Ministry of State
Science and Technology
Canada

Ministère d'État
Sciences et Technologie
Canada

Federal Science Activities

1978-79

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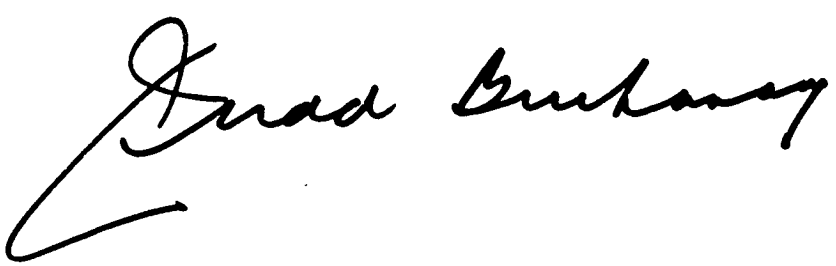
FOREWORD

This publication, the second of an annual series, reports on the scientific and technological activities to be funded by the federal government during the fiscal year 1978/79. It covers research, development, and related scientific activities in both the human and the natural sciences.

The report adds to the information given in the 1978/79 Main Estimates. It is intended to provide the public and members of the House of Commons and the Senate with a context for viewing the federal government's spending on science and technology and also to assist in the making of decisions in this area. Comments on last year's report have been welcome, and changes have been made in the format which go some way to meeting the suggestions received. The intention is to keep most of the publication in narrative form rather than to include a wealth of numerical data. I draw the attention of those seeking more statistical detail to another publication of the Ministry of State for Science and Technology, "Federal Science Expenditures and Manpower, 1976/77—1978/79", which contains tabular data and histograms complementary to this report.

The mandate of the Ministry of State for Science and Technology to develop science and technology policy in Canada and to advise the government on resource allocation in these fields gives it the comprehensive and detailed overview of federal science programs necessary to produce this publication. However, the cooperation of all federal departments and agencies that fund scientific or technological activities has also been essential, and I thank them for their assistance. The Treasury Board Secretariat and Statistics Canada must receive particular thanks. Without their help the report would have been later and less complete.



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OVERVIEW

OVERVIEW

Federal expenditures on science and technology (S&T) for 1978/79 are estimated at $1,828 million, an increase of $125 million (7.3%) over the forecast expenditure for 1977/78. Expenditures on science are 3.75% of the total federal budget of $48.8 billion. The increase for 1978/79 is of the same order as in the past year ($125 million), when forecast expenditures rose 7.9% to $1,703 million.

The fact that total science expenditures will remain in 1978/79 at approximately the same level in real dollar terms, and at about the same proportion of total Federal expenditures as in 1977/78, reflects the policy of restraint the Government has applied to this as to other parts of its expenditure program. It reflects also, however, the belief that scientific programs represent an essential investment for the long term, for which support should be maintained even in a time of fiscal difficulty and many urgent competing demands. Within the total envelope of science expenditures changes have been made in the allocations of resources to reflect new assessments of priorities and judgments about the most effective ways of achieving results. These include for example, an increased emphasis on encouragement of R&D in the industrial sector, through further implementation of the contracting-out policy and some new measures of indirect assistance through tax credits that do not appear within the estimates of budgetary expenditure.

Expenditures for 1976/77, 1977/78, and 1978/79 by the departments and agencies that are the major funders of science activities are detailed in Figure 1. These 18 departments and agencies account for about 88% of the total science spending by the government. Of these, Environment will spend $309 million, 17% of the total federal science expenditure. The next largest funder is the National Research Council with $197 million representing a 12% increase over 1977/78. Other major funders are Agriculture with a 12% increase to $135 million, Energy, Mines and Resources with a 6% increase to $126 million, and Statistics Canada with a 2% increase to $139 million. Industry, Trade and Commerce, as a result of the ending of one of its support programs, will drop to $66 million, a decrease of 20% over 1977/78. Transport's estimates also show a decrease, a drop of 12% to $44 million. Further details on these activities and expenditures are given in this report in the section on Major Funders. The man-years devoted to science and technology within these departments and agencies are detailed in Figure 2. A slight decrease of 0.7% to 34,520 man-years is estimated.

Some $1,191 million (a 9% increase over 1977/78) will be spent intramurally. This represents 65% of the total science expenditures. These *Intramural* expenditures include $108 million for capital projects and $37 million for the costs of administration of extramural programs resulting in a net intramural expenditure of $1,046 million. The increases in intramural expenditures are strongly dominated by salary increases.

In addition to the scientific activities that are undertaken in federal laboratories, the government also funds *extramural* science activities. Of the $638 million to be spent extramurally, $275 million will go to Canadian industry. Universities will receive $241 million, non-profit institutions $26 million, provincial and municipal governments and other performers $47 million, and foreign performers $49 million. Figure 3 provides additional details.

Science activities consist of *research and experimental development (R&D)* and *related scientific activities (RSA)*. R&D refers to creative work undertaken on a systematic basis to increase

Figure 1

FEDERAL EXPENDITURES ON THE NATURAL AND HUMAN SCIENCES BY MAJOR FUNDING DEPARTMENTS

Department	($ Millions)		
	1976/77	1977/78	1978/79
Agriculture	106.5	120.0	134.7
Communications	17.8	35.6	52.3
Energy, Mines and Resources	95.4	118.0	125.5
Atomic Energy of Canada Ltd.	99.6	84.6	94.4
Environment	269.3	289.9	309.1
External Affairs			
Canadian International Development Agency	22.6	24.2	27.6
International Development Research Centre	32.4	31.8	33.8
Industry, Trade and Commerce*	115.2	82.6	65.7
Statistics Canada	145.4	135.8	138.6
National Defence	74.4	87.0	95.9
National Health and Welfare	49.5	59.9	62.7
Medical Research Council	51.9	58.1	61.4
Science and Technology			
National Research Council	145.3	175.5	196.6
Grants and Scholarships Program (NRC)	94.3	99.5	106.6
Secretary of State			
Canada Council — Social Science and Humanities Research Program	29.2	31.4	32.2
Transport	33.3	50.0	44.1
Urban Affairs	6.8	7.3	8.8
Central Mortgage and Housing	13.1	13.5	15.6
Total Major Funders	**1,402.0**	**1,504.6**	**1,605.6**
Others	176.0	198.4	222.4
Total Federal Science	**1,577.9**	**1,703.1**	**1,828.0**

*The decrease in the science expenditures of IT&C is the result of the ending of the Industrial Research and Development Act which has been superseded by tax incentives.

Figure 2

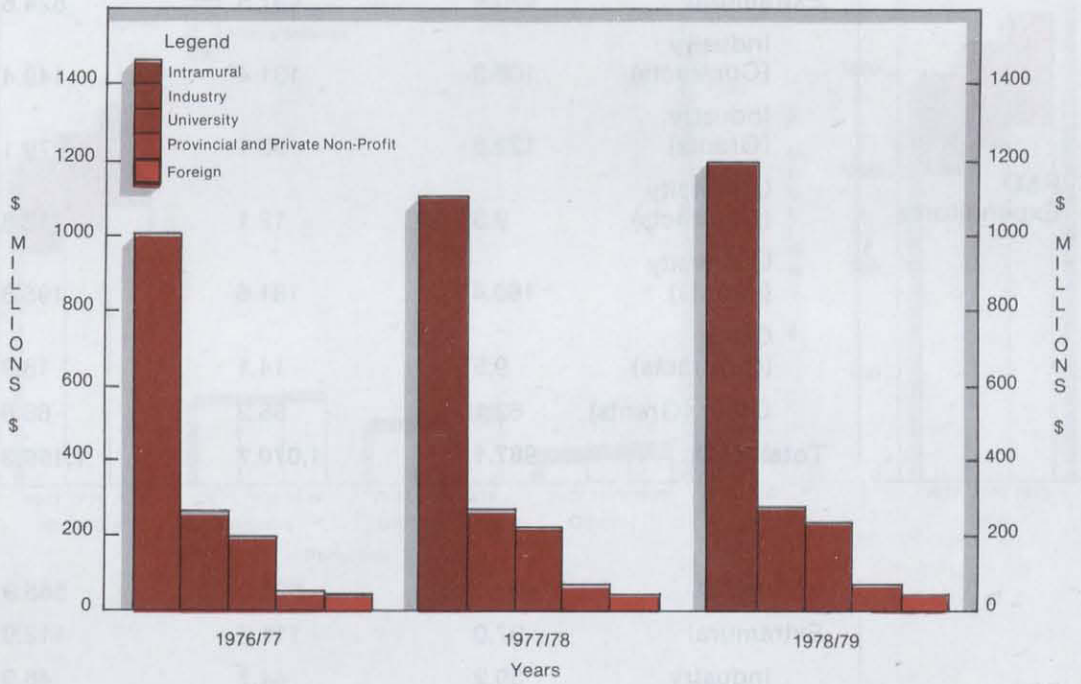
MAN YEARS DEVOTED TO ACTIVITIES IN THE NATURAL AND HUMAN SCIENCES BY MAJOR FUNDING DEPARTMENTS

Department	(Man Years)* 1976/77	1977/78	1978/79
Agriculture	4,186	4,169	4,179
Communications	422	425	425
Energy, Mines and Resources	2,435	2,401	2,378
Atomic Energy of Canada Ltd.	2,321	2,301	2,341
Environment	7,177	7,270	7,326
External Affairs			
Canadian International Development Agency	51	51	51
International Development Research Centre	331	344	355
Industry, Trade and Commerce	183	178	169
Statistics Canada	6,397	5,456	5,111
National Defence	2,126	2,164	2,186
National Health and Welfare	1,105	1,134	1,159
Medical Research Council	39	39	40
Science and Technology			
National Research Council	3,055	3,069	3,076
Grants and Scholarships Program (NRC)	48	57	55
Secretary of State			
Canada Council — Social Sciences and Humanities Research Program	96	97	102
Transport	222	238	228
Urban Affairs	102	67	54
Central Mortgage and Housing Corp.	173	138	138
Total Major Funders	**30,469**	**29,598**	**29,373**
Others	5,027	5,177	5,145
Total Federal Science	**35,496**	**34,775**	**34,518**

*Man years are reported in tenths and do not necessarily add to totals due to rounding.

Figure 3

FEDERAL EXPENDITURES ON SCIENTIFIC ACTIVITIES BY PERFORMER — 1976/77 TO 1978/79



Performer	($ Millions / Percentages)[a]					
	1976/77		1977/78		1978/79	
	$	%	$	%	$	%
Intramural	1,010.5	64.0	1,094.3	64.3	1,190.5	65.1
Extramural	567.4	36.0	608.8	35.7	637.5	34.9
Industry	268.2	17.0	269.1	15.8	275.4	15.1
University	197.6	12.5	225.9	13.3	240.6	13.2
Private Non-profit and Other[b]	54.6	3.5	70.5	4.1	72.9	4.0
Foreign	47.1	3.0	43.3	2.5	48.6	2.7
Total	**1,577.9**	**100.0**	**1,703.1**	**100.0**	**1,828.0**	**100.0**

(a)Details do not necessarily add to totals due to rounding.
(b)Includes provincial and municipal governments and provincial research councils.

Figure 4

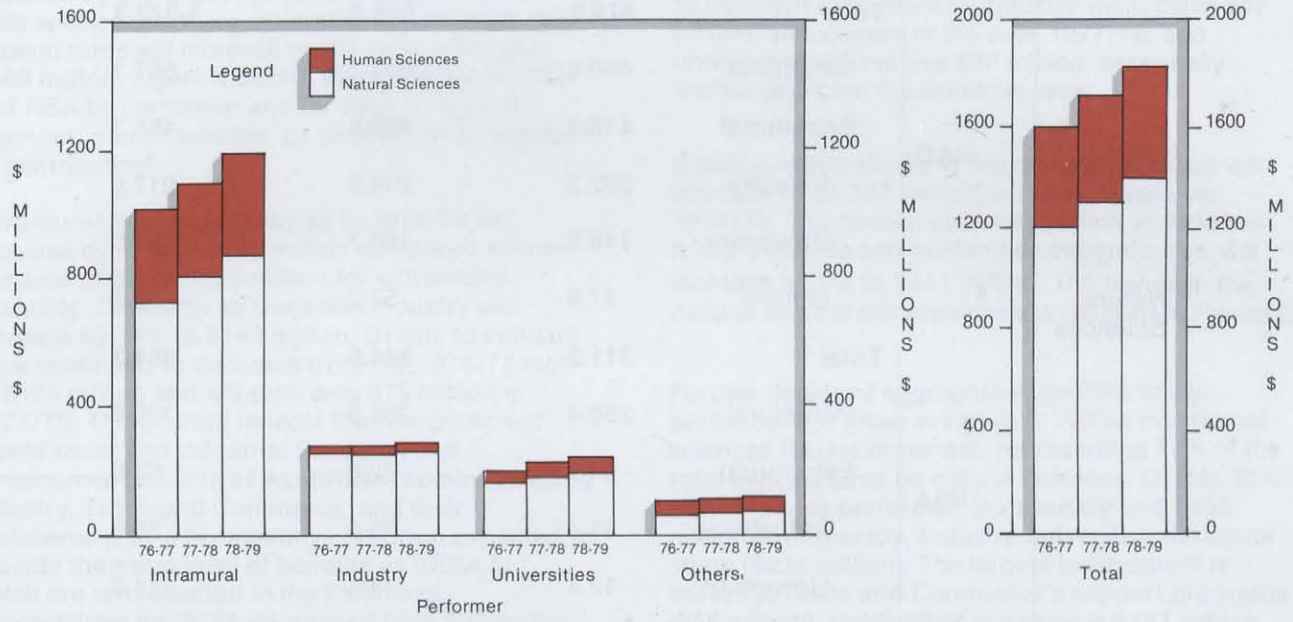
FEDERAL SCIENCE EXPENDITURES BY TYPE OF ACTIVITY AND PERFORMER

Activity	Performer	($ Millions)* 1976/77	1977/78	1978/79
R&D Expenditures	Intramural	516.7	573.3	634.6
	Extramural	470.4	497.5	524.6
	Industry (Contracts)	106.3	131.4	149.4
	Industry (Grants)	122.6	93.1	79.1
	University (Contracts)	9.5	12.1	12.8
	University (Grants)	160.4	181.6	195.8
	Other (Contracts)	9.5	14.1	18.8
	Other (Grants)	62.1	65.2	68.6
	Total R&D	**987.1**	**1,070.7**	**1,159.3**
RSA Expenditures	Intramural	493.8	521.0	555.9
	Extramural	97.0	111.3	112.9
	Industry	39.2	44.7	46.9
	University	27.7	32.2	32.0
	Others	30.0	34.5	34.0
	Total RSA	**590.8**	**632.3**	**668.8**
Total Science		**1,577.9**	**1,703.1**	**1,828.0**

*Details do not necessarily add to totals due to rounding.

Figure 5

FEDERAL EXPENDITURES ON THE NATURAL AND HUMAN SCIENCES BY PERFORMER



		$Millions[a]				
		Performer				
		Intra-mural	Industry	Univer-sities	Others[b]	**Total**
Natural Sciences	1976/77	717.1	253.8	160.9	59.0	**1,190.8**
	1977/78	793.0	249.9	182.8	65.6	**1,291.4**
	1978/79	867.8	254.4	195.5	69.0	**1,386.7**
Human Sciences	1976/77	293.4	14.4	36.7	42.7	**387.2**
	1977/78	301.3	19.2	43.1	48.2	**411.7**
	1978/79	322.7	21.1	45.1	52.5	**441.3**

(a) Details do not necessarily add to totals due to rounding.
(b) Includes foreign performers and Canadian private non-profit organizations.

Figure 6

FEDERAL GOVERNMENT EXPENDITURES BY TYPE OF SCIENCE AND PERFORMER

			($ Millions)*		
			1976/77	1977/78	1978/79
Natural Sciences	R&D	**Total**	**879.5**	**946.9**	**1,022.3**
		Intramural	460.8	511.1	567.1
		Extramural	418.8	435.8	455.3
		Industry	222.3	214.8	217.6
		University	148.5	168.7	181.0
		Others	47.9	52.2	56.7
	RSA	**Total**	**311.2**	**344.5**	**364.3**
		Intramural	256.4	281.9	300.8
		Extramural	54.9	62.6	63.6
		Industry	31.4	35.0	36.8
		University	12.4	14.1	14.5
		Others	11.1	13.4	12.4
Human Sciences	R&D	**Total**	**107.6**	**123.9**	**136.9**
		Intramural	55.9	62.2	67.6
		Extramural	51.7	61.7	69.3
		Industry	6.6	9.6	10.9
		University	21.4	25.0	27.6
		Others	23.7	27.1	30.8
	RSA	**Total**	**279.6**	**287.8**	**304.4**
		Intramural	237.5	239.1	255.1
		Extramural	42.1	48.7	49.3
		Industry	7.8	9.7	10.2
		University	15.3	18.0	17.5
		Others	19.0	21.0	21.7

*Details do not necessarily add to totals due to rounding.

the stock of scientific knowledge or to discover new applications for existing knowledge. RSA is work closely related to, but which should be separately identified from, R&D. It includes such activities as education support, scientific and technical information services, general purpose data collection, etc. R&D expenditures are estimated to increase by 8% to $1,159 million, which is 63% of the total science spending estimated for 1978/79. RSA expenditures will increase by 6% to an estimated $669 million. Figure 4 details expenditures on R&D and RSA by performer and for R&D by type of payment, that is, whether by contract or by a grant or contribution.

Intramural R&D expenditures in 1978/79 will increase by 11% to $635 million compared with an increase of 5% to $525 million for extramural spending. Contracts to Canadian industry will increase by 14% to $149 million. Grants to industry have continued to decrease from the 1976/77 high of $123 million and will total only $79 million in 1978/79. This change reflects the termination of grants under the Industrial Research and Development Incentives Act (IRDIA) administered by Industry, Trade and Commerce, and their replacement by a tax incentive program expected to provide the same level of benefits as IRDIA but which are not reflected in the Estimates. Expenditures on IRDIA decreased from $40 million in 1976/77 to $15 million in 1977/78 to zero in 1978/79. Further information on industrial support is given under industry in the Extramural Activities section.

Contracts to universities are estimated to increase by 6% to $13 million in 1978/79. University grants are estimated to increase by 8% to $196 million, largely as a result of a $12.6 million increase to the three granting councils, discussed in the Universities section.

Contracts to other performers will increase to $19 million, an increase of 33%, and grants will grow 5% to $69 million. The bulk of the expenditures are CIDA and IDRC grants to foreign performers, discussed further in the International section.

RSA expenditures will increase by 6% to $669 million in 1978/79. The bulk of this, $556 million (83%), will be spent intramurally. Of the $113 million to be spent extramurally, industry will receive $47 million, an increase of 5% over 1977/78, and universities will receive $32 million, essentially unchanged from the previous year.

Science expenditures in the *natural sciences* will increase to $1,387 million, a 7% increase over 1977/78. The *human sciences*, which include the social sciences and humanities expenditures, will increase by 7% to $441 million. The trends in the natural and human sciences are detailed in Figure 5.

