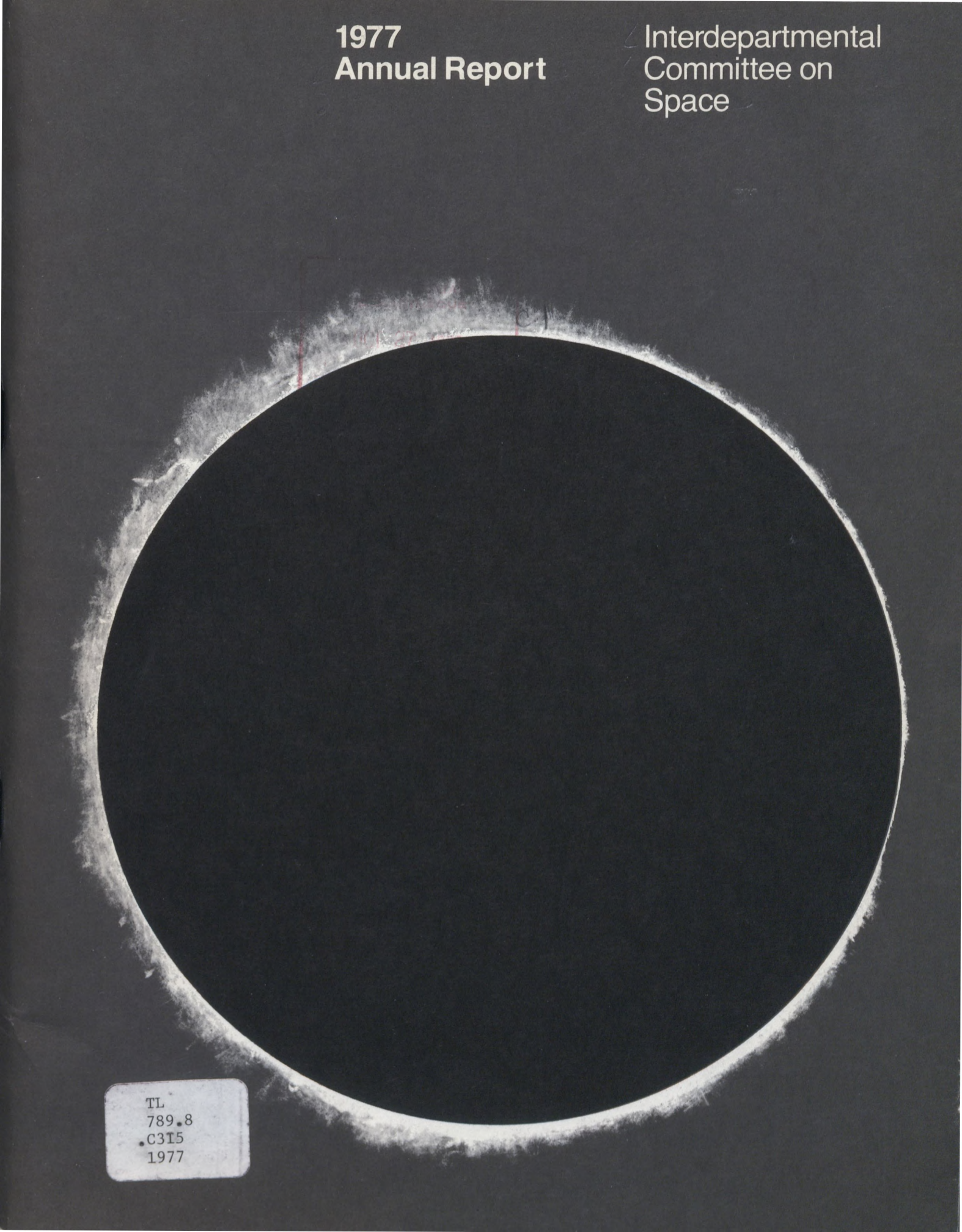
1977 Annual Report

Interdepartmental Committee on Space



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
August, 1978

ICS ANNUAL REPORT - 1977

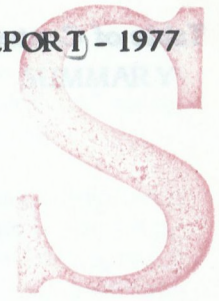


Table of Contents

SUMMARY

During 1977, the Committee met five times and in particular was active in defining the various possibilities offered to Canada in its effort to upgrade its relationship with the European Space Agency. Following the visit of Mme Jeanne Sauvé, to the ESA Council meeting in February 1977, a working group of the ICS was formed to begin the exploratory talks with ESA officials. A number of meetings were held between the working group and ESA executive both in Ottawa and in Paris, which resulted in a draft agreement presented to the ESA Council. Discussions are continuing.

A Vice-Chairman for the ICS was elected this year. Dr. D.I.R. Low, member for the Ministry of State for Science and Technology was chosen by the membership.

Progress of the major projects in the space program during 1977 was as follows: the building and testing of the engineering model of the Remote Manipulator System (RMS), carried out in part during 1977, will continue until the Critical Design Review, scheduled for April 1978. The first flight unit of the RMS is expected to be delivered to NASA, on schedule, in July 1979. The General Purpose Simulation Facility (SIMFAC) began operation in May 1977, and has been successfully utilized since, in both the design of the RMS and in demonstration of its operation to astronauts.

The Hermes experimental program was carried out successfully, despite a few spacecraft subsystem problems that developed during the year. Major experiments were carried out in the field of tele-health, education, government services, community interaction and technology. The results of the experiments and the performance of the spacecraft have been so satisfactory that the program will continue into 1978.

At the very end of the year, the U.S. LANDSAT 1, launched in 1972, was permanently shut down, after nearly six years of successful operation. LANDSAT 2, launched by NASA in 1975 is also being received in Canada and continues to perform satisfactorily. LANDSAT 3, which contains a number of improvements over the first two satellites is scheduled for launch in March 1978. The Canadian ground receiving stations are being modified where necessary to be able to secure data from LANDSAT 3.

Much of the planning for the Canadian experimental program to be carried out with the U.S. SEASAT "A" was accomplished during 1977. This included setting up a full-time project office, letting out contracts for installation of a

synthetic aperture radar (SAR) aboard a CCRS aircraft, the construction of a SAR processor and modification of the Shoe Cove satellite receiving station to receive SEASAT "A" data. SEASAT "A" is scheduled to be launched in June 1978.

Canadian participation in SPACELAB was approved by NASA during 1977. A joint proposal of six experiments was proposed in 1976 to NASA, by the Massachusetts Institute of Technology (MIT) and the Canadian Defence and Civil Institute of Environmental Medicine (DCIEM). Four of the experiments are to be under the scientific direction of DCIEM. NASA indicated that they were prepared to fly some of the experiments on SPACELAB 1 in 1980, with the remaining experiments to be flown on subsequent SPACELAB flights. Although only U.S. and ESA astronauts will fly on SPACELAB 1, the possibility exists for a Canadian payload specialist to fly on subsequent SPACELAB flights.

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 only a feasibility study in the next year and a re-evaluation of the program requirements.

The major development in INMARSAT during the year came from a proposal by a consortium consisting of COMSAT General with certain European interests for a "Joint Venture", which would provide continuity between the end of MARISAT (1981) and the earliest operational INMARSAT system (1985). The proposal is being clarified and evaluated through a series of meetings in late 1977 and early 1978.

Canadian government space expenditures for FY 1977/78 totalled approximately $65 million. Of that amount, approximately 65% was expended in Canadian industry, and 9% in U.S. industry. This spending pattern is an improvement over FY 1976/77, where 56% of the total expenditures had been expended in Canadian industry and 12.5% in U.S. industry. Government expenditures in Canadian universities has declined, both in absolute and relative terms, from $1.5 million (3.2% of total budget) in FY 1976/77, to $1.2 million (1.8% of total budget) in FY 1977/78. Again this year, the Shuttle Remote Manipulator System was the largest item of expenditure, accounting for 51% of all expenditures in Canadian industry, and for 74% of all expenditures in U.S. industry.

OUTLOOK FOR THE FUTURE

It is expected that in 1978 the negotiations between Canada and ESA on upgrading Canada's relationship with the Agency will be concluded. Closely tied to those negotiations is the possibility of Canadian participation in the ESA's H-SAT program.

The feasibility studies on MUSAT will be completed in FY 1978/79, and it is expected that full program approval will be sought.

The Memorandum of Understanding with NASA and Centre National d'Etudes Spatiales on a Search and Rescue Satellite system (SARSAT) is expected to be concluded in FY 1978/79. Similarly, a letter of agreement will formalize NASA's acceptance of DND/DCIEM's proposal for SPACELAB 1.

Finally, a major new scientific program, called POLAIRE, including a satellite and a major ground data communication network is expected to be proposed to the ICS in the coming year. The program is described in this report.

THE ICS IN 1977

Sub-Committee for the Industrial Aspects of Space Policy

The sub-committee met twice during 1977. In both cases the members were briefed by companies with space-related capabilities: SED Systems Ltd., of Saskatoon, Saskatchewan, and Miller Communications Systems Ltd., of Kanata, Ontario, outlined their company capabilities, corporate objectives, and long-term plans.

The sub-committee was represented on the inter-departmental working group responsible for investigating and developing proposals on closer association between Canada and the European Space Agency, and for follow-on negotiations with the Agency. An examination was made of the implications of various levels of closer association, including the resulting business to Canadian industry from ESA, and possible adverse effects on the U.S./Canada relationship.

The sub-committee was also represented on the interdepartmental working group which, under the leadership of the Treasury Board Secretariat, studied the effects of the government's space program on the Canadian space industry, and the implications of the establishment of a viable industrial prime contracting capability in Canada.

Finally, a watching brief was maintained of moves in the U.S.A. toward the reduction of the export of U.S. technology, and the possible impact on the Canadian space sector.

Sub-Committee for the Scientific Aspects of Space Policy

During 1977 the sub-committee held two meetings: the 23rd meeting at the University of Western Ontario in London, on February 24, and the 24th meeting at the National Research Council in Ottawa on October 14. At its 23rd meeting, the sub-committee provided the mechanism which set up an advisory group to advise the Space Science Coordination Office on the relative priorities it should follow and the planning of future space science projects. At the present time, the advisory group comprises of eight members representing government, universities and industries covering all the major areas of space science. This group met for the first time on September 9, 1977 and is expected to meet again in the spring of 1978. The sub-committee also considered and commented on a number of reports presented to it by the SSCO. As a result of its recognition of the scientific satellite project study carried out by the SSCO and its endorsement as a scientifically-significant program for Canada, this proposal (now known as POLAIRE and described further in this report) is under consideration by the Council and management of NRC.

Sub-Committee for the International Aspects of Space Policy

The sub-committee (IASP) held four meetings during 1977, its 29th through 32nd, and participated in one meeting of the Interdepartmental Committee on International Science and Technology Relations (ICISTR).

