

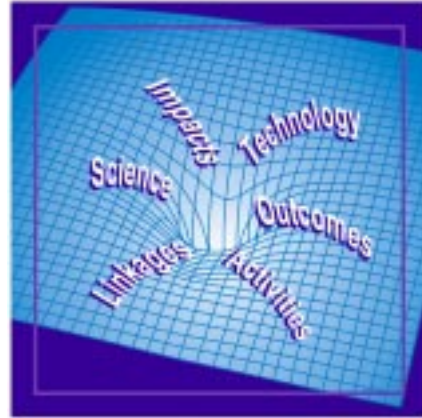


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A Five-Year Strategic Plan

For the Development of an Information System for Science and Technology

1998



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Statistics Canada
Science and Technology Redesign Project

A Five-Year Strategic Plan

For the Development of an Information
System for Science and Technology

1998

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Note of appreciation

Canada owes the success of its statistical system to a long-standing partnership between Statistics Canada, the citizens of Canada, its businesses, governments and other institutions. Accurate and timely statistical information could not be produced without their continued co-operation and goodwill.

Foreword

A Strategic Plan for the Development of an Information System for Science and Technology

The Science and Technology Project of Statistics Canada, launched some three years ago with significant financial contributions from Industry Canada, has as its goal the provision of statistical information and insights about the status, evolution and socio-economic impacts of science and technology in Canada. This is clearly an ambitious objective which perhaps will never be achieved fully, but which we hope to approximate over the years to come.

The project was conceived from the beginning with the intention of evolving gradually a *coherent* body of information - not an easy task in a field as broad and complex as science and technology. An early priority was, therefore, the development of understanding of just what the statistical study of science and technology should ideally encompass, who are the main *actors*, what *activities* should be considered in-scope, what *linkages* should be explored, what *outcomes* should be measured, and finally what *impacts* should be analyzed. This challenging conceptual work was successfully carried out, with the intimate involvement of Statistics Canada's Advisory Committee on Science and Technology. It is described in the document "Science and Technology Activities and Impacts: A Framework for a Statistical System" and is published in the same series as this Strategic Plan.

This current Strategic Plan, in effect, represents Statistics Canada's concrete proposals for the next several years, designed to move us much closer to the concepts and vision outlined in the Framework. We hope that it will be widely discussed by key users and potential users of the proposed information. Their perspectives and needs will, undoubtedly, result in some modifications of this plan, particularly in its outer years.

In addition to the conceptual and planning work, which culminated in this *Strategic Plan* and the earlier *Framework*, the project has also been engaged in producing new statistical information. It successfully developed or improved surveys of Research and Development, of innovation, of the commercialization of intellectual property in universities, and of technology use. These surveys have established the feasibility of much of what is proposed here. Additional insights were gained through the analytic exploitation of these and related data sources.

I am looking forward to Statistics Canada moving forward, together with the help and support of our partners and clients, in using this Strategic Plan as a guide for the future development of the Project. I also hope that the evolving project will make a major contribution to our understanding of the set of complex and profound issues that are encompassed in Science and Technology - broadly interpreted.



Ivan P. Fellegi
Chief Statistician of Canada

Table of Contents

1.	Introduction	7
	Purpose	7
	Background for the Strategic Plan	8
	Motivation	9
	Why Statistics Canada	10
	Outline of What Follows	10
2.	Statistical Infrastructure	10
3.	Establishing Networks of Users, Respondents and Advisors	13
4.	Communication and Dissemination	13
5.	Organization and Management	15
6.	Financial Resources	16
7.	Priorities	19
8.	Planned Activities and Outputs	20
	Building Capacity	20
	Data Development	24
	Analytical Projects and Outputs	25
9.	Conclusions	26
Appendices		
	Appendix I: Outputs of the Information System for Science and Technology	27
	Appendix II: Members of the Advisory Committee on Science and Technology Statistics	32

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The staff of Statistics Canada's Science and Technology Redesign Project would like to thank Dr. Martin Wilk and Mr. Jacob Ryten for their substantial and exceptional contribution to the drafting of this document. Their help is very much appreciated.

1. Introduction

Purpose

This Project is intended to provide statistical information on the status, evolution and socio-economic impacts of science and technology (S&T) in Canada.

While earlier efforts of Statistics Canada in the area of S&T answered basic factual concerns such as “How much was spent on research and development (R&D)?” or “What was the geographic distribution of government research grants in Canada?” the current strategic plan is formulated so as to develop a broader capacity, to help answer questions such as:

- Do R&D cooperation arrangements (e.g. consortia) improve competitiveness or productivity of participating firms?
- What is the net contribution of commercial innovation to creation of good jobs in the innovating industry?
- What is the cost balance of environmental regulation compliance in relation to the economic benefits of associated innovations?
- What are the socio-economic impacts of the extension of wireless communication?
- How does foreign direct investment affect technology transfer?

And a host of others, many of which cannot be anticipated.

Some S&T statistical information is currently available, such as:

- Patent data
- Source of funds for R&D
- Expenditures and personnel for R&D, by industry sector and region
- Innovation data for some industries
- Use and planned use of some technologies (e.g. biotechnology)

Other data can be relatively easily developed, such as:

- Comparative characteristics of firms that engage in R&D, invent, innovate or use advanced technologies, in relation to those that do not.
- Distribution of federal grants by industry, in number and value.
- Distribution of personnel, with advanced education and social or physical sciences specialization, by industry sector.

However, to address concerns about the socio-economic effects of S&T requires major increased capacity, both of data collection and analytical capability.

Background for the Strategic Plan

The present document is an operationally-oriented companion to the Statistics Canada report "Science and Technology Activities and Impacts: A Framework for a Statistical Information System."¹ As outlined in that report, the S&T system comprises a set of Actors engaged in Activities, the Linkages among those, and their Outcomes, leading to Impacts on the socio-economy. Conceptually, we are concerned with the evolution of, and interactions among, the generation, transmission and applications of S&T knowledge.

Actors: Persons or institutions engaged in S&T activities.

Activities: The creation, transmission, or use of S&T knowledge, or of a combination of these. R&D, invention, innovation, use and planned use of technologies, related training and development are examples of activities.

