1979

Annual Report

Interdepartmental Committee on Space

Annual Report

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 purpose is 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 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
December 1980

ICS ANNUAL REPORT - 1979

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PREFACE

In Memoriam[1]

John Chapman, the Father of Canada's Space Program

The McNaughton Gold Medal Award of the Institute of Electrical and Electronics Engineers (IEEE) was awarded posthumously on October 5 to John Chapman, who until his death on September 28, was the Department's Assistant Deputy Minister (Space Program), known around the world as the father of Canada's space program.

E.F. Glass, IEEE director for Canada, made the presentation to Mrs. Chapman in Deputy Minister Bernard Ostry's office. Also present were Dr. Chapman's five children.

The McNaughton Gold Medal was presented in recognition of Dr. Chapman's "outstanding contributions as a professional engineer to the development of Canadian engineering excellence". It was just one of numerous awards and accolades bestowed upon Dr. Chapman during his career as the driving force behind Canada's satellite programs.

Dr. Chapman was on a business trip to Vancouver when he died in his sleep of a heart attack. In making the announcement public, Communications Minister David MacDonald said, "Canada has lost an extraordinary individual. Dr. Chapman played a major role in virtually every space activity in Canada. Canada's space program is where it is today to a very large extent because of his efforts".

Dr. Chapman initiated and guided Canada's entry into space by way of the Alouette and ISIS satellites, which gained Canada an international reputation in space science. In 1967, he was appointed chairman of a government task force to study and advise on satellite communications in Canada. The report published in 1968, was entitled, "A Domestic Satellite Communication System for Canada", but became widely known as "The Chapman Report".

Telesat Canada, the domestic commercial satellite corporation, was established a year later as a result of the report's recommendations.

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(1) Reproduced from "Modulation", No. 23, December 1979. Published by the Department of Communications.

Dr. Chapman was also a prime mover behind Canada's Communications Technology Satellite (CTS) program which started in 1971-72. The CTS program resulted in the launch in January 1976 of Hermes, the eighth Canadian satellite and the first geosynchronous communications satellite to operate in the 14/12 GHz frequency band. When launched, it was the world's most powerful communications satellite and a forerunner of the direct-to-home broadcast satellite.

"One of Dr. Chapman's current enthusiasms was the idea of providing direct-to-home TV by satellite to people in remote and rural areas of Canada. He saw this prospect back in 1971, a prospect which is close to realization with the inauguration in Ontario only three days ago of the first direct-to-home satellite broadcast service", said Mr. MacDonald on 28 September.

Dr. Chapman led a successful government-industry mission to Australia in August, which demonstrated Canadian industrial and scientific capabilities in the field of high-powered broadcasting satellites and small, low-cost earth stations.

He had pushed for the development of a prime contracting capability in Canada for the construction of commercial satellites, and his efforts came to fruition in May 1979 when Telesat Canada announced the award of the contract for the ANIK-D satellites to SPAR Aerospace Ltd. of Toronto.

Colleagues within the Department of Communications described him as an unusual combination of outstanding administrator and scientist. "He was extraordinarily farsighted in seeing the possibilities of satellite technology", said one.

Bernard Ostry, the Deputy Minister of Communications, said Dr. Chapman was one of the most outstanding public servants in the history of this country.

Dr. Chapman was born in London, Ontario in 1921, and obtained a B.Sc. in radio physics at the University of Western Ontario in 1948. The following year he obtained a master's degree in physics at McGill University, and two years later, a doctorate in physics from the same university.

In 1951, he was named a senior scientist at the Defence Research Telecommunications Establishment (DRTE) at Shirley Bay, on the outskirts of Ottawa, where he was in charge of the ionospheric research section. He was later named superintendent of the communications wing. In 1959, he was appointed deputy chief superintendent of DRTE.

He was Canadian coordinator of the successful Alouette-ISIS scientific satellite program undertaken by Canada (Defence Research Board) and the United States (National Aeronautics and Space Administration). The program began in 1959 with Alouette I, and is continuing with two of the four satellites, ISIS I and ISIS II, still operational after eleven and ten years in orbit respectively. As a result of his work on this program he received numerous awards for contributions to space research.

Early in July 1968 he assumed the headquarters position of deputy chairman (scientific), DRB. Shortly afterwards, he was loaned to the office of the Postmaster General to assist in planning a new government department to be called the Communications Department.

In January 1970, Dr. Chapman was appointed Assistant Deputy Minister for research with the Department of Communications. In 1974, he was appointed Assistant Deputy Minister, space program, in the Department of Communications.

From 1972, Dr. Chapman was the chairman of the Interdepartmental Committee on Space which is responsible for coordination of Canadian space activities.

SUMMARY

The following paragraphs summarize the various activities pursued by the member departments of the ICS during calendar year 1979.

