailored approaches for departments to use in attracting, developing and managing their work force.

Extensive consultations were held to review human resources issues from both management and employee perspectives. These resulted in *A Framework for the Human Resources Management of the Federal Science and Technology Community*, available as a companion report to this document.

The management framework focuses on new directions for science in government and on the opportunities for its employees. It addresses issues raised in the Science and Technology

Review consultations, the business plans of various departments, and recommendations made in the Auditor General's 1994 report. Overall, the framework is designed to provide practical policies and cost-effective tools to align S&T organizations and staff with the direction and business of their departments.

To put the framework into action, a management structure has been created, and projects have begun in five key areas. It is expected that these projects will serve as pilots for other departments and occupational groups to address human resources issues.

As an example of an early, related approach in S&T human resources management, the Communications Research Centre has three initiatives under way. These aim to: bring in young scientific staff to work with, and learn from, older personnel contemplating retirement; permit non-permanent researchers to work on long-term projects; and allow engineering staff opportunities for advancement outside the management stream.

The Auditor General pointed out a number of other critical areas that require better management. They included setting clearer goals and priorities; a focus on results; better identification of both potential uses for, and users of, these results; and increased accountability for making the desired changes. The government endorses these recommendations.

This approach recognizes individual ministerial accountability. It allows each department and agency to adopt a management framework suited to its particular mandate, services and operational environment.

This initiative responds to calls heard during the S&T Review for a revamping of the information base used to track and evaluate S&T performance. The new system will tell

The government will create a new S&T information system for Canada designed to measure the country's progress in becoming more innovative and more competitive internationally.

Canadians how government initiatives are working to promote innovation, diffusion of technology and adoption of new ideas by all sectors of the Canadian economy.

Taken together, these changes will make a significant difference in how the federal government manages its S&T assets and activities — a difference Canadians will soon see for themselves because of the increased transparency and accountability that will result.

INTERGOVERNMENTAL COOPERATION AND COORDINATION

The federal government is committed to advancing the Canadian innovation system by establishing results-oriented partnerships with the country's key agents of innovation. A major focus of this effort will be to engage other governments in Canada in collaborative relationships.

Science and technology are critical to the economic and social development of all regions, provinces, territories and municipalities in Canada. Through the S&T activities of their departments and agencies, the contributions of their research institutes and councils, and the expert advice provided by their external advisory bodies, these governments play a vital role in Canada's innovation effort.

An effective governance system for science and technology in Canada demands closer cooperation and coordination of effort among governments. Past high-level initiatives in this direction have been well-intentioned but have not resulted in much discernible progress. Such approaches do not work well unless they are made real through concerted, pragmatic efforts to deal with issues of overlap and duplication, specific opportunities for collaboration, and the sharing of information, analyses and best-practice techniques. For all concerned, it is time to repurpose intergovernmental relations in science and technology.

This new direction for intergovernmental cooperation and coordination in S&T must respect the Canadian reality. We have evolved an inherently flexible and decentralized system of innovation. This is evident in the variation among provinces and territories with respect to how S&T is managed and governed, which ministries have responsibility for S&T, the types of S&T being performed, the levels of investment, and so on.

For its part, the federal government has taken major steps to put its own house in order. It is now in a good position to widen and deepen intergovernmental cooperation in many areas of S&T activity. For example, Industry Canada, the National Research Council and Western Economic Diversification Canada are working with the four western provinces to examine technology clustering opportunities. This initiative will be formally recognized in a Science and Technology Memorandum of Understanding with the western provinces.

Other initiatives will follow. We must build on existing relationships between federal and provincial departments. And where they are needed and make sense, we must develop new institutions and instruments to facilitate improved intergovernmental relations, whether through regional arrangements or bilateral arrangements. To help shape this process, the government will initiate results-oriented discussions with provincial and territorial governments. These will be directed to identifying new, practical forms of partnerships and other mechanisms for cooperation and coordination of S&T activities in areas of mutual interest.

To improve intergovernmental cooperation and coordination of Canada's S&T effort, the government will initiate discussions with representatives of provincial and territorial governments, as well as with other interested parties, on the federal government's S&T strategy and to identify opportunities to strengthen the Canadian innovation system.

In support of these efforts, federal science-based departments and agencies will develop explicit strategies for working with their provincial and territorial counterparts on S&T activities of mutual interest.

6. Providing Direction

To ensure that departments and agencies act together to reach S&T goals, a common framework of operating principles is being adopted. This kind of government-wide direction will guide the departments and agencies in preparing and implementing S&T plans.