Linkages: The means by which S&T knowledge is transferred among actors. Measures include the flow of graduates to industries, the licensing of intellectual property from government or universities for use in industry, co-authorship analysis, and the identification of the sources of ideas and technologies in surveys of activities.

Outcomes: Medium term consequences of activities. An outcome of an innovation may be more high-skilled jobs in the innovating firm. An outcome of the adoption of a new technology may be greater market share for the adopting firm.

Impacts: Longer term consequences of activities, linkages and outcomes. Wireless telephony is the result of various activities, linkages and outcomes, and it has wide ranging economic and social impact.

The present Project is a product of three factors:

- the earlier S&T statistics program at Statistics Canada²
- a proposal by a Working Group of Statistics Canada's S&T Advisory Committee³

¹ Statistics Canada (1998), *Science and Technology Activities and Impacts: A Framework for a Statistical Information System*, Statistics Canada, Science and Technology Redesign Project, Ottawa.

² The earlier activities of Statistics Canada in this field were useful. But their analytical impact was limited because the information obtained was restricted to ascertaining what were the basic inputs into the knowledge generating process.

³ Industry Canada (1996), *An Information System for S&T*, Federal Science and Technology Review, Working Group on the Development of Science and Technology Statistics, Final Report, Industry Canada, Ottawa.

- initial funding by the Minister of Industry in connection with the 1994-1996 federal S&T Review⁴

Since its initiation in 1996, the Project has:

- added expert staff
- developed several user communities
- established extended contacts with expert advisors
- produced a conceptual Framework for the Project
- carried out a number of information gathering surveys (e.g. 1996 Survey of Use and Planned Use of Biotechnologies)
- held several workshops (e.g. Workshop on Regional Innovation in March 1997, and Workshops on outputs of the Project in February and March 1998)
- produced a number of published reports (e.g. A Dynamic Analysis of the Flows of Canadian Science and Technology Graduates into the Labour Market)
- provided information, on request, to a number of users

A full list of current products and activities is given in Appendix I.

Motivation

S&T is a dominating influence in human civilization. It plays a major role not only in economic matters, but also in quality of life, and of course in the advancement of knowledge. It is clearly in the public interest to develop systematic, objective and reliable public information concerning S&T. The fact that the S&T system is extremely complex, and may be very difficult to control or influence, makes the data development requirement even more critical.

Government concerns interact with the S&T system at a number of key junctures. They range from health care policies and clinical practices, to taxation subsidies for R&D, to education programs and to environmental protection legislation. And yet it is widely recognized that many of the measures and subsequent decisions are taken without adequate quantitative evidence to support decisions. Not only is there a need to have evidence of the efficient use of S&T resources but public information is also required on the desirable and undesirable consequences of S&T developments - on employment and unemployment, on wealth generation and on wealth distribution, on family convenience and on family coherence, on national security and on international hazards, etc.

⁴ Industry Canada (1996), *Science and Technology for the New Century: A Federal Strategy*, Federal Science and Technology Review, Industry Canada, Ottawa.

Why Statistics Canada

The present Project represents a major change in Statistics Canada's S&T program: an extension of past responsibilities not only in resources but in the scope of inquiry - an initiative to meet critical demands for information in support of S&T policy and program decision-making.

The advantages of siting this undertaking in Statistics Canada are persuasive:

- Statistics Canada is legislatively empowered to gather information and is equipped with staff and structure to carry out information-gathering operations of the scope and with the reliability that the S&T challenge requires.
- Under the Statistics Act, Statistics Canada has full access to administrative data - including tax data - which not only lessens the cost of burdensome measurements but also significantly reduces response burden.
- Statistics Canada has public credibility, developed over decades, in regard to its professionalism, integrity, arms length objectivity and absolute respect for confidentiality.
- Statistics Canada possesses extensive data bases from other programs which are invaluable in the analysis and interpretation of S&T data.
- Statistics Canada has the facilities to respond to short-term S&T policy information requests, while also having a long-term perspective in establishing capabilities to meet long-run data requirements.
- Statistics Canada has well-established international connections to ensure consistency of concepts, definitions, methods, etc.

While the fruitful development of this Project will require intimate interactions and co-operation with many S&T institutions and actors, there is no viable alternative to Statistics Canada taking central responsibility-supported by broadly based advice and guidance - for this important project.

Outline of What Follows

The remainder of this paper presents plans over a five year horizon for building the S&T information development capacity of Statistics Canada - including statistical infrastructure and staff, networks of users and advisors, communication, organization, budget, priorities and anticipated outputs.

2. Statistical Infrastructure

The foundation for Statistics Canada capacities is its professional and operational infrastructure. The infrastructure is made up of several basic elements:

- Institutional attributes which include a culture and reputation for integrity, objectivity, impartiality and respect for confidentiality;
- Professional attributes include capacity to define, design, survey, compile and disseminate publicly relevant information;
- An unequalled accumulation of sound and retrievable information on; for example:
 - Households, their structure and location;
 - Businesses, their structure, tax liability, location, size and nature of productive activity;
 - Non-profit organizations, their objectives, structure and location;
 - Descriptions of the ways in which the government of Canada in its three levels is organized and interacts with the economy and with Canadian society.
- Operational capabilities and legitimacy to carry out record linkages across data bases, with full assurance of confidentiality.

The S&T Project will, of course, utilize these basic capacities, with appropriate payment of associated costs.

Notwithstanding these capacities and Statistics Canada's previous experience with S&T statistics, the expanded S&T project requires additional new and specialized capabilities. These include:

- staff and/or consultants with S&T expertise to advise on the cognitive aspects of survey questionnaires;
- profiles of the institutions, and a register of the appropriate persons, from whom to gather specialized data on S&T;
- expertise in managing "focus groups" for S&T exploratory studies;
- expertise in conducting S&T - relevant case studies for exploratory probes;
- expertise to analyze complex S&T and related data: to identify, as possible, direct; outcomes of S&T activities; to assess the indirect impacts of S&T on the socio-economy; and to provide an analytical context for illuminating general and specific policy and decision issues.

Developing these incremental infrastructure requirements will involve a mixture of strategies:

- work to augment the existing capability to "profile" complex businesses, research, teaching and government institutions
- setting up additional training programs for staff with a focus on S&T
- contractual arrangements with outside expert consultants for data gathering issues
- establishing and maintaining a network of advisors

- recruiting persons with strong analytical talents
- establishing fellowships and consulting mechanisms to carry out mission-oriented integrated analyses.