During 1977 the sub-committee was concerned primarily with Canada's involvement in the U.N. Committee on the Peaceful Uses of Outer Space (UNCPUOS). Instructions were prepared for the 20th Anniversary session of UNCPUOS, for the 14th session of its Scientific and Technical Sub-Committee and the 16th session of its Legal Sub-Committee. As usual, Canada played an active and constructive role in these sessions, particularly in regard to the technical and legal questions relating to remote sensing, the proposed U.N. conference on outer space, and the development of a set of principles to regulate direct television broadcasting by satellite.

In its preparation for these sessions the sub-committee reviewed Canada's position on the dissemination of data and information obtained from remote sensing satellites. As a result of that review it was decided that a small interdepartmental group would study the question further. The group is expected to make its recommendations early in 1978. The Canadian Delegation to the UNCPUOS was successful in obtaining an instruction from the Committee to its S&T sub-committee that the latter, in its general consideration of remote sensing, should give particular emphasis to the question of the coordination on a global basis of remote sensing activities. Considerable progress was made during the year in negotiating a draft set of principles on direct broadcast satellites. Canada continued to urge the adoption of principles which would provide an effective balance between the need to facilitate the orderly development of an important new area of technology and the need to protect the sovereign right of states to regulate their communications systems. Finally, the UNCPUOS also decided that a working party of the S&T sub-committee would be established to examine all the issues related to the question of holding a U.N. outer space conference and it was expected that firm recommendations would be put before the 1978 session of the UNCPUOS.

The IASP sub-committee initiated an examination of the possibility of increasing Canada's cooperation in space with Japan. Some member departments indicated interest in pursuing the question, which was also discussed at an ICISTR

meeting attended by the Science Counsellor in Tokyo. By the end of the year concrete steps were being taken, including the scheduling of both short and extended visits, with a view to providing the basis for building a more substantive relationship. There was also some discussion in the sub-committee concerning the need generally to take a more systematic approach to questions of bilateral cooperation in space. It was felt that the sub-committee should be better equipped to provide both information on foreign space programs and a framework for the coherent development of Canada's international cooperative efforts. In this connection the implementation of specific measures will be discussed in the sub-committee in the near future.

During the year the sub-committee continued to monitor developments regarding the possible upgrading of Canada's status vis-à-vis the European Space Agency. Discussions with ESA executive centred on the terms of a proposed umbrella cooperative agreement and it was expected that Canada's relationship with the agency would continue under review into 1978.

The ICS Secretariat

Perhaps the most time-consuming activity carried out by the secretariat in 1977, has been the various tasks associated with the brochure Canada in Space. From the working draft produced under contract early in the year, numerous modifications and updates were carried out to the English text, leading to an approved English version in early summer. At this time, the text was turned over to the Information Services branch (DIS) of DOC for final editing, layout and printing. DIS also agreed to provide editing services for the French version of the brochure. Due to unforeseen difficulties, a final French version was not obtained before late December, after extensive work by both DIS and ICS secretariat staff. It is now expected that the brochure will be issued at the end of this fiscal year.

The 1976 ICS Annual Report was also produced by the secretariat as well as other internal reports for the ICS.

With the collaboration of the staff from the International branch of DOC, the ICS secretariat prepared the briefing material for Madame Jeanne Sauvé, Minister of Communications on the occasion of her visit to the European Space Agency's Council meeting in February 1977. On that occasion Mme Sauvé expressed Canada's desire to improve its

relationship with the agency. Similarly, a briefing book was prepared by the secretariat for Drs. Chapman and Morley's visit to Japan in May 1977.

Liaison was maintained during the year with the Canadian Embassies in Paris and Washington and established with the Embassy in Tokyo. The ICS secretariat invited Dr. Petreyman of ESA to speak at a meeting of the Associate Committee on Space Research of the NRC in London, Ontario. The secretariat also participated in the initial discussions between Canada, U.S.A., France and the U.S.S.R. concerning possible joint participation in a search and rescue satellite system.

A number of companies were visited in early fall to obtain information on the level of exports achieved by the Canadian space industries. This was part of the secretariat's input to the Treasury Board secretariat study on the effect of the government's space program on the Canadian space industry.

Finally during the year, the position of Assistant Secretary for International and Industrial Affairs was created and staffed.

The Space Science Coordination Office was established in 1976 in the National Research Council to enable it to fulfill its role as the lead agency for space science. It was also agreed with the NRC that the SSCO would carry out the liaison and coordination functions of the ICS secretariat in the area of space science.

With the objective of establishing a long-term plan for space science activity in Canada, the SSCO identifies definite tasks to be performed and assigns them to committees, working groups and task forces which, from time to time, report back on their findings.

Activity in the area of small scientific satellites resulted in a significant proposal (POLAIRE) described elsewhere in this report, which is presently under consideration by the Council and management of NRC. Working groups also prepared reports on plasmas, atmospheric sciences, astronomy and life sciences. Another committee is considering Canadian involvement in the U.S.A. AMPS program with the provision by Canada of a Wave Injection Facility as one of the AMPS building blocks. Working groups have also been active in defining organized campaigns, future use of balloons and the use of guns for launching probes. Recommendations will be made to the SSCO early next year.

Thin lunar section educational kits were obtained from NASA and made available to Canadian universities on short-term loan. The response from the departments of geology of Canadian universities was very encouraging, so much so that all could not be accommodated during the 1977/78 academic year. A request to NASA for the use of a second kit was readily fulfilled and to date, over 20 universities have used the kits for teaching purposes as well as in some cases, public display.

DEPARTMENTAL PROGRAMS AND FACILITIES

NATIONAL RESEARCH COUNCIL

The National Research Council of Canada (NRC) 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, the NRC has its own computation centre, and manages the Canada Institute for Scientific and Technical Information (CISTI). The NRC also administers funds made available for research grants to universities and industry, and for scholarships to post-graduate students.

The space and space-related responsibilities of the NRC can 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 Space Research Facilities Branch manages and operates a permanent rocket launching complex at Churchill, Manitoba, semi-permanent rocket launching sites at Cape Parry and Resolute, N.W.T. and a mobile balloon launching facility currently based at Saskatoon, Sask. In addition, the Herzberg Institute of

Astrophysics is active in planetary sciences, space physics and astronomy; and finally the National Aeronautics Establishment of the NRC, in addition to being the Canadian agency responsible for the Remote Manipulator System is also active in the area of non-cartographic applications of photogrammetry, and dynamic stability of aircraft.

Remote Manipulator System (RMS)

Following consultation with Canadian industry and negotiations with NASA, in July 1975 the National Research Council (NRC) undertook the design, development, flight qualifications and manufacture of the first flight unit of the RMS for the Advanced Space Transportation System (Space Shuttle) and the design and construction of 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 vehicles, and also to retrieve recoverable payloads. As the arm itself cannot be effectively tested in a gravity environment, a simulation facility, SIMFAC, located at SPAR Aerospace Projects Ltd., facilities in Toronto, uses mathematical modeling techniques to test the RMS in two dimensions under simulated zero gravity conditions. The facility will also be used in the development of manipulator systems for non-space applications.

Following the successful completion of the Preliminary Design Review of the RMS in October 1976, the critical design phase has continued through 1977 together with the building and testing of the engineering model. This will continue into 1978 with the Critical Design Review scheduled for April 1978. The first flight unit of the RMS is scheduled for delivery to NASA in July 1979 and is to be flown on a Space Shuttle test flight in September of that year.

The General Purpose Manipulator System Simulation Facility (SIMFAC) was put into operation on schedule, in May 1977 and is providing data on simulated arm operation to support the design and to demonstrate to the astronauts the operation of the arm.

The successful completion of this project should ensure for Canada:

- world pre-eminence in the most advanced teleoperator technology in space, with potential for applications in other environments, and a high visibility for its products.

- an initial contract with the U.S.A. for two complete, two-arm systems. As NASA's initial plans are to build five orbiter spacecrafts, there is potentially a requirement for a further three complete, two-arm systems;

- the improvement of the ability of Canadian industry to design and build space systems as envisaged in the government's space policy.

POLAIRE

Nearly all the energy that sustains life on this planet comes from the sun in the form of electromagnetic radiation or light waves. A second source of solar energy is the fluctuating flux of charged particles which stream out from the sun, called the solar wind. Until quite recently it was thought that because the energy input from the solar wind is very much less than that from sunlight, its effects could be ignored. It is now recognized, however, that changes in the solar wind somehow trigger changes in weather. In fact, it even appears that this small quantity of energy exerts some subtle control on the effects produced by the very much larger energy input of sunlight. This is one of the major puzzles now facing space science and various NASA and ESA satellites will investigate the energy transfer processes in the outer regions of the magnetosphere.

Almost all of the particle energy deposition into the atmosphere occurs at high latitudes in the region of the auroral zone known as the polar cap. As a result of ISIS-II studies it is known that there is a "hole" in the protecting field into which solar particles can pour in and thereby reach the earth's atmosphere. This is known as the magnetospheric cleft. Because of its privileged location, Canada is the only country in the world from which observation of this cleft can be carried out both from ground based and satellite-borne instruments.

The objective of the POLAIRE mission is to study the energy transfer phenomena associated with this process. The satellite is designed to monitor the flow of energy in all its forms past the satellite orbit altitude and to trace the degradation of that energy by remote sensing from the satellite and from the ground.

In order to carry out this process, the satellite itself will carry approximately 14 instruments which will carry out more than 55 experiments identified in the preliminary.

In addition to the spacecraft the program incorporates a number of semi-permanent ground stations, telemetry read-out stations and a command station.

Preliminary costing of this program, including the ground-based observations, the supporting rocket program, and the analysis and interpretation of the results, is indicated to be approximately $78 million in 1977 dollars over the 10-year period.

The mission is deemed to be of great scientific value. Evidence of this is to be found in the interest of a number of international groups from Sweden, Denmark, France, and Japan, who have offered to participate in the project and in the fact that NASA has offered to discuss various means of cooperation between this mission and contemporary NASA satellite missions.

A scientific satellite provides an ideal opportunity to introduce new technology to industry. Two new developments are on the horizon. These are the advent of the microprocessor and the introduction by NASA of the Space Transportation System. In addition, the instruments, particularly the optical ones, are close to present state of the art and should eventually find applications in such fields as remote sensing. It is important that Canadian industry be among the first to acquire this new technology if it is to remain competitive. It is an objective of this program to successfully transfer this new technology which now resides principally in the research laboratories to Canadian industry. There are also opportunities for industrial innovation in the ground-based segment and data platform development in data communications and in a central data processing facility.

Space Research Facilities Branch (SRFB)

The 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. The rocket and balloon programs which are implemented by SRFB

are approved by the Canadian Sounding Rocket Planning Group (CSRPG). The CSRPG approves a program based on a recommendation from its scientific evaluation panel which rates the scientific value of proposals from Canadian scientists. With the collaboration and assistance of specialists from industry, SRFB will arrange 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 format. In addition, the branch will provide engineering support for the balloon program including the evaluation and initial procurement of electronic equipments.