The operating principles for S&T policies and programs strongly reflect the advice received throughout the S&T Review process. They are as follows:

- **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; and**
- **promoting a stronger science culture.**

The way departments and agencies apply these principles to their S&T activities will vary depending upon their roles and responsibilities. Nor will all the principles apply equally to all departments.

The operating principles are the qualitative benchmarks against which results will be measured and evaluated under the new management system described above. This accords with the recommendation of the Auditor General of Canada for rigorous evaluations of departmental S&T activities to determine their effectiveness, plan future research and hold managers accountable.

The companion action plans from the major science-based departments and agencies outline in more detail the way they are implementing these operating principles and related management practices.

INCREASING THE EFFECTIVENESS OF FEDERALLY SUPPORTED RESEARCH

The federal government is a major player in Canada's research and development activities. Of about \$3.5 billion the government spent on R&D in fiscal 1994-95, about one-half (\$1.6 billion) went to federal organizations, most of it (\$1.4 billion) to federal laboratories. The Medical Research Council, the Natural Sciences and Engineering Research Council and the Social Sciences and Humanities Research Council fund \$830 million in university research and training. With constrained budgets and the increased need for R&D to promote sustainable job creation and growth and a high quality of life, it is essential that decisions on federal research and training activities be based on rigorous criteria for effectiveness.

SCIENTIFIC EXCELLENCE

The first requirement for effectiveness is excellence. The scientific, economic and environmental merits of a particular activity are best confirmed through external review, in which an independent assessment is made of the potential, design, performance and impact of the proposed research effort. Many federal research establishments already have such review processes in place.

Each federal research facility and program will establish and follow a rigorous schedule for submitting its proposed research activities to an expert review by clients, stakeholders and peers in order to ensure the scientific, economic and environmental excellence of its research.

RELEVANT LINES OF ENQUIRY

Where it makes sense to do so, the government intends to put its intramural R&D activities to a market test in order to generate research that is relevant and has a high potential for yielding economic or social benefits. Many departments have client-based advisory boards to assess the relevance of their scientific and technological activities. These evaluations provide an excellent litmus test of the likely uses of the proposed research. Typically, these bodies represent the immediate clients of the department, such as an industry sector.

All departments and agencies that have not already done so will establish advisory bodies with external representation and ensure that the composition of these bodies benefits from a broad, multidisciplinary constituency.

FULL VALUE FOR MONEY

At a time of scarce resources, all government spending, including S&T, must meet stringent tests of cost-effectiveness.

The research conducted in federal laboratories should complement rather than duplicate the work carried out by the private sector. The government agrees with NABST that “where it is more appropriate, feasible or cost-effective, federally funded S&T activities should be performed in the private sector or in universities.”

Departments and agencies will regularly and systematically assess whether their performance of S&T might be better carried out by others.

The government recognizes that it has a legitimate role in expanding industry’s capacity to assume and carry out a greater share of Canada’s research effort. The government also acknowledges the importance of balancing the need to foster commercial applications with the need to ensure the continuity and stability of long-term and regulatory research and the best use of tax dollars.

Federal departments and agencies will work toward the objective of strengthening the research and technological capability of Canadian firms when deciding which research activities should be conducted in-house and which should be contracted out.

TRANSFER OF KNOWLEDGE AND TECHNOLOGY

As NABST observed, “Scientists must recognize the links between their research and the key economic interests of the country and be ready to transfer their results to entrepreneurs promptly for effective commercialization.” For their part, entrepreneurs must become more aware of the products and services with commercial potential that are emerging from Canada’s S&T efforts.

Many federal laboratories and research establishments have taken a pro-active approach in encouraging linkages between the producers and users of knowledge. Such linkages not only disseminate new knowledge more widely, but also provide opportunities to transfer technologies that could have significant commercial spinoffs. While technology transfers provide financial returns to federal laboratories, through royalty payments that are then used to support other research, their primary purpose is not to raise revenue. Rather, the principal benefits of such transfers are to the economy at large. They advance knowledge, transform research into exploitable know-how, share expertise, and spread ownership and responsibility for Canada’s S&T effort to all players in the economy. The government supports this direction.

The transfer of knowledge and technology is an explicit objective of federal S&T, and departments and agencies will be closely evaluated on their efforts in meeting it.

CAPTURING THE BENEFITS OF PARTNERSHIP

A major challenge in Canada’s innovation system is not the quality of its research or the ability to generate new ideas but using that knowledge productively. Federal S&T must be effectively connected to other participants in the Canadian innovation system, including industry, provincial and municipal governments, labour and business organizations, and educational institutions.