Attaining the objectives of the Project requires recognition of a key distinction between the gathering of observed data (e.g. expenditures on research, enrolments in institutions of higher learning, number of degrees awarded, etc.) and inferring connections (e.g. between the application of new technologies and an increase in market share). For the latter there is no option but to acquire strong analytical capabilities).

Specifically, the management of the Project intends to work on the following fronts:

- increase the analytical capacity to extract more information out of existing data, particularly data that have not yet been systematically related to each other;
- prepare additions to existing surveys and other data gathering activities with the help of advisors, focus groups, workshops, and case studies;
- add to its survey taking capacity so as to be able to respond effectively to on-going demands for information;
- strengthen existing ties to counterpart institutions, at home and abroad, engaged in the collection and analysis of S&T data as well as those concerned with standards for such activities.

The data collection capacity will be organized so as to respond to two kinds of information needs:

- regular requirements on the matters which may change sufficiently often to warrant annual or shorter term observation (for example, innovative processes deployed in a particular sector of the economy; advanced technologies installed in replacement of less efficient processes etc.)
- *ad hoc* requirements that demand prompt response. This is a capability that Statistics Canada has developed - e.g. its two surveys on the preparedness of Canadian industry to confront the "millennium bug".

The development of these capacities, over time, will, of course, be heavily influenced by the timing of emerging user demands, by the practicalities of recruitment and by expenditure constraints.

3. Establishing Networks of Users, Respondents and Advisors

Many S&T communities exist, both formal and informal, including scientific societies, private sector research organizations, the federal research granting Councils, National Research Council, science and technology-relevant federal and provincial government departments, a number of private non-profit research organizations, research universities, etc. Most of these may be Users, Respondents and Advisors at various times. Continuing attention is essential to maintain and extend their co-operative participation in the S&T Information System Project.

The Statistics Canada Advisory Committee on S&T Statistics⁵ (which has played an important role in the initiation of this Project) is a key ingredient in sustaining these networks. Overlapping membership of Project Staff and Advisors on other S&T Committees (e.g. Committee of Science ADMS; NSERC, SSHERC and MRC Committees; Industry Canada S&T Advisory Committee; Advisory Council on S&T; etc.) is a desirable condition which the Project's management will seek to establish.

While the S&T Information Project will have some staff qualified for such relationships, as a practical matter much of the needful networking must depend on inducing advice from S&T communities and from Voluntary Advisors.

To encourage voluntary collaborative interactions, the Project will emphasize openness in its operations and plans, and welcome suggestions and criticisms regarding its products and priorities.

The Project will develop its private sector networks as well as maintain its international connections.

Use of networks, qualified external advice and voluntary advisors

The activities required to use external sources of expert advice effectively cannot be fully formulated or quantified. However, the successful implementation of this Project requires a high degree of dependence on such sources because of the subject matter complexity, and the need to carry out important activities in an analytical mode.

4. Communication and Dissemination

For information to be useable it must be available and known to potential users. For information to be potentially useful, it must be responsive to the needs of clients. Both these factors depend on effective modes of communication.

⁵ Current membership list is shown in Appendix II.

The S&T Project depends and relies heavily on the foundation of Statistics Canada's communications infrastructure: of news releases, publications (written and electronic-marketing), dissemination mechanisms, etc.

In addition, the Project will:

- sponsor fellowships and personnel exchanges to further analysis of S&T data;
- utilize Workshops on special topics;
- arrange productive International Conferences, with invited papers;
- be responsive to invitations for seminars and lectures on S&T information topics;
- sponsor and report on Case Studies on specific S&T topics (e.g. the current trends in voice telecommunications services);
- sponsor publishable research investigations (e.g. the impact of S&T on family coherence);
- seek active participation in international committees and conferences of relevance;
- provide special tabulations of available data on demand;
- support, and collaborate with, S&T researchers and policy analysts;
- develop appropriate media contacts for public dissemination of findings.

Fellowships, internships and exchange programs are operative in several areas of Statistics Canada.

A Workshop on Regional Innovation was held in March 1997.

An International Conference, with invited papers on the Productivity Paradox, was held in April, 1997.

Members of the Project have been invited speakers at international conferences in France, the Russian Federation, the UK and the US in 1997 and 1998.

Members of the Project are participants or observers in a number of committees related to S&T in Canada, the OECD, and, as observers, in the European Union.

An inventory of past activities and products of the Project is given in Appendix I.

5. Organization and Management

The Project requires staff resource capabilities in three general categories:

- creative analytical capacity to identify productive areas for initiation of data development and for analysis of existing data bases. Such personnel need also to act as brokers and builders of consensus with S&T communities;
- expertise to design and operate data gathering vehicles, such as surveys, administrative data access and record linkages;
- personnel to manage effective advisory, workshop, conference and consultative activities, as well as handling publication and dissemination by various means (e.g. Internet, Media, etc.).

These considerations are suggestive of a corresponding organization and management structure, bearing in mind that specific resources for specific requirements may be drawn from inside the Project, from inside Statistics Canada, from outside paid consultants and from Voluntary Advisors. But responsibility for each of these requirements must of course lie with Project Managers.

The skills to deal with data collection reside within Statistics Canada as do those for effective administration and management. The issue for the evolving Project is how to increase the complement of assigned persons and how to orient them to the new challenges. Mechanisms to do this are part of the Agency's culture and practice and include: competitions for openings; short-term assignments from elsewhere in the Agency to spend six months to two years as part of the Project Team; contractual alliances with other groups within Statistics Canada; and external recruitment.

For analytic staff, the issues are significantly different. The Project is especially dependent on having a core of analytical staff. Statistics Canada analysts are mainly economists and sociologists oriented to interpretation of business and trade data from the System of National Accounts and to the extensive body of social statistics. While these skills are highly pertinent to the Project, they need to be augmented by the concepts and definitions used in the measurement of S&T activities, linkages and outcomes, in order to confront the socio-economic and human impacts of S&T.

The Project will allocate resources to staff training, to recruiting personnel interested in acquiring empirical experience in the evolution of S&T, to facilitate fellowships and internships in the study of S&T systems, and to enabling exchange programs with other relevant institutions, national and international.