Further details of aggregate expenditures by performer are given in Figure 6. Within the natural sciences R&D is dominant, representing 74% of the total expenditures on natural sciences. Of this, $567 million will be performed intramurally and $455 million extramurally. Industry will receive the major share ($218 million). The largest involvement is Industry, Trade and Commerce's support programs ($58 million). Universities will receive $181 million. The RSA activities totalling $364 million include $301 million to be spent intramurally.

In the human sciences, RSA is the dominant activity representing 69% of the total. R&D is performed both extramurally and intramurally, the totals being $69 million and $68 million respectively. R&D expenditures in the human sciences are dominated by National Health and Welfare and the Canada Council, which will spend $19 million and $17 million respectively. In RSA $255 million is to be spent intramurally and $49 million extramurally. Statistics Canada with $130 million dominates this category.

SPECIAL APPLICATIONS

Introduction

Energy

Food

Oceans

Space

Transportation

SPECIAL APPLICATIONS

Introduction

Departments and agencies generally carry out and support scientific activities in direct pursuit of their own objectives. Most of these activities are discussed in the Major Funders section. There are, however, areas of scientific application—energy, transportation, space, oceans, and food—that cross departmental mandates. For example, in energy R&D, The Department of Energy, Mines and Resources has a primary interest in energy production and conservation, while Transport Canada is involved in research on energy transportation and in the efficient use of energy in transportation and the Department of Fisheries and Environment is concerned with the environmental effects of fuel utilization. Given that individual departments and agencies normally determine the allocation of their resources, there is clearly a need in these cross-departmental application areas for a coordinating and managing mechanism to establish priorities among the contributing activities and to provide advice on how resources should be allocated among these activities.

The interdepartmental committees, which have been formed for this purpose, have emerged independently and at different times and have been structured and have mandates to meet the differing needs of these areas. EMR, as the lead department, chairs and provides the secretariat for the Interdepartmental Panel on Energy R&D, whose objective is to develop proposals for an integrated program of energy R&D. It is required to report to Cabinet and the Treasury Board on the utilization of existing resources and to recommend changes of priority for new or existing resources where appropriate. The panel has influenced budgetary decisions since 1976/77. The recently organized Interdepartmental Committee of Transportation R&D has a similar mandate.

For the other three application areas—space, oceans, and food—the interdepartmental committees have primarily a coordinating function and do not make recommendations on resource allocation on a program basis.

Energy

Total estimated expenditures by the government on energy-related scientific activities will be $183.5 million in 1978/79, for an increase of $23.1 million over 1977/78. Of these expenditures, $144.5 million are coordinated and reviewed by the Interdepartmental Panel on Energy R & D. The balance of the expenditures are for studies on resource assessment, environmental impact, and socio-economic aspects. Details of the expenditures recommended by the panel, organized under five major groupings or tasks, are given below.

Established in 1975, the Panel on Energy R & D has been charged with the responsibility of analysing the S & T opportunities and problems of the various energy delivery systems available to Canada and recommending a priority-ranked and coordinated program of scientific activities and associated resources. For both 1977/78 and 1978/79, Energy Conservation and Renewable Energy Resources have been identified as the priority areas in awarding incremental funding, receiving 67% of $10.1 million in 1977/78 and 79% of $15.0 million in

1978/79. Energy conservation promises the cheapest route to balancing energy supply and demand in the near future, while renewable energy resources must be the ultimate response to energy supply problems. Traditionally industrial R & D has not been oriented to these areas. Because of the disaggregated nature of savings from energy conservation and the delayed payoff from most renewable sources R&D in these areas requires initial government support.

combustion, for gasification, and for conversion to liquid fuels. The energy potential of Canadian forests, harvested on a constant yield basis, will also be studied. Because renewable sources frequently produce energy intermittently, R & D on energy storage systems such as hydrides, batteries, and fuel cells will receive increased support. In addition, work will begin on the assessment of the technical and commercial factors involved in developing hydrogen as a fuel.

FUNDING OF FEDERAL ENERGY R&D PANEL TASKS

	Incremental Funding						Total Funding	
	1976/77		1977/78		1978/79		1978/79	
Energy R&D Task	$M	%	$M	%	$M	%	$M	%
	(millions of dollars and percent distribution)							
Renewable Energy Resources	1.0	10	3.3	33	6.3	42	13.6	9
Energy Conservation	1.8	19	3.4	34	5.6	37	16.7	12
Fossil Fuels	3.9	40	1.5	15	1.4	10	15.2	11
Nuclear Power	1.1	11	—	—	0.3	2	90.3	62
Energy Transportation & Transmission	1.7	18	1.0	10	1.2	8	7.4	5
Coordinating & Monitoring	0.2	2	0.9	8	0.2	1	1.2	1
Total	**9.7**	**100**	**10.1**	**100**	**15.0**	**100**	**144.5**	**100**

Note: Incremental funds are net new expenditures after allowance has been made for price increases.

Estimated expenditures for scientific activities related to renewable energy resources will be $13.6 million in 1978/79, an increase of $6.3 million over 1977/78. Spending on feasibility studies of solar heating for houses, commercial buildings, and in district heating systems will be significantly increased, and research on direct conversion of solar energy to electricity will be doubled. The work of the National Research Council and the Department of Fisheries and Environment related to the design and development of large wind turbines will be complemented by new studies of the integration of wind-generated electricity into existing power distribution systems.

Funding of R & D for biomass sources of energy will be increased to assess and demonstrate the potential of forestry and mill waste for direct

The 1978/79 estimated expenditures for R & D in energy conservation will be $16.7 million, an increase of $5.6 million over 1977/78. NRC will spend an additional $1.0 million in developing methods for improving the energy efficiencies of residential and commercial buildings. Transport will strengthen its investigation into ways to reduce liquid fuel consumption and to use substitute fuels in freight and passenger transportation, with an increase of $1.1 million. EMR will contract out a new $0.6 million project to investigate such concepts as co-generation, energy cascading and waste heat utilization to increase efficiency in power generation using conventional fuels. Fisheries and Environment will continue its cost-shared program with industry ($1.2 million) to develop and demonstrate technologies to recycle industrial waste,

complementing Industry, Trade and Commerce's program (1.5 million) to encourage energy-conserving systems and technology in industry.

In 1978/79 investigations will continue on potential energy savings with better town planning, energy-efficient consumer products and altered life styles.

Next in priority of incremental support has been R&D related to new Canadian opportunities in fossil fuel supply—the tar sands, heavy oils, and western coal deposits. While R&D on conventional sources of fossil fuel has been carried out by the multinational companies as part of normal operations, the unique problems of these new sources will at least initially require public support to develop the necessary technology. The special problems of oil and gas exploration, production, and transportation in the North also require governmental involvement. The major mechanisms for federal participation in fossil fuel R&D are federal-provincial and federal-provincial-industry cooperative programs. For example, the Alberta-Canada Energy Resources Fund ($96 million over six years), which is entering its third year, is concentrating on R&D related to coal mining and to increasing the yield from conventional oil and gas fields. An agreement between the federal and Saskatchewan governments is expected to lead to field trials of a method of increasing the recovery of heavy oils, starting in 1978/79. Each government will contribute $8 million over five years. Intramurally, research will continue at NRC and Energy, Mines and Resources on improving commercial oil production from the tar sands. In 1978/79 Environment will begin a four-year government-industry investigation of the environmental aspects of off-shore drilling near Baffin Island. Ninety percent of the $13 million estimated cost will be borne by industry but the objectives have been set by the government.

Increased scientific activity related to coal resources is being spurred by an annual increase of 10% in domestic consumption and projections of annual requirements of 100 million tons by the end of the century. The economics of coal development in northeast British Columbia are being jointly studied by the federal and provincial governments. It is expected that a project to investigate an accelerated substitution of coal in electrical power generation will be undertaken under the Canada-Nova Scotia Oil Conservation and Substitutions Agreement. Collaboration with industry and utilities will continue in 1978/79 on the evaluation of coal utilization and of more efficient mining and cleaning methods. For example, R&D is underway to develop methods for burning coal of variable quality and sulfur content (and even municipal garbage) which would not exceed pollution limits and would be cheaper than conventional coal-fired equipment.

Incremental funds of $1.2 million have been allotted to Energy Transportation and Transmission for 1978/79. One particularly important problem is the transportation of oil and gas through Arctic waters. R&D will be expanded to include ice movements, weather systems, ocean depths, and the Arctic performance of vessels, ports, and guidance systems. The expected increase in coal utilization requires R&D on new handling and transportation technologies both for solid coal and coal slurries. Increasing reliance on natural gas pipelines and the possible widespread use of liquified natural gas and hydrogen in the future requires the development of safe storage and handling systems. Northern pipeline studies, including their impact on northern development, will continue to be important. Specifically, there will be a feasibility study of supplying gas to northern communities from a large-scale Yukon pipeline. Another project will study the preservation of renewable energy resources during and after pipeline construction. The Canadian Electrical Association will receive an additional $0.3 million for R&D on electrical transmission and this will be complemented by a strengthening of NRC's research on high voltage transmission and measurement.

Under the Nuclear Power task, additional funding of $0.3 million is being provided to NRC in 1978/79, to assist in establishing a coordinated national program of research into controlled fusion. The purpose of the program is to maintain scientific awareness of international developments and to provide a scientific base upon which to develop an applied program, if and when this should be warranted. No incremental funding has been provided to the nuclear power R&D program of Atomic Energy of Canada Limited, although continuing support is required to maintain the competitive position of the CANDU reactor system and the Canadian nuclear industry.

The first major goal of AECL's program, the full scale demonstration of reliable and competitive electricity supply from the CANDU reactor, has been achieved with Ontario Hydro's Pickering generating station. The next major goal is to maintain reliable operation of the nuclear system including heavy

water production, as the number and size of generating stations increase. Goals for the forthcoming future include the demonstration of radioactive waste disposal and development of the technology for advanced fuel cycles that promise a nearly self-fueled CANDU reactor. The long-term goal (beyond 2000) is to exploit advanced nuclear power systems involving fusion and/or electro-breeding of fissile materials by means of intense neutron generators when their use is appropriate. Discussion of the structure of AECL's R&D program will be found in the Major Funders section.

Details of total energy-related S&T expenditures by department and agency are given below.

FEDERAL SCIENCE EXPENDITURES ON ENERGY

Department/Agency	1976/77	1977/78	1978/79
		(millions of dollars)	
Total	**148.3**	**160.4**	**183.5**
Atomic Energy of Canada Ltd.	96.7	82.5	92.2
Energy, Mines and Resources (Earth Science Services Program)	12.7	15.1	16.1
Energy, Mines and Resources (Energy Program)	16.6	28.8	30.6
National Research Council	10.2	16.4	24.8
Transport	—	3.5	2.8
Nuclear Control Board	0.6	1.1	1.8
Public Works	0.2	0.4	0.6
Urban Affairs	0.8	0.8	1.1
Central Mortgage and Housing Corp.	1.3	1.5	1.7
Environment	5.4	6.4	7.8
Others	3.8	3.9	4.0

Food

Technical innovation in the food sector, particularly in minimizing costs of production, is important not only to the domestic consumer but also to the maintenance of Canada's position as a major food exporter. The importance of the food sector is recognized in "A Food Strategy for Canada", published in May 1977, which states that the government's food policy is to provide Canadians with a nutritious, palatable diet at reasonable cost.

Although expenditure data on food S&T activities have not been specifically collected, it has been estimated from data on food-related work that the government will spend about $197.6 million in 1978/79 in this area, an increase of $20.3 million from 1977/78.

Both within the government and in Canada as a whole, Agriculture Canada has the major role in science and technology related to food production and processing, with an estimated expenditure of $134.7 million in 1978/79. One objective of the department's research is to establish new varieties of crops better suited to Canadian conditions. For instance, Manitoba farmers are experimenting with varieties of dill and Jerusalem artichoke, crops not previously grown successfully, and new wine and table grapes have been introduced in Ontario. A soybean variety called Maple Arrow is now available to growers in regions once found too cool for this crop.

As one example of a variety of projects aimed at improving animal and poultry breeds, the department is working with 60 breeders of registered Ayrshires in Ontario and Quebec to find out whether Ayrshires from Finland can contribute desirable characteristics to the breed.

The department's research into more effective control of plant diseases, insects, and weeds is pursued on several fronts. One project showed that it was possible to reduce the number of nodding thistles by 90% by releasing certain kinds of insects that feed on these weeds. In another experiment, male codling moths that had been sterilized by radiation were released in the apple orchards of the Similkameen Valley of British Columbia and effectively controlled the moth population. And in Ontario, Agriculture's scientists have identified as tomato ring spot, a virus that causes a serious decline in grapevines, and have developed procedures for using different rootstocks to overcome the problem.

In the area of research activity concerned with farming methods, of considerable promise is the discovery by the department's Lethbridge research station that under certain circumstances soil bacteria in the region of the roots of wheat can absorb, or fix, nitrogen directly from the air. New ways have also been developed to harvest and store grass as silage or hay that reduce both labour costs and the waste of the crop's nutrients. A cooperative study with the B.C. Forest Service has shown that land that has been cleared by loggers and reseeded can be used as cattle pasture for the first three years without damage to the young trees, a discovery that holds much promise for western ranchers.

At NRC, food research projects range from basic research on the improvement of nitrogen fixation by plants, the production of sex attractants for insect control, and studies on the nature of bacteria that spoil meat, to such practical applications as the development of high-protein pea chips from field peas and the commercial cultivation of edible sea weeds. The NRC will spend $10.7 million on food-related research in 1978/79.

The Fisheries and Marine Service of the Department of Fisheries and Environment plays a significant role in food research, with an estimated expenditure of $37.3 million in 1978/79. In addition to research designed to increase production of table-ready fish products and the strengthening of stocks of indigenous species such as lobster and Pacific salmon, the department is studying ways of improving the nutritional value of fish. The extension of Canada's coastal jurisdiction to 200 miles has increased the opportunities for Canadian exploitation of this food source. Aquaculture, involving the husbandry of aquatic plants and animals, will receive increased attention.

Other Environment expenditures on food-related scientific activities will total $0.7 million in 1978/79. The Environmental Management Service is studying the use of forest biomass for animal feed. This source of animal feed would free grain supplies for direct use in feeding man. The water quality activities of the service are also related to food in that they are aimed at reducing toxic substances in water and consequently in the food chain. Also relevant is the research in climate change conducted by the Atmospheric Environment Service at an annual cost of about $0.5 million. Since food production is so dependent on climatic conditions, improvements in predicting climatic change would assist food producers to plan more successfully.

One of the responsibilities of National Health and Welfare is to regulate the production of food to ensure an adequate level of safety and nutrition. Before the introduction of new foods and food technologies, the department requires documentary evidence that its regulations will be satisfied. For example, it determines to what extent processed foods should be fortified with essential nutrients. In general, by means of research, the department establishes criteria and regulations for the control of toxic materials and microbial hazards such as botulism and salmonella in foods and drinking water. A concerted effort is being made to reduce sources of infection and to ensure product safety at the market level. As a result of the research on lead toxicity in children, all baby foods, other than infant formulas and canned milks, are now packaged in glass or tin-solder containers, and the feasibility of a further reduction in allowable lead levels in food is being investigated.

Consumer and Corporate Affairs conducts some food-related scientific activities for the purpose of improving its consumer-protection regulations, which complement those of NHW.

In addition, Industry, Trade and Commerce also supports some industrial research and development related to food (approximately $0.8 million in 1978/79), though its primary objective is industrial support.

Oceans

Canada has more coastline than any other country, and its continental shelf, covering 250 million hectares (about a million square miles), is larger than the land area of most other countries. With the declaration of a 200-mile jurisdiction in 1977, ocean-related research has become increasingly important in the government's S&T programs. In 1978/79 it is expected that $61.1 million will be spent on ocean-related science activities, an increase of 14% from 1977/78. Further details are provided below.

FEDERAL SCIENCE EXPENDITURES ON OCEANS

Department/Agency	1976/77	1977/78	1978/79
		(millions of dollars)	
Total	**47.9**	**53.8**	**61.1**
Environment	33.8	37.5	44.2
Energy, Mines and Resources	4.5	4.6	4.7
National Research Council	0.7	1.9	0.9
National Defence	3.8	4.5	4.3
Others	5.1	5.3	7.0

In response to the growing interdependence of the government's ocean activities, the Panel on Ocean Management was established early in 1976. Chaired by the Department of Fisheries and Environment as the lead agency in ocean policy matters, the panel includes senior officials from 12 departments and agencies. The panel has defined the ocean management functions and the supporting systems Canada will require over the next 10 years. Six main areas of responsibility have been identified: renewable resources (primarily fisheries), non-renewable resources (primarily off-shore hydrocarbons), protection of the marine environment, development and control of navigation, defence, and international concerns.

NRC and Ocean and Aquatic Sciences of Fisheries and Environment have a continuing program to develop data buoy technology with Hermes Electronics of Dartmouth, Nova Scotia. 1978/79 will be the fourth year of the program, which began as an unsolicited proposal, initially funded by Supply and Services and subsequently by Environment and NRC.

As part of its international activities Canada participates in and supports programs of the Intergovernmental Oceanographic Commission, an agency affiliated with the United Nations. Ocean and Aquatic Sciences is supplying drifting buoys for the First Global Atmospheric Research Experiment, a weather monitoring project organized by the World Meteorological Organization and the IOC; it is part of the long-term Global Atmospheric Research Program. In addition, as a part of the Integrated Global Ocean Stations System, Canada regularly transmits and receives data on sea surface temperature, salinity, and ocean currents through the World Ocean Data Centre in Washington.

Energy, Mines and Resources carries out research and field surveys in the coastal areas and the continental shelf as part of its earth sciences program, an activity whose importance has greatly increased because of the offshore oil and gas potential. The department has contracted out oceanographic studies at Pond Inlet, N.W.T., to obtain data on Arctic water columns and the characteristics of sea ice formation. A related project was the construction of the portable satellite-receiver station to receive LANDSAT imagery of ice and cloud conditions in the Arctic, both for geoscience purposes and as an aid to navigation in northern waters.

By participating in the American satellite project SEASAT-A, Canada expects to develop techniques for all weather surveillance of its 200-mile limit. Microwave sensors will be able to measure such ocean properties as sea state, geodetic elevation, temperatures and wind velocity at the surface, and will also be able to monitor floating ice, icebergs, and ship movements through cloud cover.

Scientists and engineers of Huntec '70 Limited have made a major breakthrough in underwater exploration by inventing a stable, towed, underwater, seismic profiler. The unprecedented

accuracy of the device will permit precise measurement of sea bottom profiles and deposits in depths up to 3,000 metres. NRC and EMR are cooperating with Huntec '70 by providing development funds and technical assistance.

An ocean-related research facility opened in 1977/78 was the deep-diving complex at the Defence and Civil Institute of Environmental Medicine, Toronto. It is described in the section covering the Department of National Defence.

