7th Annual Report 1975

Interdepartmental Committee on Space

Comité Interministériel sur l'Espace

INTERDEPARTMENTAL
COMMITTEE ON
SPACE

7TH ANNUAL REPORT - 1975

TO THE

MINISTER OF COMMUNICATIONS

PUBLISHED BY THE ICS SECRETARIAT
OTTAWA, APRIL 1976

Highlights of 1975

This Report presents for the first time the outlook for the next five years for Canada's Space Program, as seen by the ICS. It shows that expenditures on government programs in 1975/76 are expected to reach $43 million, an increase of $8 million over 1974/75. The Government and Telesat Canada will spend about $30 million on capital equipment, an increase of $4 million over the previous year. There are indications that the order-books of the manufacturing industry will be healthy until 1977/78. Expenditure on two major development projects, the Space Shuttle Attached Remote Manipulator System (SRMS) and the fourth Telesat satellite project, will peak in that year.

The cost of leasing satellite services by government departments and Crown corporations continues to grow, reaching $16 million in 1975, an increase of one million dollars over the previous year. Leasing costs will peak at $37.4 million in 1978/79, when the DOC begins to use the Telesat dual-band satellite.

During the year, another major element of Canada's space policy was set in place when the Minister of Communications was given the task of recommending a restructuring of the Canadian space manufacturing industry, to the end that satellites could be built in Canada for the domestic and export markets, and the ICS was charged with the responsibility of maintaining the health and viability of the industry.

The year also saw the renewal of the ERTS/LANDSAT agreement with the USA, a review of the SRMS project, and the accreditation of Canada to membership in the European Space Agency as an observer.

The Outlook for the Future

The Canadian space program, in common with the space program of the USA, Europe and Japan, is intended to develop an industrial base, and to extend market opportunities at home and abroad, in both service and manufacturing industries. The Canadian space program has two main elements--projects of federal departments and agencies, and those of Telesat Canada, the corporation operating Canada's domestic communications satellite program.

The ICS plans on publishing, in the next year, an illustrated brochure on "*Canada in Space*", which will describe the program and the organization for carrying it out. The brochure will also describe Canada's space industry, and its products.

The ICS expects to receive proposals for new projects, dealing with communications, resource sensing satellites and search and rescue satellites. The time for decisions on programs to replace those which will be completed in the next year or two is approaching, if a viable manufacturing industry is to be maintained. The ICS looks forward to an increasing Canadian content in these projects, as a result of imppovements in the performance of our industry.

Relations between Canada and the European Space Agency (ESA), are expected to become closer, because of a community of interest and a natural coincidence of objectives for our Space Program and that of ESA.

About the Interdepartmental Committee on Space

The ICS was formed by Cabinet in late 1969, as a committee reporting to the Cabinet Committee on Science Policy and Technology. Its objective was to advise on policy and planning for the Canadian space activities, based on continuing review and assessment, to ensure the coordinated development of government, university and industrial activities, and international cooperation. When the Cabinet Committee on Science Policy and Technology was disbanded in late 1971, the ICS began reporting to the Minister of the newly-formed Ministry of State for Science and Technology. This reporting line and the Terms of Reference of the ICS were reconfirmed in 1974 when Cabinet approved a Space Policy for Canada. Finally, in November 1975, Cabinet directed the ICS to report to the Minister of Communications and on the same occasion gave the ICS the added responsibility of coordinating space procurement activities in Canada, so as to maintain a viable Canadian space industry.

The Committee is composed of senior officials of Departments involved in space activities who are able to speak for their departments on policy matters. At the moment, nine departments or agencies are represented on the Committee with observer status given to two others. The Committee is assisted in its work by three sub-committees which are concerned specifically with the International, Industrial and Scientific Aspects of the space policy. The membership of these sub-committees is open to other departments, industries and universities.

Finally, to support and service the ICS, a permanent Secretariat will be set up in 1976, within the Department of Communications.

More details on the membership and Terms of Reference of the ICS or its sub-committees are contained in the annexes of this report.

INDEX

1. INTRODUCTION

The purpose of this document is to report on the activities of the Interdepartmental Committee on Space (ICS) for the year 1975 and to give an overview of Canada's Space Program.

Section 2 of this report presents highlights of the activities of the ICS and of its three sub-committees; Section 3, on Canadian Space Programs, describes the major spacecraft projects Canada is involved in, both current and proposed, and the rocket research work, primarily carried out at the NRC; Section 4 outlines the activities performed in our three major space facilities; Section 5 highlights the space-related activities carried out in departments and agencies; and finally, Section 6, in addition to the expenditures for FY 75/76, presents a five-year forecast of Canadian Government expenditures in space.

More detailed information on the space activities of agencies and departments of the Federal Government as well as those of Canadian universities and industries is contained in a report on *"Space and Upper Atmosphere Programs in Canada"*, published annually by the National Research Council (NRC). The latest report, reference SRFB 092, dated January 1976, is avialable from the NRC or from the ICS Secretariat.

2. COMMITTEE ACTIVITIES

The Interdepartmental Committee held four meetings in calendar year 1975.

During the year, formal approval was given to the Terms of Reference for the new three sub-committee structure, the concept for which had been approved late in 1974. The Terms of Reference for the new International, Industrial and Scientific Sub-committees are given in Annex 2 of this report.

Although committee work during 1975 was largely of a coordinating and monitoring nature, one major program item was dealt with during the year. The ICS was requested to provide a recommendation to the government on the revised NRC program for the development of the Shuttle Attached Remote Manipulator System. After due consideration, the Committee decided to recommend that this program be continued and called for a further report at the end of Phase B in approximately one year's time. It also noted that an assessment of the market potential for manipulator systems and sub-systems for space and non-space applications and a marketing strategy to capture a fair share of the foreseen markets should be made available within the year.

On 6 November 1975, Cabinet gave the ICS the added responsibility of coordinating the Canadian space procurement activities so as to maintain a viable space industry in Canada. On the same occasion, it also changed the reporting relationship of the ICS so that the Committee now reports to the Minister of Communications.

2.1 Sub-Committee for the International Aspects of Space Policy

The Sub-Committee for the International Aspects of Space Policy is chaired by the ICS member from the Department of External Affairs. The Sub-Committee coordinates participation in international affairs that relate to space and its utilization.

During 1975, Canada participated in the 18th Session of the UN Outer Space Committee and its Sub-Committees. The legal sub-committee made progress on drafting principles to govern the use of satellites for direct broadcasting. While debate on legal implications of remote sensing remains stalled due to fundamental disagreement about the rights of "sensed" states, progress was made in the scientific and technical sub-committee in encouraging countries to use remote sensing technology.

Canada/U.S.A. cooperation in space technology continued to expand. Agreement was reached on the renewal of the 1971 treaty permitting direct Canadian readeout of ERTS/LANDSAT data. A NASA/NRC memorandum of understanding was negotiated for the design and construction in Canada of the remote manipulator system for the space shuttle. An invitation was received to participate in the Large Area Crop Inventory Experiment, and the feasibility of Canadians participating in that experiment is being assessed. The series of joint experiments in the vicinity of the magnetic polar cusp was continued.

With the reorganization of the former ESRO/ELDO into the new European Space Agency (ESA), Canada requested and was granted observer status on ESA. Preliminary discussions took place between Canada and ESA officials on the possibility of working together in areas of mutual interest.

A memorandum of understanding between CCRS and the French Centre National d'Etudes Spatiales was negotiated to permit cooperative activities in the area of remote sensing. Informal agreement was also reached with Denmark for the read-out by Canada of ERTS/LANDSAT data of Greenland.

Discussions were held with Japanese scientists on the possibility of developing bilateral cooperative projects in remote sensing and other aspects of satellite technology. Agreement was reached with Japan on obtaining data from the Japanese Ionospheric Sounding Satellite (ISS).

As in past years, Canada continued to participate in various multilateral space-related activities including Aerosat, INMARSAT, COSPAR, the ITU and the WMO.

2.2 Sub-Committee for the Scientific Aspects of Space Policy

The sub-committee on the Scientific Aspects of Space Policy of the ICS is also the Associate Committee on Space Research (ACSR) of the NRC.

In 1974, the ICS recognized the need for a survey of the future for space research in Canada, a survey which would include organizational recommendations and describe effective programs and projects. The National Research Council accepted the recommendation of the ACSR that a study be undertaken, and arranged for Dr. P.A. Forsyth of the University of Western Ontario to undertake the work. The results of Dr. Forsyth's study are embodied in his report *"Opportunities for Space Research in Canada"*. The report is now under consideration by the NRC and it has also been referred to the ICS. During 1976, both NRC and the ICS are expected to respond to the recommendations of the Forsyth Report.

