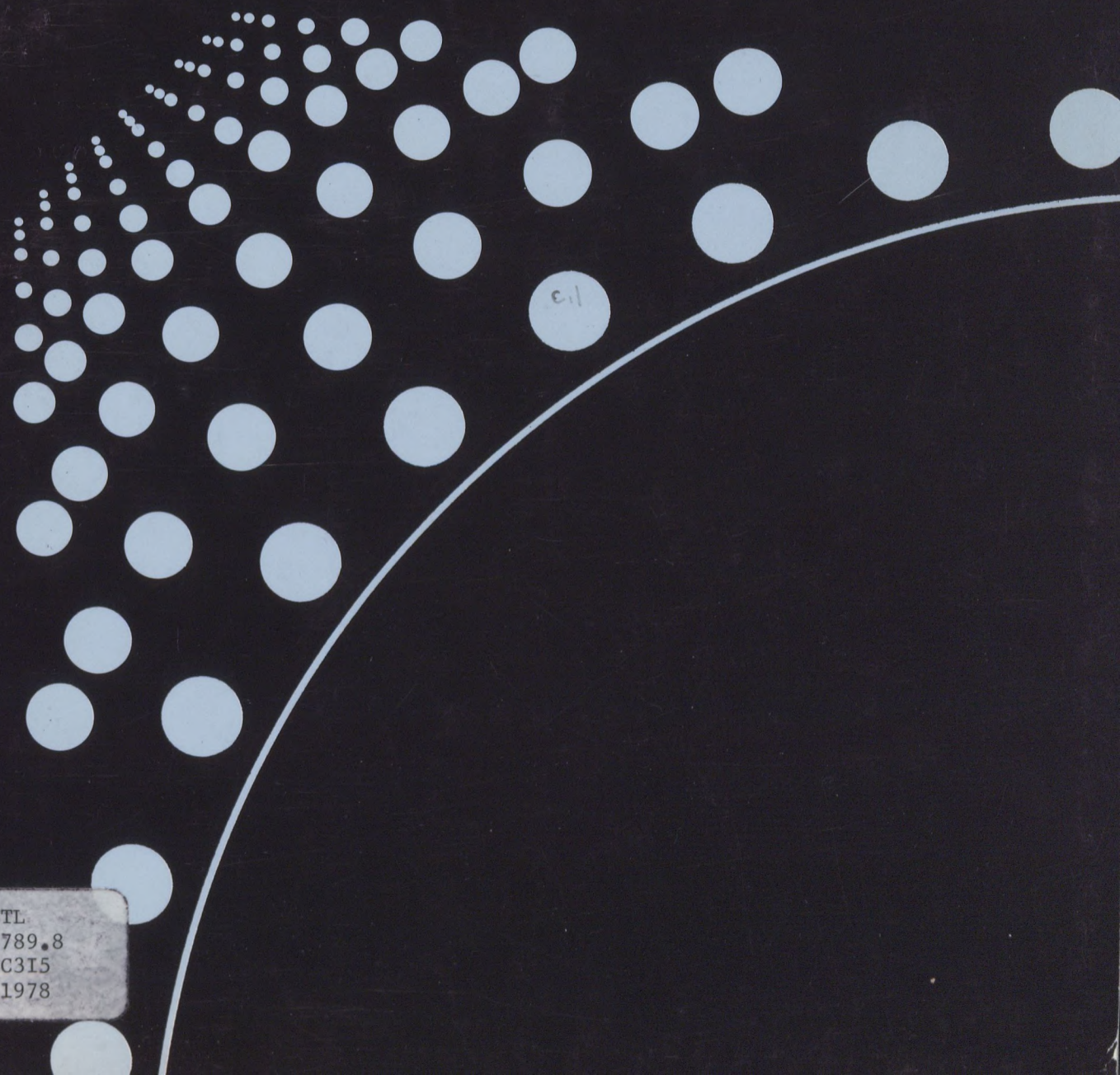
1978 Annual Report

Interdepartmental Committee on Space



INTERDEPARTMENTAL COMMITTEE ON SPACE (ICS)

ANNUAL REPORT - 1978

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.

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

This report is in accordance with the Terms of Reference covering the activities of the Interdepartmental Committee on Space.

Produced by the ICS Secretariat
November 1979.

ICS ANNUAL REPORT - 1978

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SUMMARY

During 1978, the Interdepartmental Committee on Space (ICS) held four regular and two extraordinary meetings. It was particularly active in:

- negotiating a Cooperative Agreement with the European Space Agency (ESA), which was signed in December 1978 and comes into effect on 1 January 1979;

- preparing and submitting the first Integrated Submission on Space Programs to the Treasury Board (T.B.);

- participating in a study undertaken by T.B. on the "Review of the Government's Space Programs and their effects on the Canadian Space Industry";

- preparing and publishing the brochure entitled: *"Canada in Space"*;

- studying and preparing comments on Dr. J.J. Shepherd's article recommending the creation of a Canadian Space Agency. The Ministry of State for Science and Technology has been given the responsibility of the study.

The construction and testing of the Shuttle Remote Manipulator System (SRMS) continued in 1978. The program is now in phase D, the construction, test and verification of flight hardware. Operation of the engineering model in two dimensions on the flat floor of the Simulation Facility was demonstrated in December 1978, and the first flight unit is scheduled for delivery to NASA in late 1979.

The HERMES satellite was used to conduct experiments in the fields of tele-health, tele-education, advanced technology, community interaction, TV broadcasting and government services. The results of the experiments and the performance of the spacecraft have been highly satisfactory and the program will continue until mid-1979.

ANIK-B was successfully launched in December 1978. Communications tests by DOC are scheduled to commence in February 1979, with pilot projects beginning in April. DOC leased the 14/12 GHz portion of the satellite for two years to conduct communications pilot projects as a follow-on to the HERMES experiments.

DOC, on behalf of DND, DFE and MOSST, conducted negotiations on a Canada/France/U.S. Memorandum of Understanding covering an experimental Satellite-Aided Search and Rescue System (SARSAT). A meeting was also held between SARSAT parties and the USSR's Ministry of Merchant Marine (MORFLOT) to discuss the possibility of a joint project between SARSAT and a compatible USSR system.

In March 1978, LANDSAT-3 was launched by the U.S. and Canada started receiving and processing Return Beam Vidicon (RBV) data. This data has a ground resolution of 30 m. in panchromatic mode, opening new possibilities the area of thematic mapping at larger scales.

In 1978, Canada participated in SEASAT "A", a proof-of-concept NASA satellite. Launched in June 1978, SEASAT "A" lasted approximately four months. Canada had constructed and installed a digital synthetic aperture radar (SAR) processor aboard this satellite, and modified the Shoe Cove station to receive radar data from it. In parallel, airborne SAR experiments have been conducted aboard a Convair 580 aircraft by CCRS. Data collected will be analysed and recommendations for follow-on are expected.

A joint proposal by the Massachusetts Institute of Technology (MIT) and the Canadian Defence and Civil Institute of Environmental Medicine (DCIEM), has been accepted by NASA for the investigation of vestibular physiology aboard the SPACELAB program. The experimental program is scheduled for placement aboard SPACELAB 1 and SPACELAB 4, presently planned to be launched for 1981 and 1982. There is a possibility that one of the Canadian investigators may be chosen as a payload specialist for duty aboard SPACELAB 4.

Due to difficulties encountered by the U.S. in obtaining funding authority for the AEROSAT program, a radical review of the program was carried out in 1977. Although the international organizational structure remains the same, the coordinated program has been changed to provide for only a feasibility study in the next year and a re-evaluation of the program requirements.

In late 1977, a proposal was made by a consortium consisting of COMSAT General and certain

European entities for the undertaking of a "Joint Venture", which would provide service continuity between the termination of MARISAT service in 1981 and the earliest operational INMARSAT system in 1985. The proposal was clarified and evaluated through a series of meetings in late 1977 and early 1978. Cabinet approval for Canada to participate in INMARSAT will be sought in early 1979.

Canadian government space expenditures for FY 1978/79 totalled $95.2 million. Of that amount, approximately 74% was expended in Canadian industry, and 2% in U.S. industry. This spending pattern is an improvement over FY 1977/78, where 65% of the total expenditures had been expended in Canadian industry and 9% in U.S. industry. Government expenditures in Canadian universities have declined, both in absolute and relative terms, from $1.2 million (1.8% of total budget) in FY 1977/78, to $0.4 million (0.4% of total budget) in FY 1978/79. The Shuttle Remote Manipulator System, ANIK-B and the DFL extension for ANIK C/D support accounted for almost 50% of the total government space expenditures.

OUTLOOK FOR THE FUTURE

Plans and Programs submitted by the departments involved in space activities indicate that Canada will continue to be very active in space during the coming years.

The following are examples of such activities:

a) Canada became a cooperative member of the European Space Agency, effective 1 January 1979. As a result, Canada will participate in the General Studies program of the Agency and can accede to optional programs of interest, such as remote sensing. Canada can also attend meetings of the Council and of the various program boards and committees;

b) Canada intends to use the LANDSAT-D series of satellites, which are a continuation of the U.S. LANDSAT program in which Canada participates. The first launch of LANDSAT-D is scheduled for 1981;

c) preliminary studies and planning indicate that an operational SURSAT system could be in service by the late 1980's. During 1979, Canada will be examining opportunities for cooperating in remote sensing programs with ESA or NASA, or both;

d) NRC is preparing a scientific program in the area of aeronomy and physical space science to replace the POLAIRE project. Approval in principle will be sought in 1979 for the required level of funding and for authority to negotiate a program with NASA within that limit;

e) through the Herzberg Institute of Astrophysics of NRC, Canada will continue to participate with the Max Planck Institute in Garching, Germany, in the "Firewheel" project. The experiment is scheduled to be launched on an Ariane rocket in early 1980;

f) an experimental program to investigate vestibular physiology aboard the Spacelab program has been accepted by NASA. This joint program, proposed by the Massachusetts

Institute of Technology, the Defence and Civil Institute of Environmental Medicine and McGill university, is scheduled to take place on board Spacelab 1 and Spacelab 4 in 1981 and 1982;

g) feasibility studies for a Multipurpose UHF Satellite (MUSAT) will continue with possible implementation of a system in the mid-1980's. A proposal to conduct the prerequisite Project Definition Studies will be presented in 1979;

h) a six-month evaluation of TV transmission to small low-cost television receive-only terminals in Canada will be conducted in 1979; international demonstrations are also being planned.

Other events which are expected to take place in 1979 include the following:

- The HERMES satellite, which has been so successful in demonstrating satellite communications and broadcasting with small earth stations, will be turned off at the end of 1979, well-beyond its projected two-year lifetime;

- Teleglobe Canada expects to extend its studies of the propagation characteristics of the earth-to-space path in the 14/11 GHz bands from locations in Quebec and Ontario into 1979-80;

- Cabinet approval for Canadian participation in INMARSAT will be sought in early 1979. Canada is considering participation in a pre-INMARSAT Joint Venture system to provide interim service until INMARSAT becomes operational;

- a Memorandum of Understanding is expected to be signed in 1979 between Canada (DOC), the USA (NASA) and France (CNES) on a Search and Rescue satellite (SARSAT) system. The first SARSAT launch is scheduled for early 1982;

- during 1979, Canada will participate in the first session of a working group of Experts on Nuclear Power Sources, which was established, following a Canadian initiative, by the UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS) at its 21st session in 1978;

- the Sub-Committee for the Industrial Aspects of Space Policy is considering a second briefing to industry, tentatively scheduled for late 1979;

- the 1982 annual meeting of the Committee on Space Research (COSPAR) may be hosted by Canada.

THE ICS IN 1978

Sub-Committee for the Industrial Aspects of Space Policy

The Sub-Committee for the Industrial Aspects of Space Policy held two regular meetings during 1978. It also arranged a briefing for the Canadian space industry, in cooperation with the Space Committee of the Air Industries Association of Canada, on the plans and proposals of government departments and agencies for future space activities, which was held during June.

The topics considered by the Sub-Committee at its regular meetings included U.S. policies and practices on technology transfer, and the support which departments and agencies of the Federal Government could provide to promote export sales of Canadian space products.

There was general acceptance that the U.S. increasingly is regarding its technology as a commodity to be exported only for a fair return on the investment that it represents--and, in some cases, not to be exported because of the potential risk to national security, or the loss of a commercial advantage which otherwise would be enjoyed. It also was noted that unanimity does not exist among U.S. officials and politicians as to what technology should be transferable, and on what basis. However, it was agreed that no case exists for complaint that Canada is being unfairly treated. Nevertheless, the Sub-Committee decided that it should monitor the situation, and that U.S. authorities should be briefed periodically on the industrial, technological and other benefits to the U.S. resulting from Canada's space program.

The discussion of support which departments and agencies could provide to promote export sales of space products stemmed from a view that the activities and expertise of the various departments and agencies should be more effectively harnessed toward this end. For example, Ministers and senior officials increasingly could promote the sale of Canadian space products in their contacts with opposite numbers. The acquisition of intelligence relating to potential export sales should by systematized, to increase the likelihood that all significant inputs are obtained, with maximum lead-times. Thus, highly qualified staff in departments with in-house space programs could contribute through their perception of developing trends in technology, and their expectation of upcoming foreign operational requirements. Such qualified staff also could assist with the briefing of incoming missions on Canada's

space program and capabilities, and similarly could participate in missions to other countries. It is expected that arrangements for a coordinating market organization will be agreed to and implemented during 1979.