A program with the objective of developing Canadian excellence in operating on and in ice-covered waters was initiated in 1977/78. This program will eventually involve scientific activities related to weather forecasting, ice forecasting, hydrography, communications, navigation aids, search and rescue, arctic vessel research, ice breaking, oil-spill containment and clean-up, and arctic engineering research. With the need for restricting expenditure, effort has been concentrated on oil-spill containment, under the direction of the Environmental Protection Service of the Department of Fisheries and Environment. This involves research into the behaviour of oil in ice and ice-covered waters, research on the physical properties of ice, development of improved methods and equipment for cleaning up oil-spills, and the provision of clean-up equipment.

The Canadian Hydrographic Service of Environment, with support from the Ministry of Transport, will continue a program to improve the measurement of ice thickness and bottom profiling through ice. In 1978/79 work will be expanded into ice physics and electromagnetic and acoustic propagation in ice and ice-covered waters. The service wants to test the effectiveness of hovercraft, helicopters, and tracked and wheeled vehicles as survey vehicles. Most of these studies are contracted to industry. In addition, an over-the-ice sonar system capable of detecting underwater hazards is under development as a result of an unsolicited proposal from industry.

Icebreaking trials using air-cushion technology will continue in 1978/79. One task is to reduce the spray and icing that occurs when air-cushion devices are used in the North. This technique of ice breaking has progressed far enough to be useful to the St. Lawrence Seaway Authority, the Alberta government, and the United States Coast Guard.

In 1976 the Atmospheric Environment Service of Environment began to analyse all historical ice charts on file in Ice Forecasting Central, looking for information on the rate of progress and the extent of ice break-up in Canadian Arctic waters. As this project continues, the location, amount, age, class, and size of ice flows will be defined and extremes and medians established, with the objective of publishing the Arctic Ice Atlas.

Space

An orbiting satellite often provides the only practical means of transmitting information over a very wide area. Thus, space technology has particular relevance to distinctively Canadian problems resulting from our severe climate, vast distances, and sparsely populated areas. The government's space activities are aimed at developing applications in support of national goals: improvement and

FEDERAL SCIENCE EXPENDITURES ON SPACE

Department/Agency	1976/77	1977/78	1978/79
		(millions of dollars)	
Total	**47.5**	**66.5**	**71.1**
National Research Council	29.2	36.0	30.4
Communications	6.9	14.8	23.7
Energy, Mines & Resources	9.5	9.8	10.6
National Defence	—	0.5	2.4
Environment	1.6	1.7	1.8
Transport	—	3.3	1.9
Others	0.3	0.4	0.3

extension of communications, weather forecasting, management of natural resources, search and rescue missions, and surveillance.

In 1978/79 the government will spend some $71.1 million on S&T for space applications. As shown in the table, several departments and agencies are involved in space-related scientific activities.

While each department and agency retains responsibility for the formulation and implementation of its own program, co-operation and co-ordination is exercised through a committee of senior officials, the Interdepartmental Committee on Space, which reports to the Minister of Communications. This committee has set up special sub-committees to deal with the scientific, industrial, and international aspects of space programs.

Most of the government's space-related scientific activities fall under one of three heads: R&D on systems for the performing of experiments, experiments and pilot projects using these and other systems, and the use of space systems for data collection and other operations. In the first group is the project to design, develop, and flight-qualify a Remote Manipulator System, an arm-like device with electro-mechanical joints, which is an important component of the American Space Shuttle. The work is being carried out in Canadian industry under NRC project management. The largest Canadian space project underway, it has a total budget of $89.9 million, with an estimated expenditure of $20.8 million in 1978/79.

A project in the second category is the set of experiments being undertaken by the Department of Communications on the use of the 14/12 gigaHertz frequency range, using its Hermes satellites (launched in January 1976). These frequency bands have advantages over the 6/4 gigaHertz band for certain applications because smaller, less expensive earth stations can be used and because there are fewer restrictions on where earth stations can be located, due to the absence of terrestrial microwave systems operating in the 14/12 gigaHertz bands. The Hermes satellite is currently the most powerful communications satellite in orbit and the first to have an operational 14/12 gigaHertz transponder. It provides a unique opportunity to investigate new applications and techniques of satellite communications, for example direct broadcasting to small low-cost earth stations in remote areas. The more promising applications from this project will be investigated further by using the 14/12 gigaHertz capability of Telesat's Anik-B satellite, which is due to be launched in November 1978.

One project that contains elements of all three categories of space related research is called SEASAT-A. SEASAT-A will be a proof-of-concept NASA satellite carrying a variety of microwave and optical sensors. Canada's participation in this program is being coordinated by the Canada Centre for Remote Sensing of Energy, Mines and Resources, and many departments will perform experiments using the data provided by the satellite. (See Oceans in the Special Applications section.) For example, National Defence employing the expertise of the Department of Communications and the Communications Research Centre will be the lead department in experiments concerned with human activities and with ionospheric and sea clutter effects and, supported by Canadian industry, will develop and provide a radar image recorder and an optical correlation facility to process data from the satellite's synthetic aperture radar.

In addition to SEASAT-A, National Defence is cooperating with the U.S. Department of Defense in the NAVSTAR global positioning system, which will use polar orbiting satellites to allow users to fix their location with greater accuracy. Another satellite system which is also in the third category and with which DND (and also the Ministry of Transport) is involved is SARSAT. Previous work by the Communications Research Centre and DND has shown that signals from the emergency locator transmitter carried by most civil aircraft and some small vessels could be detected by a suitable satellite receiver and the transmitter's geographical position determined to within a few kilometers minutes after the satellite's passing. Canada will provide the satellite amplifier-transmitter and the design of the ground station, and NASA will integrate the amplifier-transmitter with its TIROS-N weather satellites. The Ministry of Transport's participation in this and other space projects relates to its objective of improving the safety and efficiency of air and marine operations.

The Canada Centre for Remote Sensing, in addition to its SEASAT work, maintains a satellite receiving station at Prince Albert, Saskatchewan, and has recently installed another at Shoe Cove, Newfoundland. These stations receive, analyze, and distribute information transmitted by the American earth resources (LANDSAT) and weather (NOAA) satellites. The Shoe Cove station will also receive data transmitted from the SEASAT-A experiments.

These are one part of an interdepartmental program called SURSAT, also headed by the Canada Centre for Remote Sensing, to study the role of satellites in an all-weather surveillance system. Environment's Atmospheric Environment Service operates three weather satellite ground receiving stations to receive data from American weather satellites.

Energy, Mines and Resource's Earth Physics Branch also supports the operation of satellite tracking stations as part of a global network to monitor the TRANET and Beacon series of satellites. These have applications in mapping broad features of the global gravity field and in studying the geoid. The Surveys and Mapping Branch uses LANDSAT imagery as a quick updating tool for topographic maps, particularly in wilderness areas where exploration and development result in rapid and important changes, and uses other satellite-obtained information for more precise reference location in the national geodetic network.

The Space Research Facilities Branch of NRC provides national facilities, such as the balloon and rocket launching facility at Fort Churchill. Also at NRC, the Herzberg Institute of Astrophysics and the Dominion Observatory carry out research ranging from laboratory work on the spectra of molecules to astronomical observations using ground-based radio and optical telescopes and studies of the near-earth space environment using rocket and satellite techniques.

Transportation

Transportation is an essential thread in the social and economic fabric of any country, but the large, sparsely populated land of Canada depends particularly heavily on effective transportation. In 1978/79 the government will spend $97.7 million on science and technology for transportation. In addition, many transport-related research activities are reported in the sections dealing with energy, oceans, and extramural activities. Details of the major departmental expenditures are given in the table.

FEDERAL SCIENCE EXPENDITURES ON TRANSPORTATION

Department/Agency	1976/77	1977/78	1978/79
		(millions of dollars)	
Total	**76.8**	**94.3**	**97.7**
Transport	24.2	34.8	30.4
National Research Council	14.4	16.5	20.8
National Defence	6.0	9.3	11.5
Energy, Mines and Resources	2.8	2.1	2.2
Others	29.4	31.6	32.8

In addition to these major funders, Industry, Trade and Commerce supports transportation R&D in industry, with an estimated $37.4 million in 1978/79. Starting in 1978/79, transportation R&D will be coordinated by an interdepartmental panel and a program committee. Their main responsibilities will be to develop R&D objectives to meet the country's transportation requirements, develop the outlines of an R&D program, and recommend the assignment of co-ordinating responsibility for particular elements of the program to particular departments.

The major funder of transportation research is Transport, which will spend $30.4 million or 31% of the transportation research funds in 1978/79. Its projects cover improvements to existing systems as well as research and development on advanced systems and components not yet in operation. It also studies the integration of new technology with regular transportation services.

Railway research includes shared-cost programs with both major railways on train/track dynamics. With the formation of Via Rail Canada, projects are being developed in rail passenger policy areas

concerned with such matters as seating and protected crossings. The development of a new location, identification, and control system for railway signalling is proceeding successfully. The system uses transponders, which reply automatically to an electronic query, and incorporates a data link between the locomotive and the dispatch centre.

The department is proceeding with a number of road and highway research projects. A joint project with the National Research Council is investigating the use of plastic insulation to replace part of the granular fill used in northern roads so as to maintain the permafrost in a frozen state. Another study is examining the use of steel fibres to strengthen concrete in highways and bridge decks. It is estimated that some $2 million will be spent on research on highway accident reduction, including studies of the effect of improved vehicles and roads, in 1978/79.

The department has two major urban transit projects under way. Over the past two years, $1.5 million has been allocated for the design of an intermediate capacity urban transit system to run on existing railway lines and rights-of-way. One of the objectives is to reduce implementation costs so that even small cities can afford such a system. In a joint project with the City of Mississauga, Ontario, the department is developing an automated bus passenger information system that uses automatic vehicle location and computer voice response to give prospective bus riders up-to-date information on the best routing between different points. If effective, the system has potential application on other kinds of transit and promises savings in operational costs and commuter travel time.

The St. Lawrence Seaway Authority is building two shunters for a test program in the Welland Canal during the 1978 navigation season that will determine how much ship transit time can be saved. Success could increase the capacity of the seaway.

Improved methods of transport and technical assistance to the transportation industries are key elements in the research programs of the National Research Council's engineering divisions. Major projects are underway in all modes of transportation. The council's research facilities include wind tunnels, towing tanks for testing ship designs, railway track simulators, and large scale models of Canada's rivers, estuaries, and harbours to assist in managing shoreline and dock facilities.

Science activities at Energy, Mines and Resources affect transportation in various ways, e.g., by providing permafrost information for transportation decisions in the North. The portable satellite-receiving station operated by the department provides information on cloud and ice conditions for marine navigation in the Arctic. The Canada Centre for Mineral and Energy Technology is investigating various materials problems in transportation. A cooperative project with railways and rail manufacturers is developing fully weldable, premium-quality rail for use in mountainous terrain, where standard rail is quickly worn out on sharp curves.

Other departmental projects are concerned with increasing automotive fuel economy. For example, one project is investigating the forming and corrosion problems that will arise from the use of aluminum and thinner-gauge steels in the light-weight automobiles of the future. Another is examining the fuel efficiencies of new engine design, including the use of electronic microprocessors, especially in winter.

EXTRAMURAL ACTIVITIES

Introduction

Industry

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EXTRAMURAL ACTIVITIES

Introduction

Government-funded activities carried out in the private sector, other levels of government, or in other countries are classed as extramural activities. The government also attempts to create an environment that will encourage innovative capability in the private sector, through tax, tariff, patent, competition, trade, and special procurement polices and special transfer payments to the provinces.

Last year the government announced certain policy and organizational initiatives that are intended to enlarge or improve its support of the private sector. The contracting-out policy was extended to include on-going as well as new government scientific and technological requirements. In 1978 departments and agencies will assess the feasibility of contracting-out in-house scientific programs in the natural sciences and in the human science fields of urban, regional, and transportation studies. Intramural activities will be retained in circumstances in which it would not be in the national interest to contract out. Under this policy, it is expected that the government's scientific programs will augment rather than compete with scientific efforts in the private sector. Results to date indicate that the policy is benefiting small and medium-sized Canadian-owned firms, particularly those that use high technology.

In its development of policies in support of industrial research and development, the government is moving toward indirect rather than direct support. This was reflected in the 1977/78 budget, which contained a variety of measures designed to stimulate industrial investments generally and industrial R & D in particular. The budget extended the 5% investment tax credit for an additional three years and included current and capital R&D expenditures made between March 31, 1977 and July 1, 1980. This should increase R & D tax incentives to industry by more than $35 million a year. The budget also proposed a more favourable tax treatment of stock option plans for employees of Canadian-controlled private companies and allowed the deferral of capital gains taxes when the proceeds of the sale of a business are reinvested in the same line of business. It was also recommended that the Tariff Board be asked to re-examine the duty-free status of certain tariff items, particularly those dealing with scientific apparatus. The budget proposals are parts of an evolving structure for indirect funding that is being designed to complement the direct support programs. The benefits of the extended tax credits are expected to flow principally to the large and medium-sized industrial research establishments whereas the other proposals are intended to help the many small, high-technology enterprises.

The past year has also seen three significant developments in government support of science in the academic sphere. Parliament approved legislation creating two new granting councils (the Natural Sciences and Engineering Research Council and the Social Sciences and Humanities Research Council) and expanded the mandate of the Medical Research Council to include support for public health research. It is the government's intent to reorientate the support of university research under the revised councils in order to enhance the support of excellence, to encourage research towards national objectives, to foster interdisciplinary effort, to provide for centres of concentration within a regional balance of scientific capability, and to maintain a basic capacity for research training in Canadian Universities.

As a tangible expression of its commitment to the maintenance of a healthy level of scientific enquiry in

the university sector, the government increased the 1977/78 budgets of the granting councils by $20 million. This amount was to compensate for inflationary increases in the cost of research programs and to enable initiation and expansion of programs designed to meet some of the objectives above. In the National Research Council, where part of these funds were allocated to research in energy, oceanography and environmental toxicology, an enthusiastic response has been forthcoming from the academic community.

The Canadian Committee on Financing of University Research was established to provide a focal point for the exchange of information among the universities and the federal and provincial governments and to make recommendations on policies, programs and procedures affecting the financing of university research.

These actions reaffirm the government's belief not only in the importance of a healthy and active university research community, but also in the need for an environment of continuity and freedom. The granting councils will continue to apply the criterion of excellence assessed by the peer review system as a necessary condition of support. Moreover, free inquiry will continue to receive a significant proportion of council grants.

In view of the importance of an optimal application of science and technology to national issues, however, it is no longer appropriate that all university research should be supported solely on the basis that it expands the frontiers of knowledge. The capabilities of the university research community need to be applied to a much greater extent than hither-to, not only to problems of direct concern to governments and industry, but also to the more general issues facing Canadian society.

Since there are an increasing number of issues that require multi- and interdisciplinary approaches, an Inter-Council Coordinating Committee will be established with the cooperation of the three granting councils. This committee, chaired by the Secretary of MOSST and reporting to the Minister of State for Science and Technology, will have an advisory and coordinating, but not directive role. It will act as a forum for the consideration of areas of mutual concern and will seek to ensure appropriate coverage of recognized disciplines and interdisciplinary research, as well as to harmonize granting practices. It will advise on the balance among the council budgets, in the context of the budget and administrative responsibility of each council.

Extramural activities also include international activities and here the government participates in two significant ways: it cooperates in joint R&D activities with a variety of countries and international organizations, aiming to reach identified common objectives, and it finances R&D programs relevant to the interests of Third World countries as part of Canada's overseas development aid.

Industry

As has been noted, the government's support for scientific activities in industry is now a mixture of indirect support (e.g., the recently expanded contracting-out policy) and direct support (e.g., Industry, Trade and Commerce's direct incentive programs). Details of government funding are given in the table.

Government expenditures in the industrial sector will be $275.4 million in 1978/79, a $6.3 million increase over those in 1977/78. An important aspect of these expenditures is the increase of $18 million in R&D contracts, a 13.7% increase from 1977/78. The R&D grants program will show a decrease again this year, primarily as a result of the cancellation of ITC's Industrial Research and Development Incentives program. Expenditures for related science activities are expected to increase to $46.9 million.

The National Research Council is the largest purchaser of industrial science with estimated expenditures of $29.5 million in 1978/79. The bulk of this expenditure will be for the development of the Remote Manipulator System for the NASA Space Shuttle program (further details appear under Space in the Special Applications section).

The council will contract a further $5.4 million in 1978/79 through the Program of Industry/Laboratory Projects (PILP), the objective of which is to accelerate the transfer of new technology from the council's laboratories to industry. Some examples of projects are the development of thin film technology, particularly as an aid against counterfeiting of documents; purification of effluents from tar sands; and the development of photogrammetric plotting instruments to assist in resource evaluation and map making.

FEDERAL SCIENCE EXPENDITURES IN INDUSTRY

	1976/77	1977/78	1978/79
		(millions of dollars)	
Total	**268.2**	**269.1**	**275.4**
R&D Contracts — Total	**106.3**	**131.4**	**149.4**
National Research Council (Excl. PILP)	22.8	33.4	29.5
National Research Council—PILP	2.1	4.4	5.4
Atomic Energy of Canada Ltd.	36.0	23.1	21.7
Communications	3.3	13.0	24.8
National Defence	12.8	17.5	24.2
Transport	4.8	8.8	8.7
Environment	5.7	6.2	7.3
Energy, Mines and Resources	5.0	7.7	8.8
Supply and Services (Unsolicited Proposals)	6.1	6.9	6.9
Others	7.7	10.4	12.1
R&D Grants — Total	**122.6**	**93.1**	**79.1**
Industry, Trade and Commerce—(Excl. IRDIA)	65.6	58.9	57.0
Industry, Trade and Commerce—IRDIA	40.0	15.0	0
National Research Council—IRAP	14.5	15.8	18.0
National Research Council—Research Fellowships	0.9	1.3	1.6
Others	1.7	2.0	2.5
RSA — (grants and contracts) Total	**39.2**	**44.7**	**46.9**
Canadian International Development Agency	9.9	11.2	11.2
Communications	0.7	0.8	0.8
Transport	9.7	9.3	9.8
Sypply and Services (Unsolicited Proposals)	2.6	3.0	3.0
Others	16.3	20.4	22.1

Atomic Energy of Canada Ltd. will spend an estimated $21.7 million in Canadian industry in 1978/79. The nuclear industry is one of the few in Canada in which the technology base has been nationally generated rather than imported. The benefits of this are not confined to the use of nuclear power plants. For example, the development of a Canadian industrial capability in high quality metal tubing and valves for use in nuclear reactors has led to significant exports. Domestic expenditures in the nuclear industry for nuclear equipment, facilities, and sites, exclusive of expenditures for plant commissioning, financing, and administration, are forecast to exceed $1 billion in 1978/79.

The Department of Communications will spend approximately $24.8 million in 1978/79 on contracts for both space and communications research. The

department will contract-out for studies in areas such as the applicability of fibre optics to communication systems in rural areas, and the development of interactive computer graphics and image display systems.