During 1975, the membership of the sub-committee expanded to include as many as possible of the agencies engaged in activities related to space research. The sub-committee now has representatives from 9 government departments and agencies, 9 universities and 4 industries. The reconstituted sub-committee met on 20 November 1975, at which meeting the sub-committee endorsed the Forsyth report.

At the recommendation of the ACSR, the NRC established a Secretariat for the International Magnetospheric Studies Program (IMS) at the University of Saskatchewan under the leadership of Dr. B.W. Currie. Already the secretariat has been very effective in coordinating, and in some cases, helping to secure funds for, the programs of a number of Canadian researchers. This work coupled with liaison activities with other national and international bodies, an IMS newsletter and plans for an IMS bulletin indicate that the Canadian part of the IMS program will be well organized and highly productive.

The ACSR sub-committee liaising with the Committee on Space Research (COSPAR) and the Special Committee for Solar Terrestrial Physics (SCOSTEP) of the International Council of Scientific Unions (ICSU) has also been reorganized to reflect its interest in the IMS and Middle Atmosphere Programs (MAP). It is anticipated that interest in research

in the MAP will gather momentum in the not too distant future because of the importance to world weather of middle atmosphere interactions between the magnetosphere and the stratosphere.

The ACSR also acts as the Canadian National Committee for COSPAR of the ICSU. Dr. R.E. Barrington, who is the Chairman of the ACSR, is the Canadian representative to COSPAR and the Chairman of the COSPAR Finance Committee. The Secretary of the ACSR is the Canadian contact for the flow of information between COSPAR and Canada.

2.3 Sub-Committee for the Industrial Aspects of Space Policy

Although its Terms of Reference were approved by the ICS early in the year, this sub-committee has not yet begun to function.

3. CANADIAN SPACE PROGRAM

Years before Canada became the third nation to join the Space Club, Canadian scientists were launching balloons to carry scientific payloads into the upper atmosphere. Although balloons are still used extensively today, the main thrust of Canada's involvement in Space is with satellite and rocket programs.

3.1 Major Spacecraft Projects (Active)

3.1.1 Communications Technology Satellite (CTS)

This is a cooperative project between the Department of Communications (DOC) in Canada, the National Aeronautics and Space Administration (NASA) in the United States and the European Space Agency (ESA). The general objective of the project is to advance in Canadian industry the state-of-the-art in spacecraft operating in the 12/14 GHz frequency band and related ground-based technologies relevant to future communications and other satellite application systems. The principal technological objectives are to conduct satellite communication systems experiments with 12 GHz terminals and to develop and flight test:

a) A super-efficiency power tube having greater than 50% efficiency at a minimum output power of 200 watts.

b) An unfurlable solar-power array with an initial capability of over 1.0 KW.

c) An accurate stabilization system for a spacecraft with flexible appendages.

The launching of CTS into geosynchronous orbit at 116° West longitude by means of a Delta 2914 Launch Vehicle is scheduled for mid-January 1976.

Its design lifetime is for a minimum of two years. The satellite was built by Canadian industry, with overall design, project management and integration carried out by the Communications Research Centre (CRC) of DOC. In addition to the launch, some components and testing support, the United States is providing the high-powered transmitting tube for the CTS' transponder. ESA is providing two 20 watt Travelling Wave Tubes (TWT), the solar array panel design and some other components. In 1975, the assembly and test of the complete spacecraft was achieved. Thermal/vaccum testing was successfully completed at NASA/Lewis Research Center, and preparations for mission operations were completed. The spacecraft was shipped to the Kennedy Space Center launch range on 25 November, 1975.

The high-power satellite and associated ground terminals will be particularly suitable for socio-economic experiments to prove new communications services. In accordance with the recommendations made by an independent evaluation committee, the Minister of Communications has accepted proposals from 20 organizations, including Canadian universities, federal and provincial agencies, industry and native associations. These organizations are planning some 26 different experiments ranging from satellite data transmission tests, telephone and TV transmission, and reception in large urban environments, to more socially-oriented experiments in education, long-distance medical diagnosis, community interaction and satellite communications for native peoples. The individual experiments are the responsibility of each sponsoring organization, with overall coordination and assistance from DOC. These experiments are scheduled to begin in May 1976.

Under contracts awarded to Canadian industry, the earth stations and other equipment to be used in the communications experiments were delivered, and are ready for use. Ten terminals with ninety-one centimeter diameter "dish" antennae and eight with 2.45 meter diameter antennae have been procured by contract. This contract also included three network control systems providing electronics for voice communications using the smaller terminals. Another contract provided two 3 meter diameter self-contained transportable earth stations and the electronic equipment for upgrading an existing 9.14 meter station at Ottawa.

3.1.2 Space Shuttle Attached Remote Manipulator System

As part of Canada's space policy announced in 1974, the National Aeronautical Establishment (NAE) of NRC concluded negotiations with NASA for Canadian participation in the U.S. Space Shuttle program. A memorandum of understanding between NASA and the NRC, for a cooperative program leading to the development and procurement of a Space Shuttle Attached Remote Manipulator System (RMS) was signed by the NASA Administrator and the NRC President on 18 July 1975. The work involved will be contracted to Canadian industry under the provisions of the government's make-or-buy policy. The present program will culminate with the sixth U.S. Space Shuttle flight, scheduled for early in 1979.

The objectives of this program are to provide for Canada's participation in the U.S. space transportation system program, and to create in Canada a high technology aerospace industry in teleoperators. This technology is essential to future Canadian initiatives for the development of energy and mineral resources, automation in industry, and the exploitation of our ocean resources as well as in space applications.

The RMS comprises:

a) A mechanical subsystem composed of arm sections, a shoulder joint, elbow joint, wrist joint and a hand or end effector.

b) A control subsystem consisting of an operator's controller, command software and information delays.

c) An electronic subsystem including an on-board computer and its interfaces, a video system, sensor electronics, servo electronics, cables, junction boxes and power conditioning.

The high reliability required of the RMS makes it necessary to develop a means of verifying the system in a zero gravity condition during the design phase. Since the arm cannot be operated or properly tested except in a zero-gravity environment, tests will be simulated in a

General Purpose Manipulator System Simulation Facility (SIMFAC) using mathematical modelling techniques. SIMFAC will also provide a facility for the development of remote manipulator systems technology applications in non-space environments.

The RMS project is now progressing through the project definition stage (Phase B) to a key program milestone: the preliminary design review scheduled for August 1976. Phases C and D, detailed design,manufacturing and test, are to follow and the program will culminate in the delivery of the first RMS early in 1979. Work on SIMFAC is progressing through the design review stages, the procurement of long lead items has been initiated, and the system is due to be commissioned in April 1977.

In support of NRC's overall program responsibility, CRC is preparing to carry out tasks in areas of dynamics, controls, materials, thermal design and environmental testing.

3.1.3 Aerosat

In August 1974, the USA, the European Space Research Organization (ESRO), which has since become ESA, and Canada signed a "Memorandum of Understanding" to establish a joint international program of experimentation and evaluation of an aeronautical satellite system (AEROSAT). Overall program responsibility lies with the Aerosat Council. Canada is represented on the Council by members from Transport Canada, the Department of External Affairs and DOC. Transport Canada has responsibility for the Canadian experimental program in which it is supported, notably in the procurement of ground equipment, by CRC. Space Segment procurement is the responsibility of the Space Program Board, where Canada is represented by a member from DOC. The Aerosat Council and the Space Segment Board are supported by the Aerosat Coordination Office and the Space Program Office, both located in the Netherlands, and to which Canadian staff has been seconded.

An extensive program of research and development making use of the American ATS-6 satellite and a Transport Canada Jetstar aircraft, is being carried out in association with ESA, NASA, and the U.S. Federal Aviation Administration (FAA) to determine the types of communications

equipment and traffic control techniques which best meet the requirements for aircraft communications via satellite. Within Canada, modulation techniques and UHF phased array antenna designs have been carried to the point of hardware development for exploitation by Canadian firms.

The airborne phased array antenna development was carried out in industry with the support of the Department of Industry, Trade and Commerce (DIT&C). This activity was completed during November 1975; the antenna is now being flight tested by Transport Canada.

Discussions are being held between Transport Canada and the FAA concerning the development in Canada of an avionics electronics package for Aerosat. A decision is expected on this matter by the end of the first quarter of 1976.