Collaboration among universities, federal research establishments, other levels of government and private industry creates synergies that increase the effectiveness of our S&T activities by capitalizing on the special strengths and expertise that each partner brings to the effort. Moreover, such partnerships bring S&T resources and activities into Canadian regions and communities and afford new opportunities for local jobs and economic growth. The federal government is committed to using science and technology as tools to advance regional and community economic development in Canada.

For example, the Atlantic Canada Opportunities Agency, with the support of the National Research Council, is leading an initiative to more effectively link research and business interests and opportunities in Atlantic Canada. Backed by and involving all key S&T stakeholders, this initiative aims to better connect the needs and expectations of industry with the capability and focus of university and public sector research in the region.

RESEARCH CONSORTIA, ALLIANCES AND LINKAGES

The pace of technological change, increased competitive pressures and the globalization of markets and technology, combined with the high costs and risks of developing new products and services, have led firms around the world to seek new research partnerships in industry, as

All science-based departments and agencies will develop strategies for promoting partnerships and collaborative S&T arrangements with industry, the provinces, universities and other stakeholders.

well as partnerships with governments, labour and universities.

Today, federal departments and agencies are putting increasing emphasis on partnerships, alliances, networks and other linkages with provinces and territories, industry, labour organizations and universities. The federal government endorses this trend toward a “Team Canada” approach to S&T.

Many government laboratories have established research consortia and other collaborative arrangements involving university researchers and industry. These partnership arrangements not only spread the financial costs and risks associated with the research effort, they often amplify the federal government’s investment and assist in increasing the overall level of research spending in Canada.

Partnerships also serve as a technology bridge for users. They increase the skills and knowledge of workers and enhance the innovative capacity of Canadian industry, particularly among small and medium-sized businesses.

Federal departments and agencies will develop strategies for increasing inter-departmental collaboration to combine resources and eliminate duplication.

Federal departments and agencies will develop explicit strategies to integrate the social sciences in their S&T activities. Departments will work with the Social Sciences and Humanities Research Council to identify research areas in the social sciences that will better inform policy development in priority areas.

There must also be a shift away from single-issue approaches to lines of enquiry that cut across disciplines. Greater interdepartmental collaboration will help the government develop a team approach as well as eliminate overlap and duplication and achieve better results at lower cost. Efficiencies achieved in this way free up valuable funds for scientific research projects that might not otherwise be undertaken.

Social science research, too, must be solidly integrated within and across the federal S&T enterprise. The social sciences offer an array of methodologies, longitudinal data series and technical analyses that span many fields. These are vital to the design, delivery and evaluation of many complex policy areas, such as health, human resource development, immigration, economics and culture.

AN OPEN-DOOR POLICY IN FEDERAL RESEARCH FACILITIES

The federal government has a major investment in S&T facilities. Frequently they are of a scope or scale that cannot be matched by any other single organization. These facilities are a national asset that should be made more accessible to

Federal departments and agencies will take measures to improve access to their facilities and encourage an open-door approach to others engaged in scientific research.

practitioners in industry, to students, to university researchers and to the broader community.

As an example of a recently opened door, the federal government has deposited a directory of federal capabilities and assets on the Internet World Wide Web (<http://www.cisti.nrc.ca/programs/indcan/ctg.html>) to encourage dissemination of their S&T activities and R&D collaboration among sectors. Demand for this information runs high, with several thousand accesses every week, largely from universities and businesses.

A major benefit of opening up the labs to a broader set of S&T performers and users is that it expands their capabilities. It also helps diffuse new technologies and gives industry a much better understanding of the research activities in federal facilities. Moreover, it offers federal laboratories opportunities to generate revenue through cost recovery and fee-for-service arrangements. These revenues can cover the incremental costs of performing the service and fund additional research.

EMPHASIZING PREVENTIVE APPROACHES AND SUSTAINABLE DEVELOPMENT

PREVENTIVE APPROACHES

There has been a growing recognition that the best and usually less expensive policy is to prevent problems from occurring. This has led

to an emphasis on fostering healthy lifestyles and improved nutrition. In the environmental field, it is better to work to prevent environmental degradation from occurring than to clean up its effects.

Our S&T priorities should therefore shift from reacting and problem-solving to anticipating opportunities and issues, assessing risk and bringing together the multidisciplinary resources required. These resources include not only the hard sciences but also the insights provided by the health and environmental sciences as well as the social sciences and humanities. There is a central place for S&T in developing innovative means to make all Canadians aware of preventive approaches and to make them partners in taking up these approaches.

Historically, all countries have looked to science to help solve problems — usually only after they have arisen. Marshalling scientific resources in search of a cure for a problem that might have been prevented is short-sighted and costly, in dollars and, more important, in the irreversible damage that may have been caused. We cannot afford to spend money solving problems we can prevent.