The Department of National Defence will spend approximately $24.2 million in industry in 1978/79 for the design and production of prototypes and for service-test models of equipment for the armed forces.

The main purpose of the Science Centre of the Department of Supply and Services is to manage contracts with the private sector on behalf of other departments and agencies. It also serves as a focal point for unsolicited proposals for science and technology and manages a fund of $12 million to assist departments in the bridge-financing of proposals that are within a department's mission. This mechanism provides interim funding for an unsolicited proposal if the department does not have sufficient resources in its own current budget to fund the complete proposal. From its inception to the end of 1977 a total of $32.3 million has been committed from the unsolicited proposal fund with an additional $13.2 million committed from the sponsoring departments' own budgetary resources. For 1978/79 an estimated $9.9 million will be spent in industry, $6.9 million for R&D and $3.0 million for RSA.

Another large component of government funding of R&D in industry is through direct incentive grants. Industry, Trade and Commerce is the major contributor to industrial R&D funding under this form of financing. In 1975, after studying the effectiveness of its granting programs, the department decided to consolidate several industrial R&D programs into one Enterprise Development Program and to widen its scope to include other aspects of innovation. The program supports product development, pre-production design and engineering, productivity studies, and market feasibility and strategy studies. The department assesses the commercial prospects of projects in the context of the applicant's resources and constraints, the market opportunities, and the strategy proposed for mobilizing resources to exploit the market. Normally up to 50% of the eligible costs of accepted projects are covered.

Subsequently, the program was expanded to include technical assistance for small companies. This permits payment of 50% of the value of a technical assistance contract between a small company and approved organizations such as provincial research institutions, up to a maximum of $10,000. It is estimated that up to $23.0 million will be spent in 1978/79 for the innovation assistance component of the program compared to forecast expenditures of $23.4 million in 1977/78.

The Defence Industry Productivity Program, another of the incentive programs administered by ITC, provides assistance to companies for the purpose of developing and sustaining the technological capability of the Canadian defence industry as a means of generating economically viable defence and related civil exports. It helps to finance selected R&D projects and the acquisition of machine tools required for plant modernization. The costs of these projects are shared by ITC, the Canadian company concerned, and, at times, the governments of other NATO countries. Government spending on this program is estimated to be $44.2 million for 1978/79 of which about $33.5 million will be in support of development projects compared to $32.6 millions in 1977/78.

NRC also provides direct support for science and technology in industry. The Industrial Research Assistance Program provides funds for the salaries of industrial scientists engaged in long-term applied research. Support is concentrated on the establishment of new industrial research teams or the expansion of existing groups. This program supports about 10% of the scientists engaged in R&D in the manufacturing industries. The estimated level of funding for 1978/79 is $18.0 million compared to $15.8 million for 1977/78, an increase of 14%.

The Grants and Scholarship program of NRC will assist in the transfer of commercially promising technology from the universities to Canadian industry. For example, grants are made under the sub-program Project Research Applicable in Industry to support applications in industry arising from research advances in universities that appear to have promising commercial benefits. These grants are normally for two years or less. The results may be published unless patent or commercial considerations indicate otherwise. A variety of fellowships are also available to encourage university graduate students and faculty members to spend some time in an industrial environment. Estimated expenditures under these programs are $1.6 million for 1978/79, an increase of 23% over the corresponding 1977/78 figure of $1.3 million.

NRC also operates the Technical Information Service to provide scientific and technical information and assistance primarily to small and medium-sized Canadian manufacturing firms. This service uses an in-plant "help-them-to-help-themselves" approach by drawing on the field staff's practical experience and the experience of NRC and other government research personnel. Its budget for 1978/79 is $1.9 million.

University

The government's expenditures in the university sector include direct support in the form of grants and contributions and contracting for S&T requirements in support of departments' missions. The total expenditures for 1978/79 are estimated at $240.6 million, a 6.5% increase from 1977/78. Further details are given in the table.

FEDERAL SCIENCE EXPENDITURES IN UNIVERSITIES

	1976/77	1977/78	1978/79
		(millions of dollars)	
Total Expenditures	**197.6**	**225.9**	**240.6**
Total R&D	**169.9**	**193.7**	**208.6**
R&D Grants	152.5	173.3	187.5
Medical Research Council	45.5	51.0	53.9
National Research Council — Grants and Scholarship Program	79.5	83.9	90.9
Canada Council — Social Science and Humanities Research Program	9.6	9.6	12.1
National Health and Welfare	9.7	12.7	13.0
Others	8.2	16.1	17.6
R&D Contracts	9.5	12.1	12.8
Research Fellowships	7.9	8.3	8.3
Total RSA	**27.7**	**32.2**	**32.0**
Total Education Support	**23.1**	**24.7**	**24.7**
Medical Research Council	1.0	1.3	1.4
National Research Council — Grants and Scholarship Program	8.2	8.7	8.7
Canada Council — Social Science and Humanities Research Program	7.6	8.1	7.4
Others	6.3	6.6	7.2
Other RSA	4.6	7.5	7.3

Eighty-seven percent of the government's direct support of university science is for R&D; the remainder is for RSA. This support is largely in the form of grants-in-aid of research funded primarily through the three granting councils, the Medical Research Council, the National Research Council, and the Social Sciences and Humanities Research program of the Canada Council. These three councils provide over 70% of the government's direct support to the university sector.

Although still at a relatively low level, contracted R&D is estimated to increase by 6% next year. Research fellowships awarded to individuals to carry out research or obtain advanced training will continue to be a significant avenue of R&D support at $8.3 million in 1978/79.

Seventy-seven percent of RSA, or $24.7 million, will be for education support in 1978/79. Education support covers grants to individuals or institutions intended to support the post-secondary education of students in the natural and human sciences, but does not include general purpose grants to the institutions.

The NRC, with the largest grant and scholarship budget of the three granting councils, will pay to the universities an estimated $100.4 million in grants in 1978/79, compared to $93.4 million in 1977/78. Of this amount $81.3 million (81%) will be awarded under the Peer Adjudicated Grants Activity for grants-in-aid of research to selected individuals and groups for regular research operating expenses and equipment.

Grants totalling $9.6 million will be awarded in 1978/79 under the Developmental Grants Activity to individuals, groups, and institutions for major research installations, special research programs and projects, and regional development of research capability to meet needs related to scientific, economic, and resource development.

The Highly Qualified Manpower Training and Development Activity, with estimated payments of $9.5 million in 1978/79, provides scholarships and fellowships in national competitions to post-graduate students, scientists, and engineers for advanced study in universities.

In order to provide a strong incentive for university researchers in science and engineering to undertake research in selected priority areas of national concern, NRC has recently established a Strategic Grants program under the Developmental Grants Activity and will provide special funds amounting to $2.6 million in 1978/79 for research in energy, chemical/environmental toxicology, and oceanography. This special support is in addition to a substantial amount of relevant research supported under regular grants.

The Medical Research Council's estimated grants to university science in 1978/79 will be $57.8 million, compared to $54.6 million in 1977/78. About two-thirds of the 2,200 active investigators in the health sciences in Canadian universities and teaching hospitals receive at least some support from MRC. This support represents 43% of Canadian expenditures on health research.

Much of the research supported by the council is basic research aimed at increasing knowledge in health sciences. For instance, biochemical studies of glycolipids and glycoproteins may increase understanding of certain inherited neurological diseases and their prevention or management. Studies on the biochemistry of brain amines may provide insight into the cause and treatment of schizophrenia.

Another large segment of the work the council supports is applied research, relating to clinical trials of new drugs, the improvement of diagnostic and treatment methods, and the development of new therapeutic procedures and devices. For example, research is being conducted on the more complete use of donated blood and a computer method for the early detection of cardiac disorders is being developed. A nation-wide study has determined that amniocentesis is a safe and effective method of diagnosing genetic disease.

A new program of heart research development grants will be launched in 1978/79. It should stimulate research into cardiovascular disease, which has accounted for approximately half of all deaths in Canada in recent years.

Supporting these research projects and programs accounts for about 80% of the council's expenditure each year. A further 18% of the budget goes to the direct support of health science personnel. The council continues to make a major contribution to the salaries of some 70 senior career investigators in universities across the country, who devote their full time to research and the teaching of graduate students. A similar amount is spent to support, for a five-year period, the salaries of young scientists taking up their first faculty appointments so that

they can launch research programs before assuming the usual teaching duties.

In addition to various programs based on national competition, a similar number of training positions are supported under grants for research support, where the recipients are selected locally by the researchers concerned. The majority of those who receive such awards will become the active investigators and highly qualified teachers of the future.

A small amount of the council's funds goes to the support of small working groups, modest research grants to each dean of medicine, dentistry, and pharmacy for local research needs, and payment of dues to international scientific organizations in the health sciences.

Grants to the university sector under the Social Sciences and Humanities Research program of the Canada Council are estimated to be $24.4 million in 1978/79 compared to $23.3 million in 1977/78. The majority will be devoted to direct support of research through the provision of research grants, leave fellowships for full-time research, general research grants, and negotiated grants.

It is likely that the support of graduate study, which has remained at a fixed level for several years, will receive early consideration by the new council, since the report of the Canada Council's Healy Commission on Graduate Studies is expected early in 1978. The recent decline in demand for research grants appears to be ending, and changes in budgetary allocations may be necessary as the trend becomes established.

Among the other government departments and agencies supporting university science, National Health and Welfare is the largest funder, with an estimated support of $16.8 million for 1978/79. As its principal funding mechanism, the National Health Research and Development program will provide over $11 million to support extramural studies and R&D projects, in such areas as improving existing health services; testing the cost and effectiveness of new types of service, including home care for the elderly; identifying and measuring occupational health risks; tracing the spread of diseases; improving the understanding of mental health factors; assessing the efficacy of public health measures; and developing programs for improving lifestyle.

Agriculture Canada expects to award university operating grants totalling $3.8 million in 1978/79 of which $1 million will be for support of graduate training. Also included are extramural research grants ($0.3 million in 1978/79) to support research complementing departmental activities. Besides these grants, $1.8 million will be contributed for the expansion of veterinary medical facilities.

Energy, Mines and Resources expects to provide grants totalling $1.3 million in support of university research, approximately equally distributed among the Earth Science Services, Mineral and Energy programs.

Of the $2.0 million for university research support coming from Fisheries and Environment in 1978/79, $1.0 million is for water resources research, $0.3 million for meteorological research, and $0.3 million for forestry research projects, and $0.4 million is for marine and aquatic research and fisheries and marine economic research.

Industry, Trade and Commerce has, since 1967, established ten industrial research institutes and nine centres of advanced technology connected with or located on university campuses across Canada. In addition, three industrial research associations have been established since 1973 with departmental assistance. After receipt of start-up financial assistance most of these institutions are now self-supporting. The 1978/79 requirement for continuing support to those institutions not yet self-supporting is estimated to be $1.5 million.

Through NRC, the government will continue to provide contributions of $8.7 million in 1978/79 for the completion of ancillary equipment and for the operating costs of TRIUMF, the medium energy proton accelerator and meson facility located at the University of British Columbia. This is over and above support of research being conducted at TRIUMF, which is funded by the grants and scholarships program of NRC and other non-government sources.

The Transportation Development Centre of Department of Transport will continue to provide $1.1 million to universities to encourage research training in disciplines and areas of study of particular relevance to the transportation field.

Provincial Sector

As part of its extramural scientific activities, the government not only funds provincial S&T but undertakes joint programs with the provinces. Regional Economic Expansion supports programs of research on the development and adjustment of manpower resources in selected areas, and programs related to industrial research and development services to industry. Most of the S&T activities that the department funds are in the Atlantic provinces and Quebec.

In 1978/79 Energy, Mines and Resources expects to provide $10 million to the Alberta/Canada Energy Resources Fund for energy research and development projects and nearly $2 million to the joint Canada-Saskatchewan program for the development of heavy oil recovery technology. The department also estimates that $1.3 million will go to the province of Newfoundland under the Mineral Development Agreement with that province. EMR's Earth Science Services program will contribute $0.2 million to Manitoba for an evaluation of its non-renewable mineral resources.

The various services of Fisheries and Environment have extensive contacts with the provinces. For example, the department is associated with the Alberta Oil Sands Environmental Research Program. Atmospheric Environment is the lead agency for the meteorological and air quality aspect of this study, and expects to spend approximately $0.4 million on it in 1978/79.

Over $17 million is being allocated for contributions by Environmental Management toward federal-provincial projects, e.g., the James Bay Environmental Assessment program, federal-provincial flood damage reduction agreements, federal-provincial river basin plan implementation agreements, and the Canada-Ontario Great Lakes Water Quality agreement. These programs involve federal-provincial cooperation in addressing problems and opportunities in renewable resources management and environmental quality.

The Health Programs Branch of National Health and Welfare will contribute approximately $10 million from its Health Resources Fund to the provinces and territories for the construction of research facilities.

The Income Security and Social Assistance program estimates that it will contribute $4 million to the provinces (including welfare agencies, schools of social work and some individuals) to support activities for the improvement of welfare services. The program will also spend about $1 million each for guaranteed income experimental projects and for contributions to the provinces (and also people and organizations) for the purpose of developing and implementing welfare information systems.

Transport uses S&T to identify and develop cost-effective road safety programs that affect the driver, the road, and the vehicle. These programs are designed to be implemented by federal and provincial government departments. Transport also assists the provincial governments in measuring the effectiveness of road safety programs such as vehicle inspection, driver licensing, and driver education. Transport's Administration program plans to contribute $0.4 million to provincial and municipal governments for research and demonstration projects, and the Surface Transportation program will spend $0.9 million for various research and demonstration projects dealing with urban transportation.

The Ministry of State for Urban Affairs works closely with the provinces and their municipalities to have them develop criteria and plans for urban development, and also provides financial support so that provincial and municipal governments can produce and implement comprehensive development plans for city centres.

Atomic Energy of Canada Ltd.'s provincial cooperation occurs chiefly in its working relations with electric utilities that have nuclear generating programs, currently Ontario, Quebec, and New Brunswick. Three prototype reactors owned by AECL are operated by the utilities in these provinces under contract to the corporation. All three serve as test-beds for development work ranging from fuel-related studies to the design and development of special instrumentation for the nuclear reactors. AECL undertakes joint R&D programs in many areas with the utilities and with provincial research institutes and negotiates cost-sharing arrangements when appropriate.

International

This section discusses government expenditures on international scientific activities performed both domestically and in the foreign sector. Estimated expenditures for 1978/79 are $76.9 million. The principal agencies involved in supporting activities in the foreign sector are the International Development Research Centre (IDRC) and the Canadian International Development Agency (CIDA). Details are given in the table.

projects in the most effective way without regard to the source of the resources. Since IDRC's primary goal is to enable institutions and individuals in developing countries to become self-reliant, heavy emphasis is placed on developing these countries' own research capability. Accordingly, about 7% of the centre's resources to date have been spent on research in Canada, at universities and elsewhere, in support of field projects in the developing regions.

FEDERAL SCIENCE EXPENDITURES IN THE INTERNATIONAL SECTOR

	1976/77	1977/78	1978/79
		(millions of dollars)	
Total	**70.1**	**70.1**	**76.9**
by foreign performers			
Canadian International Development Agency	8.5	8.1	11.2
International Development Research Centre	23.5	21.1	21.9
National Research Council	6.7	3.9	2.2
Others	8.4	10.2	13.3
Sub-Total	**47.1**	**43.3**	**48.6**
by domestic performers			
Canadian International Development Agency	14.1	16.1	16.4
International Development Research Centre	8.9	10.7	11.9
Sub-Total	**23.0**	**26.8**	**28.3**

Canada has been praised for some of the innovative approaches it has taken in recent years for the application of S&T to international development. In 1975, the last year for which comparable data is available, Canada and Sweden led the OECD countries in the share of gross national expenditure on R&D devoted to the problems of less developed countries, with 2% of expenditures going to that purpose.

IDRC's 1978/79 estimated science expenditure will be $33.8 million, while CIDA estimates it will spend $27.6 million on funding scientific activities on behalf of the Third World. IDRC's funds are disbursed as untied aid, which allows the recipients to secure the best available professional skills and to finance

The centre emphasizes research support for improvements in food production and nutrition, for improvements in health care in rural communities, for the understanding of the processes and impact of modernization and change, and for improvements in the means of collecting and disseminating information for and about development.

Complementing IDRC's direct funding of research projects, CIDA's scientific activities are an integral part of its programs of bilateral and multilateral aid and aid to non-governmental organizations. Most of the agency's multilateral aid for S&T work goes to support international organizations that have clear commitments in this area. Priority is given to

research programs aimed at improvements in food production and to programs of specialized training.

The agency's non-governmental organizations program, initiated in 1968, recognizes the increasing emphasis many private organizations are placing on development assistance. The main objectives of the program are to stimulate the development efforts of non-government organizations by giving matching grants so as to tap the expertise available in the private sector and to encourage greater public support for Canada's aid effort. By making grants to these organizations CIDA hopes to encourage them to channel their resources directly to the community level, thus in turn encouraging the communities to greater efforts in self-development.

In addition to IDRC and CIDA, a number of departments have become involved in international development activities. For example, Agriculture Canada provides technical experts for CIDA projects in a number of developing countries. Research has been carried out on several major projects, among them agricultural development in Zambia, a soil survey and wheat production project in Tanzania, dryland farming in India and Sri Lanka, training of wheat breeders in Brazil, and soil surveys in Malasia. About 12 man-years are annually devoted to these programs.

Although S&T activities in support of the developing nations are the major area of government expenditures on science in the international sector, cooperative scientific activity is carried out in a number of other areas.

Currently the largest joint R&D activity with another country is NRC's project to develop the Remote Manipulator System for the NASA Space Shuttle (see the Special Applications section). The other major project—the Canada-France-Hawaii telescope—also involves NRC; it is described in the Major Funders' section. Canada is also negotiating the terms of a working relationship with the European Space Agency.

A wide variety of smaller cooperative activities such as exchanges of information and scientific personnel, in fields ranging from marine science to pollution control, take place under bilateral agreements with West Germany, France, Belgium, and the Soviet Union. Visits of scientific delegations are being exchanged with the People's Republic of China. Much more extensive, but less formalized, are the many instances of collaboration between federal laboratories and their counterparts in other countries in almost every field of science.

An example of cooperation with international organizations is Canada's support of the oceanographic programs of UNESCO's Intergovernmental Oceanographic Commission. The Ocean and Aquatic Sciences activity of the Department of Fisheries and Environment also takes part in projects such as the International Commission for the Exploration of the Seas and the Committee for the Challenges of Modern Society (a committee of the North Atlantic Treaty Organization).

MAJOR FUNDERS

MAJOR FUNDERS

Introduction

Although the government support of science discussed in the Special Applications section may be considered as the cutting edge of its scientific activities, the majority of the science expenditures are of concern mainly to a single department or agency. The activities of these major funders are described in this section, which is organized in a similar manner to the 1978/79 Estimates, i.e., by ministry, department, and agency and by programs within the department or agency. Limited data on expenditures and manpower by program are provided for the past, current, and estimates year. Detailed expenditure data for the major funders and for the remainder of the government's scientific activities are provided in the companion document, "Federal Science Expenditures and Manpower, 1976/77-1978/79".