The industrial briefing was attended by 66 representatives from Canadian companies, and 25 government representatives. Almost all companies which make up the Canadian space industry were represented. The following departments and agencies gave presentations on their possible future space activities: Communications; Transport; National Defence; Energy, Mines and Resources; Fisheries and Environment; National Research Council. In addition, the Chairman of the ICS outlined and discussed the Government's space policy, and representatives of the Electrical and Electronics Branch of IT&C gave a presentation on export opportunities for space products. The briefing appeared to be well received by the industry. The Sub-Committee subsequently decided that such briefings should be held in the future at intervals of one to two years, the actual dates to be determined by the Sub-Committee, taking into account changes and developments in government plans and proposals since the previous briefings. The next briefing tentatively is scheduled for late 1979.

Sub-Committee for the Scientific Aspects of Space Policy

The Sub-Committee for the Scientific Aspects of Space Policy was established by the National Research Council in April 1959 to serve as an Associate Committee to the Council. Members for the Committee are drawn from industries, universities and government. Its functions are to:

- advise the Interdepartmental Committee on Space on the scientific aspects of space;
- advise the National Research Council on matters relating to space research;
- act as the Canadian National Committee for the International Council of Scientific Union's Committee on Space Research (COSPAR);

- review and comment on space science programs and plans of the Space Science Coordination Office, and

- serve as a forum for exchanging and developing ideas in space science by people representing geographic and disciplinary interests for all across Canada.

During 1978, the Sub-Committee held two meetings: the 25th meeting at the University of Alberta, Edmonton, on 2 March and the 26th meeting at the National Research Council, Ottawa, on 19 October. This year the Sub-Committee has been instrumental in recommending the extensions of the post of the Canadian Coordinator for the International Magnetospheric Studies (IMS) program, the provision of incremental funding for national and international workshops for the IMS, the funding of a monograph on space research, the hosting by Canada of the 1982 COSPAR and associated meetings, and the re-orientation of its Sub-Committee for SCOSTEP to emphasize the importance of the Middle Atmosphere Program (MAP) during the 1982-85 period.

In the area of a national program plan for space sciences, the Sub-Committee endorsed, in principle, the objectives of a draft Canadian Space Science Program for the period 1979/83, prepared by the SSCO of NRC. The Sub-Committee had supported the prior development of the Polaire program and expressed disappointment at the withdrawal of this scientific satellite proposal.

International Magnetospheric Studies Program (IMS)

Canadian-based activities have produced much data significant to the objectives of the IMS. The most important of these have been the magnetometer lines and the continued recording of data from the ISIS satellites. The incremental funding for university participants made it possible for them to undertake significant campaigns. A brochure on the subject of data will be prepared by the Canadian coordinator.

At present, it appears that most significant IMS data acquisition activities may end by late 1979. However, data analysis activities will grow in importance and will need support for participating Canadian scientists.

Sub-Committee for the International Aspects of Space Policy

The Sub-Committee (IASP) had an active year in 1978, holding five meetings. While the Sub-Committee focuses mainly on the multilateral aspects of Canadian space policy, it is also involved in bilateral relations.

Much of the work of the Sub-Committee concerned Canada's involvement in the UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS) and its two Sub-Committees (Scientific and Technical, and Legal). Of particular importance was the Canadian-initiated effort in the Sub-Committees and the parent Committee following the COSMOS 954 incident of January 1978, to provide for international consideration of the implications of the use of nuclear power sources in space. The UNCOPUOS agreed at its 21st session to establish a working group of experts to study this question, and following approval by the General Assembly, plans were made for its first meeting to take place during the 1979 session of the Scientific and Technical Sub-Committee. An ad hoc interdepartmental committee has been created by the IASP to coordinate Canadian participation in this group.

As usual, Canada played an active role in these UNCOPUOS sessions, particularly in regard to remote sensing of the earth by satellite, the development of a set of principles to regulate direct television broadcasting by satellite and the proposed UN Conference on Outer Space. While little progress was made on the first two questions, it was decided that an outer space conference should take place before 1983. The 1979 session of the Outer Space Committee is to make recommendations concerning the arrangements and agenda for the Conference.

The IASP is also involved in a number of bilateral issues. Cooperation in space was discussed during the sessions of the Canada-France Scientific Mixed Commission and the Canada-Japan Consultations on Science and Technology.

Following the completion of negotiations concerning a cooperative agreement between Canada and ESA, a group of officials from the European Space Agency attended a special meeting of the Sub-Committee to describe the Agency's activities.

DEPARTMENTAL PROGRAMS AND FACILITIES

NATIONAL RESEARCH COUNCIL (NRC)

The National Research Council of Canada (NRCC) undertakes and sponsors scientific and technological research in a broad range of disciplines, including aeronautics, astrophysics, biology, building, chemistry, mechanical engineering, physics and electrical engineering. In addition to extensive laboratories and other facilities, NRC has its own computation centre, and manages the Canada Institute for Scientific and Technical Information (CISTI). The NRC also provided administration for funds made available for research grants to universities and industry, and for scholarships to post-graduate students. The responsibility for university grants is now vested with the Natural Sciences and Engineering Research Council.

The space and space-related responsibilities of the NRC cna be divided into three main areas: research in the space environments, utilizing rockets, balloons and scientific satellites; research from the space environment, such as remote sensing of the earth and observation of astronomical objects beyond the earth's environment, and research in the space environment including the development of equipment and instruments for use in the severe space environment.

To carry out these responsibilities, the NRC receives advice from its Associate Committee on Space Research, plans through its Space Science Coordination Office and manages and operates its scientific programs through its Space Research Facilities Branch. The Herzberg Institute of Astrophysics of the NRC conducts scientific investigations and the National Aeronautical Establishment is responsible for the Remote Manipulator System, non-cartographic applications of photogrammetry and dynamic stability of aircraft.

Space Science Coordination Office (SSCO)

The SSCO was established in 1976 to bring together the diverse interests of the space science community in universities, industry, government agencies and elsewhere into a coordinated national scientific program by identifying opportunities and cooperative approaches. While its ultimate task is to formulate and coordinate an integrated space science program for Canada, it set out with a first objective to identify and define the various components of that program. To achieve this objective, a number of working groups examine the fields of aeronomy and space physics, astronomy, life sciences, lasers, large space platforms, satellite solar power systems, atmospheric dynamics and material sciences in space, identify interests and recommend participation in national and international programs. Canada has considerable experience in doing scientific and technological research and development work in space. Programs identified by the SSCO for implementation ensure that Canada will sustain and improve research competence in space science; provide a significant fraction of the new knowledge needed to make science-based decisions relating to the use of space; provide for the training of young scientists and engineers in areas that will be the focus of much activity in the future; and provide Canadian industry with a series of challenging opportunities for industrial innovation in the leading edge of space technology.

During 1978, the SSCO continued to define the scientific work that required the use of balloons. It also identified three scientific campaigns of interest namely: to investigate the morphology and the mechanisms of the pulsating aurora (possible launch in January-February 1980); to conduct a more detailed investigation of the dayside cleft centered on Cape Parry, possibly in December 1979; to test and compare various electric field

measuring techniques. The SSCO also set up the Space Science Evaluation and Planning Group to develop an overall program of campaigns and individual experiments, assuming at the same time the evaluation function of the former Scientific Evaluation Panel.

As a result of suggestions made by its Space Astronomy Working Group, two study contracts were awarded to the University of British Columbia which resulted in the two reports: "A Canadian Space Telescope" and "The Ultraviolet Sensitization of Solid State Detectors". The first might lead to the development of a 2000 x 2000 element charge-coupled device in the near future. Further details of the space telescope required study and a small technical committee is being set up. As a result of the second study, a further study contract was awarded to York University to examine specific materials suitable for improving the ultraviolet sensitivity of detectors. Under contract from the SSCO, the University of British Columbia is studying the possibilities of forming and silvering a membrane mirror in space.

The Herzberg Institute of Astrophysics of NRC is participating in the international Feuerrad (Firewheel) experiment led by the Max Planck Institute in Garching, Germany. This project is part of a continuing scientific effort to probe the properties of the distant magnetosphere using active techniques. Canadian participation in this experiment is gratifying since it promises to provide new perspectives of physical processes occurring in the distant region where magnetic substorms originate. The experiment will be launched on an Ariane rocket in early 1980. Its purpose is to study the interaction of artificial ion clouds of barium plasma with ambient electric fields, magnetic fields, and plasma in the inner plasma sheet region near midnight.

The SSCO has also sponsored studies and established watching briefs to ensure maintenance of active interest in life sciences, lasers, material sciences, solar power and other shuttle-based scientific activity.

In 1978, NRC proposed the POLAIRE project which, due to a reduction in public expenditures, was withdrawn. To continue its studies, the SSCO set out to define a draft program for the area of aeronomy and physical space science which is presently under discussion. It is proposed that Canadian activities be directed increasingly toward participation in international programs such as NASA's. The scientific objectives of this participation

include improving our knowledge of the physical interactions between the magnetosphere, ionosphere and atmosphere, particularly at high latitude. The mode of implementation will be to undertake the development in Canadian industry of selected facilities and instruments for selected missions as the Canadian contribution. By adopting this approach to international participation, we should be able to maximize the scientific benefit and the opportunities for industrial innovation. Approval in principle will be sought for the increased level of funding and for authority to initiate discussions with NASA on the basis of the funding level.

Space Research Facilities Branch (SRFB)

The Space Research Facilities Branch (SRFB) is an organization which supports Canadian space science by planning and conducting rocket and balloon launch campaigns. The Branch will consider rocket and balloon launches from any location in any season in order to meet scientific objectives. Services are provided to non-Canadian organizations on a cost-recovery, time-available basis. Rocket and balloon programs which are implemented by SRFB are approved by the Canadian Sounding Rocket Planning Group (CSRPG).

Engineering Section

The Engineering Section of SRFB implements sounding rocket programs by procuring rocket motors and monitoring the design and fabrication of instrumented rocket payloads by Canadian industry. In conjunction with the Operations Section of SRFB and with the assistance of specialists from industry, the Engineering Section arranges for the launching and tracking of sounding rockets, acquisition and recording of telemetered data, recovery of rocket and balloon payloads and conversion of scientific data to appropriate formats. In addition, the Engineering Section provides engineering support for the balloon program including the evaluation and initial procurement of electronic facilities.

During 1978, SRFB launched a total of seven rockets. Three Black Brant VIIs, one Nike-Black Brant VB for the Univerisities of Calgary, British Columbia, Saskatchewan and Toronto, and for NRC/HIA were all launched from the Churchill Research Range.

The program for 1979 comprises six sounding rocket projects and one satellite sub-payload. Presently under development is a Black Brant VA payload that will be launched during the eclipse in February 1979 from a temporary launch site at Red Lake, Ontario. This complex payload for the Universities of York and Saskatchewan and NRC/HIA will be equipped with a SAAB S-19 guidance system to improve trajectory penetration of the umbra, an attitude-control system for pointing at the solar corona and an imaging array data transmission system for the York U.V. spectrometer. Also under development is a sub-payload for the satellite Firewheel designed and manufactured by the Max Planck Institute of the Federal Republic of Germany.

Operations Section

The Operations Section of SRFB is responsible for the management and operation of the NRCC facilities for launching scientific sounding rockets and high altitude balloons. The facilities include:

- The Churchill Research Range (CRR) - the main base of operations for NRCC rocket programs;

- expeditionary rocket launching sites at Cape Parry, N.W.T., Resolute Bay, N.W.T. and Red Lake, Ont.;

- a mobile balloon launching facility currently based at Saskatoon, Sask.

During 1978, a total of seven Canadian and five U.S.A. rockets were launched at the CRR. Additionally, 192 meteorological and 11 ozone-sonde rockets were launched as part of continuing programs supported at the CRR for the U.S.A.F. 2nd Weather Squadron and the NASA Wallops Flight Center, respectively. During the same period, a total of five scientific balloons were flown--one from Cold Lake, Alberta, and four from Yorkton, Sask. Two of the four balloons flown from Yorkton were for American scientists. The remainder were for Canadian scientists.

Plans were completed during 1978 for converting the Churchill Research Range from a main base of operations to an expeditionary rocket launching site and for establishing a rocket and balloon operations support base at Gimli, Manitoba. This plan

will be put into effect commencing 1 April 1979. From that time onward, all of the rocket operations and some of the balloon operations will be conducted on an expeditionary basis. The Gimli facilities base will have the capability for launching balloons locally and it is expected that most of the balloons in the Canadian program will be flown from this base.

Commencing in February 1978, the CRR has provided technical and housekeeping support for the Japanese Northern Ground Station which was installed at the Range in September/October 1977 to track the Japanese EXOS-A satellite.

In preparation for a cooperative Canada/USA program to launch a number of rockets during the solar eclipse of 26 February 1979, two expeditionary rocket launching sites were established in the Red Lake area of Northern Ontario.

National Aeronautical Establishment

Teleoperator Remote Manipulator System (RMS)

As part of an expansion of Canada's space policy announced in 1974, the National Aeronautical Establishment (NAE) is engaged in a cooperative program with the Lyndon B. Johnson Manned Space Flight Centre of the National Aeronautics and Space Administration (NASA). The program is to design, develop and construct for delivery to NASA, the first flight unit of the Remote Manipulator System (RMS) for the Advanced Space Transportation System--the Space Shuttle--and to design and construct an RMS Simulation Facility (SIMFAC). The RMS is an arm-like device which will be used to deploy payloads, satellites, and other space devices, from the cargo bay of the Space Shuttle Orbiter vehicle and to retrieve recoverable payloads.