DIT&C, in cooperation with DOC, continued its efforts to ensure maximum Canadian industrial benefit in the procurement of the Aerosat spacecraft. To this end, meetings and discussions were held with potential Canadian suppliers, with the U.S. prime contractors who are the lead members in the three consortia expected to bid, and with a number of their European member firms.

At the time of writing, the Aerosat Council and the Aerosat Board had met, early in January, and had agreed to issue Requests for Proposals (RFP) on 1 March 1976. It is now expected that a contract will be awarded in November 1976.

3.1.4 Dual-Band Communication Satellite (Telesat Canada)

Canada's domestic communications satellite system, owned and operated by Telesat Canada, became operational in January 1973. With the successful launch of ANIK III in May 1975, the domestic system has now three operational satellites and 58 earth stations (including three transportable earth stations) providing television, radio, voice, data and facsimile transmission services to urban, rural and remote regions across Canada and in the Far North.

In December 1975, Telesat awarded a contract to RCA Corporation for the supply of a fourth satellite, the Dual Band Communication Satellite sometimes referred to as F.4, or ANIK 4, even though it has not been officially named yet. This satellite, to be launched in 1978, will have 12 transponders operating at 4/6 GHz to replace the Anik 1 channels and 4 transponders operating at 12/14 GHz. The latter capacity will be leased by DOC, for experimental use as a follow on to CTS, to acquire commercial experience with this type of system, and to develop a market for services at 12/14 GHz.

3.2 Major Spacecraft Projects (Planned)

3.2.1 Multipurpose UHF Satellite Communications System

An interdepartmental study group headed by DOC has been examining the feasibility of a Multipurpose UHF Satellite Communications System (MUSAT) to meet specific Canadian communications needs. Such a system could be designed to meet government requirements for:

a) communication to itinerant field parties.

b) communication to aircraft and ships.

c) data retransmission from sensor platforms.

d) crash beacon relay for search and rescue operation.

It was concluded that a substantial need exists for this type of service, that the system would be technically feasible and the costs acceptable to users.

As result, the study group recommended that the next stage in planning, project definition, be undertaken to define more precisely all aspects of the system. In particular, because of known problems

in transponder design, studies, to verify a preferred design were begun in industry. This advanced development work is necessary to enable specifications to be established for the transponder performance, prior to calling for proposals.

3.2.2 Experimental Ocean Surveillance Project (SEASAT)

The Government of Canada must economically provide surveillance and environmental monitoring off her coastal waters overlying the continental shelves on the East and West Coast and in the Arctic. This is needed to support maritime activities in the areas of fisheries, pollution control, ice reconnaissance, atmospheric and ocean resources, petroleum exploration and production, and search and rescue.

During the past year, Canadian scientists and engineers have participated with NASA and user agencies in the United States, in the technical planning of an ocean surveillance satellite called SEASAT. An official invitation to participate in the SEASAT program is expected to be received from the US Government early in 1976. An interdepartmental task force will be set up under the direction of the Inter-Agency Committee on Remote Sensing to prepare a Cabinet submission outlining Canada's proposed mode of participation in the program.

Though sovereignty and jurisdictional control are major long-term benefits of this experimental program, the potential economic benefits are also very significant. In a study undertaken by the Canada Centre for Remote Sensing (CCRS) on the potential gross economic benefits of an integrated airborne and satellite remote sensing system applied to operations in Canadian waters, the economic benefits were estimated to have a lower bound of $92 million per year by the year 2000. These estimates are related to various scenarios of economic activities and are based on the use of operational ocean surveillance satellite systems with high Arctic coverage.

In the shorter term, the experience and expertise to be developed in the course of this program should put Canadian electronics industry in a very favourable position to be world-suppliers

of digital radar image processors to a sizeable international market for both aircraft and satellite surveillance systems amounting to several million dollars per year.

3.2.3 Search and Rescue Satellite (SARSAT)

DND is responsible for providing air search and rescue services on behalf of Canada under ICAO agreements and for coordinating all marine search and rescue services. If the position of a downed aircraft is not known, many hours of flying are often involved in the search. This fact, coupled with an increase of SAR incidents of approximately 12% a year, has seriously tasked DND's resources to meet Canada's international commitments. It was recognized in the 1960's that a satellite based system could increase significantly our SAR capability, and DND sponsored two studies by Leigh Instruments Ltd. in 1972 and 1974.

The initial study concluded a geostationary satellite would not significantly increase our SAR capability. A second study by Leight Instruments was directed towards use of a non-geostationary satellite system in conjunction with the use of emergency locator transmitters (ELT), which are now mandatory for Canadian aircraft. The results of this study, formed the basis of DND's proposed SARSAT system.

In mid-1975, working level contacts were established between NASA and DND. NASA indicated they were working on a similar concept and suggested that engineering discussions between the two agencies might be useful. It soon became evident that NASA were interested in a possible joint program to demonstrate the feasibility of the SARSAT concept and informal discussions have since confirmed this position. Discussions are now being held for the purpose of defining the elements of a cooperative program with NASA.

R&D activities are continuing at DOC/CRC to develop the overall system parameters. During the past years, work has progressed, using the radio-amateur Oscar 6 satellite, to develop techniques of pin-pointing location of ELTs. The accuracy of locating an ELT has improved so that it can now be positioned within 6 miles of its location. Work is continuing on the program.

A joint program between NASA and DND can provide the required "proof-of-concept" test of a SARSAT system with a single satellite launched about 1980.

3.2.4 International Maritime Satellite System (INMARSAT)

In 1972 the Inter-Governmental Maritime Consultative Organization (IMCO) established a Panel of Experts to study satellite systems which could enhance the safety of life at sea, and improve public communications and vessel traffic management. The Panel of Experts, which included Canadian officials from DOC and Transport Canada, recommended the establishment of such a system. An international conference, was convened in April/May 1975 by IMCO, to consider the report of the Panel of Experts and the need for an international, intergovernmental organization to manage the maritime satellite system. The conference is to convene a second session in February 1976 to complete its work. Canada is playing an active role in these discussions.

3.3 Rocket and Balloon Research

The Space Research Facilities Branch (SRFB) of the NRC is a scientific support organization which specializes in planning and conducting field operations anywhere in the world, as well as in operating research stations using permanently located facilities. The Branch develops sounding rocket and balloon programs, implements the programs by procuring rockets and balloons, and monitors the engineering and fabrication of payloads instrumented by Canadian industry. SRFB engineers, assisted by specialists from industry, launch and track sounding rockets and balloons, acquire and record telemetered data, recover payloads and convert data into appropriate formats. The Branch publishes engineering reports and general annual reports covering all Canadian space programs.

3.3.1 Rocket Systems Section

During 1975, SRFB launched a Black Brant VB, and Black Brant VI and a Nike-Black Brant VB, from the Churchill Research Range.

The Nike-Black Brant VB was developed by Bristol Aerospace Ltd. (Winnipeg) in collaboration with SRFB, and with cooperation from the Goddard Space Flight Center of NASA and the U.S. Air Force Cambridge Research Laboratories. The Nike-boosted VB has significantly better performance potential than the standard VB. The advantage of this vehicle is that scientific payloads will have nearly 40% more time in which to collect data at higher altitudes than was previously attainable with the VB. The first engineering test flight took place on 4 December and was successful.

SRFB plans to launch, in the Fall of 1976, a payload equipped with an attitude control system to make measurements of cosmic X-rays and of the moon's reflectance from a range at Woomera, Australia. This flight is part of a continuing study which has involved launches from Arctic Canada and Hawaii.

3.3.2 Scientific Balloon Launching Facility

In response to a need for balloon facilities for Canadian scientists, SRFB is establishing a national mobile facility capable of launching the larger balloons required for upper atmosphere research. The facility will be established with the cooperation and support of the Atmospheric Environment Service of Environment Canada. The launch program is scheduled to begin in July 1976.

4. CANADIAN SPACE FACILITIES

4.1 David Florida Laboratory (DFL)

The David Florida Laboratory at CRC is an environmental testing facility where spacecraft components are tested under a thermal vacuum and vibration environment similar to that encountered in space. The facilities also include a satellite integration and test area, and R.F. anechoic chamber, an antenna range, and an attitude control system laboratory. The facility exists as support for the Canadian space activities in industry, universities and government departments. During the year, the laboratory was used for the CTS environmental testing and provided other technical support to the CTS project. The laboratory is procuring and installing additional equipment to provide the test facilities for the Space Shuttle Attached Remote Manipulator System.