For example, health care is only one of many inputs to health. Social and physical environments, human biology and genetic endowment, economic status and individual behaviour are also key determinants of health. The evidence to understand where good health comes from is necessary to guide investment decisions and target areas for action.

Health Canada is closing research gaps that are critical to managing environmental impacts on health. It is developing test protocols for assessing the infectivity and toxicity of, and exposure to, new biotechnology products. The department is also assessing the potential health effects of new substances and the health risks faced by residents of the Great Lakes basin.

Federal departments and agencies will specifically incorporate foresight, risk assessment and prevention practices in their S&T activities to improve their ability to anticipate and address issues before they become problems.

As well, Health Canada and the Medical Research Council are addressing the critical issue of health determinants.

Prevention requires a concerted effort, however, since in some ways it goes against our customs and institutional practices. We must make Canada's S&T activities more forward-looking — in the products we develop, the processes and inputs used in production, our approaches to health care and the delivery of social services.

All departments and agencies face the need for more cost-effective approaches to developing and delivering programs and services. Advanced information technologies offer new ways of collecting and using information to provide more accessible, effective and efficient service to Canadians. At the same time, they offer the possibility of reducing operating costs, and of improving

Federal departments and agencies will make greater use of new technologies to improve the design and delivery of their programs and services to Canadians.

our ability to anticipate social and economic trends and thus respond to individual and community needs.

Departments are applying S&T to improve their research, analysis and service capacities. Human Resources Development Canada (HRDC), for example, is applying information and communications technology to respond to the direct needs of a wide variety of publics. Computer kiosks, which provide a single self-service window to HRDC services, are an example. The Information Highway will allow HRDC to move to a virtual window where people can access information and services from their homes. The department is using advanced computing technology to improve the predictive powers of its interventions for specific clients, elevating the quality of support and the success rate in improving their employability.

SUSTAINABLE DEVELOPMENT THROUGH INNOVATION

Sustainable development was defined by the World Commission on Environment and Development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” In essence, the commission stressed that our long-term economic well-being is inextricably linked to the environmental health of the planet; economic growth is dependent on environmental renewal. This reversed earlier assumptions that economic development and environmental quality were competing or even opposing goals.

Over the past decade, Canada has been one of an increasing number of countries that have accepted sustainable development as a wise public investment. This implies a number of far-reaching changes in the way we organize and manage. Sustainable development also requires

a cooperative approach by all sectors of society, which can be achieved only if Canadians have access to information and tools that will allow them to make responsible economic, environmental and social decisions.

Steps are being taken to integrate the sustainable development approach into the mandate of all federal departments and agencies. The establishment of the Office of the Commissioner for the Environment and Sustainable Development is an important step. All federal departments and agencies will be preparing Sustainable Development Strategies, including plans for the greening of their operations and policies, which will form the basis for the Commissioner to report annually to Parliament. A government-wide Sustainable Development Framework has been developed to guide the establishment of these strategies in all departments and agencies. This will provide an opportunity for departments to describe how they plan to use S&T to contribute to sustainable development.

In addition, the four natural resources departments (Agriculture and Agri-food Canada, Environment Canada, Fisheries and Oceans, and Natural Resources Canada) are jointly implementing a framework for sustainable development S&T in the natural resources sector by increasing cooperation and by working together on specific projects.

Science and technology are key to achieving sustainable development. Protecting and conserving the environment, while expanding economic prosperity and generating the jobs of the future, will require increased innovation in all sectors of society. In the industrial sector, innovative means are needed, not only to reduce the use of raw materials and energy, create less waste and promote secondary use, but also to

develop and use new materials that are more efficient and effective than the materials they replace.

The World Business Council on Sustainable Development, a group of some of the world's foremost chief executive officers, has taken a leading role in promoting the concept of eco-efficiency. The council believes that, during the next generation, businesses that have prepared for revolutionary reductions in resource use, pollution and human encroachment on ecosystems will thrive on rapidly growing demand for eco-efficient products and services. Industries participating in such an effort could reap large gains in productivity and profits, and require a highly skilled work force. They would also contribute to conserving the environment and reducing costly downstream clean-ups.

In the natural resources sector, the focus on eco-efficiency will be of increasing importance for Canadians. In a country that is one of the world's largest exporters of raw and semi-processed natural resource products, Canadian companies will face a major challenge to develop technologies that enhance competitiveness and, at the same time, contribute fully to the goal of sustainable development. Increasing S&T investment in natural resources management, conservation, recycling and alternative products will be required. The viability of communities that harvest or deplete resources will also have to be considered as part of an integrated ecosystem approach to resource management and decision making. New technologies for the restoration of degraded areas, particularly contaminated lands, wildlife habitats and harbor sediments, will also find ready markets in Canada and internationally.