Rocket and balloon launches are conducted from the Churchill Research Range, a permanent rocket-launching complex located at Churchill, Manitoba, from semi-permanent rocket-launching sites at Cape Parry and Resolute, N.W.T. and from a mobile balloon-launching facility currently based at Saskatoon, Saskatchewan. Until now, balloon operations were conducted on an expeditionary basis at locations such as Cold Lake, Alberta; Yorkton, Saskatchewan and Churchill, Manitoba.

Finally, through government-to-government agreements and memoranda of understanding, SRFB makes its space science support facilities available to foreign scientists on a non-interference cost-recovery basis.

During 1977, ten Canadian and eight U.S. sounding rocket launches were conducted. A total of nine scientific balloons were flown, four in support of Canadian scientists and five in support of U.S. scientists. Two of the ten sounding rockets were launched from Cape Parry, N.W.T, in December 1977 as part of Canada's contribution to the international magnetospheric studies program and continuing Canadian study of the magnetospheric cleft. These two launches marked the first use of the Nike-Black Brant VB rocket system from an expeditionary launch site. The rest of the rocket launches were from the Churchill Research Range. Four scientific balloons were flown from Churchill, one from Cold Lake, Alberta and four from Yorkton, Saskatchewan. NASA sponsored all the U.S. sounding rockets and two of the U.S. balloons. The balance of the U.S. balloon program was sponsored by the National Science Foundation. The Great Whale Geophysical Station, a ground-based instrument facility which was operated by SRFB, was phased out during 1977. The Earth Physics branch of Energy, Mines and Resources continued to operate a magnetometer at the site.

Proposals for rocket and balloon flights into the path of the total solar eclipse of February 26, 1979 are under study. A joint Canada/US rocket program with up to 15 launches, is envisaged at this time. Two potential launch sites, Red Lake and Pink Lake, Ontario have been surveyed and found generally suitable. The balloon flights, which will probably be from a launch site in the Prairie provinces, will mark one of the first attempts ever to intercept a relatively short time geophysical event with a balloon-borne platform.

Large High-Speed Wind Tunnel

This facility of the National Aeronautical Establishment (NAE) division of the National Research Council of Canada is located at Ottawa, Ontario.

The tunnel which became operational in 1963, is of the blowdown type with a 1.5 metre 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 38 cm x 152 cm 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 other foreign agencies.

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 1977, the Institute was active in auroral spectra and photometry, studies of diffused radio aurora and

the sunlit auroral oval, rocket measurements of auroral plasma, the operation of 35 mm all-sky camera, inter-comparison of the physical features and 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.

DEPARTMENT OF COMMUNICATIONS (DOC)

Hermes

The HERMES satellite is the result of 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 in geostationary orbit, 36,000 km above the Equator at 116° West longitude and has been successfully operating since that time.

Since its launch, a number of spacecraft subsystems problems were experienced, but none were serious enough to prevent the planned program of experiments from being carried out. The performance of the spacecraft has been so satisfactory that a third year of operation is being planned over and above the originally planned two-year lifetime of the spacecraft.

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 1977, in the field of tele-health, the University Hospital of the University of Western Ontario provided

medical assistance in anesthesia, x-ray and other image analysis and clinical consultation to the Moose Factory Hospital at James Bay. The Faculty of Medical and Educational Television Centre of Memorial University at St. John's Newfoundland provided continuing medical education to four remote hospitals in Newfoundland and Labrador.

In the field of education, l'Université du Québec in cooperation with le Ministère des Communications du Québec provided numerous televised short courses to university campuses throughout Québec in order to test the usefulness of multidirectional communications for the development of the educational network. The University of Carleton (Ottawa) and Stanford University (California) exchanged graduate courses during the fall and winter terms of 1976/77 by means of a two-way digital video compression system. The Public Service Commission conducted teacherless management training courses between Ottawa and St. John's Newfoundland using fully interactive two-way video-communications. The Ministry of Education of British Columbia with the participation of a consortium of educational institutes conducted an interactive audio and video experiment between Vancouver and Chilliwack, Kelowna, Dawson Creek, Campbell River and Pitt Lake to evaluate the concept and possibilities of tele-education.

In the field of government services, the Government of Ontario conducted a series of satellite communication tests including voice, data and TV between Toronto, Thunder Bay, Sioux Lookout, Red Lake and Big Trout Lake to assess the immediate and long term impact of this technique for the provision of services in emergencies, forest fire detection and control, police, medical and general administration. The Government of Manitoba in an experiment linking satellite terminals in Thompson and Brandon to a government computer centre in Winnipeg demonstrated data retrieval and filing systems in an attempt to evaluate decentralization of its operations.

In the field of community interaction, the Alberta Native Communication Society conducted interactive audio and video experiments linking Edmonton to northern native communities at Fort MacKay, Pearless Lake, and Chipewyan, Assumption, Wabasca-Demarais and Grouard. During the experiments, programs were transmitted in education, legal services, health care and community development and interaction. The purpose of the experiment was to evaluate the usefulness of this technique in serving the needs and concerns

of the northern communities. Le Ministère des Communications du Québec also conducted interactive voice and video experiments between communities (e.g. St. Raymond and Buckingham and Les Îles de la Madeleine and Montréal).

In the field of technology, the Communications Research Centre carried out experiments on Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA), high rate Data transmission, propagation measurements and small terminal evaluation. L'Hydro-Québec, Montréal, conducted technology experiments in channel characterization and in clock synchronization. The University of Toronto, in cooperation with the Green Bank Observatory, West Virginia, and the Owen's Valley Observatory in California, continued the experiment in radio interferometry to provide high resolution measurements of cosmic sources. Technical experiments were also carried out by the University of Waterloo in signal processing techniques, by the McMaster University in modulation and demodulation for high rate data transmission, and by the CBC in broadcasting and reception in an urban environment.

HERMES symposium - In November 1977, the Royal Society of Canada (RSC), in cooperation with DOC and NASA, held a symposium on the HERMES experiments performed during the previous two years by both Canadian and American experimenters. The proceedings of the symposium will be published by the RSC in early 1978.

Third-year operations - NASA and Canadian experimenters have requested an extension of the original two-year mission through 1978, for the purpose of continuing and extending the current program of experiments. In preparation for a third-year of operations, north/south station-keeping manoeuvres were carried out in December 1977 to reduce orbit inclination.

In Canada, the independent evaluation committee met again in December to review proposals for third-year experiments. Fourteen proposals were considered of which four were approved. The remainder will be reviewed at a meeting in February, 1978.

ANIK-B

Shortly after the beginning of the HERMES experimental program, a follow-on program was foreseen to further develop the more promising of the communications services identified with HERMES. To this end, DOC signed in 1977, a

two-year lease, to start in 1979, to use the 14/12 GHz portion of Telesat's ANIK-B satellite, due to be launched in November 1978. In addition to its 6/4 GHz payload intended to backup the ANIK-A system, the satellite will carry a 14/12 GHz payload including four regional beams. The payload is being built in large part by Canadian industry using technology developed in the HERMES program.

The communications program in the 14/12 GHz band, will continue the exploration and development of new communications services by satellite. It is planned that the program will include several carefully-selected pilot projects to test the provision and use of new services by communications satellites under normal operating conditions. It is further planned that the projects continue for an extended period, probably one to two years, 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. As presently planned, projects will be carried out under the general headings of telehealth, television program production and delivery, teleeducation, postal system applications, public telecommunications applications, communications in remote areas and advanced technology experiments. Projects in these areas are being developed cooperatively by appropriate federal and provincial agencies, and carriers. In addition to pilot projects, a number of more exploratory social and technological experiments are planned.

Experimental Use of SYMPHONIE Satellite

During 1977, 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 included dialogues between professional groups in the fields of administration, health, education, human and physical sciences, and cultural exchanges between small communities in France and Québec. 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.

NCAP (Northern Communications Assistance Program)

The Northern Communications Assistance Program (NCAP) is administered by the Department of Communications

and consists of a program of contributions to cover the capital costs of the communications facilities required to bring reliable long distance telephone service to all communities in the Northwest Territories. The common carriers will invest similar amounts in capital and operating funds for local exchange equipment and operating costs of telephone circuits between communities.

The long-distance telephone links to be funded through NCAP will be provided either by satellite ground stations or terrestrial circuits, whichever is the more economic means of serving a given community. The aim is to provide a level of service equivalent to that available within southern Canada.

The satellite ground stations installed to provide telephone service under the NCAP program will be designed to accommodate the future addition of CBC radio and television circuits at minimal cost.

Teleglobe

Teleglobe Canada owns and operates three commercial communications satellite earth stations: two at Mill Village in Nova Scotia and one on Vancouver Island at Lake Cowichan. These provide communications services with overseas terminals via the INTELSAT IV satellites.

The forecast of increasing traffic via satellite, and the subsequent INTELSAT plan to operate with a three satellite configuration over the Atlantic Ocean, formed the basis for Teleglobe's decision to construct a new 6/4 GHz earth station, to be known as the Laurentides earth station, in the Laurentian area north of Montréal. The new station will differ from existing Teleglobe earth stations in that it will use a beam waveguide antenna with a dual polarization frequency re-use capability with all communications equipment located at ground level. The Laurentides station will become operational in mid-1979.

During 1977, 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 1978-79. 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 currently conducting continuing 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. The measurements, which are being carried out under an INTELSAT contract, may be extended for another year. The new set of measurements will employ COMSAT test equipment in addition to existing facilities. This study will allow Teleglobe to evaluate the effect of rain depolarization on the quality of future transmissions employing a frequency re-use technique.

During 1977, Teleglobe continued preparations for an international digital communications conference, which will be held in Montréal from October 23 to 25, 1978. The conference will address all aspects of digital communication via satellite for the provision of international, domestic and specialized services, and their relationship to terrestrial systems, including new developments in digital technology and techniques for voice, image and data processing. Previous conferences were held in London (1969), Paris (1972) and Kyoto (1975).

Multipurpose UHF Satellite (MUSAT)

Studies on a multipurpose Ultra-High Frequency (UHF) satellite communications system have determined that such a system would be cost-effective in meeting government requirements for reliable communications to land, air and sea-based mobile and transportable terminals. Further studies are being carried out to establish the technical feasibility of the satellite and ground terminal designs prior to completion of the program definition.

Work continued during the past year on the technical feasibility of the transponder and antenna system which would be required for MUSAT. The fabrication of a "brassboard" transponder model which was initiated in 1976 was completed successfully in 1977 and detailed performance testing and evaluation have begun.

The proposed MUSAT communications system would require easily portable earth terminals suitable for use in remote locations. Initial cost and implementation studies have identified the difficulty of achieving an adequately portable antenna, as well as a potential scheduling problem due to the long development times associated with some components. As a consequence, an advanced development phase was initiated. A concept study of possible portable antenna configurations was completed and development of a prototype antenna is planned. Contracting action was initiated for the development of a laboratory prototype of an integrated voice channel unit suitable for portable and mobile earth terminals.