4.2 Canada Centre for Remote Sensing

The Canada Centre for Remote Sensing (CCRS) is the nucleus of a national program in remote sensing. The Centre serves federal and provincial agencies, universities, industry and the general public.

The activities of the Centre are concentrated on the Earth Resources Satellite Program, the Airborne Remote Sensing Program and the Applications Program. Facilities include a satellite ground receiving station at Prince Albert, Saskatchewan, four aircraft equipped with a variety of sensors and navigation equipment, a data processing system, sensor development laboratories and advanced instrumentation for image processing and analysis. These facilities are available to scientific investigators and to users of remote sensing data. The Centre also fosters international cooperation in the peaceful use of space technology.

Notable events in 1975 included the successful completion of negotiations with NASA regarding the renewal of the ERTS agreement, and approval by Cabinet of the terms of the renewal. One of the new requirements applied by NASA to all ground station operators is a user's fee of $200,000 per year, effective 1 August 1976. This fee applies to the Prince Albert station and the government has directed that it be recovered from purchasers of satellite data.

The Canadian firm of MacDonald, Dettwiler and Associates of Vancouver has completed the construction of a semi-mobile satellite receiving station to be installed in Pouch Cove, Newfoundland. The station is now assembled near Vancouver airport and is undergoing its final check-out. Images, so far produced by the station, are of excellent quality. This is a significant achievement in the development of low-cost ground data handling facilities.

Discussions have been held with the European Space Agency, during which the proposed Canadian and European program in all-weather (microwave) remote sensing have been discussed. In particular, interested Canadian researchers and resource managers were able to discuss these program with Mr. J. Plevin of ESA on 6 June at CCRS. A letter from Mr. R. Gibson, Director General of ESA, has since been received, proposing the establishment of a common working group to further study the possibilities of Canadian-European cooperation in this field.

A three-year contract was let by CCRS to ISIS Limited of Prince Albert, to process and market, to a wide sector of Canadian users, LANDSAT and DOAA imagery received at the Prince Albert Satellite Station.

Finally, an agreement for scientific and technical cooperation in the field of Remote Sensing has been signed between CCRS and the Centre National d'Etudes Spatiales of France. The agreement provides for the establishment of a yearly program of exchanges and joint undertakings.

4.3 Rocket Ranges

The Space Research Facilities Branch of the NRC provides launch site facilities, launch site services and range safety functions for the Canadian rocket program. The SRFB is responsible for the operations of the Churchill Research Range (CRR) in Manitoba and the Great Whale Geophysical Station in Quebec, and for the maintenance of a campaign facility at Cape Parry, N.W.T.; and a small facility at Resolute, N.W.T.

4.3.1 Churchill Research Range

During 1975, a new contract for operations at the Churchill Research Range (CRR) was negotiated and the contractor manpower level was reduced to 34 from 59. Manitoba Hydro extended commercial power lines to the launch site, which resulted in a long-term saving in manpower at CRR. Parts of the steam heating system in the launch complex were deactivated and replaced by local heating systems to conserve both manpower and fuel. Full time operation of the range is being maintained.

4.3.2 Cape Parry

A campaign station capable of launching the larger Black Brant rockets was established at Cape Parry in 1974, in support of a scientific study of the Magnetospheric Dayside Cleft. Two Canadian instrumented Black Brant rockets were launched successfully from this location in December 1974. The Los Alamos Scientific Laboratory launched two U.S. instrumented Black Brants in January 1975 on behalf of the U.S. Energy Research and Development Administration (ERDA). During the summer of 1975, NRC made a number of improvements to the Cape Parry facilities in preparation for further use of the site by ERDA. Two Black Brant rockets were launched successfully from the site by ERDA in November and December 1975. NRC provided the services of a Range Safety Officer for these missions.

4.3.3 Great Whale Geophysical Station

The Great Whale Geophysical Station in Quebec is operated on a continuing basis by the NRC through a contract to Pan American World Airways. The station makes various geophysical measurements for Canadian and foreign scientists. A magnetic observatory is operated at this station on behalf of the Department of Energy, Mines and Resources.

The Department of Physics of the University of Calgary launched small scientific balloons from this station in July 1975.

5. CANADIAN SPACE ACTIVITIES (BY DEPARTMENTS)

5.1 Department of Communications

In addition to its responsibilities in major programs, such as the CTS and the international Aerosat program, DOC is also active in a number of other space-related areas.

5.1.1 Small Satellite Communications Terminal

The objective of this project is to anticipate requirements for small earth terminals and to pursue forward-looking R&D in the areas of digital modulation, coding, and small terminal control systems. Techniques and equipment in these areas are developed in industry, prior to their introduction into Canadian and international systems. This project is specifically directed towards low-data-rate, reliable and compact ground terminals. The techniques studied will be applicable to a wide variety of communications systems including small terminals systems for use with Telesat, CTS, INMARSAT, AEROSAT, military tactical satellites, and MUSAT.

5.1.2 Microwave Propagation along Satellite-Earth Paths

Rain, snow and ice affect adversely radio signals from satellite. During 1975, precipitation attenuation data obtained from radiometers at seven locations across Canada, were analysed.

Transhorizon propagation data obtained at 15.7 GHz over a 500 km path are being analyzed to separate different propagation mechanisms.

Ice clouds have been identified as an important but usually neglected source of scattering. A new experiment under development will provide information on the relative importance of various scatter mechanisms and provide a foundation for the development of prediction techniques.

Special instrumentation has been developed to use the Communications Technology Satellite for measurements of precipitation attenuation and depolarization. This experiment will provide data essential to the design of satellite communication systems in the 12 and 14 GHz bands.

The measurements of fading, made at low elevation angles in the high Arctic, have been analyzed to obtain cumulative distributions of path attenuation, coherent bandwidth, and correlation between uplink fading at 6 GHz and downlink fading at 4 GHz. These results will be used in the design of future satellite communication links to the far north of Canada.

5.1.3 Electronic Development for Communication Satellites

There is a continuing need to monitor and to sponsor development of microwave technology, microwave semi-conductor devices, methods for analysis of failure modes, space radiation effects and electronic materials technology. Development contracts were placed in Canadian industries in order to establish a design capability in industry for the production of marketable 3-30 GHz microwave components.

5.1.4 Symphonie

A CRC mobile earth station was, in January 1975, the first earth station to receive signals over the Western antenna beam for the French/German Satellite Symphonie I. Signal strength measurements

made at CRC verified the predicted satellite performance, and established the feasibility of satellite communications to earth stations located at Ottawa via Symphonie.

5.1.5 Future Programs

Planning for programs such as MUSAT, SEASAT, and SARSAT is under way. The programs of contracts to industry, to demonstrate the feasibility of specific components and sub-systems, which have a good potential for future Canadian satellite systems, is being expanded. DOC will also participate in several international satellite ventures, including the Aerosat program, the international maritime satellite organization (INMARSAT), and will perform experiments with the Franco/German Symphonie Satellite.

5.2 Transport Canada

The major space activity in 1975 of Transport Canada has been on the Aerosat Program, which has been described previously in this report.

In 1976, Transport Canada will also use the MARISAT Satellite to evaluate the effectiveness and efficiency of ship-to-shore communications. MARISAT will be launched by Comsat General of the United States in mid-February 1976. The satellite, which has an "L" band capability for voice, teletype and facsimile communication is expected to be operational in mid-April. Ship terminal equipment has been rented and installed on the Sir John A. MacDonald icebreaker. If successful, MARISAT could materialize as a viable commercial venture for the Canadian Electronics Industry.

5.3 Department of National Defence

During the past year it has been necessary for DND to reduce its support of both the Defence Industrial Research (DIR) Program and the Defence Research Board (DRB) University Grants Program and ultimately to terminate them at the close of the 1975/76 fiscal year. On the other hand, DND plans to participate in the joint development of the NAVSTAR Global Positioning System and the SARSAT Search and Rescue Satellite with the United States. At this time, the precise nature of DND participation in these space-related projects is not decided. DND has also decided to expand its contribution to the NORAD Space Detection and Tracking System (SPADATS) through acquiring and operating a second Baker-Nunn camera facility at St. Margaret's in New Brunswick. This new facility, which is scheduled to begin operation in July 1976, will complement the Canadian Forces Baker-Nunn camera facility now operating in Western Canada as an integral part of the NORAD/SPADAT System.

5.4 Environment Canada

During the year, the Department of the Environment continued developing interpretation methods and applications for images from the Landsat satellites. DOE undertook sponsorship and joint funding, with DSS, of an unsolicited proposal to carry out research into methods applied specifically to the Boreal Forest region. Agreements with NASA regarding use of the LANDSAT Data Collection System were renewed and the network of terrestrial platforms extended. Tests were carried out on the use of the SMS/GEOS Data Collection Systems and a Canadian-built transmitter certified for use.