The design, development and construction of both the RMS and the SIMFAC are all being carried out by a Canadian industrial team. SPAR Aerospace Ltd. (SPAR) of Toronto, Ontario, is the prime contractor and is also responsible for overall program management with CAE Electronics Ltd., and Spar Technology Ltd. both of Montreal, Québec, and Dilworth, Secord, Meagher, and Associates Ltd. (DSMA) of Toronto, Ontario, as the principal subcontractors (see also Activities in Industry section).

The program is now in Phase D, the construction, test and verification of flight hardware. Operation of the engineering model in two dimensions on the flat floor of the SIMFAC was demonstrated in December, 1978. The first flight unit is scheduled for delivery to NASA in late 1979 and will be flown on a Space Shuttle test flight in 1980.

Since in the gravity environment of earth the RMS can only be operated in two dimensions, the verification of its operability in all three dimensions in a zero-gravity environment has been simulated in SIMFAC--a General Purpose Manipulator System Simulation Facility using mathematical modelling techniques. The facility is also being used to train astronauts in the operation of the RMS and will be used, in the future, for the development of teleoperator technology for underwater and other hazardous environment applications.

Dynamic Stability of Aircraft

This is a cooperative program by the National Aeronautical Establishment (NAE) with the Goddard Space Flight Centre of the National Aeronautics and Space Administration (NASA) and has relevance to both high performance military aircraft and the Space Shuttle.

The program aims at determining certain dynamic stability parameters that may be of high significance for flight at high angles of attach, which is typical for both the modern flighter aircraft and the Space Shuttle Orbiter vehicle. The program consists of developing new experimental techniques, constructing the associated hardware and instrumentation systems, and applying these for experiments in wind tunnels, both at NAE and NASA.

Large High-Speed Wind Tunnel

This facility of the National Aeronautical Establishment (NAE) Division of the National Council of Canada is located in Ottawa, Ontario.

The tunnel, which became operational in 1963, is of the blowdown type with a five-foot square working station and is built to withstand an internal pressure of seventeen atmospheres.

A unique feature of the tunnel is the NAE High Reynolds Number 15" x 60" Two Dimensional Test Facility (the NAE 2-D insert) which has been used since 1969 to test airfoil characteristics in the transonic range at Reynolds numbers which are close to the full-scale values. This facility has also been used to investigate supercritical airfoil designs and also jet augmented airfoils.

The overall facility is used extensively by the Canadian aerospace industry, for research by the scientists of the National Aeronautical Establishment, by other Canadian Government departments and agencies, by the National Aeronautics and Space Administration and agencies of other foreign countries.

Non-Cartographic Applications of Photogrammetry

The techniques of photogrammetry common to aerial mapping and surveying are being applied to non-cartographic uses. Techniques have been developed in the National Aeronautical Establishment for dynamic engineering photogrammetry where closed circuit television is coupled with computerized analytical data processing to measure dynamic events real time. These techniques are now being considered for a variety of applications including the Remote Manipulator System to facilitate the grappling, manipulation and positioning of objects in space.

Herzberg Institute of Astrophysics

The Herzberg Institute of Astrophysics is engaged in a number of space and space-related activities. These range from laboratory work to determine characteristics of molecules likely to be found in space, to astronomical observations using ground-based radio and optical telescopes, to studies of the near-earth space environment using rocket and satellite techniques.

During 1978, the Institute was active in auroral spectra and photometry, studies of diffuse radio aurora and dayside aurora, rocket measurements of auroral plasma, rocket photometry of the nightglow, Pc 5 pulsations, the operation of 35 mm all-sky camera for meteor research, inter-comparison of the physical features of particles collected by balloon-borne instruments and rocket-borne collector, the study of

infrasound from meteors, observation and recovery of meteorite, meteor research, magnetospheric studies and cosmic ray studies. The HERMES satellite was also used by the Astronomy section of the institute to study long-base interferometry by satellite link. The section also carried out routine daily measurement of the intensity of the solar radio flux and has continued to use the Ottawa River solar observatory solar patrol telescope.

Canadian-based activities have produced much data significant to the objectives of the International Magnetospheric Studies Program (IMS). The most important of these activities have been the magnetometer lines and the continued recording of data from the ISIS satellites. Incremental funding for university participants made it possible for them to undertake significant campaigns. At present, it appears that most significant IMS activities may end by mid-summer 1979. A brochure on the subject of data will be put together by the Canadian Coordinator, Dr. B.W. Currie.

DEPARTMENT OF COMMUNICATIONS (DOC)

HERMES

The HERMES satellite was launched under a cooperative program between the Department of Communications and NASA with the participation of the European Space Agency (ESA). Canada designed and built the spacecraft, the United States provided some advanced components, pre-launch testing and launched the satellite, and ESA provided several components. The spacecraft was launched in January 1976 for a planned two-year mission in geostationary orbit, 36,000 km above the Equator at 116° West longitude and has been successfully operating since that time.

While some spacecraft subsystem problems have been experienced, none was serious enough to prevent the planned program of experiments from being carried out. Indeed the performance of the spacecraft has been such that its operation has been extended into a fourth year, well beyond the planned mission lifetime.

Experimental Program

Major experiments were conducted in the fields of tele-health, tele-education, advanced technology, community interaction, TV broadcasting and government services, by universities, hospitals, federal and provincial departments, native institutions and industry.

In 1978, in the field of tele-health, HERMES was used to provide a telephone channel between Moose Factory Hospital and a nursing station at Kashechewan on James Bay. HERMES was also used to support a program in nursing education presented by the University of Montreal through which lectures were televised to nurses in four Quebec communities. The nurses participated in the discussions via audio return channels.

In the field of community interaction, HERMES was used to support extensive video teleconferences between the French-speaking communities of Zenon Park in Saskatchewan and Baie St. Paul in Quebec. There is normally little opportunity for French-speaking residents in the largely English-speaking province of Saskatchewan to meet with people in Quebec. The teleconference enabled the people in the two communities to exchange information informally on their work, educational and leisure activities. In addition, HERMES was used to interconnect four native radio stations in northwestern Ontario and four Inuit radio stations in the Ungava peninsula. The latter network was interconnected through ANIK-A with four additional Inuit villages. The interconnections enabled radio stations in each community to contribute programming to the network and improved the exchange of information between isolated communities.

In the field of government services, the Government of Ontario conducted a series of video teleconference trials between Toronto and Thunder Bay. The National Research Council also tested the use of teleconferencing in project management.

In the field of technology, the Communications Research Centre continued experiments in terminal evaluation and gathering statistical information on propagation effects. The University of

Toronto, in cooperation with the Green Bank Observatory in West Virginia and the Owen's Valley Observatory in California, continued an experiment in radio interferometry to provide high resolution measurements of cosmic sources. The National Research Council in cooperation with the National Bureau of Standards made measurements of the comparative stability of precision frequency standards.

In May 1978, HERMES was used to provide a demonstration of TV direct broadcasting to small terminals with 0.60, 0.90 and 1.2m antennas at an International Symposium on Satellite Communications in Lima, Peru. The terminals were installed to receive the TV signals in less than 1/2 day and one was re-installed in the garden of a home in 20 minutes.

The success of this demonstration contributed to a decision to conduct a six-month evaluation of TV transmission to small low-cost television receive-only (TVRO) terminals in Eastern Canada in 1979 and to consider international demonstrations in countries planning for the use of 12 GHz satellite systems.

ANIK-B Communications Program

In 1977, DOC signed an agreement with Telesat Canada to lease the 14/12 GHz portion of Telesat's ANIK-B satellite for two years commencing early 1979, with an option for a further three years. The lease provides facilities for DOC, in cooperation with other Canadian agencies, to conduct communications pilot projects to follow on from the most promising HERMES experiments.

ANIK-B was successfully launched in December 1978. Communications tests by DOC are scheduled to commence February 1979 and pilot projects will begin in April.

DOC invited proposals for pilot projects to test the provision of new services by communications satellites under normal operating conditions. The projects will continue for an extended period, of up to one year, so that user agencies can determine how to make the most effective use of the satellite

communications medium, and can evaluate benefits and limitations with respect to their particular operations. Seventeen projects were accepted by DOC. These are categorized under the general headings of tele-health, television program delivery, tele-education, public telecommunications applications, and advanced technology experiments. Projects in these areas are being developed cooperatively by appropriate federal and provincial agencies, and carriers.

Experimental Use of Symphonie Satellite

During 1978, the experimental program utilizing the Franco-German Symphonie Satellite was continued between Canada and the two satellite owners. In particular, a two-week series of video-teleconferences was held. The series included dialogues between professional groups in France and Quebec. An extended experiment was carried out in which clocks at the NRC, Ottawa and B.I.H., Paris were compared. Teleglobe is responsible for providing earth terminal facilities to non-government users, while DOC is responsible for approving experiments and for providing facilities for government-sponsored experiments.

SARSAT

The experimental satellite-aided Search and Rescue System (SARSAT) is a joint Canada, France, U.S.A. project to provide a demonstration and evaluation of the use of satellites for the purpose of detecting and locating existing emergency radio beacons operating at 121.5 GHz and 243 MHz and experimental beacons at 406.1 MHz.

During 1978 negotiations were continued on a Canada/France/U.S.A. Memorandum of Understanding covering this joint project. DOC represented the Canadian participants DND, DOC, DFE and MOSST. In addition, a meeting was held between the SARSAT parties and the USSR's Ministry of Merchant Marine (MORFLOT) to discuss the possibility of a joint project between SARSAT and a compatible USSR system. At the end of the year, performance characteristics of the proposed Soviet system were obtained and were being studied. Japan and Norway have also expressed interest in cooperation with SARSAT.

In Canada, coordination of the joint project is being carried out by an Interdepartmental Review Board with DND being the lead department and with participation by the Departments of Fisheries, Communications, Transport, Supply and Services and Industry, Trade and Commerce. A SARSAT project management organization has been established and is operating. Interim Treasury Board Funding approval was obtained, and administrative steps completed to obtain full funding approval. In the technical area, Canada is developing a ground station and has responsibility to develop and deliver three repeaters to fly onboard the NOAA-E, F and G satellites. The expected launch data for the first satellite is mid-1982, after which there will be a 15-month demonstration and evaluation phase. During this phase, search and rescue users (DND and the Coast Guard) will obtain data to assess the potential benefits of SARSAT to their operations.

European Space Agency (ESA) Agreement

During 1978, Canada negotiated a cooperative Agreement with ESA. The Agreement was signed in December 1978, and comes into force in January 1979. Under the terms of the Agreement, Canada will participate in the General Studies of the Agency. The objectives of this Agreement are:

- to improve the prospects for Canadian industry to conduct space business in Europe;
- to identify partners in Europe who share common interests in communications, remote sensing or other space programs, and
- to establish cooperative arrangements for such programs that are of mutual benefit to ESA and Canada.

Multipurpose UHF Satellite System (MUSAT)

MUSAT is a new type of geostationary satellite system under planning in Canada to meet the needs of the military and of civil government departments for UHF mobile-satellite and other specialized communications services, specially in the Canadian North, in remote areas, and in coastal waters. The primary function of MUSAT will be to provide two-way voice and low-rate data communications to ships, aircraft and lightweight manpack stations for use in field operations.

MUSAT differs from the ANIK satellites in many respects. It utilizes primarily frequencies in the 240-400 MHz band in comparison to the ANIKs which operate in the 4/6 GHz and 12/14 GHz bands; and, it provides low-capacity narrow-band services to compact mobile stations while the ANIKs provide high-capacity wide-band services to fixed stations. While different, the MUSAT and ANIKs are complementary in their functions. Where the ANIKs provide commercial fixed-satellite and broadcasting satellite services in the 4/6 GHz and 12/14 GHz bands among a network of fixed earth stations, MUSAT would provide UHF mobile satellite service to ship, aircraft, and land mobile stations and military 7/8 GHz fixed satellite service. Other services which would be provided by MUSAT include UHF data collection from fixed and mobile meteorological and earth exploration sensors, monitoring of UHF emergency radio beacons, and L-Band maritime mobile-satellite service.

In preparation for the development of the MUSAT system, the Department of Communications has been conducting research and development projects to develop relevant technology and expertise in Canada, to prove the feasibility of the MUSAT system, and to reduce technological risk in critical areas.

Hardware feasibility studies have been conducted on both the space and ground segments of MUSAT. On the space segment, a UHF brassboard transponder with an 80-watt power amplifier was designed and tested under laboratory conditions. This transponder feasibility study project also included the investigation of the passive intermodulation (PIM) noise phenomenon which caused serious problems in the U.S. MARISAT and FLTSATCOM programs. A PIM test facility was developed as well as a prototype UHF diplexer meeting stringent PIM specifications.

Earth station hardware feasibility studies have included some development on a low given UHF antenna and a channel unit for the manpack station.

Teleglobe

Teleglobe Canada presently owns and operates three satellite earth stations: one at Mill Village in Nova Scotia and one at Lake Cowichan

on Vancouver Island, British Columbia. A fourth, to be called "des Laurentides" earth station, is being constructed in the Laurentian area north of Montreal and will be operational in the second half of 1979.

The Mill Village No. I earth station, built as an experimental station in 1965 and modified in 1973/74 to meet INTELSAT's earth station requirements, is being expanded and modified to improve its operational capability to satisfy the increasing traffic demands of communications with the Atlantic Ocean region countries via the Major Path INTELSAT IV-A satellite. Modifications include changes to the antenna for dual polarization operations. The Mill Village No. II antenna already had this capability.

The Mill Village No. II earth station, built in 1968 and operational in 1969, provides the satellite telecommunications traffic to and from countries of the Atlantic Ocean region via the primary INTELSAT IV-A satellite.