Systems studies carried out during the past year include the development of system models, an examination of the feasibility of an L-band transponder for the maritime mobile satellite service in the Canadian arctic, and studies to support the coordination of a frequency plan.

ESA H-SAT

Canada has been exploring with the European Space Agency (ESA) the possibilities for increasing cooperation between Canada and Europe on space programs.

A program of particular interest to Canada is the proposed Heavy Communications Platform (H-SAT).

During 1977, a detailed proposal was developed, whereby Canadian industry would build a complete transponder and antennas to be carried on the satellite. At end-1977, the proposal, and the conditions for a Canadian/ESA agreement, were still under discussion.

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.

Through CRC, the Department of Communications provides expertise to support space applications programs sponsored by other departments and agencies. Applications programs have been identified in aeronautical and marine navigation, search and rescue, remote sensing, surveillance, weather forecasting and Space Shuttle remote manipulator development.

Space Electronics - During 1977, several separate studies were undertaken into new circuit elements for space communications systems in the SHF band (3-30 GHz). A major effort was devoted toward in-house development of a 12 GHz uncooled parametric amplifier and microwave integrated circuit (MIC) form. Concurrently, DOC funded the industrial development of a prototype amplifier at ComDev Ltd. Speculative, theoretical and experimental studies in the area of (MIC) are carried out at a modest level as an encouragement to industrial applications. One such study in an area of considerable future potential, has focused on optimum RF configurations and likely manufacturing costs of a 6 GHz data retransmission platform, for use in relaying data from a remote measuring station to some central processing location, via satellite.

Speculative, in-house development studies have enabled technical assistance to be provided to several Canadian companies concerned with state-of-the-art electronics which utilizes the latest gallium arsenide (GaAs) FET devices and varactor diodes. One such CRC development has already been exploited by Canadian industry and is the basis of a COMSAT contract.

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 geostationary orbit.

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 the past year, a simulation experiment chamber was assembled and experiments started on characterization of spacecraft dielectric materials. The facility will provide measurements of the RF energy and frequency spectrum associated with discharges on dielectric materials and will permit experimental test and materials modification. 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 HRL develops and applies techniques for reliability assessment of electronics subsystems, components, devices and materials for space communications systems. A state-of-the-art laboratory is maintained with equipment such as scanning electron microscope (SEMS), x-ray and Auger microprobes, and it is used by both government and industry.

The Laboratory has done a great deal of pioneer work in the reliability of GaAs FETs for space use; such devices are frequently used in satellite and ground sub-systems such as SHF amplifiers and oscillators. Devices and components for the Shuttle Remote Manipulator System are also being assessed for the prime contractor, SPAR.

The HRL is presently studying the best method of performing reliability analysis on large scale integrated (LSI) circuits, such as microprocessors, to ensure Canadian expertise and capability in this field.

The Space Electronics directorate of CRC has also been active during the year in assessing the technical feasibility of the transponder and antenna system for the MUSAT satellite. Construction and testing of a "brassboard" model of the transponder was completed in September 1977 following the conclusion of a system's engineering study which defined transponder and antenna requirements. Also, an advanced development phase involving contract studies of possible antenna configuration and their portability, ease of erection and implementation is under way. Numerous short studies on topics such as frequency control, sensor data readout, propagation consideration and possible modulation techniques have also been performed.

A project was established to develop and demonstrate the feasibility of low-cost terminals capable of direct television reception from 12 GHz satellites such as HERMES.

During the past year, largely as a result of contracts from DOC, SED Systems Ltd. of Saskatoon, Saskatchewan has developed low-noise amplifiers at 40 GHz and a complete line of SHF components. As a follow-on to the CRC development of a demonstration TV reception terminal employing a 1.2 metre antenna, the company also developed a 12 GHz receiver using a field-effect transistor front-end for use in Telesat's ANIK B and C ground terminals. Finally, Electrohome Ltd. is currently developing, under contract, a prototype low-frequency terminal electronics, as a basis for high-volume industrial production.

Finally, a project was constituted to study current and future requirements in the area of digital satellite communications, with particular emphasis on semi-conductor technologies and advanced components for digital sub-systems.

Space Mechanics - In keeping with its lead responsibilities for Canadian space technology development, during the past year, the Space Mechanics directorate of CRC has carried out a major effort in development and testing of a weight and cost-effective high-power solar array system of between two and ten kilowatts, designed to meet power requirements for future satellites. A fabrication and test program to qualify the new components and concepts is presently being planned for next year. At the conclusion of this development program, critical hardware of the essential power subsystem for all Canadian satellites could be procured from Canadian sources.

CRC has also been active in satellite antenna control and pointing with the objective of establishing effective aerospace control capability in Canadian industry through the exploitation of our knowledge of the flight performance of the HERMES system and of new technology development and control system components. During the past year the effort centered in developing a system simulation facility at CRC with the set-up of a hybrid computer facility embodying a large AD-5 analogue computer and a PDP11-45 digital computer. An integrated attitude-sensing and control system development was initiated in industry to satisfy the high-pointing accuracy requirements of multiple spot beam communications and surveillance satellites. It is planned to carry out a detailed design of a baseline system and to verify its performance on the CRC hybrid computer simulation facility.

CRC has also been active in orbit and attitude determination techniques. This particular project is aimed at developing capabilities that determine and predict spacecraft orbits, position, and attitude in space. Effort is presently

being directed at two main areas: an orbit perturbation measurement experiment using time division multiple access data from the HERMES satellite for determining position in orbit has been undertaken; and software, general enough to satisfy future Canadian requirements in orbit determination and prediction has been developed and will be validated using HERMES and ISIS tracking data.

Two technology experiments carried out with industrial support were completed in the past year with respect to the three-axis attitude control and stabilization system and with the testing of the HERMES deployable solar arrays. The results of the various tests have confirmed the predictions based on modelling techniques that had been developed for that purpose. The technology is now flight proven and capable of extension to larger structures of different design for future space systems.

During the transition period from expendable launch vehicles to re-usable launch vehicles such as the NASA Space Shuttle, it is necessary to consider a satellite bus capable of being launched by both types of vehicles. A study of the feasibility of a satellite bus that could satisfy potential Canadian geostationary missions of the next decade and adaptable to both types of launch vehicles was carried out by means of an industrial contract. The study established a technical feasibility of a general purpose bus. It also provided information on the technical implications of both types of launch vehicles on the current state of related space technology and associated cost and schedule estimates to implement the project. In view of the extended information base the study provides, it will enhance Canada's ability to plan and implement future space projects.

Space Systems - Three experiments were carried out using the facilities of HERMES and associated ground stations. The Time Division Multiple Access (TDMA) system, using Centralized Synchronization and Ranging (CENSAR) was specified and built. It is a new concept where precise ranging information about the satellite is obtained at the central station in cooperation with only three other stations. Any other station is able to synchronize accurately with the other four. CENSAR is suitable for use with satellites having spot-antenna beams.

A Demand Assignment Multiple Access (DAMA) experiment tested a system for satellite communication operating in a single channel per carrier frequency division

multiple access mode. Five remote controllers using microprocessors were supplemented by extensive software to provide fully demand assigned access of two-way voice, broadcast and conference calls. Pre-emption of on-going calls by higher priority calls and automatic data log of call parameters was also featured.

Finally, a high-speed data experiment was designed to test broadband capabilities of HERMES channel for digital signals. A 62.5 Mbit/s modem was designed and constructed at CRC.

Assistance was provided to the Department of Transport, in the implementation of the ground segment of the Aerosat system and in system definition and evaluation. CRC provided technical support in the procurement of the aeronautical services earth terminal. System activities were carried out involving studies of methods of access control and ranging, determination of requirements for electronic test sets and a smaller simulator, and participation in international working groups charged with system design and definition. Other work included evaluation of proposed spacecraft specifications, contractors proposed design techniques for forward error correcting coding and data modulation, and possible methods for rapid acquisition of signals when operating in a polled mode.

The Space Systems directorate also carried out studies to support applied research and development related to communications processing techniques for small terminal satellite communications systems. The techniques studied are applicable to a variety of systems including ANIK, AEROSAT and military tactical satellites. In addition, non-satellite applications, such as mobile communications, are served by developments in this project.

Conventional satellite communications systems require use of large earth terminals involving high gain steerable antennas. For mobile communications, such as aircraft, ships and transportable stations, it is impractical to use such antennas. Different communications techniques must be employed. The project, investigating techniques such as using lower frequencies and modulation techniques capable of operating at lower signal to noise ratios, is aimed at providing a basis of the design of more operationally-oriented programs such as AEROSAT, INMARSAT and MUSAT.

The project was carried out in collaboration with the Department of Transport and the Department of National

Defence which provided aircraft as flying laboratories to help conduct a series of experiments.

David Florida Laboratory

The DFL is maintained by DOC as a national facility for the environmental testing and integration of satellites and space hardware.

The facilities include four thermal vacuum chambers: 3 m dia. x 9 m high; 2.5 m dia. x 2.5 m long; 1.2 m dia. x 2.5 m long; and 1 m. dia. x 1 m long. The vacuum capabilities vary, depending on the chambers and test article outgassing, with a capability of at least 10^{-7} torr in all chambers. Temperatures can be controlled over the range - 195° C to + 150° C in all chambers. An automated temperature scanning and archival system can monitor up to 160 channels of data. All temperature data is available in digital format for future data reduction after completion of testing.

The vibration facilities include a 53.8 KN sinusoidal, a 44.8 KN random and a 27 KN sinusoidal/random system operating over the range of frequencies 2 Hz to 2,000 Hz. Both systems have the capability of monitoring up to 54 accelerometer channels simultaneously. A real-time analyzer is available for data analysis.

A screened room and related equipment are also available for RFI/EMC testing to MIL.STD. 461/462. The RF facilities also include two shielded anechoic chambers; one 4 m x 4 m x 2 m with an average reflection coefficient of -35 dB at X-band frequencies, and another 7 m x 7 m x 7 m with an average reflection coefficient of -50 dB over the frequency range of 1 GHz to 20 GHz. The latter facility is integrated into a 150 m antenna range including a 675 kg antenna positioner and appropriate remote controls necessary to achieve efficient economic operation.

A high bay clean-room integration area, 30 m x 12 m x 10 m high, is utilized for assembly and integration of satellites and space hardware. This facility has a 5 metric ton overhead crane, appropriate air-cleaning equipment, necessary ground support facilities, and an interconnecting 2 1/4 metric tons crane system, facilitating the movement of satellites throughout the environmental and integration areas.

During fiscal year 1977/78, the environmental testing laboratory was used primarily and almost exclusively in

support of the Space Shuttle Remote Manipulator System. Precise scheduling of activities however permitted other testing to be performed, for the ANIK-B transponder system and on the research prototype rigid panel solar arrays. Finally, the RF facilities of the DFL were used heavily during this fiscal year in support of projects for the Departments of Communications, Transport and National Defence.

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 of 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.