Agriculture

Program	Science Resources						Total Resources	
	1976/77		1977/78		1978/79		1978/79	
	$M	MY	$M	MY	$M	MY	$M	MY
	(millions of dollars and man-years)							
Administration	4.0	189	4.8	199	5.4	201	34.0	1,018
Research	95.7	3,758	107.3	3,728	120.0	3,725	120.0	3,725
Production and Marketing	0.9	9	1.2	9	1.2	9	441.7	2,578
Health of Animals	3.6	143	4.3	149	5.1	149	94.9	2,799
Canadian Grain Commission	2.2	87	2.4	84	2.9	95	36.0	1,080
Total	**106.5**	**4,186**	**120.0**	**4,169**	**134.7**	**4,179**	**726.6**	**11,200**

Representing 19% of Agriculture Canada's total estimated expenditures, the expenditures on science and technology in 1978/79 will be $134.7 million, a 12% increase from 1977/78. It is expected that $5.5 million will be spent extramurally, compared to $6.3 million in 1977/78, of which $0.8 million will be spent in industry and $3.8 million in universities.

The agriculture industry produces nearly two thirds of the food consumed in Canada. In addition, agricultural exports play a significant role in our international balance of trade. It is Agriculture Canada's primary aim to preserve and influence the productivity and prosperity of agriculture in Canada within the context of a total food system.

The mission of the Research Branch is to ensure the efficient production of an adequate and appropriate supply of food and agricultural products and to help to maintain a stable and profitable agricultural industry in Canada. The research program has a management-by-objectives philosophy. Most of the objectives are based on various crop and animal commodities. Goals are set so as to provide real targets for assessment, accountability, and cost-benefit analysis. Some objectives, however,

embrace a broad class of agriculture, for example soil survey or environmental protection. In others a discipline basis is used for setting objectives and goals.

Apart from Administration and Research Services, the program is organized into 14 research areas, listed here in descending order of man-years of effort: horticultural crops, cereal crops, forage crops, beef cattle, biosystematics, oilseed crops, land and water resources, field crops, dairy cattle, environmental quality, poultry, swine, sheep, and honey bees and other animals.

The department operates 47 science establishments, sited across the country so that local factors in the production and utilization of agricultural products are considered in research programs. The administration, headquarters and program planning and evaluation groups are located in Ottawa.

To ensure that department research is coordinated with research in the provincial, university, and industry sectors, and that the national research effort is responsive to needs, the branch uses three national advisory groups:

—the Canadian Agricultural Services Coordinating Committee;

—the Canadian Agricultural Research Council; and

—17 Canada Committees, each concerned with a specific commodity, discipline, or subject area.

Each of these groups has representation from the federal, provincial, university, and industry organizations concerned.

Within the research program, increasing emphasis will be placed on the breeding of new crop varieties; the efficiency of animal hybridization in the development of modern strains of animals and poultry; the protection of plants and animals from diseases, insects, and competing weeds; the culture of plants in a way that uses space, light, and nutrition with the greatest efficiency; the mechanization of as many farming operations as possible to reduce dependency on an increasingly unavailable farm labour supply; the storage of primary products for off-season demand and future export; and the utilization of agricultural production to provide Canadians with a greater variety of more appealing and nutritional processed products.

As the petroleum sources of nitrogen for fertilizer manufacture become scarcer and more expensive, one new avenue of research will focus on the microbial fixation of atmospheric nitrogen. The fact that many leguminous crops naturally draw, or fix, nitrogen directly from the air challenges scientists to attempt to extend this symbiotic relation of plants and bacteria to other crops.

A program of soil classification and mapping being run cooperatively with the provinces is one of the department's most important activities. It will take many years to complete but is already providing valuable information to planners who are attempting to improve the efficiency of land use.

Only 5% of Canada is improved farm land, and only about 2% (20 million hectares) is available for future expansion; much of it is marginal or located in less desirable climatic areas. Nevertheless, the arable land of the Canadian North is one of the last agricultural resources still awaiting development. The department is studying northern soil capacity, climate, and crops.

The Research Branch is also investigating more efficient ways to use energy in agricultural operations and the possibility of saving energy by modifying cultural practices, even though at the farm level the industry is not a major user. In addition, research is being done on the use of waste products for methane production and the use of biological materials (biomass) as an energy source. Another program is to study the conversion of agricultural waste into animal feed.

Within the administration program, science activities cover the operation of the Central Library ($2 million) and the activities of the Economics Branch ($2 million). The branch conducts research on the behaviour of economic and social variables affecting the agricultural industry, with particular emphasis on issues affecting policy development and implementation.

Research on animal diseases is carried on by the Animal Pathology Division of the Health of Animals Branch in Ottawa and at eight regional laboratories. In addition to studying the causative agents of animal diseases and methods of transmission, the division develops and improves tests for detecting diseases as well as producing diagnostic reagents and biological products for halting outbreaks of disease. Tests are also developed to qualify breeding stock, embryos, semen and meats for

export and to prevent the entry of foreign animal diseases into Canada.

The Grain Research Laboratory at Winnipeg monitors and assesses the quality of cereal grains and oil seeds grown and marketed in Canada and also conducts research on quality related to the end-usage of these crops.

The Production and Marketing Branch expects to continue its contributions at about $1 million in 1978/79 to provincial agencies, industry and universities to stimulate, develop, and adapt new agricultural crops and varieties for commercial production.

Communications

	Science Resources						Total Resources	
	1976/77		1977/78		1978/79		1978/79	
Program	$M	MY	$M	MY	$M	MY	$M	MY
	(millions of dollars and man-years)							
Communications	17.8*	422	35.6*	425	52.3*	425	105.1	1,939

*Includes transfers from National Defence ($3.4 million in 1978/79).

The Department of Communications' estimated expenditures on S&T activities in 1978/79 are $52.3 million. Approximately $23.7 million of this will be spent on space science, which is discussed in the Special Applications section.

The non-space research program is concerned with five principal problems:

—inter-operations between broadcast, mobile radio, cable, and telephone networks;

—the imbalance between urban and rural communications;

—congestion in some transmission media and under-use in others;

—the demand for new services: data processing, education, information retrieval, medicine, banking, entertainment, transportation, etc.;

—changes in government regulation.

Rural communications research is aimed at improving communications for the 20% of the population that lives in rural areas. The majority of the studies are being done by industry and universities under contract. The use of fibre optics technology in urban communication systems shows considerable promise, based on an engineering study contracted out to Bell-Northern Research Limited. A proposed field trial of a fibre optics communications system at Elie, Manitoba, will assess the feasibility and benefits of integrating telephone and broadcast services and may include the integration of data services. Such factors as reliability, ease of maintenance, and costs will be examined.

An important part of radio communications research is the development of methods for measuring radio noise and other kinds of interference in communications systems, aircraft landing systems, and the like. This research also supports the Telecommunications Regulatory Service by developing automated techniques for monitoring and sampling the radio frequency spectrum.

Research into radio propagation covers such projects as the planning and design of communication systems, the effective planning and management of the radio frequency spectrum, measuring and modelling VHF and UHF radio propagation in cities, and providing S&T information in support of Canadian positions at international meetings.

Under an agreement with the Department of National Defence, Communication's Radar Research Laboratory carries out basic research in radar and provides the Canadian expertise in microwave remote sensing for the study of radar

surveillance from satellites. In the next decade radar development is expected to lead to systems that scan electronically (without antenna movement) and automatically adapt to meet any interference and target conditions. One study, for example, is investigating a problem in radar monitoring from satellites in which ocean wave movements obscure small targets such as fishing vessels.

Visual and interactive displays are a developing feature of data systems and of business and home communication. One research project is seeking techniques for interactive visual communication over telephone lines. Another is developing low-cost visual terminals. A third study is developing specifications for home terminals that will function with the digital TV networks of the future.

The evolution of large-scale, closed computer communications systems that give time-sharing access to data files presents both problems and opportunities. Typical of such systems are electronic payment systems, electronic mail, trade systems, and urban data systems. The department is concerned both with questions of inter-networking, system privacy, security, reliability, and so on and also with the economic and social consequences of introducing such systems.

Most of the department's intramural research is carried out at its Communications Research Centre in Ottawa. The centre operates Hermes and other satellites and manages the department's major space projects and industrial contracts. Its David Florida Laboratory houses the most extensive facilities in Canada for satellite testing and integration. Expansion of the laboratory to accommodate the larger satellites of the future has begun and will continue in 1978/79.

Other examples of departmental activities appear in the Special Applications and Extramural Support sections.

Energy, Mines and Resources

	Science Resources						Total Resources	
	1976/77		1977/78		1978/79		1978/79	
Program	$M	MY	$M	MY	$M	MY	$M	MY
	(millions of dollars and man-years)							
Administration	—	—	—	—	—	—	18.9	518
Energy	16.6	377	29.8	389	31.6	390	603.3	631
Minerals	16.7	625	19.6	595	22.0	593	22.7	620
Earth Science Services	62.1	1,433	68.7	1,417	72.0	1,395	90.8	2,135
Total	**95.4**	**2,435**	**118.0**	**2,401**	**125.5**	**2,378**	**735.7**	**3,904**

Energy, Mines and Resources' total estimated expenditures for scientific activities in 1978/79 are $125.5 million. Distributed through three programs, these S&T expenditures will be 68% of total departmental estimates, exclusive of $550 million for oil import compensation. Extramural expenditures are estimated to be $36.6 million, $15.5 million to industry and $2.7 million to universities. The expenditure in industry represents an increase of 13.5% over 1977/78.

EMR's two main areas of responsibility are to stimulate the discovery, development, use, and conservation of Canadian mineral and energy resources, and to provide the earth science information needed for effective use and demarcation of the country's land mass. The accomplishment of these tasks necessitates ongoing research and information-gathering in the fields of geology, surveys and mapping, earth physics, remote sensing, energy, and resource technology, as well as in mineral and energy economics and statistics, the results of which form the basis for planning and policy in resource development. The relevant information is also made available to the private sector through

departmental information units, joint industry-government programs, and the contracting-out of studies and projects. The department's Energy program is described in the Special Applications section.

The objective of the Minerals program is to ensure adequate supply and effective use of Canada's mineral resources. Because of its important place in the economy, the mineral industry has a number of economic, social and policy implications, and research in the social sciences plays a significant role in dealing with them, particularly in the areas of international trade, frontier and regional development, and employment opportunities. Analysis and evaluation of the impact of changing patterns of mineral activities are required to develop strategies for ensuring maximum benefit from resource utilization. The Geological Survey of Canada provides support for the program through its continuing research on the assessment of mineral and energy resources and the development of new exploration techniques.

In the field of mining research, the Canada Centre for Mineral and Energy Technology has just completed publication of "The Pit Slope Manual", a 26-volume engineering guide aimed at improving the efficiency of open-pit mining. Research on underground health and safety is continuing, and planning is in progress for a joint federal-provincial-industry institute devoted solely to this topic. In ore processing, a major project is underway to develop a new process for the treatment of the large, complex zinc ore deposits of New Brunswick. By greatly increasing metal recoveries (now of the order of only 75%) the project, if successful, should open up new job opportunities in a depressed area.

The objective of the Earth Science Services program is to provide the basic knowledge of Canada's geological, geophysical, and geographical make-up that is needed for resource and land-use planning. It provides information from geological and geochemical studies and surveys and airborne radioactive and magnetic surveys and is the largest single component of the department's science budget.

The Geological Survey of Canada, as a major contributor, devotes almost all its resources to this program. It provides information on bedrock geology for use in identifying and appraising non-renewable resources, and on the overlying surficial materials and landscape to aid in assessing the impact of development upon them.

At the Earth Physics Branch, a comprehensive program of basic and applied research is directed toward a better understanding of Canadian earthquake zones and seismic risk. The branch operates 40 seismic stations from Vancouver to St. John's and in the high Arctic, and in addition provides risk assessments for major projects of national significance (dams, pipelines, and nuclear power plants). It also investigates the gravity and magnetic fields and their variations in Canada, the geothermal regime, and Canadian crustal dynamics, to support such diverse applications as navigation, transportation, communications, surveying, and geophysical prospecting.

The Surveys and Mapping Branch will continue to discharge its responsibilities for national positional services, meeting the growth in demand through improved technology rather than manpower increases. Examples of these new techniques include automated digitized terrain data systems, in which the branch is a world leader, the Inertial Survey System for secondary field surveys, and Doppler satellite receivers for primary geodetic surveys. The branch also provides the mapping services to meet the manifold needs of government, industry, and the general public.

The role of the Canada Centre for Remote Sensing is dealt with under Space in the Special Applications section. Its activities, however, extend beyond the use of satellites to encompass the whole field of remote sensing. Some application areas covered are crop evaluation, snow mapping, melting and run-off, forest management, and resource exploration. In instrumentation, work is proceeding on a prototype laser fluorsensor to detect oil spills, and the branch cooperates actively with clients to develop the techniques and systems best suited to their needs.

Atomic Energy of Canada Limited

	Science Resources						Total Resources	
	1976/77		1977/78*		1978/79		1978/79	
Program	$M	MY	$M	MY	$M	MY	$M	MY
	(millions of dollars and man-years)							
Nuclear Research & Utilization	99.6	2,321	84.6	2,301	94.4	2,341	185.3	6,218

*On 1 April 1977 the status of the nuclear generating station at Douglas Point, Ontario, changed from demonstration project to straight commercial operation and its associated costs are now part of AECL's commercial operations.

As shown in the table, the estimated science expenditures of Atomic Energy of Canada Ltd. in 1978/79 will be 12% higher than in 1977/78 due primarily to the expanded research on safeguards and radio-active waste disposal. R&D contracts to industry are estimated to be $21.7 million or 23% of the total science expenditures, a drop of $1.4 million from 1977/78. This decrease is the result of changes in the operating costs of the demonstration reactor, Gentilly I, near Trois-Rivières, Quebec. R&D contracts to universities and private non-profit institutions are estimated to increase to $1.0 million from $0.6 million in 1977/78.

The overall objective of AECL's R&D program is to develop the knowledge and technology base needed to maintain a nuclear generating system that meets the criteria of safety, economics, and energy self-reliance. Most of the program activities support at least two of these criteria, often all three. Over half of AECL's resources are directed to consolidating the competitive position of the CANDU reactor system, by increasing its efficiency, and by responding to previously unforeseen problems affecting system reliability, and by meeting increased regulatory requirements.

In 1978/79 AECL will expand two R&D activities to improve the safety of nuclear power. The first of these arises from Canada's support of the international Nuclear-Non-Proliferation Treaty, under which CANDU reactors, both domestic and export, must be subjected to international inspection to ensure that no fissile materials are diverted at any stage of operation. To make it possible for the International Atomic Energy Agency (IAEA) to verify these safeguards, an expanded joint program of AECL and the Atomic Energy Control Board was begun in 1977/78. With the approval of the IAEA, the program will provide the required research and development and concomitant engineering and installation of equipment on existing CANDU reactors. It is expected that $1.7 million will be spent on this program in 1978/79, of which approximately $0.7 million is for R&D. Total program expenditures were $0.9 million in 1977/78.

The second activity is an expanded program of R&D on the safe immobilization and disposal of radioactive materials from the operation of CANDU nuclear reactors. ("Immobilization" refers to techniques of sealing or encapsulating radioactive materials to ensure that they are in a stable and insoluble form. "Disposal" means storing radioactive materials so that they are permanently isolated from the biosphere and will need no further attention.) The program, on which AECL expects to spend $9.9 million in 1978/79, has two main components: work on geological disposal methods including laboratory work, field investigations, and test drilling leading to the selection and acquisition of a disposal site; and work on the immobilization of spent reactor fuel and radioactive waste from the processing of spent fuel. The latter component must precede the preparation of proposals for and the design of pilot plants.

AECL's R&D program, which spans the full range of technological activity from basic research to full-scale demonstration and technological support, is organized into six major elements: power reactor systems, nuclear fuel cycle, environmental protection and radioactive waste management, heavy water processes, radiation equipment and radionuclides, and underlying and advanced systems research. Planning and coordination of these elements is the responsibility of a company-wide R&D committee, under which are working parties to coordinate projects in specific areas at the several AECL laboratory sites.

The Power Reactor Systems element is concerned with R&D related to all aspects of the steam supply

of nuclear generating stations except the fuel; i.e., the reactor, moderator, heat removal, control, and ancillary systems.

The major concern in the Nuclear Fuel Cycle element is fuel performance. Computer models of fuel performance are being improved on the basis of theoretical considerations and the experimental verification of critical features of the models.

Two of the three tasks within the Environmental Protection and Radioactive Waste Management elements have already been mentioned: radioactive waste management and safeguards systems. The other tasks, the protection of man and the environment, involves environmental and biological research relating to radioactive migration and radiation effects.

Current R&D in the Heavy Water Processes element is expected to improve production efficiency to such an extent that no new plants need to be committed until at least the mid-1980s. Since the capital investment in heavy water plants is in the billion dollar range, the improvement in production efficiency will have a significant effect on heavy water costs and therefore nuclear power costs.

R&D in the Radiation Equipment and Nuclides element is conducted at Commercial Products in Ottawa, in some cases exploiting technology developed at AECL's other laboratories for other purposes. AECL has been developing a line of accelerator-type cancer therapy equipment to complement the Cobalt 60 equipment, for which Commercial Products was a pioneer and leader in world-wide sales. Commercial Products is also a leading seller of processed radioisotopes for medical use, including Molybdenum 99-Technecium 99, which has recently become a powerful tool for medical diagnosis.

The work of the Underlying and Advanced Systems Research element is conducted on three broad fronts: physics, chemistry and materials science, and advanced systems research. Relevance to the mission is an important criterion in selecting research projects. This research group has achieved a world-wide reputation which provides direct access to other major nuclear research centres through the "invisible college". Not only does it complement the applied work in AECL, but it can also respond quickly to sudden needs for fundamental scientific assessment.

Most aspects of nuclear system development require an understanding of phenomena in the fields of chemistry and materials science, e.g., corrosion of materials, radiolysis, behaviour of fission products, behaviour of pressure tubes and fuel sheaths, and so on. The research objective is to explain observed conditions, to counteract or exploit them, and thereby to ensure lifetime system reliability.

The major effort in advanced system research relates to the production of neutrons by the bombardment of heavy-metal targets with intense streams of high-energy particles. Such a system could breed fissile materials, thereby enhancing the energy that can be extracted from Canadian uranium and thorium resources. There might also be industrial and medical equipment spin-offs from this activity.

Environment

	Science Resources						Total Resources	
	1976/77		1977/78		1978/79		1978/79	
Program	$M	MY	$M	MY	$M	MY	$M	MY
	(millions of dollars and man-years)							
Administration	1.1	43	1.2	36	1.2	36	23.4	769
Fisheries and Marine	83.3	2,224	95.1	2,384	106.6	2,457	305.5	4,967
Environmental Services	184.9	4,910	193.6	4,850	201.4	4,833	285.3	6,451
Environmental Management	90.9	2,195	92.6	2,189	95.1	2,176	—	—
Atmospheric Environment	87.1*	2,584	93.1*	2,530	97.7*	2,512	—	—
Environmental Protection	6.9	131	7.9	131	8.6	145	—	—
Total	**269.3**	**7,177**	**289.9**	**7,270**	**309.1**	**7,326**	**614.2**	**12,187**

*Excludes transfers to Transport ($13.4 million 1978/79).