The Lake Cowichan earth station, which was completed in 1972 when commercial service was established, is providing satellite communication traffic via an INTELSAT IV satellite to countries of the Pacific Ocean region.

The forecast of increasing traffic via satellite and INTELSAT's plan to operate with a three-satellite configuration over the Atlantic Ocean formed the basis for Teleglobe's decision to construct the new "des Laurentides" 6/4 GHz earth station. This station, which will use a beam waveguide antenna with a dual polarization frequency re-use capability, will have all its communication equipment located at ground level in the antenna control room area. Des Laurentides station will initially be equipped with 16 receive and five transmit chains to cover expected traffic requirements in telephony, TV sound and data. SCPC transmit and receive terminals will also be installed in time for the planned opening in 1979.

During 1978, Teleglobe Canada continued its study of the propagation characteristics of the earth-to-space path in the 14/11 GHz bands from locations in Québec and Ontario. The study consists of two phases:

- the collection and analysis of experimental propagation data derived from the radiometric measurements at space diversity operated sites in Québec and Ontario;

- the investigation of the effect on the transmission system caused by signal degradations resulting from precipitation in these earth-to-space paths.

The studies are expected to extend into 1979-80. The results will be used to determine whether space diversity is required for a 14/11 GHz earth station planned for operation in that particular area.

Teleglobe is continuing its measurements at the Mill Village earth station to study the effect of precipitation on the propagation of electro-magnetic waves in the 4 GHz and 6 GHz bands. This study will allow Teleglobe to evaluate the effect of rain depolarization on the quality of future transmissions employing a frequency re-use technique, in particular with the INTELSAT V satellites.

In 1978 Teleglobe Canada, in anticipation of eventual Canadian participation in INMARSAT and the designation of Teleglobe as the Canadian signatory, participated in the Canadian delegation to the INMARSAT Preparatory Committee and its Economic, Technical, and Organizational panels.

The Fourth International Conference on Digital Satellite Communications which was attended by 434 participants from 26 countries, was held in Montreal from October 23 to 25, 1978 under the sponsorship of INTELSAT, Teleglobe Canada, the Canadian Society for Electrical Engineering and the Canadian Region of IEEE. Previous conferences were held in London (1969), Paris (1971) and Kyoto (1975). The technical program included 51 papers from 11 countries as well as exhibits and demonstrations provided by industrial and professional organizations from the United States, Canada and Europe.

Communications Research Centre (CRC)

The Canadian government is involved in the development of satellite communications because of the international character of many of the activities,

the need to exploit scarce spectrum and orbit resources in the best public interest, and because the costs and risks involved are higher than commercial organizations are generally willing to undertake.

The Department of Communications in-house program is centred at the Communications Research Centre. The principal involvement of CRC in space-related R&D activities is in three areas: space electronics, space mechanics and space systems. In addition to providing project management for major DOC space projects, each disciplinary area maintains a sufficient level of expertise to be able to provide advice, keeps abreast of international developments in satellite communications and associated technical fields, carries out studies in support of planning and policy development, and manages contracts to industry and universities.

Through CRC, the Department of Communications provides specialist expertise on space system design to support space applications programs sponsored by other departments and agencies. These programs include military satellite communications, aeronautical and marine navigation, search and rescue, remote sensing, surveillance, weather forecasting and Space Shuttle remote manipulator development.

Space Electronics

During 1978, in-house and industrial studies were started on the development of new and advanced spacecraft transponder elements. DOC funded the industrial development of 4 and 12 GHz solid-state TWTA replacement amplifiers at SPAR Aerospace Ltd. The in-house work was concentrated on 12 GHz amplifiers and evaluation of available gallium arsenide (GaAs) power FETs. These amplifiers offer advantages of weight saving and reduced thermal problems in spacecraft applications.

In conjunction with in-house work, DOC funded the industrial development (SPAR) of a passively-cooled (-100°C) all-FET receiver front-end for spacecraft transponder application. Cooling serves to reduce the receiver noise figure by about 0.1 dB/10°C, and passive cooling offers advantages in that no power is required. It is also cheaper and lighter than using Pelletier cooling, or uncooled parametric amplifiers.

This concept was subsequently incorporated into a further DOC funded industrial development contract (SPAR) for the production of a demonstration transponder for Direct Broadcast Satellite applications. This unit includes other new technologies such as a local oscillator in MIC form, modular construction, and alternate components (e.g. low-noise mixer) for 19 GHz uplink use.

A high-power combiner for use with ANIK-C earth terminals was developed under a DOC-funded contract with Com Dev Ltd., and an in-house study was started on lightweight spacecraft lens antennas which offer improved cross-polarization properties.

The sudden failure in June 1973 of a U.S. communications satellite was the first step in a realization of hazards associated with electrostatic charging on external surfaces of spacecraft in geo-stationary orbit. Since that time, numerous other spacecraft anomalies have been attributed to this phenomenon. Telesat have been concerned with the problem in regard to their ANIK series and an anomoly on HERMES was believed to be caused by a spacecraft charge build-up. In 1976, a spacecraft charging project was begun at CRC, to provide a better understanding of the physical processes involved, and to produce a set of specifications for protection from electro-magnetic interference and for testing of both subsystems and the integrated spacecraft. During 1978, the final assembly and commissioning of a simulation experiment chamber was completed and experiments started on characterization of spacecraft dielectric materials. The facility provides measurements of the RF energy and frequency spectrum associated with discharges on dielectric materials.

A computer code has been developed in industry to produce theoretical models of the interaction between the space environment and space-craft dielectric materials, particularly in regard to electron penetration configurations. Present studies have indicated good correlation between theory and practice. The University of Saskatchewan, under contract, is conducting a monitoring program of some magnetospheric parameters believed to contribute to surface charging on spacecraft in geostationary orbits. These activities are continuing.

The Space Electronics directorate has been active during the year in assessing the technical feasibility of transponder and antenna systems for the MUSAT satellite. Construction of an 80W power amplifier was completed and is undergoing life testing. Also extensive studies, in-house and with Carleton University, were conducted into the causes of passive intermodulation problems associated with multicarrier high-power systems as envisaged for MUSAT. As a result, a series of component constructional design criteria have been established. This work is continuing.

A DOC-funded contract for development of a MUSAT earth terminal channel unit was undertaken and completed by Miller Communications Systems Ltd.

In-house development of small, low-cost terminals capable of direct television reception from 12 GHz satellites such as HERMES was completed. These terminals are for single-channel reception, but are adaptable for multi-channel use, and are tunable over the entire HERMES bandwidth. Industrial contracts, funded by DOC, for component development and production of 100 such terminals were awarded to Electrohome Ltd. and SED Systems Ltd. These units will be used for direct television reception from the HERMES and ANIK-B satellites in 1979. A further DOC-funded contract was awarded to SPAR for the prototype design and production of a similar 12 GHz terminal for CATV head-end applications. In-house work is continuing on cost-effective technical improvements to such terminals.

In the area of digital communications, work was started on a new generation of Emergency Locator Transmitters and Emergency Position Indicating Radio Beacons operating at 406 MHz for use with the Search and Rescue Satellite (SARSAT). A breadboard laboratory test unit was constructed for use in systems tests on the satellite transponder. Several portable field test units are being fabricated for field trials after launch of SARSAT. Some on-going in-house research and developed was conducted on advanced components and devices (e.g. SAW filters, I^2L logic, and stable frequency sources) for use in satellite and earth terminal systems. It is planned to transfer some of this technology to Canadian industry so as to increase its capability to provide more basic electronic components for communications applications.

Space Mechanics

The Space Mechanics directorate is concerned with spacecraft thermal and mechanical design, propulsion, and with orbital and attitude prediction, determination and control.

During the past year, the directorate has sponsored development by SPAR of a light-weight, high-power solar array structure designed to accommodate the power requirements for future satellites (3 to 10 kw). Development tests have been completed and a fabrication and qualification test program is planned for next year.

Because of the requirement for more precise pointing and station-keeping in advanced spot beam communications satellites, the directorate has sponsored the development in industry of an integrated attitude sensing and control system to meet this need. This development work is supported by a system simulation facility at CRC based on a hybrid computer (AD-5 analogue and PDP 11-45 digital). During the next year, an inertial test simulator will be added to facilitate the testing of these advanced systems.

CRC has also been active in the development of computer programs that determine and predict spacecraft orbits, position and attitude in space. These have been developed to meet the needs of future Canadian programs. Based on this expertise, CRC has recently been called on to provide technical assistance on a nuclear-powered satellite working group reporting to the United Nations Committee on the Peaceful Uses of Outer Space.

Space Systems

The Space Systems directorate is concerned with concept and design of communications systems and major subsystems and with proof-of-concept experiments. The directorate continued its studies to support applied research and development related to communications processing techniques for small terminals and mobile satellite communications systems. The techniques studied are applicable to a variety of systems including ANIK, MUSAT and military satellite systems. In addition, non-satellite applications, such as mobile communications, are served by developments in these studies.

For mobile communications, such as aircraft, ships and transportable stations, it is impractical to use the large steerable high-gain antennas of conventional earth terminals. The project is aimed at providing a basis for the design of systems for such programs as MUSAT, maritime mobile systems, and navigation systems such as NAVSTAR. Methods are investigated for using lower frequencies and modulation techniques capable of operating at low signal-to-noise ratios.

CRC has also been carrying out studies for DND in connection with the GPS/NAVSTAR Global Positioning System being implemented by the USAF. DND and US/DOD have signed a Memorandum of Understanding covering cooperation in this area. Activities at CRC include GPS performance evaluation at high latitudes and support of contract studies for user terminals.

Agreement was reached during 1978 with the Canadian National Telecommunications and Canadian Pacific Telecommunications to co-sponsor an ANIK-B pilot project to demonstrate a Canadian-developed Time Division Multiple Access (TDMA) satellite communications system for "slim-route" applications. This will provide operational information concerning the new technique for the more efficient and more flexible sharing of satellite communications capacity among a number of low-capacity ground stations. Equipment development will commence in the Spring of 1979, with system trials taking place during the Winter of 1980/81.

David Florida Laboratory (DFL)

The DFL is maintained by DOC as a national facility for the environmental testing and integration of satellites and space hardware. In 1978 the decision was taken to expand these facilities to permit complete integration and testing of the large communications satellites which will be carried in the Space Shuttle. The building will be extended by 1700 square meters. The main new items of equipment to be added are a vibration tester with a capacity of 178 KN sinusoidal and 160 KN random and a large thermal vacuum chamber 6.7 x 10.7 m.

The capabilities of the existing facility are summarized as follows:

Thermal vacuum chambers

§ 3m dia. x 9m high

§ 2.5m dia. x 2.5m long

§ 1.2m dia. x 2.5m long

§ 1m dia. x 1m long

- Vacuum to at least 10^{-7} torr in all chambers
- Temperature range -195° to $+150^{\circ}$C in all chambers
- Automated temperature scanning, monitoring and recording (digital format) for 160 channels of data.

Vibration equipment

§ 53.8 KN sinusoidal system

§ 44.8 KN random system

§ 27 KN sinusoidal/random system

- Systems can monitor up to 54 accelerometer channels simultaneously
- Real-time analyser available for data analysis.

RF facilities

§ Screened room for RFI/EMC testing to MIL STD 461/462

§ 4m x 4m x 3m shielded anechoic chamber with -35 dB reflection coefficient at X band frequencies

§ 7m x 7m x 7m shielded anechoic chamber with -50 dB reflection coefficient from 1 GHz to 20 GHz and associated 150m antenna range

High bay area

§ 30m x 12m x 10m high

§ 5m ton overhead crane

§ 2½m ton crane for transfer of satellites to environmental facilities

§ Air-cleaning equipment

§ Ground support facilities

During 1978, the environmental testing laboratory was used almost exclusively in support of the Space Shuttle Remote Manipulator System. Precise scheduling of activities, however, permitted other testing to be performed for the TDRSS transponder system and other research projects. The RF facilities of the DFL were heavily used during 1978 in support of projects for Canadian Marconi Company and the Departments of Communications and National Defence.

High Reliability Laboratory (HRL)

The High Reliability Laboratory is a facility which develops and applies techniques for the assessment of the quality and reliability of electronic subsystems, components, devices, and materials for space communications. The facility is used by DOC, other government departments and agencies, and Canadian industry on a cost-recoverable basis.

The HRL facility is maintained and continually upgraded to provide state-of-the-art service and presently contains optical and scanning electron microscopes (SEMs), X-ray and Auger microprobes, electrical test equipment, laser, plastics and polymer evaluation, and clean room facilities. Equipment available to perform reliability assessments of large-scale integrated circuits (LSIs), such as microprocessors, has been evaluated and a unit will be installed in early 1979.

In the past, extensive use of the facility has been made in pioneering work on the reliability of GaAs FETs for space use. These devices are now rapidly displacing travelling wave tubes in satellite and earth terminal subsystems such as SHF amplifiers and oscillators. During the past year, a considerable number of destructive physical and failure analyses

were undertaken on components and devices for the Shuttle Remote Manipulator System in support of NRC and the Canadian prime contractor, SPAR. Support was also provided to SPAR and Telesat Canada in the assessment of devices for the ANIK-B spacecraft, and there will be a significant increase in the level of activity as work proceeds with the ANIK-C and D programs.

DEPARTMENT OF ENERGY, MINES & RESOURCES (EM&R)

General

In order to manage Canada's vast land and ocean territories in a manner beneficial to Canadians, complex, multi-purpose information systems are needed. Numerous studies have shown that remote sensing from satellites and aircraft is a cost-effective way to obtain much of the data required for such systems. The nature and volume of this data are such that they cause significant change to the systems in which they are introduced, sufficient to require the development and demonstration and new methods and installations for their processing and analysis prior to use by resource and environmental managers. Finally, it is desirable to transfer the resulting technology to private industry. The Canada Centre for Remote Sensing (CCRS) was established to carry out these functions.