The social sciences and humanities have a crucial role to play in providing models of social innovation that will enable society to adapt to living within ecological limits. The health sciences can offer greater understanding of the interplay between the health of the environment and human well-being. Science and technology must also be used to increase our understanding of how ecosystems work, as the basis for setting goals and making the right policy decisions. Hence we will need investments in innovative S&T to improve our ability to observe and understand ecosystems and to forecast trends.

The concerted development, application and commercialization of these sciences and technologies will help Canadians in the sustainable development of their economy, and prepare us to realize our potential in the rapidly developing international environmental sector.

The federal government will seek the advice of the National Round Table on the Environment and the Economy in establishing specific targets to help industries and other sectors become significantly more eco-efficient within a generation, and in understanding the implications of those targets for the development of new technologies.

POSITIONING CANADA COMPETITIVELY WITHIN EMERGING INTERNATIONAL REGULATORY, STANDARDS AND INTELLECTUAL PROPERTY REGIMES

In today's global economy, regulatory frameworks for health and safety, standards for product performance and compatibility, and intellectual property rights can create either barriers or inducements to innovation. Federal framework policies play a key role here.

MODERNIZED REGULATION

A country's regulatory regime plays an increasingly significant role in shaping its competitive advantage and economic performance. Regulations help to ensure competitive markets, public health and safety and a clean environment. But they need to be developed and implemented judiciously. Well-developed regulations can stimulate innovation and enhance the competitiveness of Canadian industry. Obsolete or badly designed regulations increase costs, reduce access to markets, and impede development of innovative products and services and their entry into world markets.

The federal government is making strides in modernizing Canada's regulatory regime by reforming legislation, streamlining regulations, simplifying procedures, ensuring that regulations are based on sound science, adopting international standards, and increasingly using alternatives to regulation that achieve the same goals.

Federal departments and agencies will aggressively seek opportunities to improve the regulatory systems in which their clients operate in order to reduce regulatory burden and enforcement costs without compromising standards of quality, public safety and sustainable development.

TRADE AND TECHNOLOGY ARRANGEMENTS AND INTERNATIONAL STANDARDS SETTING

Canada is a trading nation and an advanced open economy. We export 30 percent of what we produce; our prosperity is directly linked to our ability to sell Canadian goods and services in markets around the world. Canadians have done well through trade liberalization agreements such as the General Agreement on Tariffs and Trade, its successor the World Trade Organization, and the North American Free Trade Agreement, and in bilateral arrangements with international partners.

The policy framework for international economic relations today has shifted from trade issues as such to a broader agenda that includes investment and technology flows, intellectual property rights and international standards. Unless we take a stance on these issues, we will impair our economic performance.

Standards play a significant role in the global acceptance of an emerging technology. Increasingly, standards are negotiated internationally by governments and industry working together through international standards-setting bodies. This approach provides greater certainty for firms and reduces the ability of national governments to use their own domestic standards as barriers to technology and trade flow.

Because Canada imports most of its technology and because our exports must meet international standards, we need to be at the forefront in the development and setting of international standards. Canada's participation in international forums allows us to influence international standards and gives Canadian firms a jump start in developing products. As well, involvement in international standards setting provides an excellent source of technical and market intelligence, which we have not yet tapped systematically.

Federal departments and agencies will work with their clients and with a refocused Standards Council of Canada to increase participation in the development and setting of international standards. They will also develop plans for the systematic dissemination of information on new and emerging international standards and other innovation policy issues.

BALANCING INTELLECTUAL PROPERTY RIGHTS AND TECHNOLOGY DIFFUSION

Government laboratories around the world are expanding their interaction with outside laboratories, especially those in the private sector. Government laboratories recognize that they have a major role in improving the technological and innovative capacity of the wealth-and-jobs-producing sector of the economy. As well, there is a growing understanding that, in certain cases, the continuing viability of government labs depends on their working successfully with the private sector and transferring knowledge and technology to it.

Federal government policy now encourages the transfer of intellectual property from federally supported research to the private sector. But these policies need to be communicated better, applied more evenly and assessed regularly for their effectiveness. Only then can firms benefit fully from the commercial opportunities associated with federally developed technology, and make the investments needed to move them rapidly from the laboratory to the marketplace.

The federal government will start immediately to review its intellectual property policy in order to determine what improvements can be made to increase opportunities for commercialization and partnerships with the private sector.

Intellectual property is a complex policy area, and a number of issues remain to be resolved. These include the decision process for granting access to federally developed intellectual property, and the economic impacts when the government retains, sells or gives intellectual property to a firm.