The communication process will be managed so as to be 'two-way'. Correspondingly, the strategic and operational plans for the Project - while necessary for provision of a common focus and for decisions on resources and priorities - will be managed in implementation so as to be flexible and opportunistic as Project experiences evolve.

Acquisition of qualified Project staff will, inevitably, be gradual. The target will be to allocate Project personnel resources in the ratios of 40%, 40% and 20%, respectively, to the three capabilities mentioned above. Of course, many individuals will act in several capacities.

While staff development in the categories of data collection and administration will follow established Agency practices, the building of analytical capability for the Project may need modified approaches. Specifics of the plans for building these, and other, necessary capacities are discussed in Section 8.

6. Financial Resources

The S&T Project is in a state of major extension, planned to evolve over the five year planning horizon to a quasi 'steady state' - i.e. in terms of qualified staff complement, established collection vehicles, advisory networks and user communities.

The budgetary estimates given below are envisaged as annual averages over the five year development period. In addition to base funding from Statistics Canada's budget, the Project management will seek partnership funding, for both data development and for analytical missions, from sources such as NSERC, SSHRC, MRC, NRC, private sector institutions and various government departments. In addition, it is anticipated that there will be a demand for special data compilations and studies to be serviced on a cost recovery basis.

<u>Estimated Sources of Financing</u>	<u>Millions of \$</u>
Statistics Canada Budget	2.1
Partnerships Contribution	1.9
Cost Recovery for Special Requests	0.3
	—
TOTAL	4.3

The various capabilities and products to be produced by these expenditures are discussed in Section 8. The categories of activities which are to be funded by this budget are as follows:

<u>Activity</u>	<u>Estimated Average Annual Cost (Millions of \$)</u>	
<u>Continuing Activities</u>		3.40
Project's Own Surveys (R&D, Innovation and Diffusion Surveys)	1.35	
Data Collection through other surveys (Household Surveys, Industry Surveys)	0.40	
Research and Analysis	1.50	
Advisory Network	0.15	
<u>Ad hoc Activities</u>		0.90
Workshops, Conferences	0.40	
Focus Groups, Case Studies	0.20	
Special Requests	0.30	
TOTAL		\$4.30

The staff requirements, in full-time equivalents (FTEs), and their costs are set out below for the start of the planning period and for the steady state period at the end of five years. Costs in the earlier years will be lower as the numbers are built up.

Not all analytical staff are expected to be permanent. About half would be contractual experts.

Category of Staff	1998-1999		2003-2004	
	FTEs	Millions of \$	FTEs	Millions of \$
Management and Administration	3	0.1	6	0.3
Analytical	7	0.4	15-20	1.5
Operational	13	0.5	25-30	1.2
TOTAL	23	1.0	46-56	3.0

The difference between the estimated cost of staff and the total estimated cost of \$4.3 million, is what would be spent purchasing Statistics Canada services, such as data collection, publishing, and training.

Finally, there is cost allocations viewed from the perspective of outputs. A survey, for example, provides outputs in a variety of ways: catalogued publications, working papers, research papers, conference presentations, and the provision of information to industry, government, the public and international organizations.

There will be research papers and monographs which gather together information from a variety of sources to test hypotheses and to provide synthesis of the information on the topic. These are expensive undertakings. In addition, there will be special studies and tabulations done for clients.

The following table distributes the costs across a representative set of outputs.

<u>Category of Output</u>	<u>Estimated Cost (Millions of \$)</u>
Publications, working papers and regular tabulations	3.0
Research publications	0.4
Monographs/Books	0.4
Cost recovery studies and special tabulations	0.3
Expert Advice	0.2
	—
TOTAL	4.3

While the tables are based on a projected “steady state” condition after five years, the average costs incurred in the first five years will be lower because the build up to economy wide annual surveys or estimations of annual results will be progressive.

These estimates are uncertain because:

- only the base budget is relatively certain
- partnership potential needs to be realized as Project capacity develops
- cost recovery special requests will evolve as data collection and analytical capability evolves
- expenditures in the beginning of the five year period will certainly be less than the estimated annual average for the anticipated quasi “study state”

Of course, development of staff and facilities must be managed in anticipation of funding for without those resources the potential outputs from the Project could not be marketed.

7. **Priorities**

The potential demand for information is unlimited, though the potential use of data is not. Setting priorities is one of the continuing basic issues confronting statistical agencies.

For the S&T Information Project at this time, priorities must remain flexible to be responsive to constraints (e.g. of build up of capabilities), to opportunities (e.g. of partnerships and cost-recovery requests), to experiences (e.g. with new survey questionnaires) and to public policy issues and government S&T policy support needs, as these emerge.

The Project must be sensitive in its priorities to various areas which have been identified as foci of government concern or of general public interest. Those areas include the significance of S&T to:

- Sustainable economic development
- Advancement of knowledge
- Quality of life
- Climate change
- Biotechnology
- Societal connectedness
- Commercialization of intellectual property
- Availability of highly qualified human resources
- Literacy and education
- Health care standards
- Access to, and privacy consideration in use of, the Internet

A further area of federal government priority concern is the information needed to assess the appropriateness and effectiveness of in-house federal S&T activity (including National Research Council), of federal contractual support of R&D, of federal tax incentives for private sector R&D, of federal funding of university research supported by the granting councils - MRC, NSERC, and SSHRC.

It is premature at this time to anticipate judgements on specific priorities in this upcoming five year period. The above array will surely be considered among those areas that receive dominant attention. But many other issues may surface to challenge the above array for priority information development, such as:

- The growth of wireless communication
- The expansion of telemedicine
- The potential for telesocial service
- Control of radioactive waste
- Genetic engineering
- Extended automation of services (e.g. financial)
- Consequences of Y2000 experiences
- Reproductive technologies for humans

Data collection priorities will be responsive to competing desires - specific focus on an identified issue versus having broad relevance to S&T trends.

A current area of substantive attention of the Project is biotechnology, in which the following efforts are underway: surveys, analysis, a proposal for on-going work as a result of a Cabinet decision on the renewal of the Canadian biotechnology strategy; and, a series of meetings on on-going collaborations with policy departments involved. This may be indicative of how priorities will be influenced.