The Canada Centre for Remote Sensing (CCRS)

The Department of Energy, Mines and Resources' Canada Centre for Remote Sensing (CCRS) is the nucleus of a national program in remote sensing, introducing this new technology into the established resource management and environmental monitoring agencies in Canada. Under the guidance of the Inter Agency Committee on Remote Sensing (IACRS), made up of representatives of the Federal Government departments involved, the Centre serves federal and provincial departments and agencies, universities, industry and the general public. It coordinates the national effort through the working groups of the Canadian Advisory Committee on Remote Sensing (CACRS).

The activities of the Centre are concentrated on four major programs: the Earth Resources Satellite Program, the Airborne Remote Sensing Program, the Applications Development Program and a Research and Development Program.

These four areas of activity are the necessary components of a successful space applications program for Remote Sensing, ranging from the development of effective space-qualified sensors from airborne demonstration models to the integration of remote sensing data in resource management systems to achieve the expected economic benefits of the program.

To carry out its mandate, CCRS has two earth receiving stations, one in Prince Albert, Saskatchewan, and the other in Shoe Cove, Newfoundland, both capable of receiving and recording on magnetic tape LANDSAT and NOAA satellite data. The Prince Albert station has the Multispectral Scanner (MSS) black and white images, has a "quick-look" capability for producing near real-time medium resolution imagery, and produces microfilms and microfiche. The Shoe Cove station has the capability of processing and distributing medium resolution black and white images and of producing computer compatible magnetic tapes.

CCRS facilities also feature:

a) an Image Production System for satellite data capable of generating high resolution

black and white film from bulk tapes, of making radiometric and geometric corrections and of generating colour composites;

b) a General Purpose Data Processing system, exhibiting large-scale computer batch processing of remote sensing data, and also capable of providing computer support for remote sensing users inside and outside the Centre;

c) an application science laboratory dedicated to the development of new techniques for the analysis of remotely-sensed data and to the provision of assistance to resource managers and researchers;

d) a sensor and systems development laboratory providing for the engineering and of on-board computer and data acquisition systems, sensor interfaces, navigation systems and aircraft modifications.

CCRS also possesses four extensively modified aircraft dedicated to experimental remote sensing. These consist of two DC-3 aircraft, one Falcon 20 and one Convair 580.

LANDSAT

LANDSAT is a U.S. program in which Canada participates.

The Centre has been receiving and processing LANDSAT data since the first satellite in the series was launched in 1972. The currently-active spacecraft are LANDSAT-2 and LANDSAT-3. The two satellites together provide complete coverage of Canada at least once every nine days. Canadian data is received at two ground stations located in Prince Albert, Saskatchewan and Shoe Cove, Newfoundland. The stations receive and process a yearly average of 2,000 LANDSAT orbits, resulting in the reproduction and sale by private industry of over 15,000 satellite image prints as well as 300 computer compatible tapes. In addition, following the launch of LANDSAT-3 in March 1978, the Centre started receiving and processing Return Beam Vidicon (RBV) data from this satellite.

RBV data has a ground resolution of 30 m in panchromatic mode, as opposed to the 80 m resolution of the multispectral data, thus opening new possibilities in the area of thematic mapping at larger scales. Finally, as part of a continuing effort to meet user requirements, a laser beam image recorder was put in operation at Prince Albert, allowing the entire processing of standard LANDSAT data to be done on-site, thus reducing turn-around time to all users working on dynamic phenomena, ranging from hydrological systems to vegetation monitoring.

SEASAT "A"/SURSAT

The SEASAT "A" experiment was conducted under a Memorandum of Understanding between U.S.A. (NASA) and Canada (EM&R), signed on 19 September 1978.

Activities in 1978 included the successful reception at Shoe Cove of data from SEASAT "A", a proof-of-concept NASA satellite, carrying a synthetic aperture radar operating at L-band with 25 m resolution, a radiometer and a scatterometer, SEASAT data reception was carried out in the context of the SURSAT program, an interdepartmental effort designed to study the value of microwave sensors for ocean surveillance in any weather, including applications to ice reconnaissance, fisheries surveillance; search and rescue, weather forecasting, vessel traffic management and oil pollution detection and tracking. The satellite data was supplemented by extensive underflights using the CCRS long-range Convair 580, equipped with an advanced synthetic aperture radar with dual frequency (X and L bands) and dual polarization. Approximately one hundred scientists and resource managers were organized to carry out forty experiments in the main application fields. SEASAT "A" lived approximately four months and transmitted approximately one hundred thousand 40 x 40 km scenes of Canada. In addition, as of December 1978, the Convair 580 had collected approximately 10,000 line km of radar data. The data is now being studied by the SURSAT experimenters, and a submission to Cabinet summarizing the results of the experiments with recommendations regarding follow-on is expected to be ready in early 1980.

LANDSAT Follow-on (LANDSAT-D)

This is the continuation of the LANDSAT series, a U.S. program in which Canada participates, with an evolution towards operational systems. One of the main features of the LANDSAT Follow-on series is the addition of a Thematic Mapper, a form of multi-spectral scanner with improved spatial and spectral performance. The first launch (LANDSAT-D) is scheduled for 1981.

A notable technical challenge is the recording and processing of the large amount of data resulting from improved ground resolution and the additional spectral bands monitored by the satellite. The down-link frequency will thus be increased from S to X band, and the station equipment upgraded accordingly, including antenna, RF stages, recording and playback systems. Processing and analysis systems must also be upgraded to make full use of the improved performance of the space segment and pass on the benefits to the end user.

SURSAT Follow-on

Studies by an Interdepartmental Task Force and preliminary results from the SURSAT program indicate that an all-weather earth observation satellite system would be of significant value to Canada in the areas of ice reconnaissance, sea-state and weather prediction, as well as land-based activities. The system would be built around satellites mainly carrying a synthetic aperture radar and a high resolution visible/IR multispectral scanner. The most economical approach toward the availability of such a system to Canada would be Canadian participation in a global system which might include as initial partners the U.S.A., Europe and Japan. It is expected that such a system will be in operation by the late 1980's.

The SURSAT program office expects to report to the Cabinet on the results of the current experimental program in early 1980, including its conclusions regarding the value of an all-weather satellite observation system to meet Canadian needs, and recommendations regarding a possible SURSAT follow-on program.

DEPARTMENT OF NATIONAL DEFENCE (DND)

General

The Minister of National Defence is responsible for the formulation of defence policy and its implementation by the Canadian Armed Forces, and for the management and operation of all Canadian military establishments and facilities.

It is departmental policy to take advantage of space systems that offer the most cost-effective way of meeting defence objectives. Accordingly, the department is continually engaged in studies, departmentally and in co-operation with other Federal Government departments, of the feasibility and potential of space systems which have applications to defence. It pursues space-related research in a number of defence research establishments, and is cooperating with several agencies of Allied countries in experimental space programs, viz:

a) with the USAF in its development of a world-wide satellite navigation system, the NAVSTAR/GPS;

b) with NASA in the U.S.A, and CNES in France, in a demonstration of satellite-aided search and rescue; and

c) with the Massachusetts Institute of Technology, in Cambridge, Mass., in physiological research related to air safety, utilizing the European-built SPACELAB to be carried on board the U.S. Space Shuttle.

The Department also participates in the North American Air Defence (NORAD) Space Detection and Tracking System, operating a detection and tracking station at Cold Lake, Alta., and a detection, identification and tracking station at St. Margaret's, N.B.

Base

Research on military communications, including satellite communications is carried out for DND by the Communications Research Centre of the Department of Communications, and is monitored by the Defence Research Establishment Ottawa, which adjoins the former on the same site.

NAVSTAR/GPS

The U.S. Department of Defense has initiated a $750 million research and development program on the Global Positioning System (GPS), often referred to as NAVSTAR/GPS, to satisfy the navigational requirements of the U.S. armed services. R&D, to date, promises accuracies to the user that surpass anything currently available, along with high resistance to jamming.

GPS will be a world-wide navigation system based on 24 satellites continuously broadcasting time and satellite location data to users. Derived position accuracies better than ±10 m in a protected, jam-resistant mode, and ±45 m in an unprotected mode will be available to users. This system represents the next generation of navigation systems and is expected eventually to render many current systems obsolete or redundant.

The U.S. program is divided into three phases. Phase I, the concept validation, is nearing completion and it involves selection of a suitable design, demonstration of the military value of the system, and analysis of costs. Phase II, the system validation, is getting underway with final approval for full-scale development planned for May 1979.

This phase will involve follow-on development testing and operational testing with the goal being establishment of a two-dimensional navigation, operational capability by 1981. Phase III, the production or operational phase, will involve advanced testing, full-scale user equipment production, and full operational capability by 1987.

The possibility and economic feasibility of Canadian industrial participation in the development and procurement of the NAVSTAR user equipments was explored in response to the Canadian Defence Management Committee direction. Discussions took place with staff of the project office of the USAF Space and Missile Systems Organization (SAMSO), Los Angeles, and most of the early system and equipment specification has been provided by SAMSO.

This technical data allowed DND to contract with the Canadian Marconi Company (CMC) for an initial design study of the development of user equipment in Canada. This design study was completed in June 1977. In September 1977, CMC was awarded a follow-on contract to provide four pre-production prototypes of a high accuracy, high-dynamic use, medium jamming resistance class of user equipment deliverable from September 1979 to January 1980.

A Memorandum of Understanding with the U.S. DOD has been signed to cover cooperative R&D and the exchange of technical information. Canadian elements of R&D will include designing, and developing one or more user equipment, investigating propagation anomalies in the auroral zone, examining user equipment antennae design, and studying the integration of strapdown inertial techniques with NAVSTAR/GPS.

The R&D activities other than CMC's equipment development will be handled by the Defence Research Establishment Ottawa (DREO) with the Communications Research Centre (CRC) being called upon to provide some assistance under existing contractual arrangements with DND. It is expected that the National Aeronautical Establishment (NAE) Convair aircraft will be used for some flight testing of equipment using the Aeronautical Engineering and Testing Establishment (AETE) facilities in Cold Lake, Alberta. Further testing at the US DOD Yuma Proving Grounds test range which has been specifically

modified for testing GPS user equipment is planned along with demonstration tests using DND vehicles engaged in operational exercises.

The inauguration of NAVSTAR/GPS operations is expected to lead to progressive phasing out of older navigation systems. This should lead ultimately to operational savings of money and personnel by DND. Participation in the project will enable Canadian industry to provide user equipments satisfying Canadian Forces specifications.

The Canadian DND is also participating with nine other NATO nations in a project whose purpose is to explore the introduction of NAVSTAR/GPS in an operational role with NATO forces. A twelve-man NATO team has been integrated into the NAVSTAR/GPS Joint Program Office in Los Angeles and DND has provided one member.

The Department of Transport is monitoring the NAVSTAR/GPS project and is examining possible commercial and civil applications with the view to determining the possible future impact of the NAVSTAR/GPS system on civil aviation and maritime operations.

SARSAT

The Canadian government organizations responsible for Search and Rescue (SAR) have striven to improve their ability to locate missing aircraft and vessels, and to rescue distressed personnel from disaster sites. Canada's vast expanse, with its varied geography and frequently inhospitable weather, places major demands and extreme constraints on such activities. Technological advances in electronics and communications already have provided important aids for these responsibilities, in particular, the relatively inexpensive Emergency Locator Transmitters (ELTs) which are now in wide-spread use. Satellites offer the possibility of continuous monitoring for ELT transmissions throughout the Canadian search and rescue area of responsibility. Complete monitoring of Canada by satellite can only be accomplished effectively by utilizing near-polar orbits. The swath of a suitable satellite could cover each point of the earth at least every twelve hours, while two satellites would cover it at least every six hours, and four at least every three hours.

Canada will supply repeaters for installation on three TIROS weather satellites to be operated by NOAA. CNES will supply onboard processors which will permit EPIRB signals to be recorded and stored over the oceans, and subsequently retransmitted to a ground station at the first available opportunity. The three participants will be responsible for provision of their own ground stations. First SARSAT launch is schedule with NOAA-E early in 1982. A 15-month demonstration and evaluation will follow in cooperation with operational user agencies.

SURSAT

The Department of National Defence is participating with other federal government departments in an experimental program to determine how well radar satellites might meet the surveillance requirements expressed in an interdepartmental task force report entitled *"Satellites and Sovereignty Control"*, dated September 1976, and covering the time period 1986-2000. The program involves participation in NASA experiments with SEASAT-A data along with a set of Canadian experiments using an airborne synthetic aperture radar installed in an EM&R Convair 580 aircraft. As the power system in SEASAT-A failed after about three months of operation, this has necessitated a concentration of effort on the airborne experiments. Fortunately it is possible to simulate the satellite radar using the airborne radar, so that, combined with SEASAT-A data gathered before the failure, it is expected that the objectives of the experiments will be met.

The primary DND responsibilities in the SURSAT project are to manage those interdepartmental experiments dealing with the surveillance of human activities and to provide an optical recording and processing capability for SEASAT synthetic aperture radar data. DND is also involved in meteorological experiments and the measurement and analysis of ionospheric effects on SEASAT-A signals.

Transportable Satellite Ground Terminal

The Communications Research Centre of the Department of Communications, under DND funding, has developed a relatively inexpensive, transportable

satellite ground terminal (SGT) for military communications via the NATO SATCOM system. In October 1977 the experimental equipment was stationed at Lahr, Germany, for demonstration and testing, and has been used for communications with Ottawa via NATO SATCOM satellite III A.