The construction and testing of the Shuttle Remote Manipulator System (SRMS) continued in 1979. The program is now in its final phases and the first flight unit is scheduled for delivery to NASA in 1980. As a follow-on, in May 1979, NASA placed a contract with SPAR Aerospace Ltd. for RMS systems to equip the Orbiter fleet.

The HERMES satellite was used to conduct experiments in the fields of tele-health, tele-education, advanced technology, community interaction, TV broadcasting and government services. The results of the experiments and the performance of the spacecraft were highly satisfactory and the program continued until June 1979. In July 1979 HERMES was moved to cover the eastern region of Australia for demonstration purposes. Although originally planned as a two-year mission, the satellite was operated successfully for almost four years before operations ceased on 23 December 1979, due to a satellite malfunction.

The program of experiments carried out using HERMES demonstrated the potential of the 14/12 GHz band for delivery of a range of innovative services. The momentum was maintained into a follow-on program using 14/12 GHz capacity of Telesat's ANIK-B, a hybrid satellite launched in December 1978. The ANIK-B program involves pilot projects intended to determine the commercial viability of a range of new services. The ANIK-B program is now in its second year. An extension has been approved, to enable further development of new services and prospects (notably a project in direct satellite broadcasting) up to the point of commercial exploitation using Telesat's ANIK-C.

During 1979, the cooperative experimental program utilizing the Franco-German Symphonie Satellite continued. A notably successful experiment was the exchange of extremely precise timing information between clocks in Canada and Europe.

During 1979, DOC carried on the expansion of the David Florida Laboratory (DFL) which should be completed in 1980. This will permit complete integration and testing of the large communications satellites that will be carried in the Space Shuttle. Furthermore, the government also approved a plan whereby SPAR would integrate and partially test the third ANIK-C spacecraft in Canada. These two factors will enable SPAR to acquire the necessary practical experience to become prime contractor for the design, construction and supply of two ANIK-D satellites for which it was awarded a contract by Telesat in early 1979.

DOC, on behalf of DND, DFO and MOSST, signed a Memorandum of Understanding with NASA (U.S.A.) and CNES (France) covering an experimental satellite-aided Search and Rescue system (SARSAT). Meetings were also held between SARSAT parties and the USSR's Ministry of Merchant Marine (MORFLOT) to discuss the possibility of a joint project between SARSAT and a compatible USSR system, COSPAS. In November, an agreement, subject to confirmation, was signed by each of the SARSAT parties and MORFLOT. In Canada, coordination of the joint project is being carried out by an Interdepartmental Review Board with DND being the lead department and with participation of DOC, DFO, TC, DSS and IT&C. Under this agreement, Canada is to develop a ground station and three repeaters to fly on-board NOAA-E, F and G satellites, beginning in early 1982.

An agreement of cooperation between Canada and ESA came into effect on 1 January 1979. The Agreement provides for Canada's participation in the General Studies program of the Agency, and also allows for Canada's participation in optional applications programs. To assist Canada in receiving a reasonable share of ESA contracts during 1979, ESA sent a mission to Canada in early January 1979, for a briefing to Canadian industry. In 1979, contracts totaling around $1M were awarded to Canadian industry, in the area of remote sensing.

During 1979, Canadian government (principally DOC and ITC) took various initiatives aimed at making Canadian industry known in international fronts. Indeed, particular effort was deployed to make the Australian government aware of the Canadian technological lead in satellite telecommunications. These initiatives included:

i) demonstrations in Canada for Australian observers,

ii) numerous TV broadcast and telephony service demonstrations through HERMES in Australia and Papua New Guinea,

iii) co-sponsorship in Australia of a satellite communications workshop, and

iv) registration of interest, on behalf of Canadian industry, in the supply of major elements of an Australian national communications satellite system. Australia decided in October 1979 to proceed with establishment of a national system.

In mid-August 1979, Teleglobe inaugurated its Laurentides earth station to access the third operational Atlantic Ocean Region satellite. The antenna is 32 metres in diameter and is a wheel and track design utilizing a beam waveguide technique to pass the signal from the base-mounted feed to the antenna subreflector.

Aside from detailed documentation of results, the Canadian Surveillance Satellite (SURSAT) Program was largely completed in 1979. It provided a wealth of hard facts and information to the research and operational agencies involved and important industrial spin-offs were also achieved in the areas of radar development, operations and processing. The SURSAT Program concluded that a further period of development and experimentation with the Synthetic Aperture Radar would be in Canada's interest. A report to Cabinet on the results of the experimental program, which terminates on 31 March 1980, will be submitted in late 1980.

Within the Aerosat program, the Committee for Review of Application of Satellites and Other Techniques to Civil Aviation (ARC) met once in 1979. The feasibility study is continuing with contributions by the ARC participants and working groups. It is planned to have a final report for review by May 1981.