8. Planned Activities and Outputs

While emphasizing the need and intention to maintain management flexibility, the present plan has a core of commitments to activities and associated outputs. These fall into three substantive categories:

- ◆ Building Capacity
- ◆ Data Development
- ◆ Analytical Projects and Outputs

Building Capacity

The basic ingredients for building capacity for this Project are: financial support, an institutional foundation and qualified human resources. As discussed elsewhere, Statistics Canada provides fully the necessary institutional environment. Financial considerations have also been outlined elsewhere in this document.

What follows in this section is a discussion of strategic requirements for which, or in recognition of which, capacities need to be built or augmented.

Human Resource Capacity

The Project's success will depend critically on establishing a productive synergy among several categories of contributors. These include: Core Staff; Visiting Staff; Collaborators; and, Volunteers. Some of these will be important clients as well as contributors. Their active participation is especially essential because of the demanding breadth and depth of the information development challenge.

- **Permanent Staff**

Current staff is as follows:

- Director
- Section Chiefs and Analysts, 7
- Technical and Support Staff, 15

An additional senior manager is required to provide direction and integration of work, including contributions from collaborators and consultants.

Two additional senior technical persons are required to deal with workshops, conferences and client requests.

Increased analytical capability is essential to make sense of the enhanced flow of information. We estimate a need of some eight additional analysts on permanent staff to be added over five years.

Enlarged operational staff is necessary to support expanded data development. Estimated needs are for 25 to 30 to be reached in five years.

- Visiting Staff

We plan to augment core staff by resident visiting staff, where resident tenure might average from 3-6 months to 1-2 years. Candidates for recruitment as Senior Fellows would have extensive subject-matter and research capacity to conduct internal seminars and guide major studies; and Visiting Fellows would participate in specific sub-projects such as analytical survey design, case studies, and indicators formulation. We anticipate having one or two Senior Fellows and 4-6 Fellows resident at any one time.

- Collaborators

The Project requires producers and clients to work in close partnership to develop what is useful and practical. Such an evolution necessitates close collaboration - in formulation of indicators, in design of data development, in analytic targets and investigations, and in priorities determination.

Extension of the network of collaborators is a major task and objective, to involve departments of governments, private sector entities, universities, professional societies, industrial entities. Senior Project staff must give this need priority attention.

- Volunteers

The success of this Project may depend importantly on support and contribution from persons who do not have any direct or formal stake in the work of the Project, but who have an intrinsic interest in the substance and the importance of the undertaking. Such volunteers have played an integral role in the Statistics Canada Advisory Committee on S&T and on various Working Groups which produced a report⁶ leading to the establishment of this Project, a framework⁷ for the undertaking and the present document.⁸

There is an immediate further need for operational plans, where volunteer contributions will be sought.

⁶ An Information System for Science and Technology, Federal Science and Technology Review, Working Group Report on the Development of Science and Technology Statistics, Final Report, Industry Canada, Ottawa (1996).

⁷ Science and Technology Activities and Impacts: A Framework for a Statistical Information System, Catalogue No. 88-522, Statistics Canada, Ottawa (1998).

⁸ A Five-Year Strategic Plan for the Development of an Information System for Science and Technology, Catalogue No. 88-523, Statistics Canada (1998).

There is an emerging need for an independent Editorial Board.

In addition to the present Advisory Committee, we perceive the value of ad hoc volunteer advisory bodies to advise and assist on specific matters such as indicators design, workshop and conference agendas, and communications.

The "care and feeding" of volunteers is an important Project management responsibility.

Capacity to Develop Information

Information development for this Project involves three distinguishable elements: capacity to ask insightful questions and design effective questionnaires; operational capacity to gather pertinent data; and capacity to analyze and interpret data objectively and comprehensively.

- Formulate Questions

Building and sustaining this capacity is an unending challenge for this Project. Mechanisms to be utilized will be varied - some planned, many opportunistic. The former include use of focus groups, workshops, consultation committees and case studies. These would be managed in part by core staff, in part by consultant contracts.

The opportunistic contributions may be equally important, albeit informal: feedback from clients, comments from seminars; suggestions from bilateral discussions; ongoing communication from a developing network of collaborators and volunteers; interactions with Statistics Canada colleagues and with policy analysts in government and business; and, initiatives of social and physical science researchers.

- Develop Data

The basic infrastructure and operational expertise to solicit, gather, compile and process data is well-established in Statistics Canada. The Project has currently a number of data development programs in established operation. These include:

- Annual estimates of expenditure on R&D, Innovation and Diffusion
- Use of Household surveys and Industry surveys
- Workshops and conferences
- etc.

These capabilities need to be augmented by an ad hoc capacity to provide for targeted efforts to produce more detail in a timely fashion or to focus on specialized data for special cases.

Further directions for investigation by the Project need to be recognized and formulated focussed on cross-economy issues such as: capital availability and investment; specialized human science and technology resource

availability; etc. Such investigations may depend on linkage among various data files, including administrative and taxation information.

The Project must also develop a strong focus on the socio-economic concomitants of S&T: implications for labour force and employment; impact on population mobility and integration; effect on family culture; impact on community and social cohesion; impact on national physical and cultural infrastructure in education, health care, administration of justice, policing, transportation, communication, and, processes of governance.

Implications for data development capacity will include utilizing existing household survey vehicles, exploiting existing survey and administrative data, employing data linkage and developing sophisticated analytic approaches.

- Analysis

S&T evolution is diverse and complex. Making sense of observational data, however carefully developed, is correspondingly complex. Many threads of connection may be needed to provide understanding with reasonable integration and objectivity. This process of analysis is essential to the successful development of the present Project.

The direct response of the Project to this need is to stimulate and encourage analytical work, in part by its core staff, but also by facilitating data access, by coordinating collaborations among creative researchers and policy analysts, and by providing publication and contractual incentives.

Capacity to Communicate and Network

Effective communications is, of course, essential for the public interest usefulness of the Project - communication to the public, as well as a spectrum of constituencies such as researchers, policy analysts, corporate planners and managers, investors, human resource managers, educators. The modalities and media of communication will need to be correspondingly diverse.

The planned efforts would include a regular media-oriented newsletter, scholarly publications and monographs, seminars, conference talks, workshops, special audience presentations, and an Internet web site.