DOE scientists also participated in experiment teams of the NIMBUS-5, Skylab and Appollo-Soyuz missions. Participation in the GEOS-3 experiments was approved by NASA. Data from NOAA satellites was used in mapping ice cover and movement, and thermal patterns in the Pacific. Work continued on research into microwave properties of ice and optical properties of fresh water.

The Atmospheric Environment Service (AES) agreed with the National Environmental Satellite Service (NESS) of the U.S. National Oceanic and Atmospheric Administration (NOAA) to increase cooperation in the area of meteorological satellite data applications. AES put into operation an advanced receiving station in Downsview, Ontario for data collection from the current series of NOAA satellites. These images, and those from Landsat, are being used as supplementary data in the ice reconnaissance program.

Research is continuing into applications of Landsat and subsequent Earth Observation Satellites. There is a requirement to study new methods of position fixing, data transmission, and oceanographic forecast, particularly if our offshore responsibilities are extended to the 200 mile limit. The SEASAT program, described earlier in this report, is of great interest in this respect.

Data collection systems will continue to receive attention. DOE will use available systems via Landsat, SMS/GEOS, and NIMBUS-6. The Argos system, operated by the Centre National d'Etudes Spatiales (CNES) of France on the Tiros series of satellites, will be used on future ocean buoy programs.

Participation in international programs will continue with data analysis from the Skylab mission and GEOS-3, and preparation for taking part in approved experiments in NIMBUS-6.

5.5 Industry, Trade and Commerce

5.5.1 Design, Development and Manufacture of Future Canadian Communications Satellites

In order to determine the extent to which Canadian industry could provide the next generation of Canadian communication satellites,

a study was carried out by a Canadian industrial team during the first quarter of 1975. The study was funded by DIT&C.

This study includes an estimate of the capital costs necessary to achieve various levels of Canadian content. The salient results are summarized in Table 1.

The expenditure of $3M, resulting in an increase of Canadian content initially to 45% and subsequently to 55%, was considered justified; the subsequent increase of Canadian content was attributed to later commercial programs and further technology programs beyond CTS. Having estimated the capital costs necessary for various levels of Canadian content, the authors then commented that they probably should be doubled at least, as cost estimates derived by the method employed tended to be optimistic!

The study also suggests that if the Government of Canada and Telesat Canada adopt a policy of sustaining demands for Canadian space systems at an average level of at least $30M per annum, a Canadian content of at least $23M per annum would result after accounting for necessary imports of some subsystems and components, and that the industry then would be in a favourable position to develop additional export markets to a level exceeding $20M per annum.

The study also recommended that government and industry work together to follow up the study and develop a plan for the organization of a single, cohesive industrial team.

5.5.2 Organization of the Canadian Space Industry

As a result of the April 1974 cabinet decision on a Canadian Policy for Space, DIT&C has participated in discussions with DOC and MOSST toward a possible restructuring of the Canadian space industry. These deliberations were reflected in a jointly-sponsored Memorandum to Cabinet during the Fall of 1975.

Table 1

CONDITION	TOTAL CUMULATIVE UPGRADING EXPENDITURE	RESULTING CANADIAN CONTENT
1. Foreign prime contractor	$0M	20%
2. Canadian prime contractor	$0M	40%
3. Canadian prime contractor		
plus:		
a) Some upgrading of staff capabilities for systems engineering and management, and acquisition of some additional sub-system and unit/component design, manufacture and/or test capabilities.	$3M	45% initially 55% finally
plus:		
b) Environmental test facilities	$18M	60%
plus:		
c) Capability to manufacture and test reaction control system, and to manufacture travelling wave tube amplifiers for the 4/6 and 12/14 GHz bands	$30.5M	75%

As a consequence of the decisions resulting from the latter document, a series of co-sponsored government/industry meetings is planned to further explore the various possibilities for a restructuring of this industry.

5.5.3 Industry Support

The Department has supported Canadian industry through its Program for Export Market Development (PEMD) in bids to foreign countries for earth resources and communication satellite ground stations for SHF Transponders and for visits to Japan for market evaluation.

In addition, it has been supporting, under its Defence Industry Productivity Program, a program of base technology development for remote manipulators at Spar Aerospace Products Ltd. This project is aimed at applications in a number of fields: space, underwater, medical and nuclear. During 1975, the space activities were concerned with both anthropomorphic and orthogonal axis manipulators. The 1976 work activities will stem from tests performed during 1975 and will be primarily concerned with interfaces between manipulators and shuttle orbiter payloads.

Finally, in conjunction with the U.S. Army, the Department provided funding support to Bristol Aerospace to develop a new meteorological rocket which is capable of carrying a 7 lb. payload to an altitude of 250,000 ft. Although primarily intended for meteorological sounding, it also would be useful for other applications such as ozone measurement and radar calibration. The new rocket has been tested successfully by the U.S. Army, by NASA and by the NRC.

5.6 National Research Council of Canada

Highlights of NRC space activities have been described in section 3.1.2, under Remote Manipulator System and in section 3.3, under Rocket Research.

5.7 Department of Energy, Mines and Resources

The Department of Energy, Mines and Resources space activities are concentrated in the Canada Centre for Remote Sensing and have been described in Section 4.2.

6. EXPENDITURES IN SPACE

Canadian Government Expenditures on Space Activities are shown in graphical form in the four attached figures.

Figures 1 and 2 show the overall expenditures in space, covering the years 1974/75 to 1980/81. The leased services are given in Figure 2, to separate them from the program expenditures. It should be noted that the information for the years 1976/77 to 1980/81, does not represent any commitment on the part of the departments or agencies, but rather their best estimates, at this time, of the cash flow for space activities in the years to come.

Figure 3 extracts the three major capital programs, in which the Canadian Government is presently engaged: CTS, the Shuttle RMS and the Aerosat program. For information, it also includes an estimate of Telesat Canada major capital expenditures for the same period. Finally, Figure 4, shows, by department or agency, the space expenditures budget for fiscal years 1975/76 and 1976/77.

The graphs clearly show one of the problems of establishing a viable Canadian Space Industry. There is a very sharp decline in major programs expenditures in 1979/80 and 1980/81 as shown in Figure 3. This decline is very serious, since it is tied in with mainly one program: the Shuttle RMS. The presently planned programs do not appreciably alleviate the problem, as is shown in Figure 1. If the industrial loading is to be stabilized, there is a requirement to plan, now, for major expenditures in the years 1979/80, 1980/81.