In July 1979, INMARSAT came into existence. Twenty-nine countries (including Canada) are already parties to the INMARSAT Convention. Canada played a major role in the establishment of INMARSAT. Its permanent headquarters will be located in London, U.K. The Canadian operating entity is Teleglobe Canada.

The test and evaluation program on the MARISAT terminal was completed in 1979 and the terminal has become a part of the operational equipment of the Coast Guard icebreaker John A. MacDonald.

In 1979, DOE installed a GEMS 300 image analysis system at the Pacific Forest Research Centre and completed the conversion of two ground receiving stations operated by the Atmospheric Environment Service (AES). The latter is to permit receiving data from the new TIROS-N/NOAA series of polar orbiting meteorological satellites.

In May and November 1979, phases of the Grand Banks experiments took place. These experiments are designed to test detectability of fronts and ocean current boundaries by microwave remote sensors and operational responsibility is shared between the principal investigators at the Institute of Ocean Sciences and U.S. Navy's NORDA facility in Bay St. Louis.

In March 1979, Canada continued receiving and processing LANDSAT-3 data. These data have a ground resolution of 30 m. in panchromatic mode, opening new possibilities in the area of thematic mapping at larger scales. A laser beam image recorder was also put into operation at Prince Albert, to reduce turn-around time to all users working on dynamic phenomena.

A joint proposal by the Massachusetts Institute of Technology (MIT) and the Canadian Defence and Civil Institute of Environmental Medicine (DCIEM) to carry out studies in vestibular physiology on SPACELAB has progressed satisfactorily. The experimental program is scheduled for placement aboard SPACELAB I, presently planned to be launched in April 1982. The flight crew for SPACELAB I visited DCIEM for four days in 1979 for training in the Space Sled linear acceleration experiment, the orientation experiment and the motion sickness experiment.

In 1979, DND entered into a bilateral understanding with the U.S. Air Force for the development of NAVSTAR/GPS military receiver equipment in Canada. Canadian Marconi was awarded the contract. Also, ship-to-shore satellite communications was demonstrated successfully using a Canadian-designed shipborne terminal and the U.S. FLTSAT system.

Canadian government space expenditures for FY 1979/80 totalled $70 million. Of that amount, approximately 58% was expended in Canadian industry and 10.7% in U.S. industry. This spending pattern is a deterioration over FY 1978/79, where 74% of the total expenditures had been expended in Canadian industry and 2% in U.S. industry. Government expenditures in Canadian universities have increased, both in absolute and relative terms, from $0.4 million (0.4% of the total budget) in FY 1978/79, to $0.5 million (1.7% of total budget) in FY 1979/80. The Shuttle Remote Manipulator System, ANIK-B and the DFL extension for ANIK C/D support accounted for almost 50% of the total government space expenditures.

OUTLOOK FOR THE FUTURE

The "Canadian Space Program; Five-Year Plan (80/81-84/85)" prepared in 1979 by the ICS, and plans and programs submitted by the departments involved in space activities indicate that Canada will continue to be very active in space during the coming year.

The following are examples of such activities:

a) Canada intends to play an active role in the European Space Agency (ESA) through participation in the General Studies program and in optional programs of interest. Indeed, following reviews of the possibilities of cooperative projects with ESA, DOC proposed participation in the definition phase of ESA's Large Satellite (L-SAT) Communications Satellite program and EM&R proposed participation in ESA's Remote Sensing Preparatory Program (RSPP). Approval for Canadian participation in both activities is expected in early 1980. Canadian participation in the following construction phases of these programs will depend upon the results of these preparatory programs and approval from ESA members participating. Such a decision should be taken in late 1980 for L-SAT and in early 1982 for the RSPP;

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

c) preliminary studies and planning indicate that an operational SURSAT system could be in service by the late 1980's. In this regard, planning will begin in pareparation for the National Oceanographic Satellite System (NOSS), a NASA Operational Demonstration Satellite to be launched in mid-1980's. During 1980, Canada, while participating in ESA's RSPP, will continue examining the possibility of developing a Canadian radar satellite possibly in cooperation with other countries;

d) in March 1979, Treasury Board gave approval, in principle, to NRC to negotiate a cooperative Space Science program with NASA. The program envisaged would extend over a period of several years and a final agreement should be signed in early 1980;

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

rocket in May 1980. In addition, NRC will continue its sounding rocket research program with active aurora-perturbation experiments such as project "Waterhole" as well as large multidisciplinary programs such as the "Pulsating Aurora" campaign;

f) an experimental program to investigate vestibular physiology aboard the Spacelab program has been accepted by NASA. This joint program, proposed by the Massachusetts Institute of Technology, the Defence and Civil Institute of Environmental Medicine and McGill University, is scheduled to take place on board Spacelab I in April 1982;

g) DOC will conduct a two-year program of studies directed towards Canadian participation in a joint program with NASA to develop, launch and demonstrate a UHF mobile satellite system for public and government applications;

h) DOC will continue and expand the series of experiments, pilot projects and trials using 14/12 GHz band, which was initiated with HERMES. 14/12 GHz leased capacity on Telesat's ANIK-B spacecraft will be used for this purpose.