Workshops or Round Table Discussion Groups may be especially valuable for communication, for feedback and to establish and strengthen networks for collaboration. Such workshops may combine promotional, research and priority setting objectives. Typically, a workshop would be oriented and facilitated by advance commissioned papers. However participants were designated, all proceedings would be in the public domain.

The continued attention to building networks must recognize that networking is a "trading" activity and must be perceived as "win-win" by all participants. This orientation applies both nationally and internationally, with respect to other statistical agencies, OECD committees, professional statistical and scientific associations, as

well as Canada's research granting Councils, National Research Council, science-based government departments.

While personal connections are crucial to networking and also to communication, these initiatives require creative and persistent planning and management by senior technical personnel.

Data Development

Over the five year planning horizon, the Project capacity will produce a wide variety of statistical data. The available products will include (but not be limited to) the following:

Of Relevance to Knowledge Generation

Yearly estimates of:

- R&D expenditures
- R&D personnel
- R&D funding sources
- Nature of R&D - (product, process)
- Fields of research

Of Relevance to Knowledge Transmission

- Innovation (building up to yearly, economy wide estimates)
 - Sources of innovation
 - Costs of innovation
 - Types of innovation
 - Characteristics of innovative firms
 - Barriers to innovation
- New Technologies (building up to yearly, economy wide estimates)
 - Sources of new technologies
 - Costs of new technology implementations
 - Type of technology use
 - Characteristics of firms using advanced technologies
 - Barriers to use of technologies
- Intellectual Property Commercialization
 - Characteristics of intellectual property developed by Canadian universities
 - Characteristics of intellectual property developed by government laboratories

Of Relevance to Knowledge Use

- Socio-economic objectives of federal government S&T spending
- Use and planned use of technologies by firms and governments
- Use and planned use of technologies by households
- Objectives of innovation by firms

Of Relevance to Skilled Personnel

- Yearly estimates of supply of highly qualified personnel
- Yearly estimates of demand, by business, government, university and other, of skilled personnel

Targeted Data Development

It is expected that there will be a number of data development initiatives with in-depth targeting which will be established with supportive partners. An example is current survey activity of the biotechnology sector. Other potential areas may be S&T utilization in health care, in environmental monitoring and protection (including radioactive waste), in administration of justice, in education, in financial systems, in communication services, in transportation services, etc. As part of these initiatives, a standard classification system for technologies will be developed in co-operation with S&T communities.

Analytical Projects and Outputs

Investigations of impacts of S&T on the socio-economy is a complex challenge because of: long time lags; confounding of many effects; variation in cultural, geographic and political circumstances; and, other complicating factors. Assessment of impacts will, in general, not derive from direct statistical observations - analysis of relationships and creating of theoretical models and theories are necessary.

The Project will stimulate and support such analytical activity by staff internal to Statistics Canada, by organizing Workshops/Conferences pertinent to appropriate themes, by facilitating access to data by academic researchers, by organizing mission-oriented teams of researchers, by seeking appropriate candidates for Statistics Canada fellowships.

In general, it is expected that virtually all significant analytical projects managed by the Project will be sponsored by, or have partnership support from, one or more non-Statistics Canada institutions. Potential partners would include federal and provincial government organizations, universities, foundations, businesses, private sector societies and associations.

Example of topics which might be considered are:

- Impact of innovation in the workplace and in the labour market
- The dynamics of job location for new graduates
- The impact of S&T on business organization and management
- The impact of medical S&T on population health
- The impact of S&T on child education and development
- The impact of S&T on family formation and family relationships.

9. Conclusions

This Strategic Plan is designed to produce significantly improved understanding of, and decision-making regarding S&T activities in Canada.

The Plan contemplates average yearly financial expenditures of about twice the base budget of \$2.1 M - the additional funds to be contributed by partners and clients whose cooperation and interests are fundamental to the implementation and usefulness of the Project.

The Plan is founded on the existing capabilities of Statistics Canada, but recognizes that additional advice, expertise and collaboration of S&T communities must be harnessed for the Project to be successful.

While the building of Project capabilities will be challenging and gradual, it is confidently expected that the Project will continue to increase its production of useful information products regarding S&T.

Appendix I: Outputs of the Information System for Science and Technology, 1996-1998

CATALOGUED PUBLICATIONS

Annual Publications

- 88-202-XPB Industrial Research and Development, 1997 Intentions (with 1996 preliminary estimates and 1995 actual expenditures)
- 88-204-XPB Federal Scientific Activities, 1997-98^e

Service Bulletin on Science Statistics

88-001-XPB, Volume 21 (1997)

- No. 1 Scientific and Technological (S&T) Activities of Provincial Governments, 1987-88 to 1995-96
- No. 2 The Effect of Country of Control on Industrial Research and Development (R&D) Performance in Canada, 1993
- No. 3 The Provincial Research Organizations, 1995
- No. 4 Federal Government Expenditures on Scientific Activities, 1997-98
- No. 5 Industrial Research and Development, 1993 to 1997
- No. 6 Software Research and Development (R&D) in Canadian Industry, 1995
- No. 7 Distribution of Federal Expenditures on Science and Technology, by Province and Territories, 1995-96
- No. 8 Total spending on Research and Development in Canada, 1986 to 1997^e, and Provinces, 1986 to 1995
- No. 9 Estimation of Research and Development Expenditures in the Higher Education Sector, 1995-1996
- No. 10 Research and Development (R&D) Personnel in Canada, 1986 to 1995
- No. 11 Biotechnology Research and Development (R&D) in Canadian Industry, 1995
- No. 12 Research and Development (R&D) Expenditures for Environmental Protection (EP) in Canadian Industry, 1995
- No. 13 Research and Development (R&D) Expenditures of Private Non-Profit (PNP) Organizations, 1996

Volume 22 (1998)

- No. 1 The Provincial Research Organizations, 1996
- No. 2 Federal Government Expenditures on Scientific Activities, 1998-99
- No. 3 Federal Government Personnel Engaged in Scientific and Technological (S&T) Activities, 1989-90 to 1998-99^e
- No. 4 Biotechnology Scientific Activities in Selected Federal Government Departments and Agencies, 1997-98
- No. 5 Total Spending on Research and Development in Canada, 1987 to 1998^e, and Provinces, 1987 to 1996
- No. 6 Distribution of Federal Expenditures on Science and Technology, by Province and Territories, 1996-97
- No. 7 Estimation of Research and Development Expenditures in the Higher Education Sector, 1996-1997
- No. 8 Research and Development (R&D) Expenditures of Private Non-Profit Organizations, 1997