A portable satellite ground station for receiving and processing LANDSAT and NOAA satellites data, designed and constructed by McDonald, Dettwiler and Associates of Vancouver, B.C., began operations in Shoe Cove, Newfoundland early in 1977. Since then, it has been routinely receiving LANDSAT and NOAA satellites data and producing quick-look images in computer tapes. The Prince Albert, Saskatchewan station continued its normal operations, receiving and processing data from the same satellites. A new facility for the

production of high-quality imagery using laser beam recorders was completed at Prince Albert during the year and will become operational in 1978. ISIS Limited, of Prince Albert, continued to process and distribute the imagery.

On January 6, 1978, NASA shut down LANDSAT 1 permanently, because of orbit degradation and failure of major systems. Originally launched in 1972, the satellite produced useful data for nearly six years, a period considerably longer than the design life expectency. LANDSAT 2, launched in January 1975, continues to perform satisfactorily.

The third LANDSAT satellite will be launched in March 1978. It differs from the first two satellites in several ways: a fifth band has been added to the multi-spectral scanner (MSS); two return-beam video cameras operating side by side, producing black and white 40 m images which have twice the resolution of the Multi Spectral Scanner (40 m versus 80 m); and finally a number of improvements have been made to the on-board telemetry control and data recording systems and to the configuration of the spacecraft itself.

Canada Centre for Remote Sensing (CCRS)

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, made up of representatives of the concerned federal government departments, the centre serves federal and provincial agencies, universities, industry and the general public. It coordinates the national effort in conjunction with the thirteen working groups of the Canadian Advisory Committee on Remote Sensing representing the disciplines which support or use remote sensing techniques.

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

Data Processing Division - Recording and processing of data from the LANDSAT and NOAA series of satellites continued throughout the year. On the airborne side, an operational capability for recording and processing of infrared-sensed data was completed and development work took place on other sensors. Of particular interest was the commissioning of a continuous strip-film recorder. This low-cost unit was developed in-house and enables a user to have a reasonable quality color image strip of his data within a short turnaround time. It has been used on a regular basis for airborne infrared NOAA and LANDSAT data.

Applications Division - The Applications Division provides the centre's main contact with the user community. During its early phases, the major efforts of the division were expanded in support of the satellite program in order to instruct the Canadian remote sensing user community on the application of satellite-acquired data. In the past year, significant advances have been made in the development of automated analysis techniques for satellite data.

Technical Information Services - As part of its function as a national centre for remote sensing, CCRS operates a library which maintains an up-to-date collection of literature and imagery, remote sensing and related topics, distributes the reports of the centre and operates an information exchange with remote sensing centres in Canada and abroad. Documentation on remote sensing is made available through a machine readable catalogue called RESORS (remote sensing on-line retrieval system). By entering a search strategy based upon a controlled keyword vocabulary, one is supplied with an immediate listing of bibliographic references ranked by degree of correlation to the keywords used. The image library maintains large files of LANDSAT imagery in various formats as well as selected imagery from NOAA and SKYLAB to assist users in selection and ordering of products. Special efforts are made to provide remote sensing centres with up-to-date information and image catalogues.

SEASAT "A"/SURSAT

Following the recommendation to the government in December 1976 that Canada move towards the utilization of all weather radar satellite systems to assist in meeting her surveillance requirements in the period 1980 to 2000, a program named SURSAT, involving participation in the U.S. SEASAT-A experiment was approved. The program, coordinated by CCRS is a joint one and involves eight departments of

the Government of Canada, provincial government agencies and several universities and industrial participants. During 1977, a formal organization to carry out the work was set up, including the establishment of a senior review board, a program office and a project office staffed on a full-time basis by personnel seconded from participating departments. Much of the planning and other preliminary work which needed to be done before the experimental part of the program could start was accomplished during 1977. This included letting of contracts for installation of an airborne SAR on a CCRS aircraft, arranging for the collection of ground truth data, designing and constructing a processor for satellite SAR data and modifying the Shoe Cove satellite station in Newfoundland to enable reception of SEASAT-A data. In addition, several contracts for the supply and, in some cases, the design of a number of major pieces of equipment for receiving, recording and the optical processing of satellite data were let. The SEASAT-A satellite is scheduled for launch in June 1978. Data reception and processing of the airborne experimental work will start in the fall of 1978.

More than 100 investigators have submitted experiments utilizing satellite and airborne data in conjunction with ground truth data to test the validity of the satellite data. These experiments include such things as sea-in ridger, waves, surface winds, sea surface temperatures, various sizes of ships etc.

DEPARTMENT OF NATIONAL DEFENCE (DND)

Spacelab

In 1976 a proposal for experiments in vestibular physiology to be performed on board SPACELAB I was presented to NASA by the Massachussetts Institute of Technology (MIT), as a joint proposal from MIT and the Canadian Defence and Civil Institute of Environmental Medicine (DCIEM), Toronto. Six experiments were proposed, two to be under the scientific direction of MIT and four under the scientific direction of DCIEM. Consultants in physiology from McGill University in Montréal would also be involved. In 1977, after various screening processes had taken place, NASA indicated it was prepared to undertake some of the proposed experiments on SPACELAB I which is expected to be flown in 1980. The negotiations are continuing.

Canadian defence and aeronautical interests in the proposed experiments stem in part from the fact that 25% of all aircraft accidents involving fatalities are caused, at least partially, by disorientation. The mechanisms causing disorientation in pilots are understood to some extent, and it is known that the vestibular system of the inner ear and brain stem is involved as a prime mover. In the SPACELAB experiments, DCIEM will expand its investigation of the basic mechanism of the vestibular systems, with resulting benefits to flight safety, and the understanding of some aspects of human performance.

ESA will also be involved with one of DCIEM's SPACELAB experiments by supplying a "space sled", used in physiological experiments.

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 communication already have provided important aids for these responsibilities, in particular, the relatively inexpensive Emergency Locator Transmitters (ELTs) which are now in widespread 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.

During 1977, informal discussions were held between the U.S. (NASA) and Canada (DOC and DND) and France (CNES), with the aim of setting up a joint experimental program for the demonstration of satellite-aided search and rescue. The discussions were based on the use of NOAA meteorological satellites, with Canada to develop and supply the repeater portion of the experimental SARSAT instruments and the Canadian ground stations. The U.S.A., Canada and France will participate in the demonstration and evaluation phase. Full details of the joint program await conclusion of a Memorandum of Understanding between NASA, DOC and CNES. Multi-lateral talks were initiated with the U.S.S.R. to ensure operational compatibility between the SARSAT system and a similar Soviet system.

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 February 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 1984.

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 Organizational (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 January 1979 to July 1979.

A Memorandum of Understanding with the U.S. DOD has been drafted 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.

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 Department of Transport is monitoring this 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.

SPADATS (Space Detection and Tracking)

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 Nunn 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 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 (or lack of in the case of a stable object) is measured

by a sensitive photometer placed at the focus of a telescope. At present the SOI is operating in an off-line analogue mode. Digital operation, on line to NORAD Headquarters, is planned to be available later in 1978.

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 1 1/4 ton truck), and of modular design for ease of future modifications.

DEPARTMENT OF FISHERIES AND ENVIRONMENT (DFE)

Remote Sensing and Data Collection Program

The major portion of this program continued to be development and demonstration of applications of LANDSAT imagery. Work was carried out in the area of biophysical and ecological land classification; in the development of methods to monitor land use and integrate the data with other geographic information systems; in the production of digitally-enhanced images for assistance in forest fire prevention and fighting; and in inventoring forest resources in the Yukon Territory. Pilot studies were carried out in monitoring of forest resources with particular emphasis on design and sampling strategies. Research was also carried out into interpretation methods for defining snow lines from satellite images.

Remotely-sensed data from satellites has become an accepted and fundamental part of Arctic operations and research, where it is being used to map regional ice distributions and movements, and to monitor the conditions in wild fowl nesting habitats for purposes of production estimation. Position location and data retransmission using satellites is now also a standard technique in arctic and oceanographic research. Several sites are operating in the Arctic and testing for a Global Atmospheric Research Program (GARP) experiment in the southern oceans was completed in 1977. The facility for receiving and distributing data from the LANDSAT

data collection system was installed in Prince Albert to serve the approximately 30 platforms operated in Canada, mostly for transmission of water-level data.

Long-range planning envisages the increased use of DFE facilities for the provision of a broader range of environmental information to the public and to major economic sectors such as agriculture, forestry, industry and transportation. Remotely-sensed data from satellites will be an increasingly important component of total observing systems and will logically lead to modifications of existing conventional networks.

As part of the Global Atmospheric Research Program, Canada will be contributing 80 oceanographic buoys which will be tracked in the southern oceans with the help of satellites. In Canada, the network of data collection platforms using the GOES satellite will be expanded and facilities installed for receiving the retransmitted data directly in Canada. There will be experiments using the ARGOS system for data retransmission to be launched with the TIROS-N Satellite in 1978.

Scientists from DFE will participate with experiment teams associated with the NIMBUS-G satellite in comparing ocean colour measurements made with a 256-channel spectrometer against the Coastal Zone Colour Scanner, in testing the Solar and Backscattered Ultraviolet and Total Ozone Mapping System, and in studying the use of the Scanning Multichannel Microwave Radiometer for measurements of ice and snow cover.

Development of LANDSAT applications will continue in the future with stress particularly on data suitable for the National Forestry Statistics Program, on a digital data base on a UTM grid suitable for forest fire operations, on coastal zone and other land use and bio-physical classification studies, and on hydrologic applications including snow mapping.

During 1978 the data processing equipment to process directly acquired VISSR data from an already installed 10 metre dish antenna system directed at GOES-EAST will be completed at the Satellite Data Laboratory in Downsview. This facility will provide some six sectors of VISSR data at various resolution and scales to eastern Canadian weather offices. Real time distribution of sectors will be by dedicated land line circuits. The system will provide repetitive coverage of the specific areas of interest in infrared and visual modes at half hour intervals day and night to permit tracking and monitoring of storm system development. Data will also be

available for research and for developments related to techniques in applying sequential coverage methods to forecast problems (i.e., CRT sequential display, motion picture or video tape loops, visual motion perception techniques).

Meteorological Satellite Program

The Atmospheric Environment Service (AES) of DFE operates 4 meteorological satellite ground receiving stations across Canada to provide real-time data in support of its weather forecast and ice prediction services and to conduct research related to the application of meteorological satellite data to meet departmental responsibilities.

The Satellite Data Laboratory at AES Headquarters in Downsview and the Arctic Weather Centre in Edmonton are both equipped to receive and process Very High Resolution Radiometer (VHRR) data from the current NOAA series of operational weather satellites in polar orbits. The data received at the Downsview station are digitally processed, enhanced, and transmitted to some 15 major weather offices across the country via a national photographic facsimile circuit. Additionally, processed data at full resolution and suitably enhanced is transmitted to the Ice Central Forecast Office in Ottawa via a dial-up data telephone circuit. Each of the receiving offices is equipped with a photographic facsimile receiver to reproduce the transmitted images in high quality photographic formats. The capability for digital processing and enhancement allows the transmitted imagery to be specially tailored to meet the requirements of the user office.