The Department of Environment's, including Fisheries (DFE), estimated expenditures on scientific activities in 1978/79 are $309.1 million, representing 50% of the total departmental estimates. As the table shows, the department's activities are organized under three programs: Administration, Fisheries and Marine, and Environmental Services. This latter is further divided into Environmental Management, Atmospheric Environment, and Environmental Protection.

In the Fisheries and Marine program the estimated S&T expenditures, $106.6 million, are 12% higher than in 1977/78. The estimated extramural expenditures will be essentially unchanged at $5.9 million with $4.0 million in industry and $0.9 million in universities. Extension of Canada's ocean jurisdiction to a 200-mile limit, together with rapid changes in fish stocks and in market demand, have greatly increased the need for scientific activities in the program. Research is directed at improving the supply and production of fish through conservation, preservation, restoration, augmentation, and culture. Stock assessment and biological research are essential elements of fish conservation in setting catch-quotas and other controls. In order to optimize fish catches, considerable effort is being directed at modelling the dynamics of fish populations, such as the interaction between cod, herring, and mackerel. Surveys on the larval or juvenile forms of fish are also performed to establish the bio-energetics of food conversion in the growth of various species. These surveys are complemented by research on fish nutrition and diets, including plankton surveys, and on disease vaccines, controlled reproduction, ocean survival, and lake fertilization.

In the case of harp seals, for example, tagging studies will be continued to determine the relationship between herds in the Gulf of St. Lawrence and those off the shores of Newfoundland. Biological studies are also conducted on the pregnancy, maturation, and mortality rates of various marine mammals. The Fisheries and Marine program also directs the research required to set regulations under the Ocean Dumping Act, for controlling the dumping of substances harmful to the marine environment. The preparation of nautical charts from surveys to production is another of its responsibilities, through the Canadian Hydrographic Service.

In Environmental Management, scientific activities conducted under the four broad areas of inland waters, forestry, wildlife, and lands are directed to improvements in renewable resource conservation and to the management and enhancement of environmental quality. These activities will involve estimated expenditures of $95.1 million in 1978/79. It is intended to spend $6.9 million extramurally, with $2.4 million in industry and $1.8 million in universities.

With respect to the quality of inland waters, greater emphasis is being placed on the establishment of limits for radioactive contamination and thermal pollution. In water management research, there will be increased effort in water quality modelling of rivers, agricultural and other non-industrial problems, studies of national water demand, and in site-specific research on reservoirs and inter-basin transfer. Special attention will be paid to a study of the Yukon basin, the implementation plan for the St. Lawrence Water Quality Study, and integrating the results of water quality studies with regulations for the Ottawa River. Emphasis on water quality surveillance of the Great Lakes will be continued.

Forestry activities deal mainly with forest protection, management, and conservation. Priority is being given to the development of methods of controlling the spruce budworm, particularly to methods that are less ecologically damaging. Studies of the ecological and economic effects of forest fires will continue, as will work on forest replacement techniques, with particular attention to genetic improvement of stock for planned reforestation. Research will also be directed toward an increased understanding of the impacts of economic development on the forest ecosystem. A complementary activity is the development of a national forest inventory and cost-benefit data related to forest management and utilization. In the area of forest products utilization, there will be increased emphasis on research on the use of forest biomass for energy and food, and the development of wood-based adhesives.

In wildlife activities, more emphasis is being placed on non-game bird species under the Migratory Birds Conservation Program and priority is being given to the completion of sea bird inventories on both coasts. The critical issue of the impact of native hunting of migratory birds will require increased attention. The management of National Wildlife Areas and their use for public information and education will require more effort in 1978/79. More attention will be paid to research on rare and endangered wildlife species and to trans-boundary

wildlife populations, for example the Porcupine caribou herd.

Under land activities, monitoring of federal land use and mapping of northern land use will continue. Work on the national ecological land inventory will shift to gap-filling as ecology studies for specific purposes, for example, baseline studies in given regions, are undertaken. The Environmental Management activity will continue to provide expertise and advice in the development of environmental assessment guidelines and review of completed environmental assessment studies. Major new requirements will likely include off-shore tanker traffic, drilling and pipeline construction in the Pacific and Yukon regions, energy developments in the Western and Northern region, and Labrador developments and Bay of Fundy tidal power in the Atlantic region.

In response to the recently-enacted Environmental Contaminants Act, work on toxic substances formerly located in the water management, forestry, and wildlife activities is being combined into a single activity that provides a better understanding of the flow of chemicals through the environment and the overall effects of toxic substances.

Atmospheric Environment's 1978/79 estimated expenditures for scientific activities are $97.7 million. Essentially unchanged from the previous year, extramural expenditures will be $3.0 million, with $2.1 million going to industry and $0.5 million to universities. Of these expenditures, 72% are for the continuing scientific operations of the weather prediction and ice prediction systems, involving national data collection, analysis, and dissemination. Atmospheric Environment also operates the national climatological data collection and archival system. These activities, complemented by metereological research projects, enable the service to provide consulting services in applied metereology. An important scientific activity, conducted in cooperation with industry, is connected with oil drilling in the Beaufort Sea. About $0.3 million, matched by Canadian Marine Drilling Ltd., is being spent to develop a computerized forecast system.

Estimated S&T expenditures in Environmental Protection for 1978/79 are $8.6 million, $3.6 million of which is to be spent in industry. Environmental Protection is responsible for the effective application of pollution control regulations, joint pollution control activities with other levels of government, reviewing applications for pollution abatement incentives, and developing regulations for solid waste management and the disposal of hazardous materials. The Cooperative Pollution Abatement Research (CPAR) program and the Demonstration of Pollution Abatement Technology (DPAT) programs are two extramural programs for encouraging industry to carry out R&D in pollution abatement. In 1978/79 CPAR will spend an estimated $1.5 million on R&D to reduce pollution in the pulp and paper industry and DPAT will spend $2.0 million, on a shared cost basis with industry, to develop and demonstrate abatement techniques and equipment for air and water pollution.

Canadian International Development Agency

	Science Resources						Total Resources	
	1976/77		1977/78		1978/79		1978/79	
Program	$M	MY	$M	MY	$M	MY	$M	MY
	(millions of dollars and man-years)							
CIDA	22.6	51	24.2	51	27.6	51	699.8	969

The Canadian International Development Agency estimates its 1978/79 expenditures on S&T activities at $27.6 million. Ninety-four percent or $25.9 million of CIDA's expenditures will be spent extramurally, $11.2 million in Canadian industry, $3.5 million in Canadian universities, and $11.2 million in the foreign sector.

The agency encourages the economic and social development efforts of Third World countries through programs of bilateral and multilateral assistance and financial support to non-governmental organizations.

A number of CIDA's bilateral projects lend support to the conduct of S&T activities in developing countries. For example, the agency supports two wheat production pilot projects in Tanzania and Zambia, a rapeseed farming project in Peru, projects concerned with the protection of vegetable

growth in Niger, Mali, and Upper Volta, and a project aimed at improving farming methods in the dry lands of India.

Also under its bilateral program, the agency is promoting interest in more rational uses of energy sources such as wood and charcoal, and is looking at the benefits of alternate energy forms, e.g., biomass, wind power, and solar converters. The agency is directly involved in the establishment of small, wood-fired electricity generating stations in Sumatra and has recently identified two similar opportunities in Bolivia.

CIDA's multilateral program includes support for a number of international organizations with an S&T orientation, for example, the Consultative Group for International Agricultural Research. This organization coordinates the activities of 11 centres in various countries, whose work runs the gamut from cropping techniques through the raising and health care of domestic animals to ways of disseminating research results.

Since 1976 CIDA has contributed to research programs of the World Health Organization, notably those on malaria, schistosomiasis, and other widespread tropical, parasitic diseases. The agency also supports WHO's program of research and training in human reproduction as well as the International Union for the Scientific Study of Population.

As is explained in the International section, the agency's non-governmental organizations program recognizes and supports the development assistance efforts of these organizations. A recent example is the support given to the Mennonite Central Committee, Winnipeg, for its program of agricultural product diversification and diet improvement in Bangladesh. Preliminary research showed that it was possible to grow peanuts, sweet potatoes, and other products in certain regions during the winter season. The next steps are to evaluate the economic potential of such products, to plan their integration into the agricultural cycle and the market distribution of traditional products, to determine the most appropriate forms of warehousing, marketing, and credit institutions, to train advisors, and so forth. Another example is the "Inter-Pares" project, also in Bangladesh, in which it is proposed to combine jute, the premier export product of the country, with some plastic material as a substitute for fiberglass. The goal is to develop a cheap construction material suitable for the climate of the country.

International Development Research Centre

	Science Resources						Total Resources	
	1976/77		1977/78		1978/79		1978/79	
Program	$M	MY	$M	MY	$M	MY	$M	MY
	(millions of dollars and man-years)							
IDRC	32.4	331	31.8	344	33.8	355	36.9	355

IDRC's primary purpose is to enable institutions and individuals in Third World countries to develop the research capabilities required to solve their problems. The centre will spend $33.8 million on scientific activities in 1978/79; $23.3 million or 69% will be spent extramurally, nearly all in the foreign sector.

The centre's Agricultural, Food, and Nutrition Sciences Division supports research into the development of plant, animal, marine, and forest resources. Project activities include the improvement of crops and cropping systems, fish farming and fish processing, the control of animal diseases, the use of agricultural wastes and by-products in animal feed, reforestation in arid lands, nutrition research, and the development of post-harvest technology.

An important example of the division's work is the support given to a network of projects in Africa and Asia concerned with reducing food losses through the improvement of post-harvest systems. In Senegal, for instance, the National Agricultural Research Centre (CNRA) has developed techniques for processing, drying, and storing grains that are

based on traditional methods and use local materials and labour rather than expensive imported equipment. In the projects' second phase, just starting, the techniques will be put to the practical test of village use. Simple mechanical threshers developed at CNRA will be compared with hand-threshing. Storage racks that make maximum use of the sun and wind to dry the grain rapidly will be built from locally available materials. Grain storage trials will use both improved traditional bins and an innovative multi-compartment silo developed at CNRA, to be constructed from concrete blocks manufactured on the spot. The results will be valuable to most rural communities in West Africa.

Research supported by the Social Sciences and Human Resources Division focuses on the effect of modernization and change, on strategies for harmonious development of urban and rural areas, on the development of relevant S&T, on delivery systems for mass primary education, and on the determinants of population change and the formulation of population policies. The division also administers a scholarship program to increase the number of scholars from developing nations trained in the problems of development.

The division has played a key role in support of an innovative attempt to provide inexpensive universal primary education in Southeast Asia. The key to achieving this objective has been a combination of self-instructional booklets and course flexibility, so that children can teach and test each other. One of the project's major achievements has been to spread the teaching load so that a school of 280 students that used to employ ten teachers is now run by three or four instructional supervisors.

The main research interests of the Health Sciences Division are environmental health and disease prevention, fertility regulation, rural health care delivery in developing countries, and fresh, clean water supplies.

The use of improved technology is one avenue to solving water supply problems. The centre is supporting the University of Waterloo in designing prototype pumping systems specifically for use in developing countries. The hand pumps that so frequently provide the only water supply in most villages throughout the Third World are not designed for the strenuous use they get and they often break down. The research team is concentrating on reliability, simplicity, and low cost. Complete prototype systems will be supplied to developing countries for field testing and possible local manufacture.

Helping developing countries to draw upon and contribute to the world's storehouse of knowledge can have immeasurable benefits and this aim forms a major part of IDRC's fourth program division—Information Sciences. Through this division, the centre cooperates with United Nations agencies in establishing worldwide information services in the areas of agriculture, water, and population. Other project activities include library development, computer services, specialized information centres, mapping, and communications systems.

To meet the centre's commitment to publish as widely as possible the results of research projects which it supports, a fifth division—Publications—has been established.

More information about IDRC appears in the Extramural Activities section.

Industry, Trade and Commerce

	Science Resources						Total Resources	
	1976/77		1977/78		1978/79		1978/79	
Program	$M	MY	$M	MY	$M	MY	$M	MY
	(millions of dollars and man-years)							
Trade-Industrial	111.1	177	79.9	172	63.6	163	260.9	2,396
Tourism	0.2	4	0.2	4	0.3	4	27.2	322
Grains and Oilseeds	3.9	2	2.5	2	1.8	2	87.7	49
Total	**115.2**	**183**	**82.6**	**178**	**65.7**	**169**	**375.8**	**2,767**

S&T activities in Canadian industry are supported by Industry, Trade and Commerce to stimulate innovation and promote the use of modern technology. The department will spend $65.7 million in 1978/79, a decrease of $16.9 million from its 1977/78 spending. Most of this decrease ($15 million) is due to the termination of a program of grants to industry under the Industrial Research and Development Incentives Act.

Most of the department's S&T expenditures are through the Trade-Industrial Program, discussed further under industry in the Extramural Activities section. In addition to programs designed to stimulate innovation and modernize industry the department has, since 1967, also established ten industrial research institutes and nine advanced technology centres at universities and provincial research associations. After initial financial help from the department in starting up, most are now self-supporting. Support for these institutions in 1978/79 is estimated at $1.0 million. In addition, three industrial research associations have been established with the department's help since 1973.

The Tourism Program of the department performs some in-house economic studies of tourism. The Grains and Oilseeds Program has been one of the supporting organizations in the development of a protein oil seeds plant at Saskatoon which was completed in June, 1977, and is now being run by the P.O.S. Pilot Plant Corporation, an independent, non-profit organization.

Statistics Canada

	Science Resources						Total Resources	
	1976/77		1977/78		1978/79		1978/79	
Program	$M	MY	$M	MY	$M	MY	$M	MY
	(millions of dollars and man-years)							
Expenditures	142.8	6,240	132.5	5,359	135.3	5,031	135.3	5,031
Revolving Fund	2.6	157	3.3	97	3.3	80	3.3	80
Total	**145.4**	**6,397**	**135.8**	**5,456**	**138.6**	**5,111**	**138.6**	**5,111**

All of Statistics Canada's estimated expenditures of $138.6 million for 1978/79 are in support of scientific activities, of which $0.5 million is performed extramurally. As Canada's central statistical agency, its objective is to collect and provide the statistical information needed both for understanding the Canadian economy and institutions and for the development of economic and social policies and programs.

A key economic indicator produced by the agency is the Consumer Price Index, which has direct and indirect effects on nearly all Canadians as a result of its extensive use. Another key indicator of the national economic status is the set of statistics derived from the Labour Force Survey. The survey provides a definitive picture of the labour force which is useful to government and industry planners.

Work will continue in 1978/79 on up-dating and further developing the Gross Provincial Product figures that were released in 1977, and several macro-economic regional estimates are being developed.

The Business Statistics Integration group, previously called the Task Force on the Integration of Economic Statistics, will continue in conjunction with other government departments to test the ability of large firms to supply information required by government departments and the National Statistical System at a consistent quality level.

During 1978/79 Statistics Canada will analyse and disseminate socio-demographic and geographic data derived from the 1976 Census, and the questionnaire design for the 1981 Census will be completed. In response to a growing demand it will continue to develop programs of social statistics. One of the continuing programs is a comprehensive study of the number of people likely to enter the labour force from the educational system. The result of this study will be an analysis of the people who will be available to the labour force, by age and sex, by province, and by education, between

now and 1986. An analysis of university enrollment trends related to the faculty positions available will continue and projections will be made for the immediate and long-term future. Another project is the development of information systems on justice, in which the agency is collaborating with Justice, the Ministry of the Solicitor General, and the provincial departments of the attorneys general.

The annual up-date of the Renal Failure Register, a composite statistical and clinical data base of end-stage renal failure patients in Canada, will again be carried out. The up-date on each record reflects the transplantations performed, the incidence and characteristics of dialysis treatment, the number of deaths occurring, and the profile of new patients. The inventory of dialysis and transplant facilities is also up-dated annually. All of this is carried out in collaboration with the Kidney Foundation of Canada. Following the development and testing program carried out in 1977/78, the Canada Health Survey will be conducted in several locations across Canada in 1978/79 in conjunction with National Health and Welfare.

The Family Expenditure Survey will be undertaken in 1978/79. It will provide the data needed to monitor and re-weight the Consumer Price Index, allow evaluation of the effects of the anti-inflation program, determine the wage adequacy level (the poverty line), and provide data for policy evaluation exercises such as the ongoing social security review.

National Defence

	Science Resources						Total Resources	
	1976/77		1977/78		1978/79		1978/79	
Program	$M	MY	$M	MY	$M	MY	$M	MY
	(millions of dollars and man-years)							
Defence	74.4*	2,126	87.0*	2,164	95.9*	2,186	4,344.5	116,319

* Excludes transfers to other departments ($9.4 million in 1978/79).

The Department of National Defence's estimated expenditures for scientific activities in 1978/79 are $95.9 million, an increase of 10% from the previous year. Its S&T program is aimed at improving the operating capability of the armed forces by the effective application of science and technology to all departmental functions, ranging from stategic policy decisions through military operations to the maintenance of effective personnel and material resources. The analysis of new technology developments and their impact on operations is an essential element in the timing and selection of equipment acquisitions. The department depends, in part, on the R&D activities of other government departments and private agencies, and on the sharing of S&T information with Canada's allies.

Its intramural R&D program contributes to the international sharing of S&T information and provides the knowledge base for the application of S&T to equipment acquisitions and operations. Conducted at six Defence Research Establishments at various locations across the country, the program comprises three technology groups, Human Protection and Performance, Sensors and Electromagnetics, and Ordnance and Vehicles.

Human protection and performance covers a spectrum of science ranging from the protection of the soldier in a variety of natural or man-made environments, to the performance of men at high altitudes or in ocean depths. The human-engineering of equipment is another research activity, involving studies of human perception, vision, and hearing, and of the effectiveness of man/machine systems.

One significant project in this field in 1977/78 was the installation of a deep diving facility at the Defence and Civil Institute of Environmental Medicine, Toronto. It can simulate the characteristics of depths up to 5,600 feet, making it the deepest hyperbaric complex of its kind in the world. It consists of three 2,500 psi chambers which are inter-connected but can be pressurized independently. This facility will be available to serve the needs of other government departments, the academic community, and industry, as well as DND.

In-house programs in sensors and electromagnetics include research in underwater acoustics, electronic warfare, electro-optics navigation, magnetics, and command and control

systems. In addition, the Communications Research Centre of the Department of Communications carries out contracted and cooperative work on radar and communications.