DND has a requirement for a number of these SGTs for use with its NATO and UN forces. Approval is being sought for an industrial model which would be air transportable (by Hercules aircraft), truck-mounted (on a 1¼ ton truck), and of modular design for ease of future modifications.

Spacelab

A joint proposal prepared by the Massachusetts Institute of Technology (MIT), the Defence and Civil Institute of Environmental Medicine (DCIEM) and McGill University has been accepted by NASA for the investigation of vestibular physiology aboard the Spacelab program. Canadian interests in the program result from the need to understand the functioning of the organs of balance and certain areas of the brain and their relationship to the phenomenon of disorientation in aircrew. This experimental program is scheduled for study aboard SPACELAB 1 and SPACELAB 4, presently planned for 1981 and 1982.

DCIEM has been very active in meeting their responsibilities for participation in these studies in space. A simulator has been built at DCIEM of the "space-sled" which is being made by the European Space Agency (ESA). DCIEM has been especially involved with studies of the perception of linear acceleration and a provocative motion sickness test using the "space-sled" simulator. In addition, DCIEM will conduct a one-week course for the training and indoctrination of the SPACELAB 1 flight crew members in the performance of these particular experiments in space. There is some optimism that one of the Canadian investigators may be chosen as a payload specialist for duty aboard SPACELAB 4.

SPADATS (Space Detection and Tracking and Identification)

Canada participates in SPADATS through its involvement in NORAD which has operational responsibility

for the system. There are two NORAD monitoring systems in Canada equipped with Baker Numm cameras. One is located at Cold Lake, Alberta and the other at St. Margaret's, New Brunswick. As photographs are taken, these cameras move in synchronization with the stars, the latter consequently appearing as points of light on film. Any non-astronomical source in the sky, such as a satellite, shows up as a streak of light.

In addition, the St. Margaret's, New Brunswick station is equipped with a Space Object Identification (SOI) system. Unique to the St. Margaret's station, the system combines optical and electronic equipment to analyse the light reflected from a space object. As for a radar return, the signal will vary as the reflection cross-section of the object changes. The scintillation parameters of the signal will be determined by the size, shape and rotation of the reflecting surface. Variation of intensity is measured by a sensitive photometer placed at the focus of a telescope.

After operating for some months in an off-line analogue mode, the SOI system became fully operational in October 1978, a digital output from the system being connected on-line to NORAD Headquarters.

Facilities

The Aerospace Engineering Test Establishment (AETE), Canadian Forces' Base, Cold Lake, Alta., operates an environmental rocket launching and recording facility at the AETE Primrose Lake Range near Cold Lake. Sounding rockets are launched from this range, providing temperature and wind data to heights of 50 km and more.

DEPARTMENT OF FISHERIES AND ENVIRONMENT (DFE)

General

In Canada, the responsibility for the environment is shared between the Federal and Provincial Governments, with each level having jurisdiction over different aspects of the environment. There are also some areas of concurrent jurisdiction. The provinces have direct management responsibility for most environmental and resource matters within their borders, with the Federal Government exercising responsibility for those matters clearly within its jurisdiction and for matters which the provinces cannot readily or cost-effectively undertake separately. The responsibility for fisheries and oceans is more clearly within the Federal Government mandate.

Among those areas in which the Department of Fisheries and the Environment has been active in a lead role is the development and demonstration of space technologies for assisting in the management of fisheries, provision of ocean and ice information, gathering of meteorological data, and inventory of forest, water and land resources. Some of the work is done in cooperation with the Canada Centre for

Remote Sensing on one hand and provincial agencies on the other. In addition to satellites, aircraft provide data particularly for programs of ice reconnaissance and forest inventory.

The Environmental Remote Sensing and Data Collection Program

Activities within this program are carried out in units of the Environmental Management Service located in various establishments throughout Canada. Projects are selected on the basis of need to provide information to research or operational programs, or as demonstrations of technology capable of meeting requirements for environmental management information for both the Federal and other levels of government.

During 1978, the Applied Resource Image Exploitation System (ARIES) was delivered to the Canadian Forestry Service. This system has been used not only by scientists from the Forestry Service but also by personnel from other departments and agencies. It is proving to be a fast and flexible system for digital image analysis and enhancement with potential for further development and sales both in Canada and abroad. Also during 1978 the Geostationary Operational Meteorological Satellite (GOES) data collection and distribution system became operational at the Prince Albert Satellite Station. It is operated by a contractor for the Water Survey of Canada and provides a capability for receiving data on one channel of the GOES located at 135° W over the equator. For data collection platforms operated on other channels or using the eastern GOES, data is received in the USA. A study by the Water Survey concluded that transmission of data from remote hydrometric stations using satellites is cost-effective even without consideration of the increased benefits of a shorter delay in acquisition of data.

A large part of the program, as in previous years, consisted of use and research on interpretation of Landsat images. Within the Forestry Service, projects included detection of insect damage, clearcuts and regeneration, forest classification, and generation of forest statistics. Landsat images were enhanced to assist in forest fire management, where they can provide current information on forest roads and fuel types. Lands Directorate began compilation of an ecoregion map for Canada based significantly on Landsat imagery.

Landsat images were used in ecological surveys for many parts of Canada. They are suitable for identification of major ecological land units and land use systems.

Participation in the SURSAT program was to have provided data from a satellite-borne synthetic aperture radar (SAR) for evaluation in various applications. Data was not acquired for all proposed experiments because of premature failure of the SEASAT satellite.

Scientists from the Inland Waters Directorate were involved also in the Nimbus-7 instrument teams, where they have participated in evaluation of the Coastal Zone Colour Scanner (CZCS) for use on the Great Lakes and the Scanning Microwave Multichannel Radiometer (SMMR) for mapping of snow cover.

The Meteorological Satellite Program

The Atmospheric Environment Service carries out a program of both research and operations in the use of data from meteorological satellites.

The operational program makes use of images from both geostationary and low-orbiting meteorological satellites. Images from low-orbiting satellites are received by the Edmonton and Downsview facilities which, during 1978, underwent conversion to enable reception of the new TIROS-N family of NOAA satellites. Simpler facilities, capable of receiving the lower resolution APT transmissions, are operated in Vancouver and Halifax. During 1978, the AES installed in Downsview a receiver for the Visual and Infrared Spin Scan Radiometer (VISSRS) signals from the geostationary meteorological satellite GOES-east. These images are transmitted in appropriate sectors of major weather centres as far west as Winnipeg. Until a GOES receiver is installed in Vancouver, that office will continue to receive GOES images from Seattle, USA. The financial statement includes, for the first time, the costs of the operational program.

The images from the geostationary satellites, received every half-hour, are used to track the motions of storm centres. The images from the low-orbiting satellites are used by Weather Offices to track fronts in the northern latitudes. Enhanced images are transmitted from Downsview to the Ice Forecasting Central in Ottawa, where they are used for mapping sea ice.

Landsat imagery is also used extensively for ice reconnaissance. An order was placed for a computerized system to monitor ice status in the Gulf of St. Lawrence.

Other quatitative mapping applications under development in 1978 were a sea surface temperature retrieval system at the Arctic Weather Centre in Edmonton, and techniques for lake surface temperature mapping and digital snow line mapping in Downsview. Negotiations were begun for a contract to develop a system to integrate information from ground-based meteorological radars with VISSR images for the purpose of forecasting motion of storm centres and extrapolating expected rainfall intensity.

With the SURSAT program, scientists participated in experiments to map sea surface temperature under all weather conditions, to determine wind speed and direction, to determine atmospheric parameters, and to apply data from the Seasat satellite for operational weather forecasts. SURSAT experiments, aimed at testing the use of the SEASAT-A Synthetic Aperture Radar for ice mapping under a variety of conditions were cut short by the failure of the satellite.

STRATOPROBE

As part of the STRATOPROBE project, two stratospheric balloon campaigns were mounted in support of Nimbus-7 experiments to measure stratospheric gases using the LIMS, SAMS, and SBUV-TOMS instrument systems.

Fisheries and Oceans Remote Sensing and Data Collection Program

This program was identified as a separate entity during 1978. The Fisheries and Oceans program consists of participation in the national SURSAT, SARSAT and MUSAT program level committees and internationally on the SEASAT Science Steering Group, the SEASAT SAR team and the NIMBUS-7 SMMR team. Between June 14 and 22, 1978, the Institute of Ocean Sciences in Sidney, B.C. hosted the Inter-Union Commission on Radio Meteorology.

Participation in the SURSAT project has involved the full-time secondment of one person to the project office as deputy manager-applications with responsibility for the overall organization of the validation experiments for airborne and satellite sensors. Individual scientists have been responsible for west coast SEASAT SAR oceanographic validation experiments and for several ice-related experiments, many of which will eventually take place early in 1979. NIMBUS-7, TIROS and GOES satellites have been used extensively for data relay from drifting and moored buoy systems. GEOS-3 altimeter data have been used to derive information on ocean waves. Three-day composite averages of NIMBUS-5 Electronically-Scanned Microwave Radiometer (ESMR) data in photographic form have been used as the basis for a 10-minute film showing the advance and retreat of sea-ice in Canadian waters between September 1973 and December 1974. The technique developed for this film has since been used by U.S. and European agencies for studies of ice conditions throughout the Arctic, in detail north of Alaska and north of Norway, and for snow cover over land areas.

Late in 1978, plans were developed by the Marine Environmental Data Services (MEDS) to utilize the First Garp Global Experiment (FGGE) drifting buoy data transmitted via TIROS satellites to produce 5-day buoy tracks, average sea-surface temperatures, sea-surface temperature anomalies relative to climatological data, and monthly buoy track pilots for the southern hemisphere. A scientist from the Institute of Ocean Sciences has been stationed in Toulouse, France, to manage the FGGE Buoy Control Centre.

TRANSPORT CANADA

Aerosat

Canada has been participating with the United States and ESA in the Aerosat program, which is intended to evaluate the use of satellites for oceanic air traffic control and communications. The objective of the program was to establish the criteria for an operational system.

It became known in late 1976 that the U.S. partner was encountering difficulties in obtaining funding authority for the program. In mid-1977, a bill to limit FAA spending to $1 million for further studies was passed by the U.S. Congress and signed into law. This event precipitated a radical revision of the program.

The international organizational structure remains the same, with the Aerosat Council as the chief body responsible to the signatories and the Aerosat Coordination Office responsible to the Aerosat Council for the day-to-day implementation of the coordinated program.

The coordinated program has been changed to provide for a feasibility study for the next year. This study will re-evaluate the requirements for the use of satellites and determine the time scale associated with the need for an operational system and will be coordinated by a Committee set up for the Aerosat Council. The Committee for Review of Application of Satellites and other techniques to Civil Aviation (ARC) met on three occasions in 1978 and has outlined a work program expected to be completed in late 1980. Membership in the ARC is open to all interested states and international organizations.

A meeting of the Aerosat Council is scheduled to take place in Ottawa in May 1979 to discuss the work program developed by the ARC.

INMARSAT

In September 1976, a Convention and an Operating Agreement on an International Maritime Satellite Organization (INMARSAT) were open for signature. The Organization will come into being 60 days after the date on which states representing 95% of the initial investment shares have become parties to the convention. It is expected that the signature and ratification process will take up to three years from September 1976.

The purpose of the Organization is to deploy and operate satellite for improving maritime communications, thereby assisting and improving the communications for distress and safety of life at sea, efficiency and management of ships, maritime public correspondence service, and radio location capabilities. The organization will seek to serve all areas of maritime communications. Canada has signified its intention to initiate domestic procedures which would permit its membership in the INMARSAT Organization. It is participating in the work of a Preparatory Committee, set up to perform studies and make preparations which will facilitate the establishment of the maritime satellite system when the Orgnization comes into effect. In Canada, interdepartmental coordination is effected by an Interdepartmental Committee on Maritime Satellites (ICMS), which approves all instructions for Canadian delegations attending the committee and panel meetings.

Four meetings of the Preparatory Committee were held during 1977 and 1978, with a fifth scheduled for May 1979. After the third meeting of the PREPCOM, the work of its panels was completed and the panels disbanded.

In late 1977, participants in the INMARSAT Preparatory Committee were approached by a consortium consisting of COMSAT General and certain European interests, with a proposal for a "Joint Venture" for a second generation Maritime satellite. The Joint Venture system will provide continuity between the end of MARISAT (around 1981) and the earliest operational INMARSAT system not expected before 1985. Present INMARSAT participants were invited to join in this joint venture, with the intention that all assets be turned over to INMARSAT when it comes into existence. Further clarification of the offer was sought through a series of meetings in late 1977 and deliberations of the Joint Venture are expected to be completed by April 1979.

Cabinet approval for Canada to participate in INMARSAT will be sought in early 1979.

MARISAT Terminal

A leased MARISAT terminal was installed on the Canadian Coast Guard icebreaker John A. MacDonald for evaluation purposes in early 1976. The project was conceived to assess the impact of satellite communication on future Coast Guard services, to gain experience in the application of maritime satellite systems, and to develop the expertise necessary to allow the Coast Guard to make optimum use of the developing global maritime satellite system. The test and evaluation program began in 1976, and will be completed in 1979. It is expected that the terminal will become part of the operational equipment of the Coast Guard.

NAVSTAR/GPS

The developing satellite system is being considered for civilian use. Studies of the system parameters and capabilities will be undertaken, prototype receivers will be purchased and evaluated under field conditions. The data collected will permit standards and regulations to be formulated by the time the system is utilized by civil aviation. The first phase project definition will start in FY 1979-80.