BUILDING INFORMATION NETWORKS: THE INFRASTRUCTURE OF THE KNOWLEDGE ECONOMY

Information drives the knowledge economy. The ability to generate high-quality, timely information and to make it available to potential users for commercial exploitation in Canada is essential to knowledge-based economic growth. The pace of technological change and the relentless rate at which new technologies and products are brought to market is a major challenge for the research community, private industry, workers and consumers.

Meeting this challenge requires an infrastructure that provides the right information at the right time to those who need it: schools, universities, communities, libraries, researchers and industry.

SHARING DATA AND ANALYSES

Government departments, agencies and research institutions are a rich storehouse of data, analyses, and industrial, technological and social intelligence. They have been less successful as clearing houses of information for potential users.

The transfer of knowledge and the sharing of scientific information and data with Canadian researchers, schools, universities, libraries and industry will be a key function of all federal departments and agencies.

COLLABORATING IN INFRASTRUCTURE DEVELOPMENT

A modern information network is the essential infrastructure of the knowledge economy. Together with innovative institutional arrangements, networks allow us to achieve synergy and cohesion in our S&T effort by bringing together the strengths and expertise of university researchers, government laboratories and private industry.

The Information Highway — the network of telephone and cable TV infrastructures and communications satellites — is already stimulating R&D in leading-edge technologies and in the diffusion of new technologies and information-based services. It also shows great promise in providing cost-effective access to high-quality health care, skills upgrading, training and social services.

Transforming today's networks into a fully integrated system, which allows Canadians to interact using audio, video and multimedia services, is a major challenge. This process offers tremendous potential for creating employment and new industries as well as for opening fresh opportunities for Canadians living in rural or remote regions and for people with disabilities. Canada is a world leader in communications

technology. We must continue to capitalize on our competitive edge by seizing the opportunities offered by the Information Highway.

The federal government has taken a leadership role in all aspects of Information Highway development. It is examining such issues as ownership and control, the appropriate balance between competition and regulation, coordination with other levels of government, intellectual property, and support for Canadian cultural content and services.

Constructing the Information Highway began as a collaborative project and it remains one. The federal government will continue to work in partnership with communities, provinces, territories and the private sector to accelerate the development of the Information Highway through strategic investments and a pro-competitive telecommunications policy.

Already Canada is at the forefront in establishing important elements of the global information society. Along with partners in the other G-7 nations, the federal government is developing networks to help manage international emergencies, deal with major maritime issues and promote joint R&D.

Federal departments and agencies will develop information services for dissemination via the Information Highway aimed at encouraging innovation, particularly at the community level.

EXTENDING SCIENCE AND TECHNOLOGY LINKAGES INTERNATIONALLY

Today, technology and investment drive trade in the world marketplace. The market for new technologies is global. Each day hundreds of billions of dollars in capital move across national borders. Production decisions are increasingly made on a worldwide basis. A more strategic approach is required to link international technology and investment opportunities to Canadian needs.

INTERNATIONAL ALLIANCES AND TECHNOLOGY PARTNERSHIPS

Canada is but one of many players in the world's science and technology effort. Only a small fraction of scientific knowledge and new technologies — less than 5 percent — is developed here. On the other hand, Canadians need access to the entire world stock of technologies, market information and state-of-the-art research, and they need to be able to engage in alliances with international partners and gain from them. Moreover, given the global scope of such diverse policy issues as health, environment, fisheries management and space research, Canada needs to take part in international scientific efforts and alliances.

For the most part, such alliances are made through business channels and academic communities. Government can also promote and facilitate them, however, especially for small and medium-sized businesses, through match-making services, technology awareness activities and S&T intelligence. Indeed, the federal government has an active international S&T intelligence system, including the network of technology development officers and S&T counsellors stationed at foreign posts, and the professional

ties federal scientists and engineers enjoy with their colleagues in other countries.

In many areas affecting our quality of life, such as the environment, health and the advancement of knowledge, the scale and scope of the S&T effort increasingly require international collaboration among researchers, institutions and governments.

International R&D partnerships provide benefits that extend well beyond commercial or other advantages specific to the partners because the technology is quickly diffused to others, including firms and workers in the same industry. Their longer-term effect is to increase the technological capability of industry as a whole.

To this point, the role played by many federal departments and agencies in promoting international S&T alliances has been largely reactive — responding to specific requests. It is time we took a more open, active and coordinated stance in helping to build partnerships that will bring the world's best technologies, research and development to Canadian firms and communities.

As an extension of their domestic mandates, federal departments and agencies will develop explicit plans to promote international S&T collaboration for the benefit of Canadian firms.