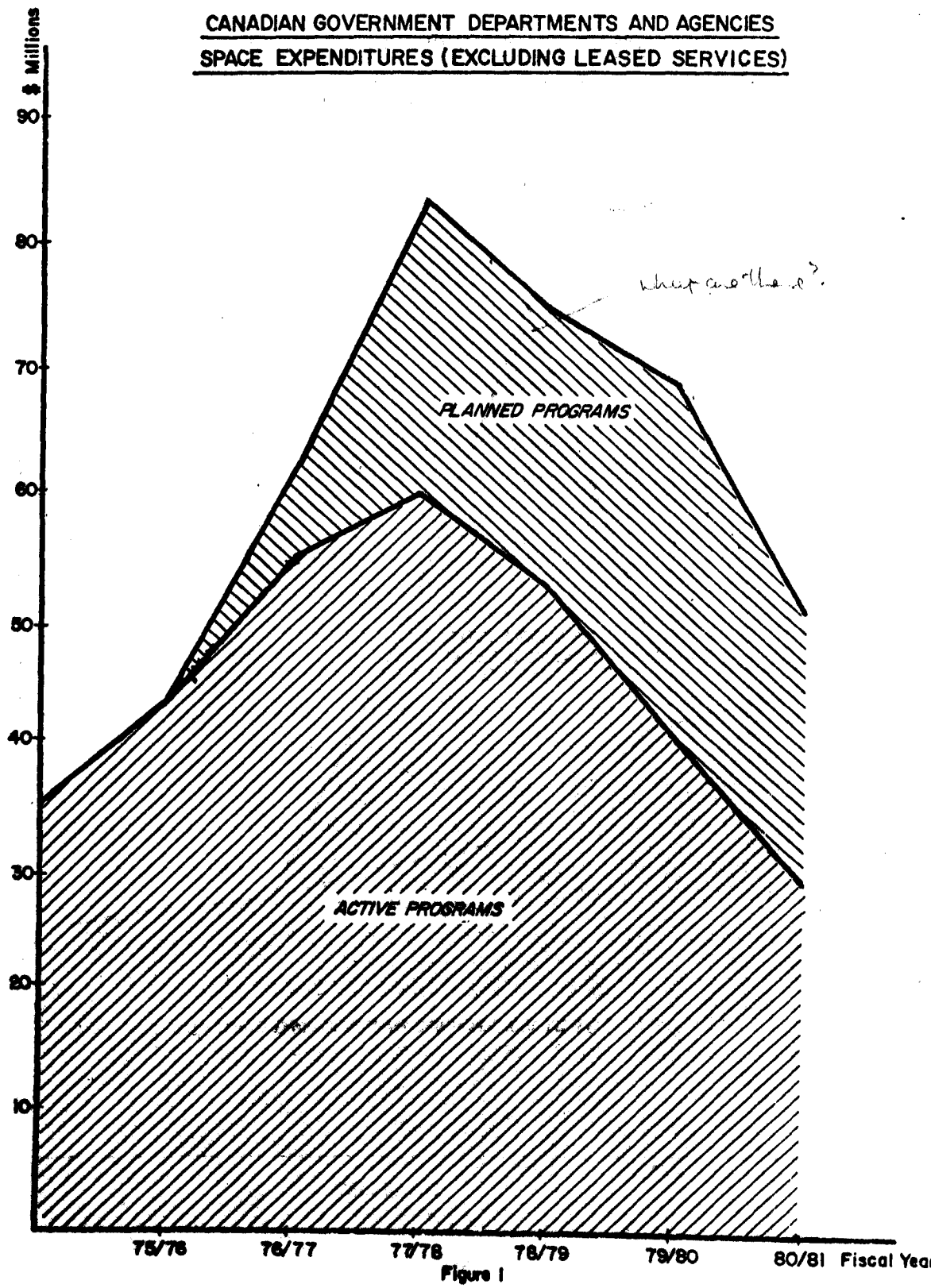
CANADIAN GOVERNMENT DEPARTMENTS AND AGENCIES
SPACE EXPENDITURES (EXCLUDING LEASED SERVICES)
$ Millions
90
80
70
60
50
40
30
20
10
PLANNED PROGRAMS
ACTIVE PROGRAMS
75/76
76/77
77/78
78/79
79/80
80/81
Fiscal Year