WORKING PAPERS - 1997

- ST-97-01 A Compendium of Science and Technology Statistics, February 1997
- ST-97-02 Provincial Distribution of Federal Expenditures and Personnel on Science and Technology, 1994-95, February 1997
- ST-97-03 Scientific and Technological Activities of Provincial Governments, 1989-90 to 1995-96, March 1997
- ST-97-04 Federal Government Expenditures and Personnel on Activities in the Natural and Social Sciences, 1987-88 to 1996-97^e, March 1997
- ST-97-05 Transfers of Funds for Research and Development in Canadian Industry, 1993, July 1997
- ST-97-06 Estimation of Research and Development Expenditures in the Higher Education Sector, 1995-1996, August 1997
- ST-97-07 Estimates of Canadian Research and Development Expenditures (GERD) - Canada, 1986 to 1997, and by Province, 1986 to 1995, August 1997


- ST-97-08 Federal Government Expenditures and Personnel on Activities in the Natural and Social Sciences, 1988-89 to 1997-98^e, August 1997
- ST-97-09 R&D Tax Treatment in Canada: A Provincial Comparison, October 1997
- ST-97-10 Provincial Distribution of Federal Expenditures and Personnel on Science and Technology, 1987-88 to 1995-96, October 1997
- ST-97-11 Commercialization of Intellectual Property in the Higher Education Sector: A Feasibility Study, October 1997
- ST-97-12 Business Demographics as Indicators of Innovation Activity, October 1997
- ST-97-13 Methodology for Estimation of Higher Education R&D Personnel, November 1997
- ST-97-14 Estimates of Research and Development Personnel in Canada, 1979-1995, December 1997

WORKING PAPERS - 1998

- ST-98-01 A Compendium of Science and Technology Statistics, February 1998
- ST-98-02 Exports and Related Employment in Canadian Industries, February 1998
- ST-98-03 Job Creation, Job Destruction and Job Reallocation in the Canadian Economy, February 1998
- ST-98-04 A Dynamic Analysis of the Flows of Canadian Science and Technology Graduates into the Labour Market, February 1998
- ST-98-05 Biotechnology Use by Canadian Industry - 1996, March 1998
- ST-98-06 An Overview of Statistical Indicators of Regional Innovation in Canada: A Provincial Comparison, March 1998
- ST-98-07 Federal Government Payments to Industry 1992-93, 1994-95 and 1995-96, September 1998
- ST-98-08 Bibliometric Analysis of Scientific and Technological Research: A User's Guide to the Methodology, September 1998
- ST-98-09 Federal Government Expenditures and Personnel on Activities in the Natural and Social Sciences 1989-90 to 1998-99^e, September 1998
- ST-98-10 Knowledge Flows in Canada as Measured by Bibliometrics, October 1998
- ST-98-11 Estimates of Canadian Research and Development Expenditures (GERD), Canada, 1987 to 1998^e, and by Province 1987 to 1996, October 1998
- ST-98-12 Estimation of Research and Development Expenditures in the Higher Education Sector, 1996-97, November 1998

RESEARCH PAPERS - 1996 to 1998

- No. 1 The State of Science and Technology Indicators in the OECD Countries, by Benoit Godin, August 1996
- No. 2 Knowledge as a Capacity for Action, by Nico Stehr, June 1996
- No. 3 Linking Outcomes for Workers to Changes in Workplace Practices: An Experimental Canadian Workplace and Employee Survey, by Garnett Picot and Ted Wannell, June 1996
- No. 4 Are the Costs and Benefits of Health Research Measurable? by M.B. Wilk, February 1997
- No. 5 Technology and Economic Growth: A Survey, by Petr Hanel and Jorge Niosi, April 1998
- No. 6 Diffusion of Biotechnologies in Canada, by Anthony Arundel, February 1999

 **Working Papers and Research Papers are available on the Statistics Canada Web Site:**
www.statcan.ca

PUBLISHED PAPERS - 1996 to 1998

Anderson, Frances and Robert Dalpé, "S&T Indicators for Strategic Planning and Assessment of Public Research Institutions", *Knowledge and Policy: The International Journal of Knowledge Transfer and Utilization*, Spring 1996, Volume 9, Number 1, pp.49-69.

Anderson, Frances and Robert Dalpé, "Contracting Out of Science and Technology Services", *Administration and Society*, Volume 28, Number 4, February 1997, pp. 489-510.

Anderson, Frances and Fred Gault, "Canadian Firms Receiving R&D Funding from Foreign Sources", *Research Evaluation*, (forthcoming).

Anderson, Frances, "Where is Research Located in Canada? A Statistical Approach", *Science and Public Policy*, December 1998, Volume 25, Number 6, pp. 396-406.

Arundel, Anthony and Antoine Rose, "Finding the Substance Behind the Smoke: Who is Using Biotechnology?", *Nature Biotechnology*, Volume 16, July 1998, pp. 596-597.

Arundel, Anthony and Antoine Rose, "Who Uses Environmental Biotechnology? Empirical Results for Canada", *Technovation*, (forthcoming).

Gault, Fred, "Research and Development in a Service Economy", *Services Indicators*, 4th Quarter 1996, Catalogue 63-016-XPB. Expanded version in *Research Evaluation*, Volume 7, Number 2, pp. 79-91, 1998.

Gault, Fred, "The Federal Strategy for Science and Technology in Canada and Statistical Measurement", Proceedings of the *Conference on Statistics, Science and Public Policy*, Hailsham, U.K., April 10-13, 1996, pp. 181-188, Queen's University, Kingston, 1998.

Hamdani, Daood, "The Temporary Help Service Industry: Its Role, Structure and Growth", *Services Indicators*, 2nd Quarter 1996, Catalogue 63-016-XPB.

Hamdani, Daood, "Job Creation, Job Destruction and Job Reallocation in the Service Sector", Proceedings of the Statistics Canada *Conference on Economic Growth and Employment*, Ottawa, September 1997.