As well, they will develop specific approaches for gathering and disseminating international S&T intelligence.

Our missions abroad will have a key role in this enterprise.

PROMOTING A STRONGER SCIENCE CULTURE

Fostering a strong science culture is everyone's business. It cannot be legislated by governments. It is the sum of all the actions, big and small, of all players in the economy. Science culture is both a mind set and a skill set. It is nurtured by attitudes that encourage curiosity, and value discovery, and are open to challenge and change. Having a strong science culture means having a pervasive appreciation of the relevance and uses of science and technology. A strong science culture must be the foundation for building a Canadian innovation system for the 21st century.

Young Canadians in particular need to understand and see the benefits of learning science and engineering, and the benefits of innovation and entrepreneurship for their future careers and adult lives. Science culture develops as young Canadians realize that science and technology are critical to many of the jobs of the future. Most governments in Canada have established programs and initiatives, directed mainly at young people and their teachers, to promote a stronger science culture. The partnership between the federal granting councils and universities for maintaining a national research platform helps ensure that students are immersed in a science culture throughout their university education. In addition, the federal government's training and re-employment programs support the use and development of new technologies to provide more accessible and flexible learning opportunities for Canadians.

In the last few years, the private sector has also become more involved, recognizing the competitive advantages bestowed by a skilled, numerate and productive work force. Today, many Canadian firms sponsor university scholarships and summer employment programs in science and engineering, provide computers in high schools and volunteer their services for career guidance. We need more firms to become

engaged in this effort as good corporate citizens with an important stake in their communities.

Equally, greater linkages between school and work are required as one means of instilling S&T into learning institutions.

Despite the apparent success of public and private programs in fostering a science culture, too many Canadians continue to view science as esoteric, difficult, intimidating and confined to a laboratory. We have some distance to go before science and technology become mainstream activities.

The widespread diffusion of information technology offers a major opportunity to bring science squarely into the lives of Canadians. A prime example is the SchoolNet Program, now linking Canada's public schools, libraries, colleges and universities to the Internet. SchoolNet is already influencing Canada's science culture. Services are being developed to attract students and educators onto the Internet and the new world of information available there. Already the Electronic Innovators program brings scientists, engineers and professionals from around the globe into contact with students and teachers in the classroom. Students can ask a question on S&T through a SchoolNet news group and get an expert response.

SchoolNet is dissolving classroom boundaries and opening up an unparalleled array of learning opportunities and world-class knowledge to children and adults alike.

Making full use of the Information Highway, departments and agencies will develop action plans to reach out to the community, including young people in schools, universities and colleges.

7. Moving Ahead

Canadians challenged the federal government with a wealth of advice during the Science and Technology Review. The government in turn has set many challenges for itself and is committed to seeing them through.

This document outlines a realistic, pragmatic and achievable plan for the federal government's contribution to reaching our long-term goals for S&T:

- applying and commercializing S&T for sustainable jobs and economic growth;
- applying S&T to improve the quality of life through effective social, environmental and health care programs; and
- achieving excellence in scientific discovery while building a broad base of scientific enquiry so that new technology can be acquired and disseminated widely.

The plan is *realistic* because it is framed within our current fiscal realities. It recognizes that we must set priorities within our S&T enterprise and that we must work more proficiently in partnership with business, academic institutions and other governments.

The plan is *pragmatic* because it sets out a series of concrete measures to improve the governance of federal S&T and to provide clear direction on the day-to-day management of S&T activities across the government. This is the first time the government has articulated in detail its expectations on the management of the multi-billion-dollar S&T investment. There are already many best practices on which to draw, but there is still much to do.

The plan is *achievable* because it emphasizes transparency and public accountability. The best way to make sure our commitments are met is to provide for a high level of parliamentary and public scrutiny. The measures outlined in this document do just that. They also provide opportunity for dialogue with all interested parties so that the government can constantly improve its contribution to the national S&T effort.

The individual reports of the key S&T departments and agencies demonstrate the plan in action. They will be regularly reviewed and renewed, drawing on the excellent proposals made during the S&T Review.

This paper is an important milestone, showing the government's commitment to do its part by deploying its S&T investment wisely. In the months ahead, the federal government will work with the provinces and territories, the private sector, universities, the research community, not-for-profit organizations and others toward developing a full national S&T strategy for the Canadian innovation system. Our ultimate success depends on the dedicated collaboration of Canadians. It is only through a genuine partnership among all players in the economy that Canada's overall S&T effort will overcome our domestic and global challenges, and maintain our place as the world's best country in which to live in the new century.