The ordnance and vehicles research program covers ships, aircraft, and land vehicles. There are projects on ship propulsion and hydrodynamics as well as on the mobility of land vehicles and their ability to travel in different terrains. Also underway is R&D concerned with electrical power sources for transport (land, sea, and air), communications (beacons), surveillance and anti-submarine warfare (radar, sonobuoys and torpedoes), and special equipment (radiation detectors, fuses) for the Canadian Forces. Improvements in reliability, energy, and power density and performance at low temperatures have been emphasized but in the future emphasis will be shifting to energy conservation. As an example of the conservation projects now underway, ship hulls are being designed to reduce hydrodynamic drag and save fuel.

Most equipment for service use is developed by industry. Technologies created in intramural research programs are transferred to industry: this is an important product of the research program. The Spinning Tubular Projectile is an outstanding example of this activity. It is a practice tank round that offers realistic training at lower cost. The idea was born at the Defence Research Establishment at Valcartier, which has considerable experience in ordnance and aerodynamics. When the research and preliminary development was complete, the technology was successfully transferred to an industrial firm for final development and production. The projectile is expected to save the Canadian Forces about $1 million a year and to sell well abroad.

The department is increasingly employing the social sciences in its research program. The Operational Research and Analysis Establishment provides expertise in operations research, the techniques of management science, social and economic analysis, strategic studies, forecasting, and futures studies. At present the main areas of study are strategic analysis, in which an active topic is the study of methods of averting war by deterrence and arms control; socio-economic analysis, to evaluate the impact of military forces on the society in which they operate; and studies relating to the efficient management of the department's large resources of manpower and material. Although most of this work is carried out in-house, some specific studies are contracted out.

The Personnel Applied Research Unit is looking at the social relations of personnel within the Canadian Forces and of the forces with the community-at-large. It has also done studies in motivational research, behavioural science, personnel selection, and management development. In 1978/79, the unit will extend its work on training methodology to areas other than flying.

The responsibility of providing scientific advice to the minister lies with the Defence Research Board. Assisted by a small permanent staff, the board conducts long-term planning and evaluation studies in research and development and provides advice on the scientific and technological activities of the defence research establishments.

National Health and Welfare

	Science Resources						Total Resources	
	1976/77		1977/78		1978/79		1978/79	
Program	$M	MY	$M	MY	$M	MY	$M	MY
	(millions of dollars and man-years)							
Administration	0.2	7	0.2	7	0.2	7	16.6	516
Health Care	14.5	83	19.0	82	19.7	84	3,246.6	271
Medical Services	0.4	20	0.7	23	1.2	24	162.6	3,966
Health Protection	21.8	844	24.9	863	27.3	866	75.2	2,169
Fitness and Amateur Sport	0.3	8	0.7	8	0.8	8	32.7	122
Income Security and Social Assistance	12.3	143	14.3	151	13.5	170	9,198.9	3,437
Total	**49.5**	**1,105**	**59.9**	**1,134**	**62.7**	**1,159**	**12,732.6**	**10,481**

In 1978/79, National Health and Welfare's estimated expenditures on S&T activities will be $62.7 million, of which $29.0 million will be spent extramurally, 58% of that sum going to universities, 25% to private non-profit institutions, 6% to Canadian industry, and the remainder to foreign and other performers.

The scientific activities of the department serve its objectives in promoting and preserving the health, social security, and social welfare of Canadians.

These activities will be directed to the collection and analysis of data to develop standards, guidelines, and regulations; the detection, elimination, and control of health hazards arising from the physical, biological, and social environments; the estimation of requirements for facilities, manpower, and services; the improvement of the design of health facilities; and the promotion of good health and improved social welfare by improving the quality of services and by encouraging Canadians to assume greater responsibility for their own health and well-being.

As the department's principal means of funding extramural science, the National Health Research and Development program, administered by the Health Programs Branch, will provide over $11 million in 1978/79. These funds will be used to support research and demonstration projects. Further details can be found in the Extramural Activities section. The Health Programs Branch also has a responsibility to develop standards for health care practices, study the needs for health services and health professionals, and design health care facilities and alternative modes of health care delivery. Another important activity is the Canada Health Survey which will begin data collection in 1978 and involve the expenditure of $0.4 million in 1978/79.

Medical Services research expenditures will be used to evaluate the use of a new type of modular nursing station (at Nelson House, Manitoba), to conduct a research project at the department's Charles Camsell Hospital in Edmonton, and to fund the production, engineering, and testing activities of the department's prosthetic services. These activities are expected to move to the National Research Council during the 1978/79 fiscal year.

Health Protection's directorates carry out programs on disease control, the non-medical use of drugs, environmental health, food safety and nutrition, and drug safety and effectiveness. The program also includes work to promote healthier lifestyles. A high level of scientific support is required, for example, in the analysis and testing of regulated products, in the development of national standards, and in monitoring national food consumption, drug usage, the incidence of disease, and the introduction of new causative agents of disease. The program is also concerned with the experimental development of safe and effective medical devices and with developing regulations for their manufacture and sale.

In support of food regulatory responsibilities the program includes research on chemical contaminants, pesticides and food additives, and microbial hazards such as botulism and salmonellosis. The purity of pharmaceuticals and cosmetics is important to prevent iatrogenic diseases. Imported and domestically produced pharmaceuticals are regularly analyzed to assure safety and effectiveness. Cardiac, anticonvulsant, anticoagulant and antiasthmatic drugs have been examined as part of a program comparing the blood level profiles (bioavailability) of different brands of drugs in volunteers. The Drug Research Laboratory develops methods for the identification and detection of impurities and illegal ingredients, such as hydrazine and chloroform.

The program has been influential in the undertaking of three life-style related studies. The first was concerned with alcohol as a factor in fatal automobile collisions in Canada and showed that young, impaired drivers were at a greatly increased risk. Another, concerned with the involvement of a broad range of drugs in fatal collisions, is now underway and the third study, on the smoking habits of Canadians, has pointed out the need to focus preventive efforts on teenage girls, among whom the regular use of tobacco increased considerably between 1965 and 1972. The branch will continue to monitor the smoking habits of Canadians in order to improve prevention programs.

Health Protection will spend an estimated $23.5 million on intramural S&T activities in the natural sciences, which will be supplemented by extramural expenditures of about $2 million for biomedical and clinical research on problems associated with the use and abuse of alcohol, tobacco, and non-medical drugs and $1.8 million in the social sciences to develop programs for dealing with these problems.

Fitness and Amateur Sport will spend $0.2 million intramurally on the development of programs to

encourage fitness and the adoption of healthier lifestyles, and $0.5 million on extramural activities concerned with the physiology and psychology of sports. Most of the extramural expenditures will be in the university sector.

The Long-range Health Planning Branch develops health status indicators and attempts to identify emerging health issues particularly with regard to prevention and helps to determine the kind of health services that will be needed in the future. Intramural science expenditures of about $0.2 million will be supplemented by contracts worth about $0.2 million. Most of the expenditures will be in the social sciences.

The Income Security and Social Assistance program will make grants for demonstration projects to provide services or resolve social welfare problems. For example, an integrated community program using occupational therapy is attempting to provide psychiatric, geriatric, retardation, and physical and other disability programs in Prince Edward Island. In the social welfare area, grants will support family planning services, demonstration projects, and evaluations.

Intramurally, the program continues to search for alternative delivery systems for social security transfer payments. One research project is the development of simulation and economic models for a program of guaranteed annual income support for the retired and disabled and income supplements for the working poor. Another will test alternative forms of delivery of social security benefits through the tax system.

One study is looking at the problem of program stacking. It is frequently the case that individuals, in gaining benefits in one program, lose even more in benefits from other programs. A major difficulty of program design had been the inability to handle the complex and simultaneous interaction of several different programs. A computer program has been developed that gives the department the ability to design new programs that can be nationally integrated with those now existing.

Medical Research Council

	Science Resources					
	1976-77		1977/78		1978/79	
Program	$M	MY	$M	MY	$M	MY
	(millions of dollars and man-years)					
Grants and Scholarships	50.8	—	56.7	—	60.0	—
Administration	1.1	39	1.3	39	1.4	40
Total	**51.9**	**39**	**58.1**	**39**	**61.4**	**40**

The objective of the Medical Research Council is to help attain the quality and scale of research in the health sciences required to maintain and improve health services. The council's sub-objectives are:

—to expand the scientific and technological base for health care;

—to improve the application of scientific principles to health care;

—to ensure an adequate research base for education in the health sciences;

—to support the training of research investigators in the health sciences;

—to support research contributing to new knowledge in the health sciences.

As with the National Research Council, nearly all the budget—96%—is used for research grants in support of research by individuals and groups in Canadian universitites and the stipends of a limited number of investigators and research trainees. This support is described in more detail in the Extramural Activities section. The remainder of the budget is used to support Canadians in other countries undertaking research training or specific research projects, including a small amount for support of international scientific organizations in the health sciences.

National Research Council of Canada

Program	Science Resources 1976/77 $M	1976/77 MY	1977/78 $M	1977/78 MY	1978/79 $M	1978/79 MY	Total Resources 1978/79 $M	1978/79 MY
	(millions of dollars and man-years)							
Engineering & Natural Sciences Research	134.2*	2,784	162.0*	2,798	181.5*	2,805	182.7	2,832
Scientific and Technical Information	11.1	271	13.5	271	15.1	271	15.1	271
Total	**145.3**	**3,055**	**175.5**	**3,069**	**196.6**	**3,076**	**197.8**	**3,103**

*Includes transfers from other departments ($1.2 million in 1978/79).

Practically all of the National Research Council's budget for the Engineering and Natural Sciences Research program and for the Scientific and Technical Information program is spent on scientific activities: $52.9 million will be spent in industry, of which $34.9 million is R&D contracts and $18.0 million is grants. Another $9.9 million will be spent in the university and private non-profit sector, largely in the form of grants, so that overall 33% of the total estimated expenditures will be spent extramurally.

The objective of the Engineering and Natural Sciences Research program is to provide a national foundation for the creation, application, and use of knowledge derived from the fields of natural sciences and engineering. The program activities are organized into six areas: basic and exploratory research, research on long-term national problems and objectives, research in direct support of industrial innovation and development, research to provide technological support to social objectives, research and services related to standards, and the management of national facilities.

About a quarter of the in-house budget is spent on basic and exploratory research. It includes studies on sub-atomic forces, spectroscopy of atomic and molecular species, cell biology and plant breeding, the theory of air dynamics, and astronomy. The program also includes the work of the Herzberg Institute for Astrophysics, which studies space physics and astronomy.

Research on such long-term national problems as energy, transportation, oceans, and food is discussed in the Special Applications section.

Research to provide technological support for social objectives covers four areas: public safety, environment, health, and education and training. Under an agreement with the Canadian Association of Chiefs of Police, the council has been performing research in areas such as protective and forensic sciences and burglary and security systems since 1974. The council aids other federal agencies and the provinces with research on vehicle and aviation standards. Development of improved techniques for determining the toxicity of chemicals, and studies on noise abatement techniques, are representative of studies in this area.

Research in direct support of industrial innovation and development includes the highly successful Program of Industry/Laboratory Projects and the Industrial Research Assistance Program. A major space project, the Remote Manipulator System for the U.S. Space Shuttle program, is being developed under contract by Canadian industry (see Space in the Special Applications section). In conjunction with the Department of Fisheries and the Environment, an ocean data system is being developed with industry. A centre of excellence in fermentation technology was established in 1977/78 which, it is expected, will lead to the establishment of an industrial microbiology capability in Canada.

NRC is responsible for maintaining primary standards and for developing new measurement standards in such fields as laser technology, acoustics, and neutron radiation. It is also developing marine analytical standards, developing criteria for determining environmental quality, indentifying radiation and noise hazards and setting standards for safe exposure levels, developing safety standards and effective systems for fire protection in buildings, and establishing standards for new construction materials.

Under its responsibilities for the management of national facilities, NRC operates research facilities such as wind tunnels, high-voltage accelerators, the Dominion Astrophysical Observatory, the Algonquin Radio Observatory, and a marine dynamics and ship laboratory for the design and testing of ships, submarines, and other vessels. It also operates space research facilities, the largest of which is the Churchill rocket range in Manitoba. It plans to launch two rockets and payloads and two large balloon flights to study the solar eclipse in February, 1979.

Two major facilities are the Canada-France-Hawaii telescope and TRIUMF, the medium-energy proton accelerator and meson facility at the University of British Columbia. The telescope is scheduled for completion in December 1978, and the council is upgrading the Dominion Astrophysical Observatory in Victoria to include a duplicate of the telescope's data acquisition and control systems. In the past year the TRIUMF accelerator has achieved its designed beam intensity of 100 microamps. A medium resolution spectrometer has recently been completed and a fast pion (or pi-meson) beam is scheduled for completion in 1978/79.

The objective of NRC's Scientific and Technical Information (STI) program is to facilitate the use of scientific and technical information by the government and people of Canada. There are three main activities within the program: the National Information Services which includes the Canadian Institute for Scientific and Technical Information, Network Implementation which is concerned with providing a network of STI services, and Research and Development which is concerned with developing standards and procedures for STI services and with improvements in providing these services. NRC's involvement in the publishing of learned journals is also included in this program.

Grants and Scholarships Program (NRC)

	Science Resources					
	1976/77		1977/78		1978/79	
Program	$M	MY	$M	MY	$M	MY
	(millions of dollars and man-years)					
Scholarships & Grants-in-Aid of Research	93.0[1]	—	97.9	—	105.0[2]	—
Operating Expenditures	1.3	48	1.7	57	1.7	55
Total Estimates	**94.3**	**48**	**99.5**	**57**	**106.6[3]**	**55**

(1) Includes $6.8 million in contributions for the support of TRIUMF, subsequently transferred to the Engineering and Natural Sciences Program of the NRC.
(2) When the Natural Sciences and Engineering Research Council is established, $0.35 million will be transferred to the NRC for support of international affiliations.
(3) Includes transfer into the program of $0.2 million.

Beginning in 1978/79 the program of scholarships and grants-in-aid of research will be administered by the new Natural Sciences and Engineering Research Council. The objective of the program is to promote and support the development and maintenance of research and the provision of highly qualified manpower in the natural sciences and engineering. Sub-objectives are:

—to support excellence in research for the creation of new knowledge in the natural sciences and engineering;

—to promote and support the development of research in selected fields of regional and national importance;

—to assist in the provision and development of highly qualified manpower.

Nearly all of the budget—96%—is used to support research and research training in Canadian universities. The program is discussed in greater detail in the Extramural Activities section. Of the remainder it is estimated that $1.6 million will be used to support Canadians undertaking research or being trained outside Canada, $1.6 million will be for research support in industry, and $1.4 million for S&T support in Canadian non-profit institutes.

Canada Council — Social Sciences and Humanities Research Program

	Science Resources					
	1976/77		1977/78		1978/79	
Program	$M	MY	$M	MY	$M	MY
	(millions of dollars and man-years)					
Regular program	29.2	96	31.4	97	32.2[1,2]	102

(1) Includes transfers from External Affairs (estimated $1.1 million for 1978/79).
(2) 1978/79 budget is on a cash basis rather than the accrual basis of previous years; for comparison, reduce 1977/78 forecast expenditures by $1.7 million and 1976/77 expenditures by $2.3 million.

The objectives of the program are to support independent research in the social sciences and humanities, to stimulate Canadian studies, and to bring the results to the public.

In comparison to the other two granting councils, a smaller proportion (76%) of the council's budget is classified as payments to universities. There are two major reasons for this. A significant proportion of leave fellowships and research grants to individuals are for research undertaken outside Canada. It is estimated that $2.9 million will be spent in the foreign sector in 1978/79. In the social sciences and humanities there is a greater need to support research communications, e.g., to help meet the expenses of conferences, provide partial support for publishing learned journals, and subsidize the publication of scholarly manuscripts. This support amounts to about 10% of the budget. The council also provides grants to cover part of the administrative costs of learned societies. An estimated $2.6 million will be paid to Canadian non-profit institutions in 1978/79. Discussion of the university support will be found in the Extramural Activities section.

Transport

	Science Resources						Total Resources	
	1976/77		1977/78		1978/79		1978/79	
Program	$M	MY	$M	MY	$M	MY	$M	MY
	(millions of dollars and man-years)							
Administration	11.5	112	14.5	118	14.7	121	84.1	1,416
Marine Transportation	4.2[1]	1	7.9[1]	11	5.7[1]	1	295.2	5,736
Air Transportation	12.2[2]	79	12.5[2]	70	11.3[2]	66	540.7	12,183
Surface Transportation	5.5	30	15.1	39	12.3	40	563.9	287
Total	**33.3**	**222**	**50.0**	**238**	**44.1**	**228**	**1,483.9**	**19,622**

(1) Includes transfer from Environment ($5.4 million in 1978/79).
(2) Includes transfer from Environment ($8.0 million in 1978/79).

In support of its objective of improving transportation in Canada, the Ministry of Transport will spend an estimated $44.1 million in 1978-79 on S&T activities, 3.0% of total departmental estimates. Extramural expenditures will be $23.7 million, with $18.5 million of this sum going to industry and $2.8 million to universities.

In 1977/78 the Assistant Deputy Minister, Research and Development, became responsible for coordinating both interdepartmental and intra-departmental S&T activities in transportation. The department has a broad range of scientific activities arising from the requirements of the Air, Marine, and Surface programs and from the Transportation Development Centre and the Strategic Planning Branch in the Administration program.

The Transportation Development Centre accounts for 35% of the department's expenditures on S&T. Sixty percent of the centre's budget is applied to

specific projects requested by other departmental groups. The remainder is applied to discretionary projects that are in support of the long-term needs of the Canadian transportation system. For short term R&D, the centre often participates in joint projects and cost-sharing arrangements with other public and private groups. It is organized into four divisions—Current Technology, Advanced Technology, Technology Applications, and University Programs.

Several S&T projects, in which the Marine Transportation and Surface Transportation Administrations are cooperating with other government and non-government organizations, are discussed under Transportation in the Special Application section. Air Transportation will be studying the environmental consequences of aircraft operations. Other studies will investigate the cause of aircraft-generated wake vortices and their effects on other aircraft, the crash worthiness of aircraft, telecommunications, and structural and human factors in the design of control towers. Using the facilities of the Air Traffic Services Simulation Centre, projects are planned or underway to study bilingual air traffic control, air terminal capacity and flow management, and the man/machine interface in air traffic control.

Urban Affairs

	Science Resources						Total Resources	
	1976/77		1977/78		1978/79		1978/79	
Program	$M	MY	$M	MY	$M	MY	$M	MY
	(millions of dollars and man-years)							
Urban Affairs	6.8	102	7.3	67	8.8	54	20.6	185

Estimated expenditures for scientific activities in Urban Affairs in 1978/79 are $8.8 million, or 43% of total departmental estimates, and represent a 21% increase over 1977/78. Extramural expenditures at $6.7 million are 23% higher than in 1977/78. $2.1 million will be spent in industry and $1.9 million in universities.

In little more than half a century Canada has been transformed from a sparsely settled rural country to one in which three out of four citizens live in towns and cities, and urbanization has become a significant research topic. The greatly increased demand on public urban services—public utilities, transportation and housing, social services, educational and cultural facilities—adds impetus to questions about the effect of urbanization on the economy, the social fabric, non-renewable resources, and the environment.