Figure 1

CANADIAN GOVERNMENTS AND AGENCIES

SPACE EXPENDITURES - LEASED SERVICES

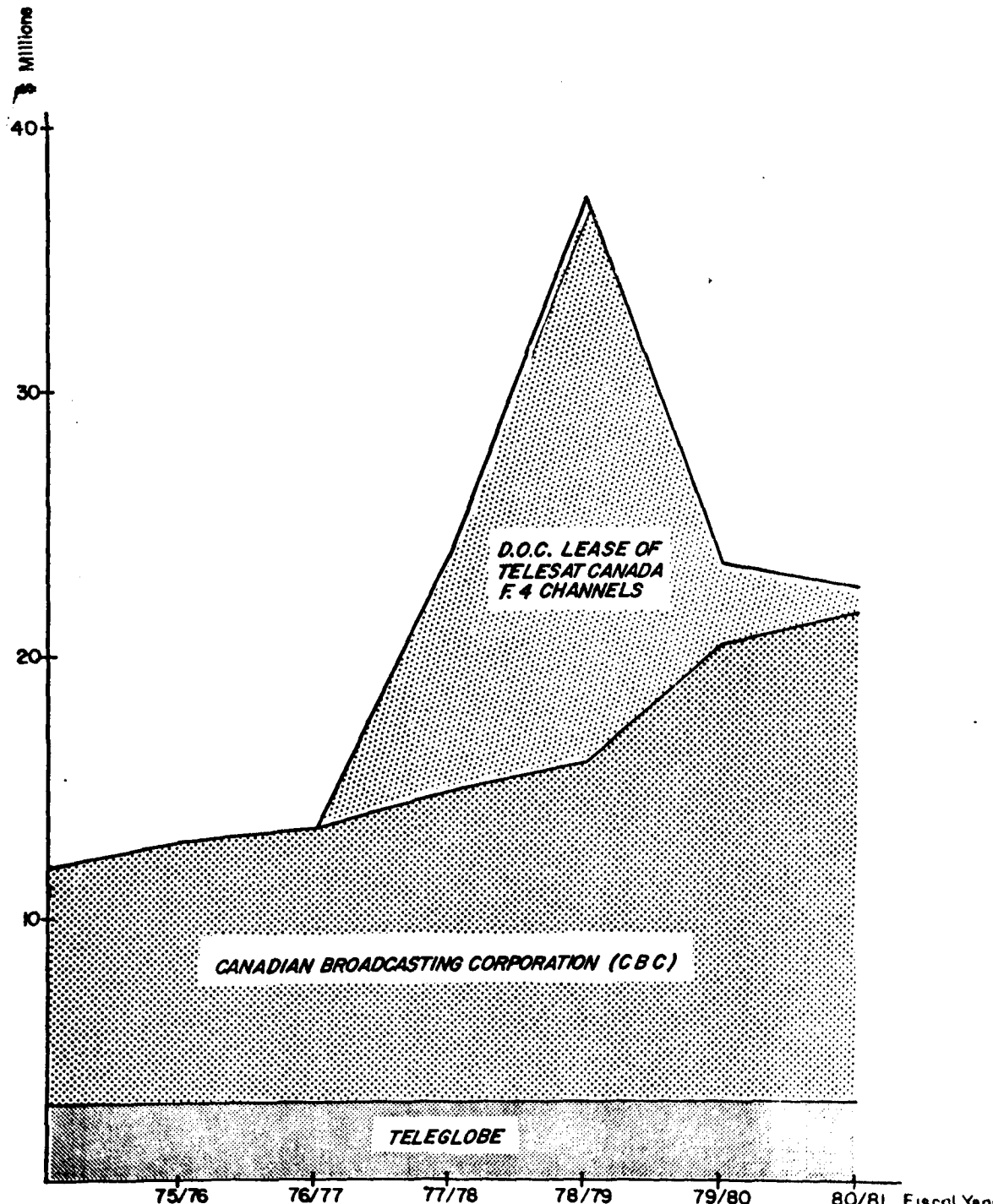

Figure 2

CANADIAN GOVERNMENT DEPARTMENTS, AGENCIES AND TELESAT CANADA

SPACE EXPENDITURES - MAJOR CAPITAL PROGRAMS

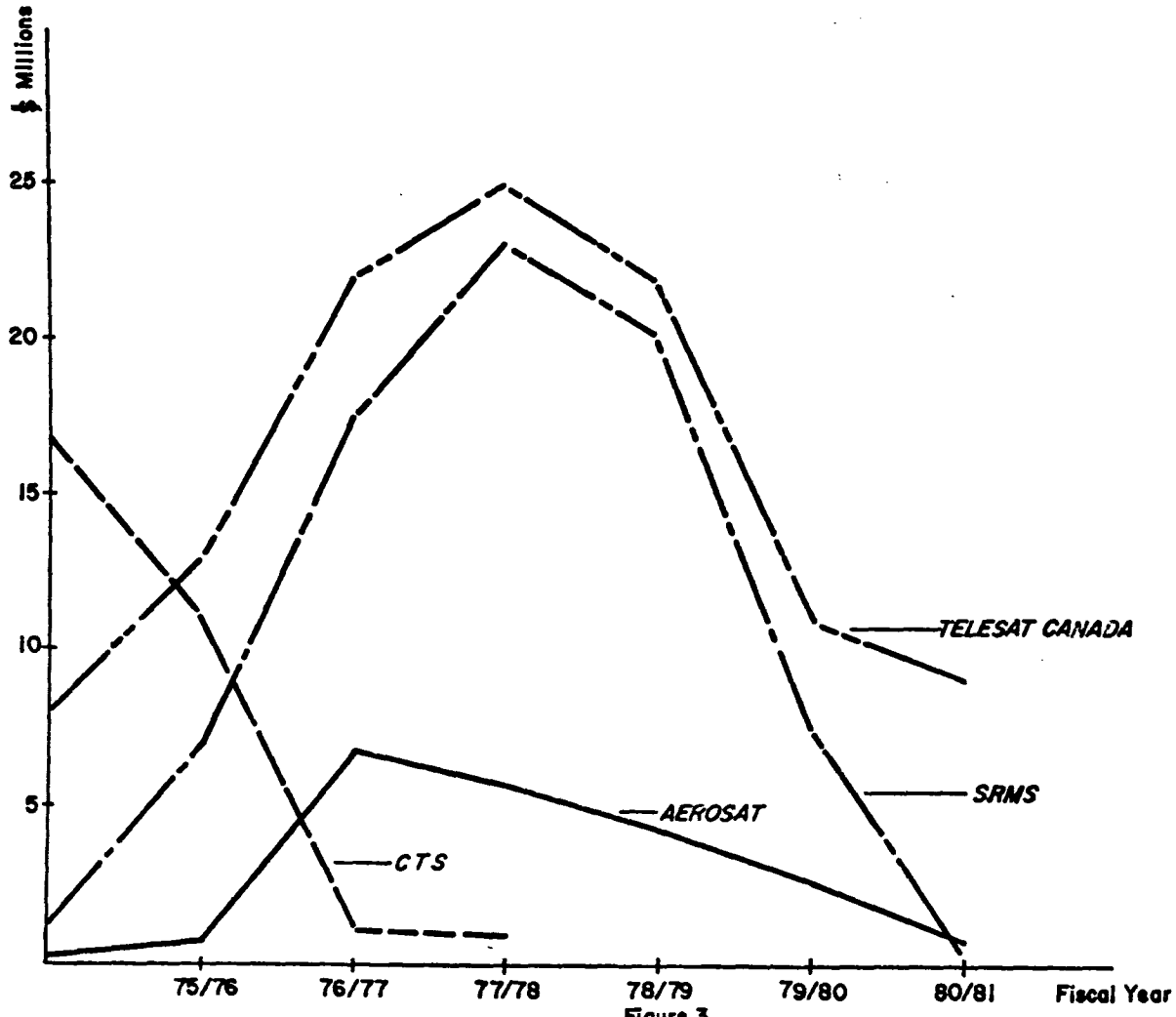

Figure 3

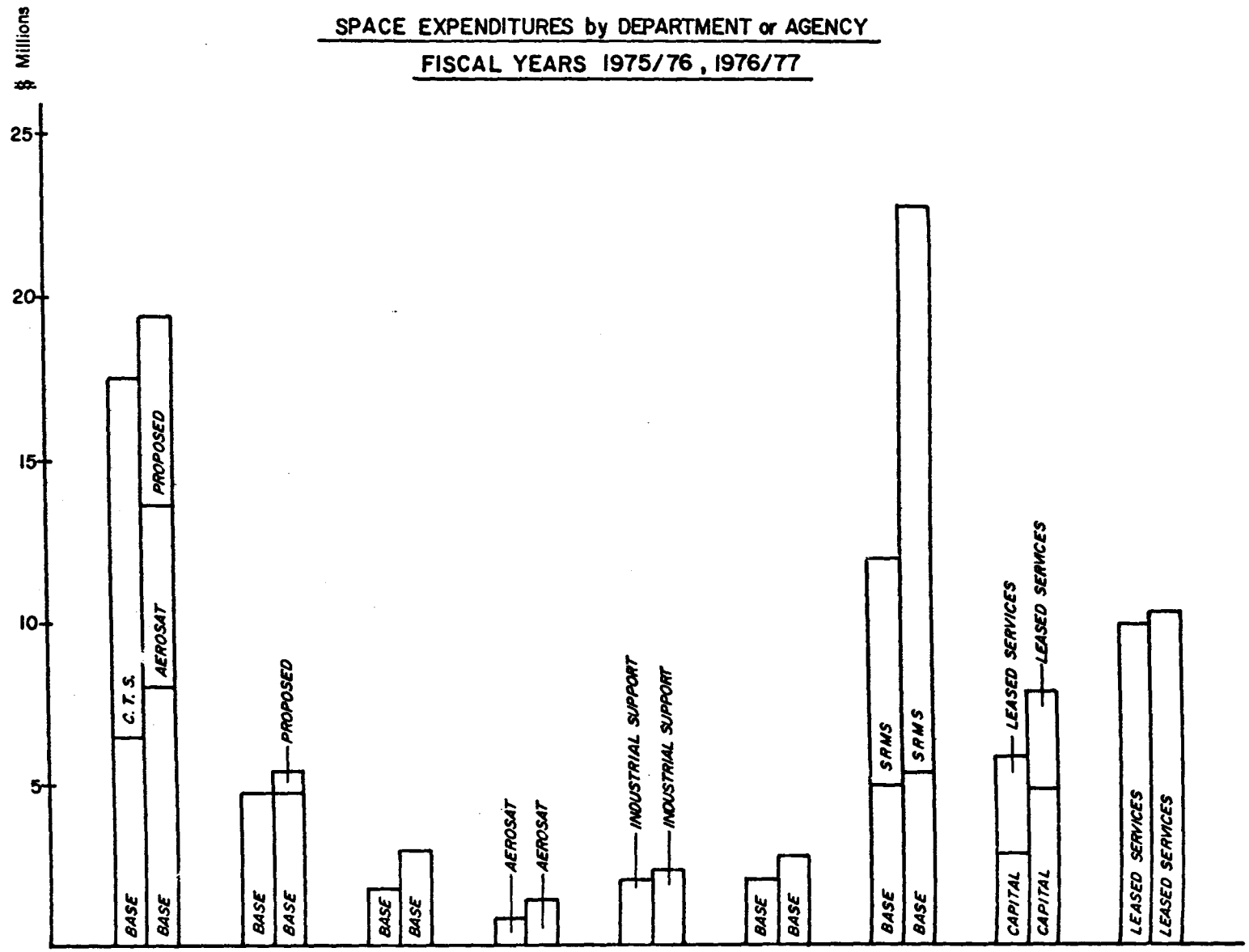
SPACE EXPENDITURES by DEPARTMENT or AGENCY
FISCAL YEARS 1975/76, 1976/77
$ Millions
25
20
15
10
5
BASE
C.T.S.
AEROSAT
PROPOSED
INDUSTRIAL SUPPORT
SRMS
LEASED SERVICES
CAPITAL
DOC
EMR
DOE
MOT
DITC
DND
NRC
TELGL
CBC

Figure 4

TERMS OF REFERENCE

INTERDEPARTMENTAL COMMITTEE ON SPACE

Definitions:

For the purposes of the Interdepartmental Committee on Space, Space is defined as the upper atmosphere and space above a lower limit of 50 kilometres altitude. Space activity includes research or other operations conducted by means of rockets, satellites, high altitude balloons, or other devices, and including associated ground-based activity.

Organization:

1. The Committee shall be composed of senior officials able to speak for their departments on policy matters, and representing:

   Department of Communications
   Department of Energy, Mines & Resources
   Department of the Environment
   Department of External Affairs
   Department of Industry, Trade & Commerce
   Ministry of Transport
   Ministry of State for Science and Technology
   Department of National Defence
   National Research Council

2. Observer status shall be accorded to representatives of:

   Treasury Board Secretariat
   Department of National Health & Welfare (Health)

3. A Secretariat for the Committee shall be provided by the Department of Communications.

4. The Committee shall have the power to establish sub-committees in areas of special interest, and the sub-committees should include representatives of other departments and agencies, industry, and universities as desirable and necessary.

5. The Committee shall report to the Minister of Communications.

Duties:

1. To co-ordinate spacecraft procurement activities so as to maintain a viable space industry in Canada.

2. To review Canadian space activity, including that of Federal Government departments and agencies, the universities, and industry, and to make recommendations concerning the optimum use of resources, the coordination of space activity, and the dissemination of information on such space activity.

3. To consider Federal policy for space activity in relation to national interests, needs and opportunities and to formulate and recommend appropriate plans and proposals.

4. To make recommendations concerning cooperation in the space activities of foreign and international entities in the best interest of Canada.

5. To report annually on February 1st, or more often if desirable, to the Minister of Communications.

TERMS OF REFERENCE

SUB-COMMITTEE FOR THE INTERNATIONAL ASPECTS OF SPACE POLICY

INTERDEPARTMENTAL COMMITTEE ON SPACE

Definitions:

For the purposes of the Interdepartmental Committee on Space, Space is defined as the upper atmosphere and space above a lower limit of 50 kilometres altitude. Space activity includes research or other operations conducted by means of rockets, satellites, high altitude balloons, or other devices, and including associated ground-based activity.