DEPARTMENT OF INDUSTRY, TRADE AND COMMERCE (IT&C)

General

In consonance with its mission in relation to Canadian industry generally, the Department of Industry, Trade and Commerce supports the development of a viable Canadian space industry. To this end, it currently is providing financial assistance under its programs to companies in the space industry for the development of a new or improved ground-based and space-borne products, and for the acquisition of capital equipment required for the development and manufacture of such products. It also promotes their international marketing through the provision of financial support for this purpose, and by arranging missions encompassing a number of companies. Interdepartmentally, IT&C seeks to maximize the benefits to the Canadian space industry from Government space programs--for example, by promoting maximum participation by industry, in particular in the higher quality activities such as management, integration and development; by favouring the approval of those proposals which offer better prospects for industrial benefits, including export sales, import displacement, non-space spin-off

products, the acquisition of new technology, and challenging employment opportunities. It also supports international relationships for which there are good prospects for sufficiently worthwhile industrial benefits in terms of the costs involved.

Industrial Support

RMS Base Technology

IT&C continued to support an RMS base technology development project at Spar Aerospace Ltd. under its Defence Industry Productivity (DIP) Program until mid-1978, when the contract then in force was completed. It is expected that a follow-on contract will cover continuing work. Approximately 30% of the expenditures during 1978 were on space-related activities: concept development of the Module Interchange System (MIS) proposal, and the development of end effectors and latch operators for the Shuttle RMS project. The non-space expenditures were devoted to activities on manipulators for underwater applications; the development of a manipulator system for paraplegics, mounted on a wheelchair; concept analysis and design of a remote manipulator system for the Tri University Meson Facility (TRIUMF) at the University of British Columbia; and general studies on force feedback control systems.

Satellite Sub-Systems and Earth Stations

The Electronics Group of Spar Aerospace Ltd. received continuing support under two DIP development projects. One project, Communications Systems, is for the development of terrestrial communications products for the microwave radio and earth station product lines. The other project, Aerospace Communications contributes to the improvement of the satellite subsystem product line for transponders and antennas in the 6/4 GHz and 14/12 GHz bands. With this support, the company has achieved significant advances in its capabilities to provide sophisticated satellite products, based primarily on the application of solid state devices and lightweight materials. Spar is internationally competitive in these aerospace products and the company is gradually expanding its market in both domestic and export sectors.

During the year, the Department also instituted processing of an application from Spar for DIP Capital Assistance for the establishment of a 1,000-foot antenna range as a significant improvement over existing antenna test facilities at the Electronics Group plant at Ste. Anne de Bellevue.

INTERNATIONAL RELATIONS

Most of Canada's space program and activities are carried out through international cooperation on both a bilateral and multilateral basis. The following covers only the highlights of Canada's international activities in space during 1978. The section of the report dealing with departmental programs illustrates the extent of this involvement.

United States of America

For a number of reasons, the USA is Canada's main foreign partner in space activities. The Administrator of NASA visited Ottawa in September 1978, for a discussion of the American and Canadian space programs and areas of cooperation. Efforts will be continuing on both sides to provide for closer cooperation during the early planning stages of programs and activities. Earlier in the year, a Memorandum of Understanding concerning Canadian participation in the SEASAT-A program was signed during the visit.

Earlier in the year, a Memorandum of Understanding concerning joint cooperation in the development of remote sensing for global crop information (LACIE) was signed. The ANIK-B communications satellite was launched from NASA's facilities at Cape Canaveral on 15 December 1978. A delegation from the People's Republic of China witnessed the launch.

European Space Agency

After a lengthy period of negotiations, a Cooperative Agreement between Canada and the European Space Agency was signed on 9 December by the Minister of Communications and the Director General of ESA. The Agreement, which will come into effect 1 January 1979, will increase Canada's participation in the Agency's programs and activities. Arrangements will be undedtaken to provide for official Canadian representation to ESA to facilitate this.

Japan

A highlight of the Canada-Japan consultations on science and technology, which took place in June, was the discussion concerning cooperation in space. Contact points were named for remote sensing, and the first meeting of remote sensing officials took place in December to identify specific areas for cooperation.

A Canadian scientist from the Department of Communications spent six months on exchange in Japan to learn more about the Japanese space program and opportunities for Canada.

Others

Liaison for effective international cooperation exists with a number of countries and in addition there is well-developed cooperation of a more informal nature, on individual and institutional levels. Canada is involved in the transfer of space technology and its applications to developing countries, particularly in the area of remote sensing. One example is a joint Canada, USA, France project to establish a regional remote sensing centre in Ouagadougou, Upper Volta, in which students from the Sahelian countries participate in a training program.

FINANCIAL SUMMARY

The financial summary data for the member departments, covering FY 1977/78 and FY 1978/79, is contained in Tables 1 and 2, and in Figures 1 to 4. Figures 3 and 4 also include the past history of space expenditures from 1969/70 until today. Unless specified, all expenditures are given in current dollars.

The financial reporting format began with last year's Annual Report has been slightly modified to include space expenditures from 1960/70 until today both in current and 1978 constant dollars. Table 1 summarizes the government's actual expenditures in 1978/79 and budgeted expenditures for 1979/80, broken down in IN-HOUSE or INTERNAL, INDUSTRY and UNIVERSITY on the one hand, and, on the other hand, into A: space systems; B: ground stations and earth terminals and C: data processing and analysis.

The government's total space expenditures of $95 million in FY 1978/79 are 46% greater than in FY 1977/78. In FY 1979/80, the budgeted space expenditures decrease by 19.4% ($18.5 million). The principal cause of this decrease is the reduction concerning the RMS project which will be close to completion and the payments made to Telesat Canada, in FY 1978/79, for use of the ANIK-B services. This decrease was somewhat compensated by the DFL extension and operations for ANIK C/D support undertaken by DOC.

It is interesting to note that the government IN-HOUSE expenditures jumped from $13 to $22 million per annum from FY 1977/78 to 1978/79 to stabilize at $22 million over the period 1978/79 - 1979/80. During the same periods, the government expenditures directed to Canadian industry have first increased by 57% (FY 1977/78 to 1978/79) and then decreased by 32% (FY 1978/79 to 1979/80). In the two fiscal years covered by this report, 74% and 63% respectively of the total government spending in space has been or is budgeted to be realized in Canadian industry.

Expenditures in Canadian universities in the form of grants or research contracts have been steadily decreasing over that period from 1.8% of total spending in FY 1977/78 to 0.4% in FY 1979/80. There has been no increase in grants from NRC in the area of space for a number of years and research contracts from the other departments have varied accordingly to departmental priorities.

The following briefly discusses the attached tables and figures.

Tables 1 and 2 show the space expenditures for FYs 1978/79 and 1979/80 broken down by departments and by categories A, B and C. In both figures the expenditures in Canadian industry are also highlighted.

Figure 1 shows the predominance of NRC and DOC as the most active departments in the area of space for FY 1978/79 and 1979/80. This predominance is seen to exist since 1969/70 as shown in figure 4. The figure also shows that almost 50% of the total government space expenditures are based on three projects, the RMS, ANIK-B and DFL extension operations for ANIK C/D support. These projects decline rapidly after a peak in FY 1978/79.

Figure 2 shows that the yearly distribution of expenditures amongst the three categories is sensibly constant. Approximately 71-74% go to category A, 19-21% to B and 6-8% to C. It also shows that in FY 1978/79 government expenditures in space are literally jumping to all time highs. However, although they still show an increase of 17.6% over FY 1977/78, the budgeted expenditures for FY 1979/80 indicate a decline of about $20 million from these record-spending levels. After a drastic jump in FY 1978/79 (an increase of 68%), the FY 1979/80 budgeted figure for IN-HOUSE expenditures seem to stabilize at the previous year's level. Finally, Figure 2 shows that most of the fluctuations in the three categories have been absorbed by Canadian industry, whose share of the expenditures goes from 69% in FY 1977/78 to 74% in FY 1978/79 and to 63% in budgeted FY 1979/80. It might be pointed out that during these years the non-Canadian industry expenditures have steadily increased from $20 to $25 and to $28 million.

Figure 3 shows the government IN-HOUSE and INDUSTRY expenditures from 1969/70 until 1979/80. Once more the Canadian expenditures are highlighted from 1976/77 onwards. The data for the years before 1976/77 does not permit such a breakdown. Once again the fact that all the increase in government space expenditures over the past 3 years has been absorbed by Canadian industry is very apparent. Over the past 10 years, approximately 68% of all government space expenditures occurred in INDUSTRY. Figure 3 also shows total expenditures in both current and constant 1978 dollars. The latter clearly indicates that from

FY 1972/73 to FY 1976/77 expenditures in the space sector declined. The apparent steady increase shown by the graph in current dollars is due to inflation.

Finally, Figure 4, shows the expenditures, since FY 1969/70 broken down by departments. It also shows total expenditures in 1978 constant dollars for these years.

TABLE 1 (x 1,000)

TOTAL GOVERNMENT SPACE EXPENDITURES								
	1978/79				1979/80			
	A	B	C	TOTAL	A	B	C	TOTAL
IN-HOUSE								
Capital & G&S	6,405	3,246	948	10,599	5,688	2,971	1,306	9,965
Salary	4,511	4,783	1,935	11,229	4,728	5,223	2,135	12,086
Sub-Total	10,916	8.029	2,883	21,828	10,416	8,194	3,441	22,051
INDUSTRY								
Canada	58,395	9,378	2,871	70,644	38,353	7,348	2,586	48,287
U.S.A.	1,120	686	358	2,164	4,858	459	269	5,586
Others	116	39	-	155	356	119	-	475
Sub-Total	59,631	10,103	3,229	72,963	43,567	7,926	2,855	54,348
UNIVERSITY	177	160	52	389	175	160	10	345
GRAND TOTAL	70,724	18,292	6,164	95,180	54,157	16,280	6,306	76,744

A: SPACE SYSTEMS B: GROUND STATIONS & EARTH TERMINALS C: DATA PROCESSING & ANALYSIS

TABLE 2

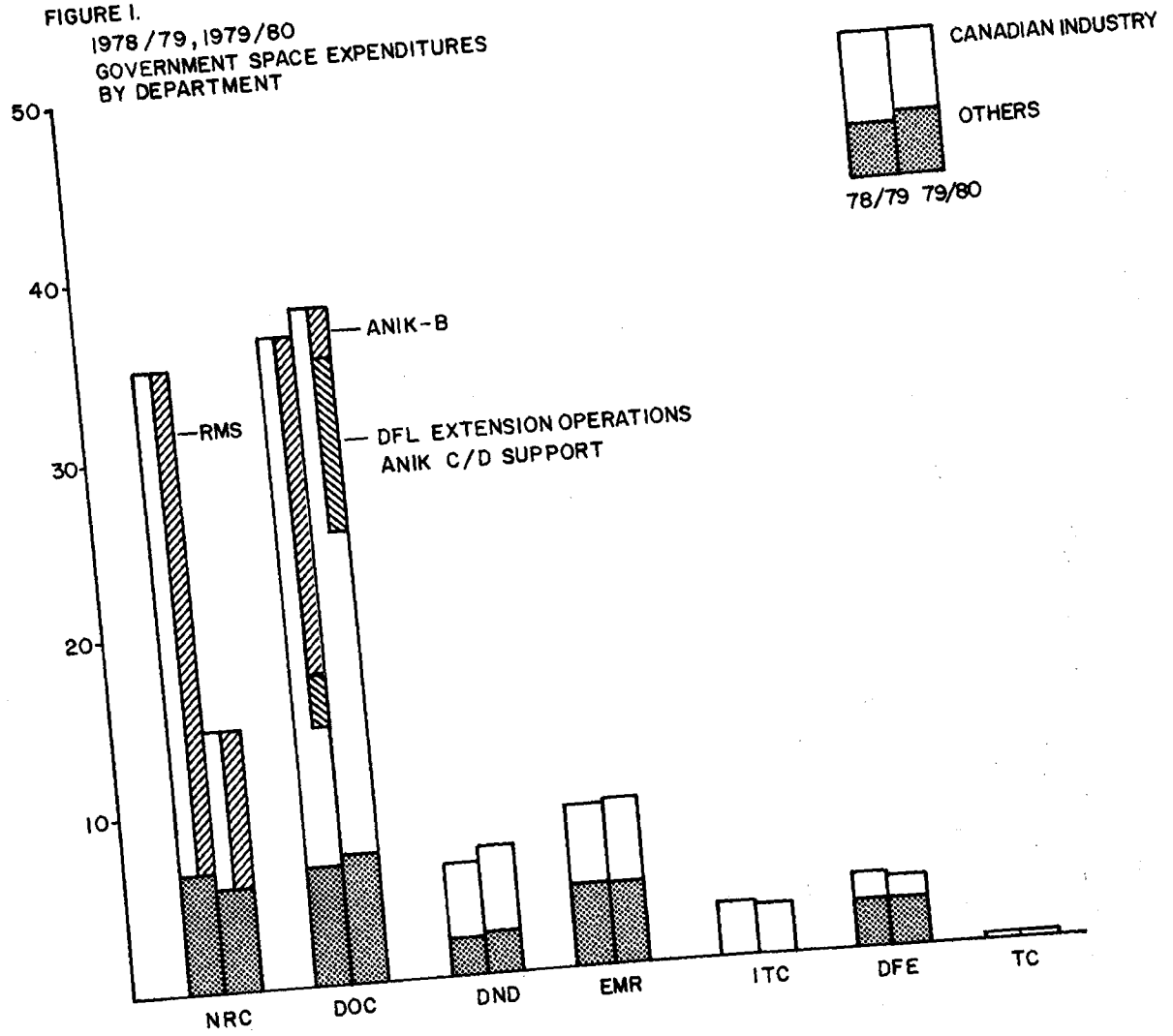
($ MILLIONS)