Annex: Listening to Canadians

During the S&T Review, more than 3000 Canadians made their views known to the government through written briefs and letters, Internet discussion groups and a series of local, regional and national meetings. They were generous with their time and in sharing their ideas. Canadians from the science and engineering community, industry and environmental organizations; researchers from the private and public sectors; and educators participated in the review. Thirty-one communities across Canada held workshops and conferences on science and technology. And more than 300 letters and briefs were received.

Within the federal government, managers of research and development and officials responsible for S&T policy worked together to conduct an internal review of federal S&T. Their studies, which also are available upon request, offer many useful suggestions for both government and the private sector.

The Prime Minister asked the National Advisory Board on Science and Technology to provide him with independent advice on the direction and nature of a federal S&T strategy. Its report, *Healthy, Wealthy and Wise*, is a thought-provoking assessment of an integrated approach to the federal S&T effort.

The S&T Review has also benefited from other constructive inputs, such as the work of the Information Highway Advisory Council; the Small Business Working Committee report *Breaking Through Barriers*; and the 1994 report of the Auditor General of Canada, which examined the overall management of federal science and technology.

The S&T Review was rich in ideas. It gave the government valuable insights on the views of Canadians and revealed the depth of their excitement with and concern for science and technology. Many of their suggestions are

addressed in this statement. Others are reflected in the specific program and policy initiatives that the science-based departments and agencies report upon in their individual action plans.

The main messages to the government in the S&T Review were:

Focus the federal S&T investment

- Maintain an S&T portfolio that includes the core competencies necessary to achieve the objectives of wealth creation, quality of life and advancement of knowledge.
- Build the federal science and technology strategy on Canada's strengths, particularly our natural resources, and on the unique combinations of national strengths in each region and community.
- Stress sustainable development in the natural resources sector.
- Strengthen policy frameworks to ensure a climate conducive to innovation in Canada.
- Advance knowledge and train highly qualified people by promoting research excellence in Canada's industries, commercial laboratories and universities.
- Complement, don't compete with, industrial and academic research.

Anticipate and adopt the right policies and regulations

- Make sound science the basis for regulations.
- Reduce regulatory burden and foster wealth creation by rewarding risk-taking, innovation and export development, while safeguarding the health, safety, security and environment of Canadians.
- Continuously build on those programs and policies that are effective and swiftly end those that are not.

Increase partnerships and collaboration

- Develop effective partnerships among industry, universities and government.
- Optimize federal investments in research and product development through new approaches to risk sharing, alliances and collaboration to maximize the strategic use of R&D in the economy.
- Encourage multidisciplinary research and reinforce the role of the social sciences in Canada's innovation system.

Capture the full benefits of new technologies

- Provide effective and cost-efficient access to technical knowledge generated in Canada and throughout the world.
- Accelerate the effective transfer of technologies developed in federal facilities to the private sector for commercial exploitation.
- Improve Canada's innovative capacity by linking Canadians to domestic and international networks and hastening construction of the Information Highway.

Promote a stronger science culture

- Make young Canadians more aware of the social, economic and environmental benefits of S&T in their lives.
- Enhance linkages between school and work to inject an S&T culture into learning institutions.
- Encourage all Canadians to help foster a strong science culture.

Manage for results

- Establish a central system of governance for federal S&T.
- Develop performance indicators for measuring S&T outcomes.
- Set performance criteria for all federal S&T programs.
- Regularly measure the impact of federal S&T programs to guide the setting of priorities.
- Increase public accountability.
- Make federal research more cost-effective by anticipating risk, focusing on prevention and emphasizing sustainable development.
- Improve the effectiveness of federal scientific and engineering personnel by emphasizing entrepreneurship, career mobility and reward systems.

Not all of the advice can be followed immediately. Some good ideas will take time to implement. In other instances, the government believes that it can achieve its objectives through different means. And in some cases, the wisdom received must also be taken up and acted on by other participants in Canada's innovation system. But one thing is certain: the S&T Review will guide federal policy and shape government's decisions in science and technology into the 21st century.

Publications

The following publications related to the federal Science and Technology Review are also available:

- *Building a Federal Science and Technology Strategy*
- *Resource Book for Science and Technology Consultations: Volume I*
- *Resource Book for Science and Technology Consultations: Volume II*
- *Summary Report of the Interdepartmental Task Force on Science and Technology Review*
plus four sub-task force reports:
Advancement of Knowledge
Quality of Life and Risk Management
Sustainable Wealth and Job Creation
Science and Technology Statistics
- *Healthy, Wealthy and Wise: A Framework for an Integrated Federal Science and Technology Strategy*

These reports may be obtained from:

Distribution Services
Industry Canada
Room 205D, West Tower
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