Organization:

1. The Sub-committee for the International Aspects of Space Policy shall be composed of appropriate officials representing:

   Department of External Affairs

   Department of Communications

   Department of Energy, Mines & Resources

   Department of the Environment

   Department of Industry, Trade & Commerce

   Ministry of Transport

   Ministry of State for Science and Technology

   Department of National Defence

   National Research Council

   plus such other Departments and Agencies from time to time as the Chairman deems necessary.

2. A Secretariat shall be provided by the Department of External Affairs.

3. The Sub-committee shall have the power to establish ad hoc working groups as required in areas of special interest.

4. The Sub-committee shall report to the Chairman of the Interdepartmental Committee on Space.

Duties:

1. To consider Federal policies for the protection and furtherance of Canada's ability and right to use space and to recommend appropriate plans and proposals for participation in international agreements and activities.

2. To make recommendations concerning cooperation in the space activities of foreign and international entities in the best interests of Canada.

3. To carry out such tasks as may be delegated by the Interdepartmental Committee on Space.

4. To provide an annual written report on January 7th of the following year, and to report at committee meetings as deemed desirable by the Chairman, Interdepartmental Committee on Space.

Approved February 13, 1975

TERMS OF REFERENCE

SUB-COMMITTEE FOR THE SCIENTIFIC ASPECTS OF SPACE POLICY

INTERDEPARTMENTAL COMMITTEE ON SPACE

Definitions:

For the purpose of the Interdepartmental Committee on Space, Space is defined as the upper atmosphere and space above a lower limit of 50 kilometres altitude. Space activity includes research or other operations conducted by means of rockets, satellites, high altitude balloons, or other devices, and including associated ground-based activity.

Background:

1. Shortly after the formation of the Interdepartmental Committee on Space, the National Research Council Associate Committee on Space Research decided at its 13th meeting held in March, 1970, that it should also act as the ICS Sub-committee on Scientific Research. This arrangement was accepted by the ICS and the NRC Associate Committee has fulfilled this dual role since that time.

2. During 1974, the ICS decided to reorganize its committee structure and reduce the number of Sub-committees from five to three. The Scientific Research Sub-committee was retained but was renamed as the Sub-committee for the Scientific Aspects of Space Policy.

Organization:

1. Membership of this Sub-committee will coincide with the membership of the NRC Associate Committee on Space Research.

Duties:

1. To give scientific advice, on specific matters, to the ICS when asked.

2. To provide a channel to keep the scientific community, (or part of it), informed of matters being considered by the ICS.

3. To seek, evaluate and present to the ICS proposals and views related to the space program that originate in the scientific community.

4. Under the authority of the NRC to fulfill the national responsibilities of COSPAR and SCSTP.

5. To provide an annual written report by January 7 of the following year for incorporation into the ICS Annual Report.

Approved June 16, 1975

TERMS OF REFERENCE

SUB-COMMITTEE FOR THE INDUSTRIAL ASPECTS OF SPACE POLICY

INTERDEPARTMENTAL COMMITTEE ON SPACE

Definitions:

For the purposes of the Interdepartmental Committee on Space, Space is defined as the upper atmosphere and space above a lower limit of 50 kilometres altitude. Space activity includes research or other operations conducted by means of rockets, satellites, high altitude balloons, or other devices, and including associated ground-based activity.

Organization:

1. The Sub-committee for the Industrial Aspects of Space Policy shall be composed of appropriate officials representing:

   Department of Industry, Trade & Commerce

   Department of Communications

   Department of Energy, Mines & Resources

   Department of the Environment

   Ministry of Transport

   Ministry of State for Science and Technology

   Department of National Defence

   National Research Council

   plus such other Departments and Agencies from time to time as the Chairman deems necessary.

2. The Secretariat shall be provided by the Department of Industry, Trade & Commerce.

3. The Sub-committee shall have the power to establish ad hoc working groups as required in areas of special interest. The membership of such ad hoc working groups in part may be drawn from outside government departments and agencies.

4. The Sub-committee shall report to the Chairman, of the Interdepartmental Committee on Space.

Duties:

1. In the light of current and proposed Canadian space activity to make policy and program recommendations concerning:

   a) The acquisition and development of relevant technological and industrial capabilities.

   b) The optimization and coordination of the use of the relevant technological and industrial capabilities.

2. As it deems necessary to carry out its duties, to review current and proposed Canadian space activities.

3. To ensure that adequate dissemination of information occurs of Canadian technological and industrial capabilities.

4. To make recommendations for the promotion of technological and industrial cooperation in the space activities of national and international organizations.

5. To carry out such tasks as may be delegated by the Interdepartmental Committee on Space.

6. To present an annual briefing to representatives of the Canadian aerospace and electronics industry to keep them informed of relevant planned and current space programs, projects and activities.

7. To report its activities on a regular basis at the meetings of the Interdepartmental Committee on Space.

8. To provide an annual written report by January 7th of the following year.

Approved February 13, 1975

Dr. S. Wagner
Director General
Office of Science & Technology
Dept. of Industry, Trade & Commerce
Room 472, 300 Slater Street
Journal North Tower
OTTAWA, Ontario
K1A 0C8

Tel.: 5-7151

Mr. D. Armstrong
Chairman
Transportation Development Agency
1000 Sherbrooke St. West
P.O. Box 549
MONTREAL, Quebec

Tel.: 183-9-283-7512

Mr. F.E. Lay
Director General
Telecomm. & Electronics Bureau
Ministry of Transport
28th Floor, Tower C
Place de Ville
OTTAWA, Ontario
K1A 0N5

Tel.: 2-3203

Dr. H. Sheffer
Vice Chairman
Defence Research Board
Dept. of National Defence
13 North Tower
101 Colonel By Drive
OTTAWA, Ontario
K1A 0Z3

Tel.: 2-6833

Mr. G. Rejhon
A/Director
Scientific Relations & Env. Problems
Department of External Affairs
Tower A, 6th Floor, Room 113
Lester B. Pearson Building
125 Sussex Drive
OTTAWA, Ontario
K1A 0G2

Tel.: 2-9304

INTERDEPARTMENTAL COMMITTEE ON SPACE (ICS)

MEMBERSHIP LIST

Members

Dr. J.H. Chapman (Chairman)
Assistant D.M. (Space Program)
Department of Communications
Room 2016, 300 Slater Street
Journal North Tower
OTTAWA, Ontario
K1A 0C8

Tel.: 5-8223

Alternates

Dr. J.G. Chambers
Director, Space Program
Department of Communications
Room 1760, 300 Slater Street
Journal North Tower
OTTAWA, Ontario
K1A 0C8

Tel.: 6-9957

Mr. R.M. Dohoo
Director General, Space Program
Department of Communications
Room 2018, 300 Slater Street
Journal North Tower
OTTAWA, Ontario
K1A 0C8

Tel.: 2-1295

Mr. F.R. Thurston
Director, Bldg. M.13A
National Aeronautical Estab.
National Research Council
OTTAWA, Ontario
K1A 0R8

Tel.: 3-2427

Dr. L.W. Morley
Director, Room 105
Canada Centre for Remote Sensing
Dept. of Energy, Mines & Resources
OTTAWA, Ontario

Tel.: 3-3350

Dr. M.C.B. Hotz
Director
Science Policy Branch
7th Floor, Fontaine Building
Department of the Environment
OTTAWA, Ontario
K1A 0H3

Tel.: 7-2347

Dr. R.E. Barrington
Radio Communications
Bldg. 2, Room 237
Communications Research Centre
P.O. Box 11490, Station A
OTTAWA, Ontario

Tel.: 596-9395

Dr. D.I.R. Low
Director, Government ~~S&T~~ Projects Division
Ministry of State for Science and Technology
Room ~~1317~~ 1218, 270 Albert Street
OTTAWA, Ontario
K1A 1A1

Tel.: 6-4949

Mr. I.S. McLeish
Senior Policy Advisor
Government S&T Division
Policy Branch
Ministry of State for Science and Technology
Martel Building, Room 1421
OTTAWA, Ontario

Tel.: 2-5931

Dr. R.C. Langille
Secretary
Interdepartmental Committee on Space
17th Floor, Journal North Tower
Department of Communications
300 Slater Street
OTTAWA, Ontario
K1A 0C8

Tel.: 6-9403

Mr. J.T. Marcotte
Assistant Secretary
Planning & Programs
ICS Secretariat
17th Floor, Journal North Tower
Department of Communications
300 Slater Street
OTTAWA, Ontario
K1A 0C8

Tel.: 6-9403

Observer

Mr. H. Palmer
Group Chief
Communications & Science
Treasury Board Secretariat
22nd Floor South, Place Bell Canada
OTTAWA, Ontario
K1A 0R5

Tel.: 2-4073