TOTAL GOVERNMENT SPACE EXPENDITURES (BY DEPARTMENT)

	1978/79				1979/80			
	A	B	C	TOTAL	A	B	C	TOTAL
Communications	30.5	5.8	0.3	36.6	33.3	4.5	0.2	38.0
National Research Council	34.7	-	0.5	35.2	14.3	-	0.5	14.8
National Defence	1.8	3.9	0.7	6.4	2.9	4.2	0.1	7.2
Energy, Mines & Resources	1.0	5.1	3.3	9.4	1.2	4.7	3.6	9.5
Industry, Trade & Commerce	1.8	1.3	-	3.1	2.3	0.6	-	2.9
Fisheries & Environment	1.0	2.0	1.3	4.3	0.2	2.0	1.9	4.1
Transport	-	0.2	-	0.2	-	0.2	-	0.2
TOTAL	70.8	18.3	6.1	95.2	54.2	16.2	6.3	76.7

A: SPACE SYSTEMS B: GROUND STATIONS AND EARTH TERMINALS C: DATA PROCESSING AND ANALYSIS

FIGURE I.
1978/79, 1979/80
GOVERNMENT SPACE EXPENDITURES
BY DEPARTMENT



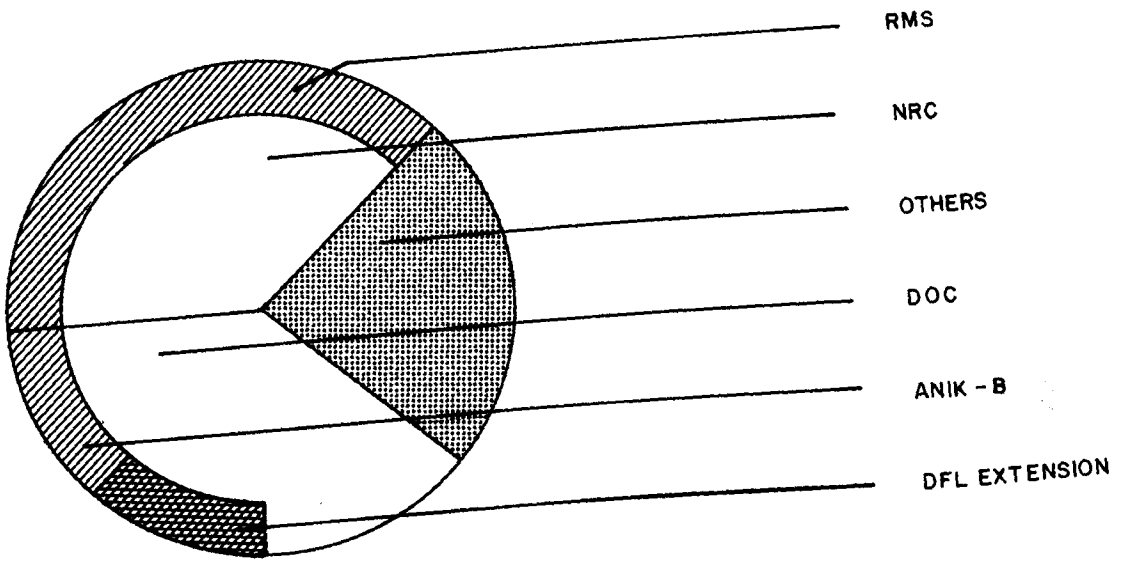
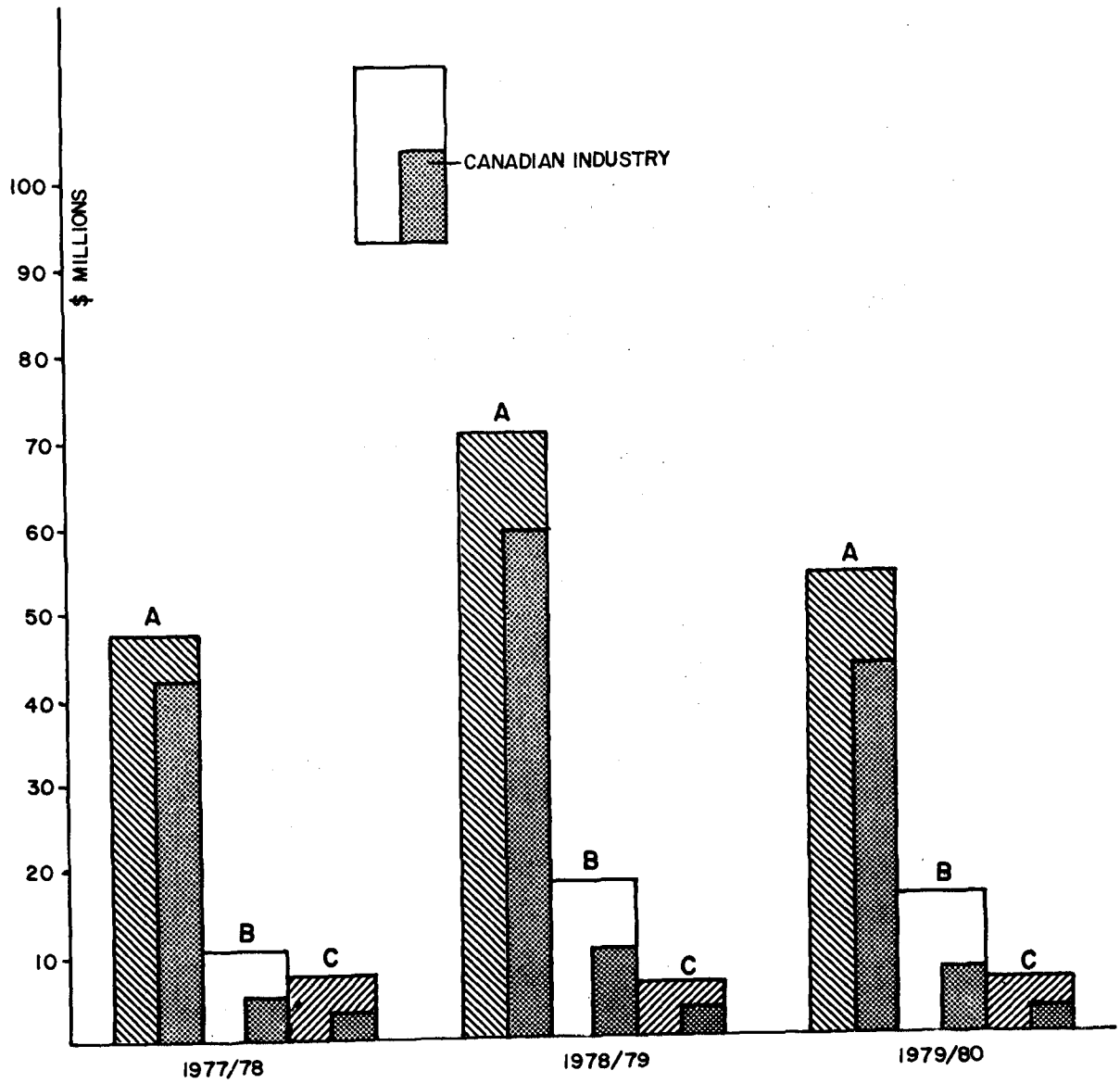


FIGURE 2

GOVERNMENT SPACE EXPENDITURES
BY CATEGORY



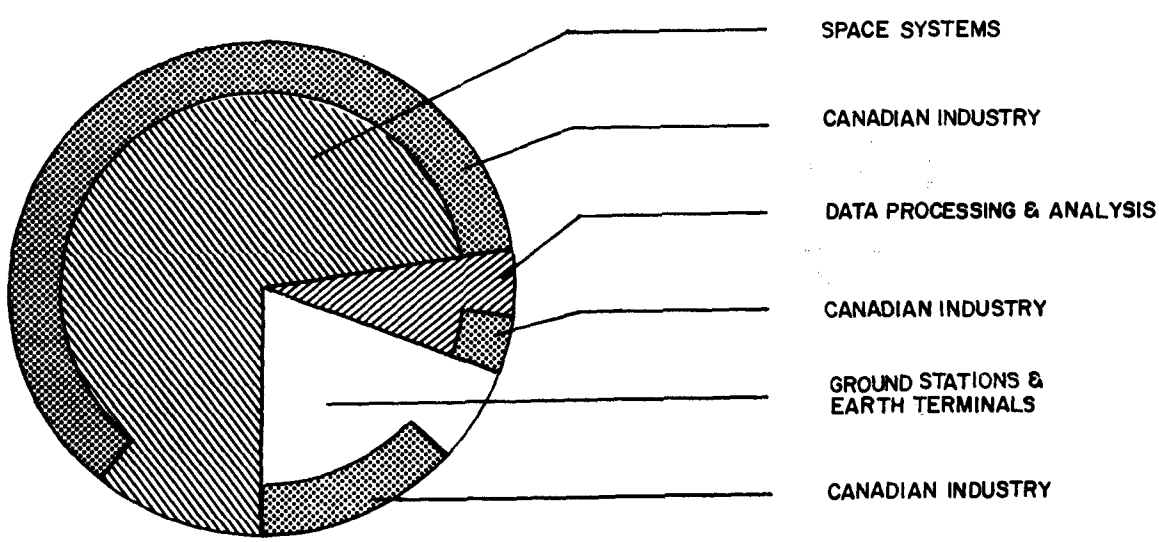


FIGURE 3

1969/70 TO 1979/80
GOVERNMENT SPACE EXPENDITURES
IN-HOUSE / INDUSTRY

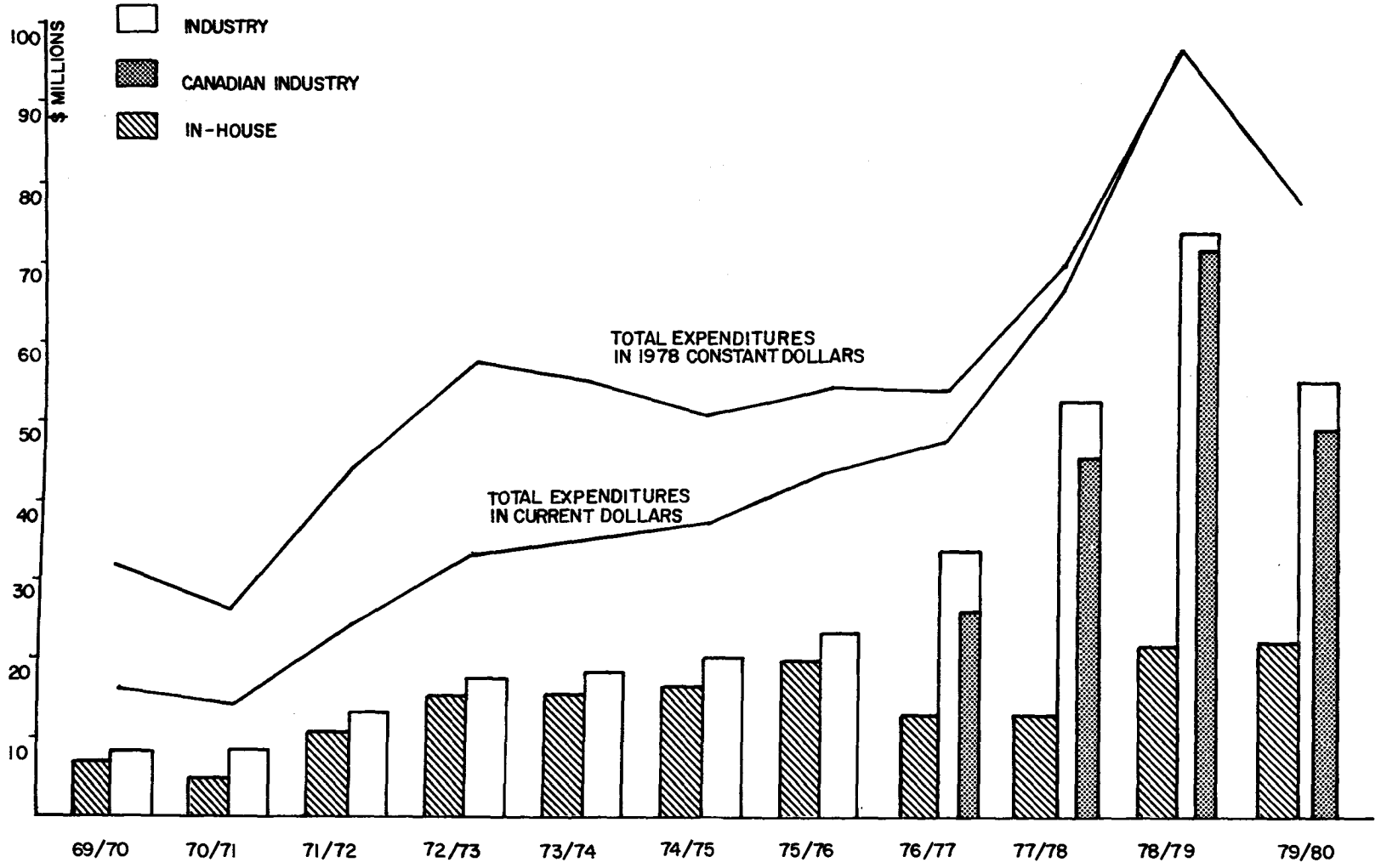


FIGURE 4

1969/70 TO 1979/80
GOVERNMENT SPACE EXPENDITURES
BY DEPARTMENT