An important part of Urban Affairs' scientific activities is policy analysis, which includes the analysis of urban problems and the recommendation of ways to change the design and delivery of federal programs to improve their sensitivity to urban conditions. This activity forms the basis for the development, in cooperation with other government departments, of federal positions and policies on Canadian urban issues and for the ministry's recommendations on federal support of provincial and municipal governments' development plans.

A small but typical research activity is a study of the recovery of public expenditures on urban transit systems through what are called land value capture mechanisms. These recover part of the costs from development projects stimulated by the existence of the transit system. The mechanisms range from direct taxation to joint public-private development. Another research project will try to identify the primary urban problems and concerns perceived by people living in the largest cities and the priorities they attach to various perceived problems.

The ministry also carries out research in support of urban development planning. For example, the use of the government's strategically placed holdings of urban property can have a marked effect on the quality of life in a city. The ministry is involved in this activity as a member of the Treasury Board's advisory committee on federal land management. A special case is the ministry's involvement, usually by funding planning studies, in the identification of the best use of urban land released when railway lines are relocated. These activities are defined by the Railroad Relocation and Crossing Act.

Central Mortgage and Housing Corporation

	Science Resources						Total Resources	
	1976/77		1977/78		1978/79		1978/79	
Program	$M	MY	$M	MY	$M	MY	$M	MY
	(millions of dollars and man-years)							
CMHC	13.1[1]	173[1]	13.5	138	15.6	138	869.2	3,761

[1]Totals for a 15 months period.

The main objectives of Central Mortgage and Housing Corporation are to promote the construction of new housing and to improve living conditions in Canada. In support of these objectives, CMHC will spend an estimated $15.6 million on scientific activities in 1978/79, 1.8% of total corporate estimates and an increase of 16% over 1977/78. $8.7 million will be spent extramurally, $4.6 million of it in industry and $1.4 million in universities. These activities include the collection and analysis of data, studies of new alternatives in housing design and technology and in patterns of human settlement, and the support of projects to test and demonstrate new ideas.

The provision of information on the availability and affordability of housing includes the analysis of capital markets, economic analysis and forecasting, and reviews of mortgage insurance fees and premiums. A continuing review of current housing programs and housing delivery is being carried out, and a major intramural study was initiated in 1977/78 to look at the cost effectiveness of housing programs in the light of social and economic changes.

To keep its housing programs and policies up to date, CMHC is carrying out research projects in such areas as housing for the elderly and the handicapped, housing policy for the 1980s, revision of the National Housing Act, shelter and income policy, housing conservation projects and settlements policy. Some of this work is conducted jointly with Urban Affairs and, in addition, there is a continuing review of housing policies with other departments.

CMHC's research is intended to stimulate innovation in housing design and technology and to bring new research through the development stages so that it can then be demonstrated to have general applicability. Housing and settlement design that promotes the conservation of energy and resources is one major topic. The broad field of building technology is another. Water and sewage treatment is an important field of research, complementing Environment Canada's efforts to improve the technology for reducing industrial pollution. The interdepartmental committee on municipal sewage collection and treatment research was set up to help CMHC review R&D projects in this area.

CMHC carries out a number of information projects, both to provide the basis for defining research requirements, e.g., feasibility and design studies, and to disseminate the results of its research activities, e.g., seminars and workshops.

A PERSPECTIVE ON SCIENCE IN CANADA

A PERSPECTIVE ON SCIENCE IN CANADA

It is the purpose of this section of the publication to put Canada's scientific activity in a context of history and of the scientific effort in other countries, using various indicators of expenditure.

Indicators of scientific activity must be interpreted with caution. International comparisons suffer from a number of deficiencies, such as differences in accounting, concepts, and methods, and it is difficult to find out how reliable the data are. Economic and other conditions that determine the level of performance vary from country to country. The same caution is needed when comparing levels and trends of scientific activity within countries. For example, there are no indicators of the effectiveness with which scientific resources are used, and often the full cost of R&D cannot even be determined.

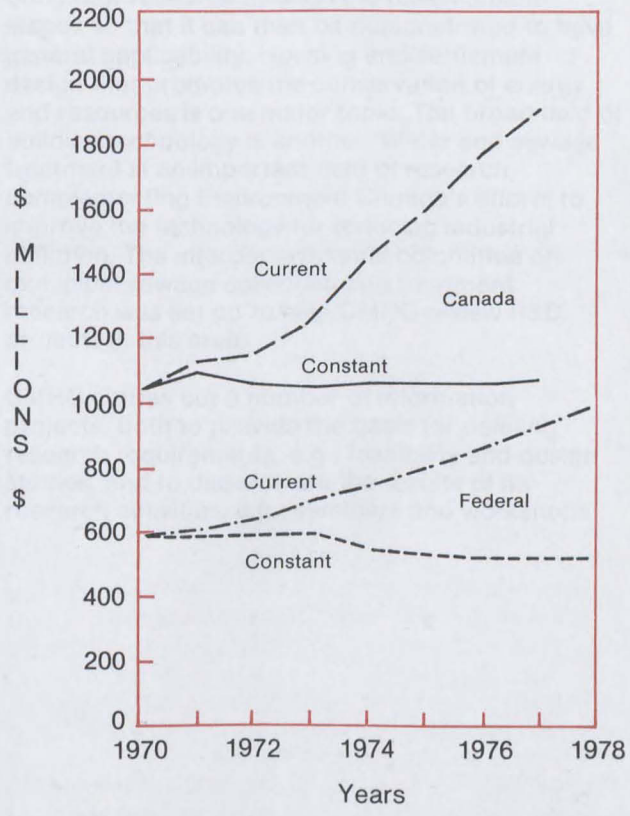
Notwithstanding these caveats, trends in science expenditures, if measured consistently over a period of time, can indicate the direction of the support of scientific activity. The international comparison of scientific expenditures similarly highlights the deviation of domestic expenditures from what is considered to be normal in other countries. Such rough guidelines may provide the first clues to the need for change in the level or distribution of the support of domestic scientific activity.

The level of R&D expenditures, R&D intensity or effort, and the distribution of research and development activity are the particular concerns of this discussion. Many countries report only expenditures on R&D in the natural sciences, so this is the only reliable basis for international comparison. But since this is generally the largest component of science expenditures it provides a good indication of the level and trends in scientific activity as a whole.

The level of gross R&D expenditure in Canada (GERD) and the level of federal government R&D expenditures (FERD) are graphically shown in Figure 1. Both current and constant dollar values are given.

Figure 1

Gross Expenditures on R&D in Canada (GERD) and Federal Expenditures on R&D (FERD) (millions of dollars, current and constant (1970))



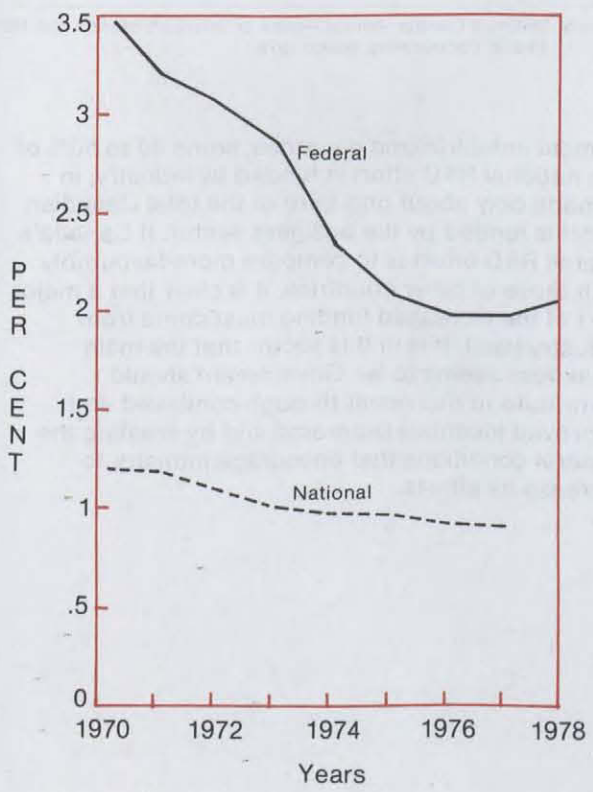
Current dollar expenditures on R&D by the federal government rise consistently between 1970 and 1978. The average rate of growth over the period is 7.1%. However, the real value of government R&D

expenditures measured in constant dollars has declined over the period. It has decreased from $587 million to $539 million in 1978. The high rate of inflation, particularly between 1973 and 1976, seriously inhibited the growth of the real value of government spending on research and development. It should be noted, however, that there has recently been some shift in emphasis from direct federal support of research and development in the industry sector to indirect support, the value of which is not incorporated in science expenditure data.

Figure 2 gives further evidence of the trend in the federal government R&D effort, measured by the ratio of total government R&D to total government spending. The government R&D effort declines steadily, from 3.55% in 1970 to 2.02% in 1976. There has been a slight recovery in the last two years and the level of effort measures 2.10% in 1978. A significant influence on this trend has been the substantial increase in transfer payments to other governments and individuals which has taken place in the 1970s.

Figure 2

Federal Government and National Research and Development Effort (percent)



Federal government research and development expenditures are a significant proportion of the national effort, over half in recent years. Figures 1 and 2 compare the federal and national trends. The national effort is measured by the ratio of national expenditures on R&D in the natural sciences (GERD) to gross national product. As is the case with the federal government, the national R&D effort declines over the period from 1.21% in 1970 to 0.92% in 1977, the last year for which national data is available. The rate of decline appears to be slowing down in the later years, which matches the apparent stabilizing of the government's effort as well. Trends in the level of GERD also describe a pattern similar to the trend in government R&D expenditures (FERD). National current dollar expenditures rise consistently from $1.0 billion in 1970 to $1.9 billion in 1977. However, the real value (1970 dollars) of the national level of R&D expenditure in 1977 is $1.1 billion, a real growth of only 0.3% over the period. The trend is put in an international context in Figure 3.

Figure 3

Percentage of Gross Domestic Product Devoted to GERD for 1973 and 1975 for Selected OECD Countries(1) (percent)

Country	1973	1975
United States	2.37	2.35
Germany	2.14	2.16
Japan	1.90	2.00*
France	1.79	1.86
Sweden	1.51	1.59
Canada	1.02	1.00

*For 1974.
Source: OECD, International Survey of Resources Devoted to R&D by OECD Member Countries.

While international comparisons are subject to the caveats in the opening paragraphs of this section, the indications are that among these leading industrial countries, the Canadian effort is relatively low and, except for the United States, it is the only country in which, since 1973, the national R&D effort appears to be on the decline.

The distribution of research and development activity among performance sectors is another informative indicator of scientific activity. The performance sectors are business enterprise, government, and university and private non-profit. Of particular interest is the performance of industrial

research in Canada. The objectives of research and development, the concrete economic and other benefits that it generates, can only be realized through innovation, the application of the derived knowledge on a national scale. Most of this innovation must take place in the industrial sector, which can only be accomplished if industry maintains a substantial R&D capability. Only through performance can R&D capability be built up and maintained. It has long been evident that the amount of scientific research performed by Canadian industry is out of balance. Figure 4 describes the situation in an international context.

Figure 4

Distribution of R&D in the Natural Sciences by Performer, 1975 (percent)

	Business Enterprise	Government	University and PNP
Canada	43.2	31.8	25.0
France	60.9	23.2	15.9
Japan	64.3	13.3	22.4
Germany	66.4	15.7	17.8
United States	68.1	15.6	16.3
Sweden	68.6	8.0	23.4

Source: 1) OECD, International Survey of Resources Devoted to R&D by OECD Member Countries.
2) Statistics Canada, Annual Review of Science Statistics, Cat. No. 13-212, Forthcoming, March 1978.

Canadian industry performs the lowest percentage of the total national effort of all the countries considered. While Canadian business enterprise performs 43% of the nation's R&D, the research and development performed in industry in other countries exceeds 60%. On the other side of the coin the performance of R&D by government in Canada is the highest of the countries considered. Hence there has been a conscious effort to redress the balance by both direct and indirect incentive programs. The results of this combination of initiatives is described in Figure 5. Since 1972 a consistent shift in the performance of R&D from government to industry is evident. The proportion of national R&D that was performed in industry increased from 39.8% in 1972 to 44.2% in 1977, while government perfomed R&D has declined from 35.3% to 31.4% over the same period. Research performed in universities, on the other hand, has remained relatively constant at between 24 and 25%. Although the shift in distribution has not been sufficient to correct the imbalance depicted by the international comparison of Figure 4, it is definitely in the desired direction. Further improvement in this direction is still necessary if our international competitive position is to be strengthened through innovation and improved productivity.

Figure 5

Distribution of R&D in the Natural Sciences by Performer in Canada 1970-1977 (percent)

Year	Government	Industry	University
1970	33.9	40.0	26.1
1971	33.6	41.4	25.0
1972	35.3	39.8	24.9
1973	35.6	40.3	24.1
1974	33.9	42.2	24.0
1975	31.8	43.2	25.0
1976	31.3	44.2	24.5
1977	31.4	44.2	24.4

Source: Statistics Canada, Annual Review of Science Statistics, Cat. No. 13-212, Forthcoming, March 1978.

In most industrialized countries, some 40 to 50% of the national R&D effort is funded by industry; in Canada only about one-third of the total Canadian effort is funded by the business sector. If Canada's overall R&D effort is to compare more favourably with those of other countries, it is clear that a major part of the increased funding must come from industry itself. It is in this sector that the main weakness seems to lie. Government should contribute to this result through continued and improved incentive programs and by creating the general conditions that encourage industry to increase its efforts.

BUDGETING FOR SCIENCE

BUDGETING FOR SCIENCE

Federal government support for science is based on the premise that science is not an end in itself but a means of solving national problems and seizing opportunities to achieve national goals.

The government's definition of national goals and its perception of problems and opportunities are reflected in the objectives set for federal departments and agencies. These objectives and priorities provide a framework for the development of programs, and for decisions on the resources to be allocated to achieve program purposes. Since science is one of a number of means a department may use to achieve a program objective, science and technology programs must compete for funds with other ways of meeting the objectives.

But since science itself is not a program, only one means of attaining program objectives, a budget is not struck on the basis of a decision on how much should be spent for science but determined as an aggregation of science expenditures justified by the programs they serve.

This is not to say, however, that in establishing the amounts to be spent for a specific science activity, the government does not take into account concerns broader than may be set out in individual departmental objectives. A department may be given the lead responsibility for reflecting these broad concerns in a particular area, such as energy R&D, and other departments that may have roles in a national R&D program will be informed of the views of the lead department on what the level of a national program should be.

Recognizing the need for science and technology to contribute to Canada's well-being, the federal government has given MOSST responsibility for advising the government how science may best be used. MOSST advises the government on the most effective use of existing and proposed science resources to achieve departmental missions and reports how well the government's science activities comply with its objectives and policies in science and technology. The advice is transmitted to the government through the minister, who is also a member of Treasury Board.

The review and assessment of science activities is integrated with the budgetary process. This process begins when departments and agencies prepare program forecasts, which outline the financial and manpower resource requirements for each program and activity. These forecasts are forwarded to the Treasury Board Secretariat by the beginning of April, 12 months ahead of the start of the fiscal year. These forecasts distinguish between resources required to continue existing programs (A Budget) and those requested for either enrichment of an existing program or the initiation of new ones (B Budget). Included in the program forecast is a science addendum that details scientific expenditures by type of science activity, by the performing sector, and by application areas (e.g., energy or transportation), as well as the manpower devoted to science.

The calendar of events leading to the 1978/79 Main Estimates is detailed in the illustration. On the left are the main activities in the preparation of the budget. The right side shows MOSST's involvement with the budgetary process.

At the start of each year MOSST prepares objectives, strategy, and guidelines for the review of S&T items in the forthcoming program forecasts. These are for the use of analysts at MOSST and the Treasury Board Secretariat. In April and May MOSST analysts consult with the Treasury Board Secretariat's analysts in the review of these departmental requests.

MOSST ROLE IN BUDGETARY PROCESS

Major Budgetary Events		MOSST Activities
	Jan. 1977	Preparation of objectives, strategy, and guidelines for review of science proposals for fiscal year 1978/79.
	Feb.	
	Mar.	Discussion with departments on program forecasts.
Departments submit program forecasts to Treasury Board Secretariat for Fiscal year 1978/79	Apr.	Science addenda received. Review and analysis of program forecasts of science departments.
	May	
	June	Briefings to MOSST Minister and Treasury Board Secretariat.
	July	
Target letters to departments	Aug.	First contacts with departments to prepare 1978/79 science publications.
	Sept.	Discussion with departments on 1978/79 main estimates and preplanning for 1979/80 program forecasts.
	Oct.	
Departments submit main estimates to Treasury Board Secretariat for 1978/79	Nov.	Main estimates science addenda received. Review and analysis of main estimates submissions.
	Dec.	Briefing to MOSST Minister.
	Jan. 1978	
Tabling of main estimates	Feb.	
	Mar.	Tabling of science activities and expenditure publication.
	Apr.	

The MOSST analysts concern themselves with both intradepartmental and interdepartmental issues. They assess the relevance of existing and proposed activities, considering not only individual departmental objectives but also the broader objectives and priorities of the government as a whole. If they find inadequate coordination, duplication of effort, or the need for improved management, they may recommend specific improvements or a detailed review of all on-going activities, either within a department or even across several departments involved in a given area of S&T activity. If they identify missing or conflicting mandates, they may recommend clearer lines of responsibility; perhaps one department will be assigned the lead role.

Early in June the MOSST Minister and senior management at TBS are briefed on trends in S&T expenditure and on specific issues and programs. This takes place before the forecast expenditures are considered by the ministers of the Treasury Board.

After the review of program forecasts, departments and agencies are told the recommended target expenditures for their main estimate submissions. These targets are based on a Cabinet-approved fiscal framework for the forthcoming fiscal year. The departments are asked to send the Treasury Board Secretariat their main estimates by November 1. Included as an addendum to each estimate is an outline of science resourcing similar in the amount of detail to the program forecast science addendum. This information is used to brief the MOSST Minister, as another contribution to the government's decision-making process. It is also used in the preparation of this publication and a companion report, *Federal Science Expenditures and Manpower, 1976/77 - 1978/79.*

The review of science expenditures is not confined to the budget-making process but is a continuing activity whose objective is to achieve greater effectiveness in the pursuit of government objectives and improved management of resources devoted to science. The fiscal constraints on the government have required departments to re-evaluate all their on-going activities to see how well they are achieving departmental and government objectives, not only as a part of the general effort to avoid waste, but increasingly out of the need to fund new projects by finding off-setting economies. The process of reviewing on-going projects, permits departmental managers to shift resources from lower to higher priority areas and in some cases allows them to seek alternate performers for instance by contracting the work out to the private sector.

Thus, although there is no separately indentified science budget of the federal government, MOSST as a central agency for science has direct influence on the decision-making process, the coordination, and the management of S&T resources.