Hamdani, Daood, "Business Demographics, Volatility and Change in the Service Sector", *Services Indicators*, 2nd Quarter, 1997, Catalogue No. 63-016-XPB, and reprinted in *Canadian Economic Observer*, March 1998, Catalogue No. 11-010-XPB.

SURVEY QUESTIONNAIRES

Industrial R&D

- Energy R&D expenditures by area of technology, 1996
- Research and Development in Canadian Industry, 1997
- Research and Development in Canadian Industry, 1997 (Industrial Non-profit Organizations)
- Research and Development of Canadian Private Non-Profit Organizations, 1997

Federal and Provincial Government S&T Activities

- Federal S&T on biotechnology, Annex to the Federal science expenditures and personnel 1997-1998
- Federal science expenditures and personnel 1998/99 (Activities in the natural sciences)
- Federal science expenditures and personnel 1998/99 (Activities in the social sciences)
- Federal science expenditures and personnel 1998/99 (Intellectual Property Management, 1997/98)
- Provincial Activities in the Social Sciences and Humanities, 1997-98
- Provincial Government Activities in the Natural Sciences, 1997-98

Innovation in Industry

- Survey of Innovation, 1996

Technology Diffusion in Industry

- Biotechnology Firm Survey - 1997
- Survey of Advanced Technology in Canadian Manufacturing - 1998
- Survey of Biotechnology Use in Canadian Industries - 1996

University

- Survey of Intellectual Property Commercialization in the Higher Education Sector, 1998

INFORMATION WORKSHOPS - 1996 to 1998

Workshops with the Canadian Intellectual Property Office (CIPO), October 9, 1996 and November 13, 1996.

Workshop with Industry Canada, January 27, 1997.

Workshop with the National Research Council (NRC), Planning and Assessment Group, February 24, 1997.

Workshop with Natural Sciences and Engineering Research Council (NSERC), March 5, 1997.

Workshop with the Medical Research Council of Canada, April 9, 1997.

Workshop with Association of Universities and Colleges of Canada, June 19, 1997.

Workshop with the Conseil de la science et de la technologie, Québec, February 4, 1998.

Workshop with University of Calgary, March 9, 1998.

Workshop with the Program on Globalization and Regional Innovation Systems (PROGRIS), University of Toronto, March 24, 1998.

Workshop with the Centre for Policy Research on Science and Technology, Simon Fraser University, October 22, 1998.

RESEARCH WORKSHOP - 1997

Workshop on Local and Regional Systems of Innovation, co-ordinated by the staff of the Program of Research in International Management and Economy (PRIME) Group, University of Ottawa, March 1997.

RESEARCH VOLUME - 1998

J. de la Mothe and G. Paquet, editors, *Local and Regional Systems of Innovation*, Kluwer Academic Publishers, Boston, 1998.

CONFERENCE PAPERS (unpublished) - 1996 to 1998

Anderson, Frances and Bert van den Berg, "Developing Statistical Indicators of the Capability to Acquire, Use and Innovate Machine Tools", Presented at the *International Conference on Technology Learning, Innovation and Industrial Policy: National and International Experiences*, Mexico City, September 25-27, 1996.

Anderson, Frances and Charles Davis, "External Steering of University Research and the Promotion of University-Industry Relations by the Natural Sciences and Engineering Research Council of Canada (NSERC), 1977-1996", Presented at the *International Conference on Technology Learning, Innovation and Industrial Policy: National and International Experiences*, Mexico City, September 25-27, 1996.

Anderson, Frances, "Technology Trajectories and the Acquisition of Knowledge: A Statistical Approach", Presented at the 2nd World Congress on the Management of Intellectual Capital, January 21-23, 1998, Hamilton, Ontario.

Anderson, Frances and André Manseau, "The Canadian Construction System: From an Industry to a Systemic Perspective", Presented at the *International Workshop on Innovation Systems and the Construction Industry*, Montreal, January 23, 1997.

Anderson Frances, "Survey of Innovation in Construction and Related Industries", Presented at the *Construction Sector Roundtable for a Strategic Study*, Institute for Research in Construction, National Research Council of Canada, September 24, 1998.

Gault, Fred, "An Information System of Science and Technology", Presented to the *Conference on S&T Indicators and Benchmarks for Policy Analysis and Public Awareness*, Centre for Policy Research on Science and Technology (CPROST) and the School of Communication, Simon Fraser University, April 17, 1996.

Gault, Fred, "The Systems Approach to Data Classification", Presented at the *Conference on New S&T Indicators for a Knowledge-Based Economy*, organized by the Committee for Scientific and Technological Policy, Directorate for Science, Technology and Industry, OECD, 19-21 June 1996.

Gault, Fred, "Measuring Innovation", Presented to the Centre for Policy Research on Science and Technology (CPROST), *Workshop on Regional Innovation*, Simon Fraser University, Vancouver, B.C., February 18, 1997.

Gault, Fred, "Overview of Innovation Information", Presented at the *Industrial Research and Innovation for Public Policy Workshop*, sponsored by the US National Research Council's Board on Science, Technology and Economic Policy (STEP), National Academy of Sciences, Washington, D.C., February 28, 1997.

Gault, Fred, "Empirical Perspective on Regional Innovation Systems", Presented at the *Workshop on Regional Innovation Systems*, organized by PRIME, University of Ottawa, March 13, 1997.

Gault, Fred, "Measuring the Global Dimensions of Science, R&D and Innovation: The View from a National Statistical Office", *Workshop on Data to Describe Resources for the Changing Science and Engineering Enterprise*, National Research Council, Washington, D.C., September 18-19, 1998.

Hamdani, Daood, "Innovation and Labour Skills: Evidence from the Consulting Engineering Industry", Presented at the *Workshop at the Centre for Research on Innovation & Competition*, University of Manchester, U.K., May 20 and 21, 1998.

Rose, Antoine, "Un nouvel indice de prix pour la déflation des dépenses de recherche et développement industriels", Presented at the VIIIe congrès annuel du Secteur de la statistique du commerce et des entreprises de Statistique Canada, Ottawa, September 1996.

Appendix II: Members of the Advisory Committee on Science and Technology Statistics

Dr. Susan A. McDaniel, **Chairman**
Department of Sociology
University of Alberta

Dr. Louis Berlinguet
Verdun, Québec

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