In addition to the VHRR readout facilities mentioned above, the AES operates Automatic Picture Transmission (APT) and GOES-WEFAX reception facilities. The WEFAX provides pre-processed imagery retransmitted by the GOES geostationary satellites from both polar orbiting and geostationary meteorological satellites for various areas of interest to Canadian forecasters. Both the Vancouver and Halifax stations re-transmit in facsimile compatible format selected data to neighbouring weather offices and to the Canadian Meteorological Centre at Montreal.

The Satellite Data Laboratory (SDL) at AES Headquarters in Downsview is the major ground receiving station for the AES meteorological satellite program and is concerned with both research and operational responsibilities. The SDL is equipped for VHF APT type reception; "S" Band High Resolution Picture Transmission (HRPT) reception of data directly

from the VHRR on the NOAA series of meteorological satellites; digitization and computer processing of VHRR directly acquired data to geographically correct these data and to annotate the reproduced imagery with major geographical outlines; reformating or enhancement of visual and IR data to facsimile compatible formats at full or reduced resolution; enhancement of IR imagery relative to sensor calibration data to reproduce imagery for special users to give temperature information such as grey scale steps for cloud and water surfaces; graphics false colour CRT display for image analysis purposes; visual Infrared Spin Scan Radiometer (VISSR) image reproduction of GOES-tap data from the GOES-EAST geostationary satellite via a landline drop from Buffalo, N.Y.; archiving approximately one year of NOAA VHRR data at full resolution on magnetic tape; an unlimited archive of processed VHRR data, in facsimile compatible format, on analogue magnetic tape; and a selected area archive of computer compatible tapes at full resolution for research and project study purposes. A paper print (non-permanent) archive is on file of routine acquisitions dating back to 1966. The prints are photo facsimile reproductions and normally do not seriously degrade for approximately 3 years. A large part of this data is still held on analogue magnetic tape. Its quality on recovery varies with age.

STRATOPROBE

Project STRATOPROBE is a research program of AES/DFE designed to study the stratosphere using high altitude research balloons. A complex, multi-experiment payload of remote sensing instruments is flown on large balloons (300 to 600 thousand cubic metres), in order to measure atmospheric constituents important in the chemistry of the ozone layer. The experiments are conducted by scientists from AES, Canadian universities and industry while the payload engineering is provided by SED Systems Ltd., under contract to AES. The Canadian launch facility is operated by the Space Research Facility Branch of NRC.

Since the beginning of the program in 1974, until 1976, eight flights were made from Churchill and Yorkton. In 1977, a high altitude flight was launched from Yorkton to measure the chlorine chemistry of the stratosphere. Two further flights were carried out at the National Stratospheric Balloon Facility in Texas as part of an international inter-comparison project sponsored by NASA. Dual launches of the AES STRATOPROBE IV payload and the University of Michigan BOSS payload on two separate balloons were made to facilitate the inter-comparison of different measurement

techniques for stratospheric constituents. The comprehensive data set of stratospheric constituents so obtained will provide a stringent test of the stratospheric models used to predict the effect of freon usage on the ozone layer.

DEPARTMENT OF TRANSPORT (DOT)

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.

A meeting of the AEROSAT Council is scheduled for January 1978 where objectives and scope of any international cooperation for a future AEROSAT program will be decided. DOT has prepared a Canadian position paper for this meeting.

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 from two to three years.

The purpose of the organization is to deploy and operate satellites 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 an interim Preparatory Committee, set up to perform studies and make preparations which will facilitate the establishment of the maritime satellite system when the organization 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.

The first two meetings of the committee were held in the spring and fall of 1977, preceded in each case by meetings of its panels. 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 are 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 is being sought through a series of meetings in late 1977 and early 1978.

It is expected that Cabinet's approval for Canada to participate in INMARSAT will be sought in the near future.

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, continued through 1977 and will extend to 1978. Subject to continuing satisfactory performance during the coming season, the terminal may become part of the operational equipment of the Coast Guard.

ATS-6 Experiment

The Department of Transport operates an airborne testing facility for the evaluation of ground to aircraft communications using the NASA ATS-6 satellite. A Lockheed Jetstar was modified to carry the necessary equipment to receive signals from a satellite, process these signals and record relevant parameters to facilitate subsequent detailed analysis on the ground. Experiments have been conducted in three general areas:

- evaluation of several voice and data modems;
- comparison of various aircraft antenna systems; and
- investigation of multipath conditions experienced by an aircraft flying over the ocean when receiving a signal from a satellite.

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

Industrial Support

IT&C continued to support an RMS base technology development project at Spar Aerospace Products Ltd. under its Defence Industry Productivity (DIP) Program. Approximately 30% of the expenditures during 1977 were on space-related activities: concept development for the Module Interchange System (MIS) proposal, and the development of end effectors for the Shuttle RMS project. The non-space expenditures were devoted to activities on underwater welding and manipulators for underwater applications; the development of manipulator systems for paraplegics, mounted on a wheel chair; 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 forced feedback control.

Satellite Subsystems and Earth Stations

During 1977, IT&C provided support to Spar Technology Ltd. (STL) under the DIP Program to continue projects on satellite subsystems and earth stations previously being carried out by RCA Ltd. With this support, the company has achieved significant advances in its capabilities to provide sophisticated transponders and antennas for communications

satellites, advances which are based primarily on the application of solid state devices and lightweight materials. The award during the year of a subcontract from TRW of California for the transponders for the Tracking Data Relay Satellite System (TDRSS) attests to the company's capabilities in this area. The support provided for the development of earth stations has enabled the company to make substantial domestic and export sales of earth stations of a variety of sizes.

During the year, the Department also provided capital assistance to ComDev of Montréal under the DIP Program toward equipment for the testing of flight-quality components for satellite, earth station and other applications.

INTERNATIONAL RELATIONS

Most of Canada's space programs and activities are carried out in one way or another with other countries. The section of this report dealing with departmental programs, illustrates this very well. The reports of the Sub-Committee for the International Aspects of Space Policy and of the Sub-Committee for the Scientific Aspects of Space Policy which is also the Canadian representative to the Committee on Space Research (COSPAR) of the International Council of Scientific Union (ICSU), also deal with international matters. The following covers only highlights of Canada's international relations.

United States of America

A number of Canadian scientists have been accepted as participants in US space programs. The Canadian scientists participate as guest experimenters on the American OAO program as members of NASA's study groups, as members of the NASA Atmospheric LIDAR Working Group, members of NASA imaging science team of the Jupiter Orbiter program, as investigators on SPACELAB and experimenters on the Long Duration Exposure Facility.

The Space Research Facilities Branch of the National Research Council entered into a Memorandum of Understanding with the U.S. National Science Foundation in October 1977 for the use by Canadians, of the U.S. National Center for Atmospheric Research Balloon Facility. SRFB sponsored and supported one balloon flight for the University of Calgary under the agreement and sponsored two other flight for the Atmospheric Environment Services of the Department of Fisheries and Environment during November and December. SRFB is also studying a proposed agreement between the U.S. and Canada which would provide for transborder balloon flights between the two countries.

Meetings were also held with NASA in Washington, followed by another meeting in Ottawa to discuss mutual opportunities in the space science area. As a result, more fruitful discussions were held concerning possible cooperation in some of NASA's future space science programs and NASA's participation in the proposed Canadian POLAIRE program.

ESA

During the year, many meetings were held between a working group of the ICS and ESA executive to obtain and

exchange information and to discuss the various alternatives concerning the possibilities for Canada to upgrade its status with the agency. These discussions followed a declaration by the Minister of Communications, Mme. J. Sauvé, at the ESA Council, expressing Canada's desire to enter into discussions with ESA on that subject.

Japan

National Research Council negotiated with the Institute of Space and Aeronautical Science, University of Tokyo, Japan, for the installation and operation of a ground satellite command and receive station located at the Churchill Research Range. This station will track the joint Japan/U.S. EXOS-A satellite scheduled for launch in January 1978.

Following the visit of Drs. Chapman and Morley to Japan in May 1977, information was exchanged with Japan and with the Japanese Embassy in Ottawa, concerning our respective space programs. Official contact points were also established: the ICS Secretariat for Canada and the Space Activities Commission Secretariat for Japan. It is expected that more visits will take place in the next year, as well as the possible exchange of scientists or engineers.

Others

Liaison for effective international scientific cooperation was established with Germany, Norway, Sweden, Japan, France and with NASA and ESA. Scientists from these countries and organizations participated in a meeting of the Science Planning Group and Planning Teams of the SSCO set up to propose the POLAIRE program. Meetings have been held with NASA to discuss Canadian/U.S.A. cooperation in the American Nimbus-G/LIMS program where AES and York Universities were having a useful scientific input.

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.

The financial reporting format began with last year's Annual Report, is maintained. Table 1 summarizes the government's actual expenditures in 1977/78 and budgeted expenditures for 1978/79, 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 $65 million in FY 1977/78 are 39% greater than in FY 1976/77. In FY 1978/79, the budgeted space expenditures grow by a further 51%. The principal cause of this large increase being the budgeted payments to Telesat Canada for use of the ANIK-B services. In FY 78/79, these amount to $20 million.

It is interesting to note that the government IN-HOUSE expenditures have remained relatively constant at $13 million per annum, over the period 1976/77 to 1978/79. During that same period, from FY 1976/77 to FY 1977/78 to FY 1978/79, the government expenditures directed to Canadian industry have increased by 72% and 70% respectively. In the two fiscal years covered by the financial information in this report, 69% and 77% respectively of the total government spending in space has been or is budgeted to be realised in Canadian industry.

Expenditures in Canadian universities, in the form of grants or research contracts have been steadily decreasing over that period from 3.25% of total spending in FY 1976/77 to 1.31% in FY 1978/79. 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 1977/78 and 1978/79 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 most active departments in the area of space for FY 1977/78 and 78/79. 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 two projects, the RMS and ANIK-B. Both 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 65-70% go to category A, 15-20% to B and 9-12% to C. Figure 2 also shows that most of the increased in the three categories have been absorbed by Canadian industry. Indeed, even though the total expenditures have more than doubled from FY 1976/77 to 1978/79, the expenditures, other than to Canadian industry, have remained constant at approximately $20 million per year.

Figure 3 shows the government IN-HOUSE and INDUSTRY expenditures from 1969/70 until 1978/79. 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.

Finally, Figure 4, shows the expenditures, since FY 1969/70 broken down by departments.

Table 1

Total government space expenditures

	1977/78 A	B	C	Total	1978/1979 A	B	C	Total
In-House								
Capital & G&S	1 942	2 087	1 026	5 055	1 784	1 469	1 142	4 395
Salary	2 969	2 997	1 992	7 958	3 311	3 390	2 211	8 912
Sub-total	4 911	5 084	3 018	13 013	5 095	4 859	3 353	13 307
Industry								
Canada	37 174	4 987	2 841	45 002	59 571	13 300	3 761	76 632
USA	4 950	436	650	6 036	4 960	489	554	6 003
Others					1 545		5	1 550
Sub-total	42 124	5 423	3 491	51 038	66 076	13 789	4 320	84 185
University	131	130	941	1 202	196	125	971	1 292
Grand Total	47 166	10 637	7 450	65 253	71 367	18 773	8 644	98 784

A: Space systems
B: Ground stations & earth terminals
C: Data processing & analysis

Table 2

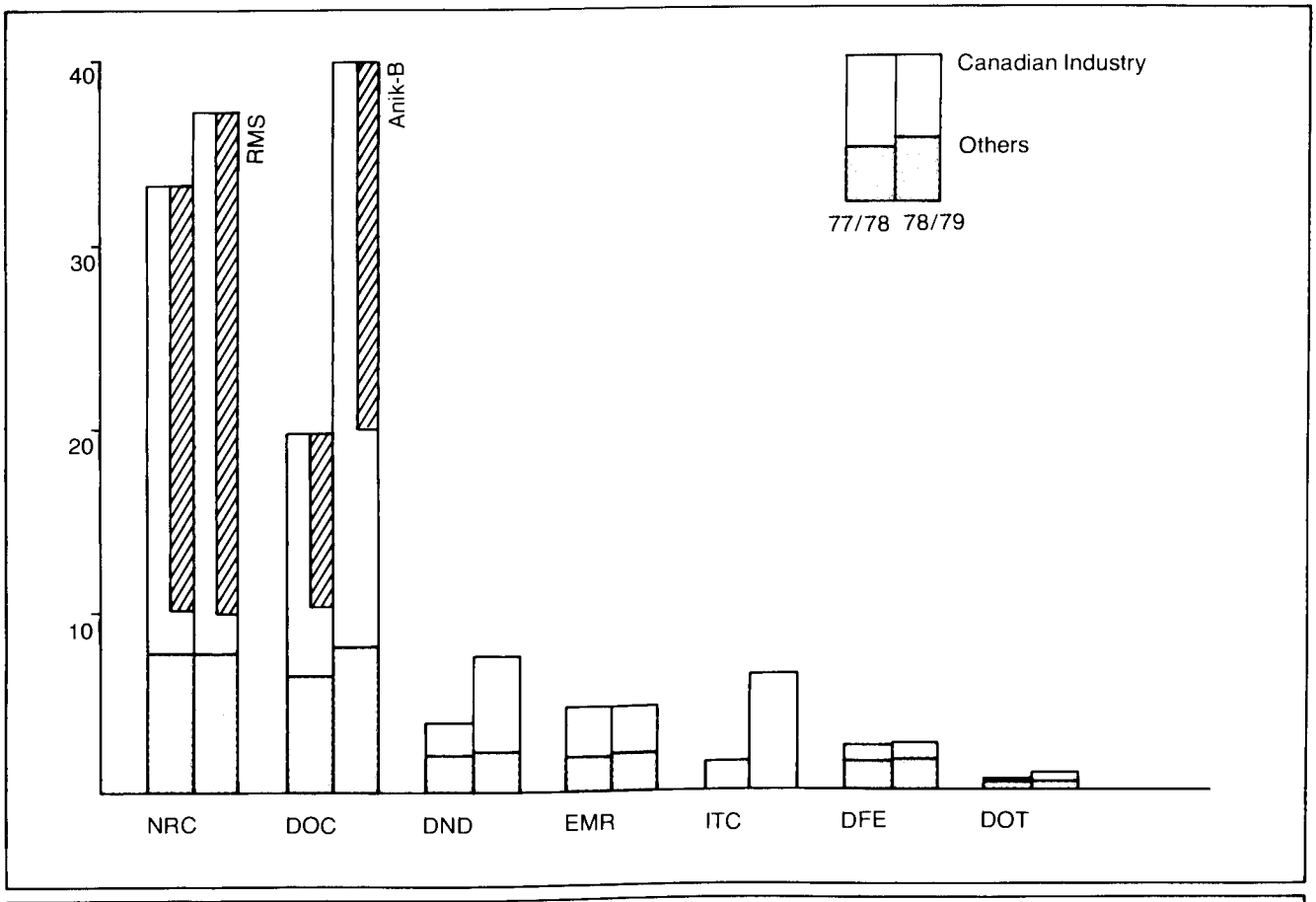
Total government space expenditures (by department)

	1977/78				1978/1979			
	A	B	C	Total	A	B	C	Total
Communications	14.4	4.6	0.4	19.4	33.5	6.0	0.4	39.9
National Research Council	31.7	—	1.3	33.0	35.4	—	1.3	36.7
National Defence	0.1	2.6	0.6	3.3	0.1	5.5	1.9	7.5
Energy, Mines & Resources	—	1.5	3.1	4.6	—	1.7	2.9	4.6
Industry, Trade & Commerce	0.8	0.8	—	1.6	1.7	4.7	—	6.4
Fisheries & Environment	—	0.5	2.0	2.5	—	0.6	2.0	2.6
Transport	0.1	0.6	0.1	0.8	0.6	0.2	0.2	1.0
Total	47.2	10.6	7.4	65.2	71.4	18.8	8.6	98.8

A: Space systems
B: Ground stations & earth terminals
C: Data processing & analysis

Figure 1

1977/78, 1978/79
Government space expenditures
by department



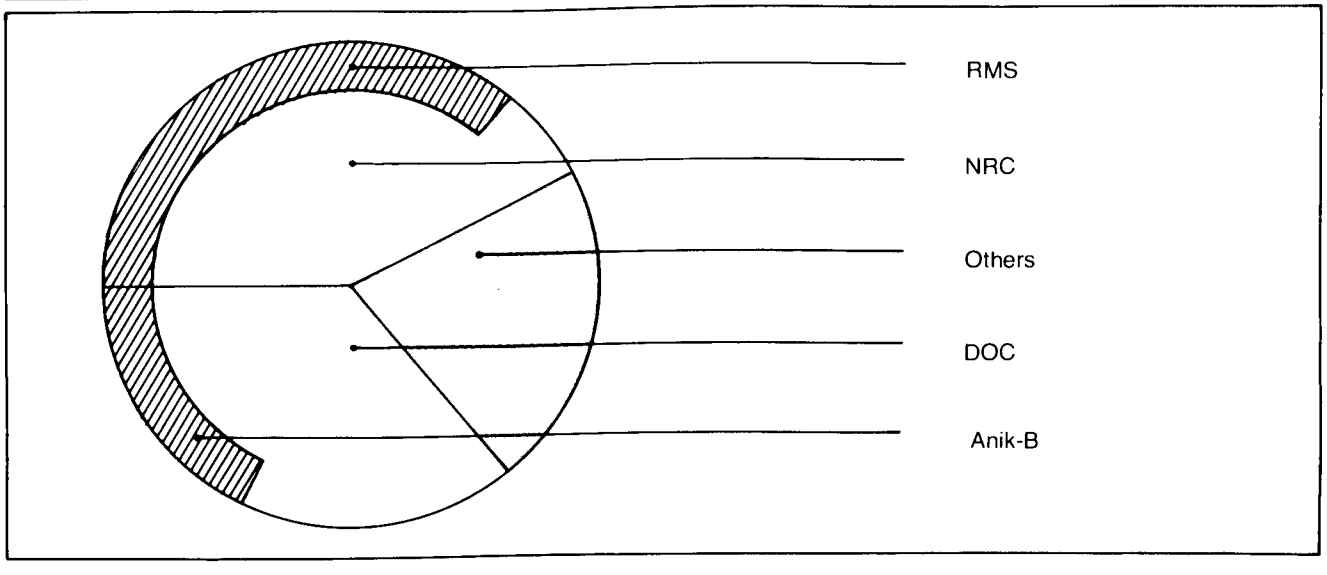
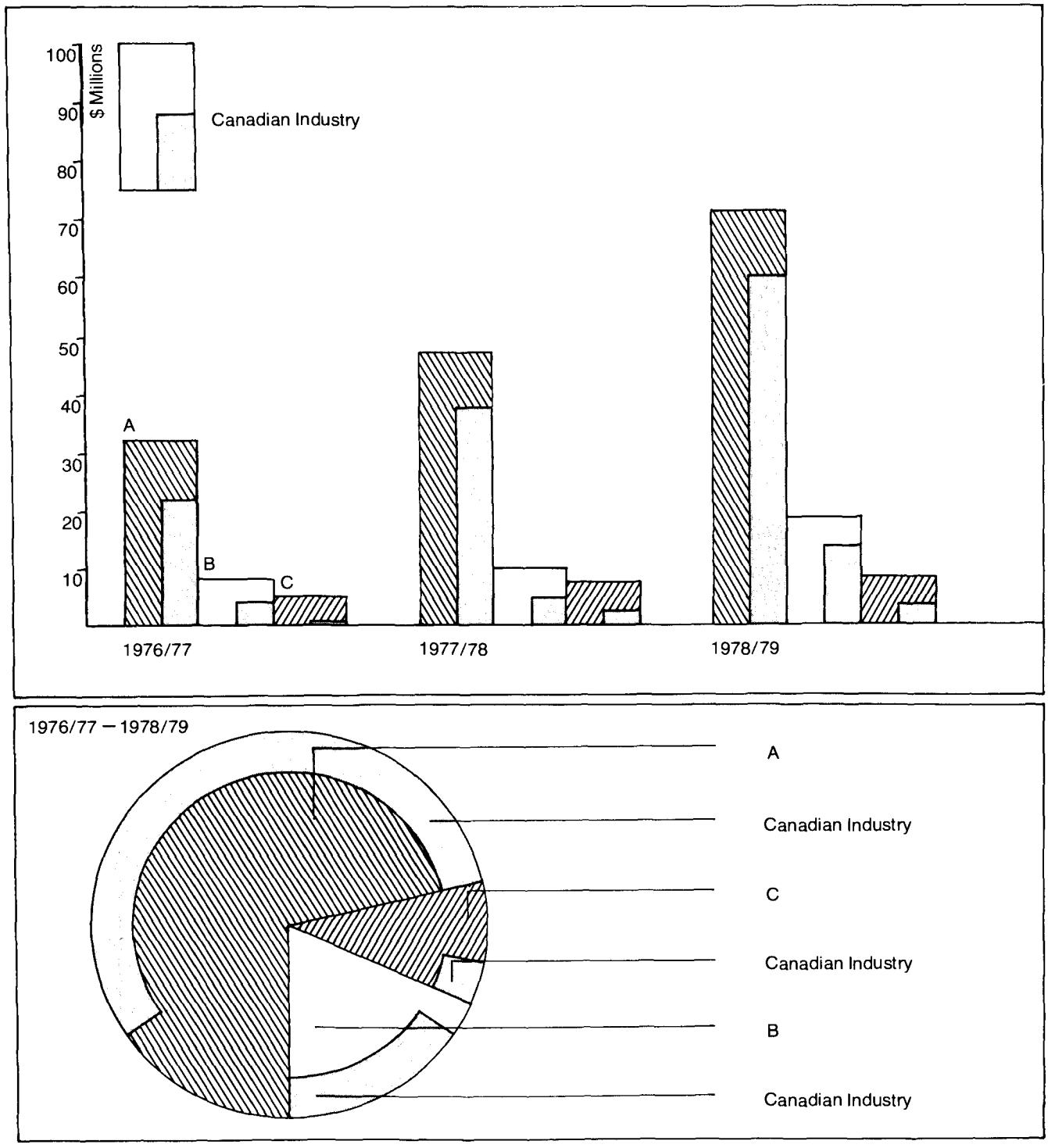


Figure 2

Government space expenditures by category



A: Space systems
B: Ground stations & earth terminals
C: Data processing & analysis

Figure 3

1969/70, 1978/79
Government space expenditures
in-house/industry

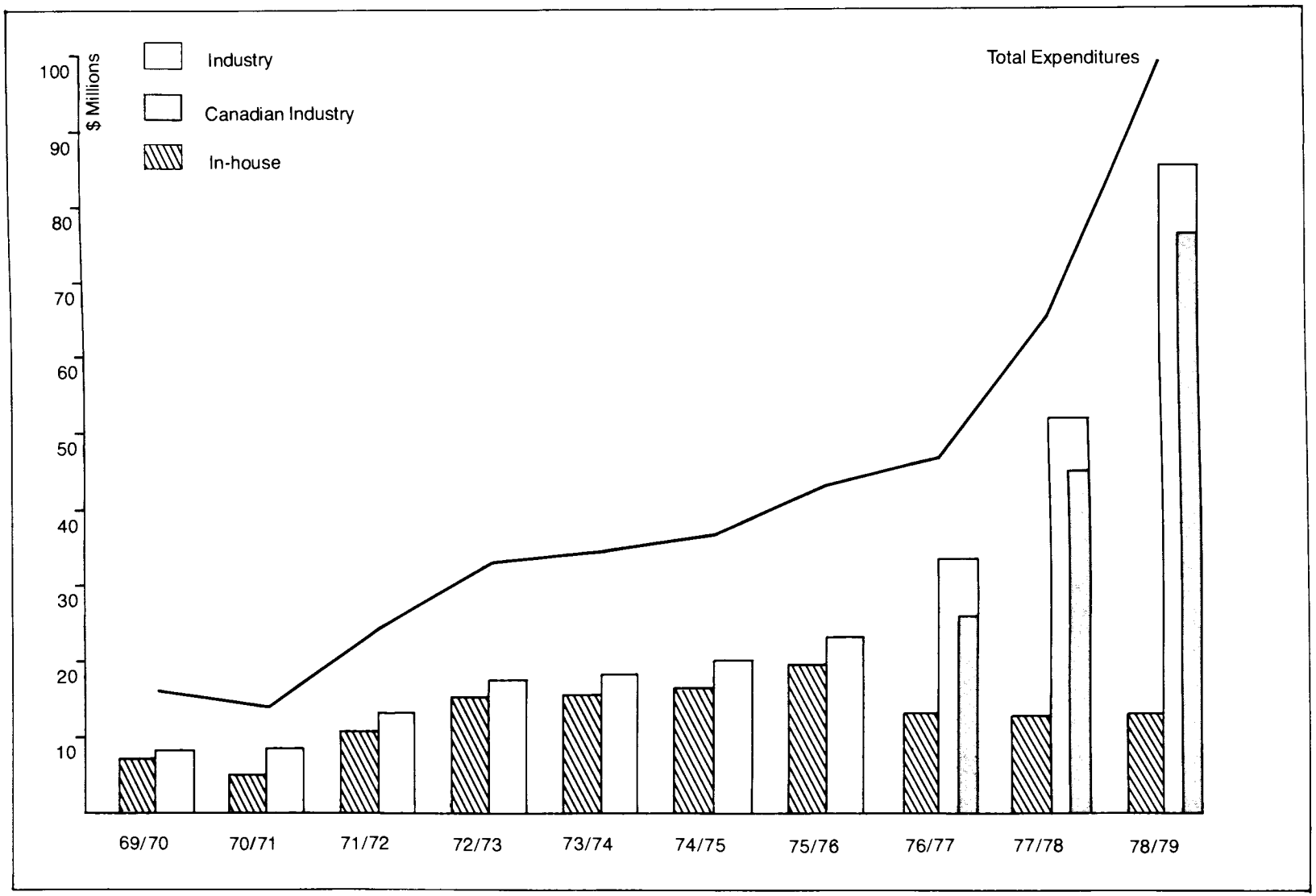
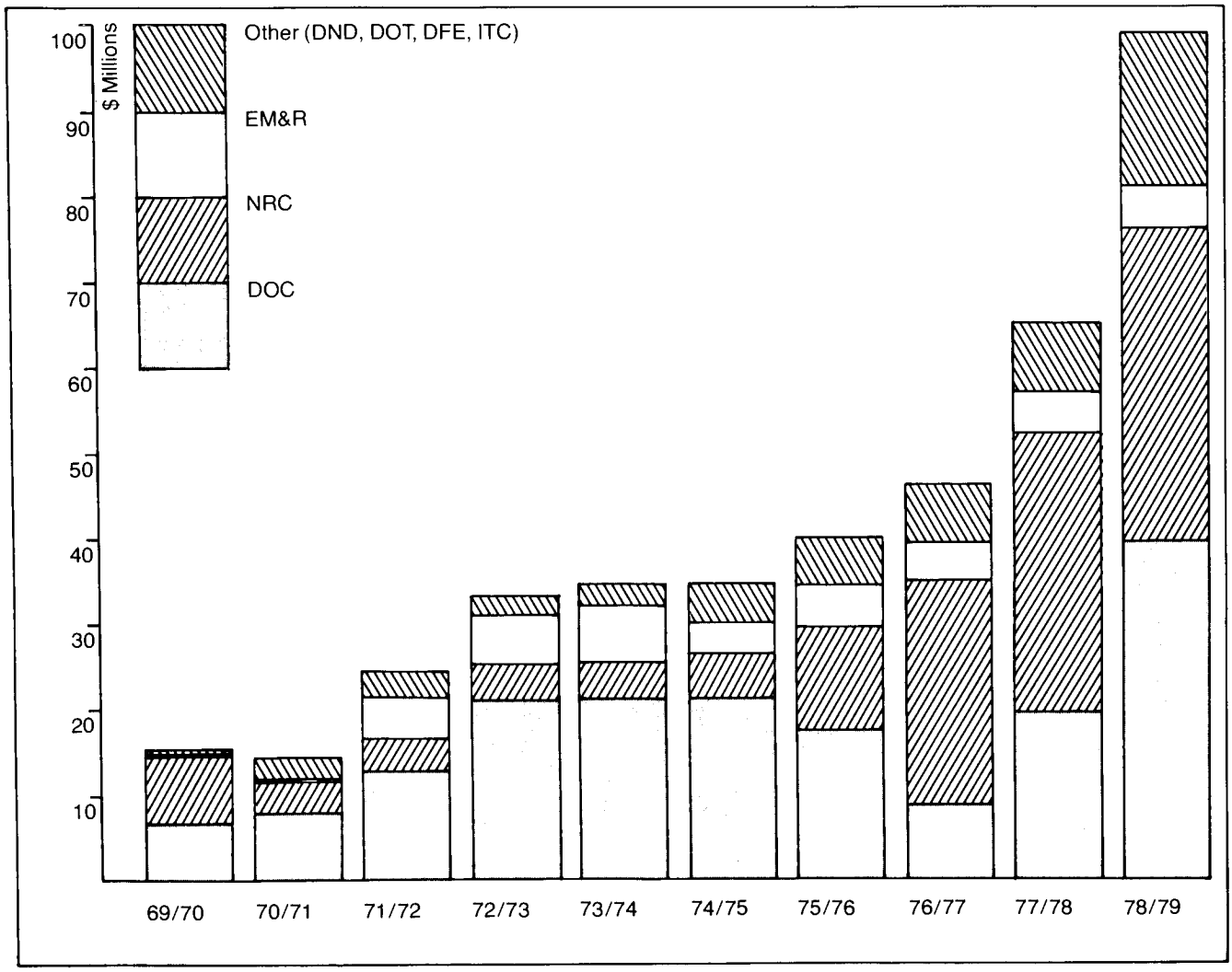
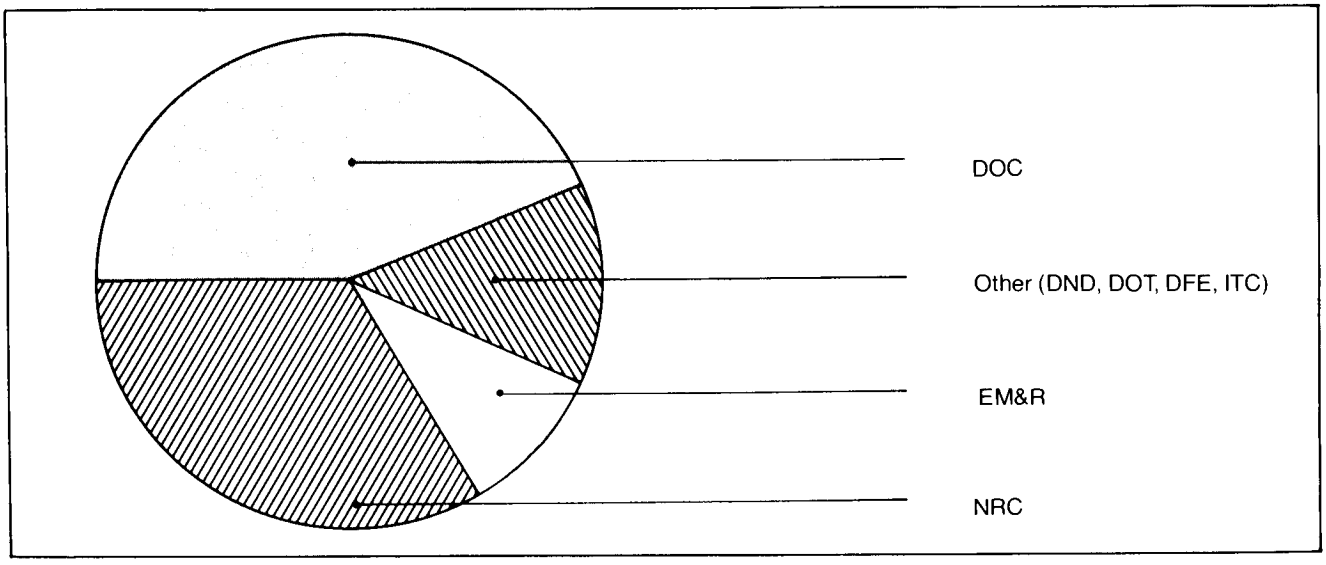


Figure 4

1969/70 to 1978/79
Government space expenditures
by department





ANNEX

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