Other events which are expected to take place in 1980 include the following:

- Cabinet approval for the Canadian Space Program; Five-Year Plan (80/81 - 84/85);

- testing will commence on drifting buoys transmitting temperature and pressure by use of the ARGOS system on polar-orbiting NOAA satellites;

- because of continuing interest of DND, NRC and the international scientific community, it has been decided to continue operation of the ISIS satellite and collection of the data for worldwide use will continue in 1980;

- mission studies for radar satellites.

Telesat's three ANIK-C satellites will operate in the 14/12 GHz band, providing heavy-route message services, broadcasting to cable head ends and other possible new services beginning in 1982.

Through its Industrial Technology Development program, DOC will continue to encourage industry to develop components and subsystems expected to be required for future Canadian and export satellite programs.

Teleglobe propagation studies in the 14/12 GHz band continued in 1979. These studies were originally scheduled to end in 1980, but have now been extended to 1981.

Starting in 1980, CRC will proceed with the industrial development of Emergency Locator Transmitter electronics to be used with SARSAT.

During 1980, Canada will continue to participate in the UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS) and in the session of the working group of Experts on Nuclear Power Sources which was established, following a Canadian initiative, by UNCOPUOS at its 21st session in 1978.

In the Spring of 1980, Canada will host a multilateral meeting on remote sensing. This meeting should re-group representatives from nations that are either operating remote sensing satellite systems or will be doing so in the near future. Its main purposes are to informally exchange views on areas of possible international cooperation in remote sensing satellite systems and to discuss possible means of improving their coordination which might be beneficial to both operators and users.

THE ICS IN 1979

During 1979, the Interdepartmental Committee on Space (ICS) held three regular and four extraordinary meetings. It was particularly active in:

- Preparing and submitting comments on the U.S. Senate Draft Bill (S)3589;
- studying possible Canada/U.S. cooperation in the field of earth resources satellites;
- studying and negotiating Canadian participation in ESA's Remote Sensing Program;
- preparing and presenting a report on Dr. J.J. Shepherd's article recommending the creation of a Canadian Space Agency;
- preparing and submitting a discussion paper to the Federal Cabinet proposing a five-year plan for the Space sector.

Following the death of Dr. J.H. Chapman (see Preface), the Committee's Vice-Chairman, Dr. D.I.R. Low, assumed the chairmanship on an acting basis.

In January 1979, Mr. L. Giroux became Assistant Secretary External Relations, within the ICS Secretariat.

In April 1979, Mr. J.R. Marchand succeeded Dr. R. Langille as Secretary of the Committee. Dr. Langille became Advisor on Space Policy to the ADM(Space) in DOC, until his retirement at the end of the year.

In August 1979, the Secretariat's Space Documentation Centre was consolidated with the appointment of Mrs. K. Lanthier as the Head of the Centre.

SUB-COMMITTEE FOR THE INDUSTRIAL ASPECTS OF SPACE POLICY

The Sub-Committee for the Industrial Aspects of Space Policy was established by the ICS in February 1975. Members for the Committee are drawn from ICS member departments but representatives from non-member departments and agencies may be invited to participate in its activities from time to time, as the Chairman

deems necessary. Its main functions are to:

- Make policy and program recommendations concerning the acquisition, development and coordination of the use of the relevant technological and industrial capabilities;

- review current and proposed Canadian space activities;

- make recommendations for the promotion of technological and industrial cooperation in the space activities of national and international organizations;

- ensure that adequate dissemination of information on Canadian technological and industrial capabilities occurs;

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

The sub-committee held two regular meetings during 1979. In addition, a briefing was arranged for the Canadian space industry to assist it to do business with the European Space Agency.

The two regular meetings were concerned primarily with an IT&C plan providing for the coordination and management of relevant interdepartmental resources in support of international marketing of Canadian space products.

The briefing on the European Space Agency that took place in early January 1979, included presentations by representatives of the Agency on ESA's organization and programs, its contracting procedures, and the actions which Canadian companies should take in order to receive invitations to tender. This briefing was attended by representatives from 36 companies and from most of the departments represented on the ICS, and it led several companies to register with ESA to receive Requests for Proposals in General Studies and Technological Research. On the following day, the members of the ESA team met with the representatives of some of the companies on an individual basis. In 1979, contracts, in the area of remote sensing totalling around $1M, were awarded to Canadian industry.

SUB-COMMITTEE FOR THE SCIENTIFIC ASPECTS OF SPACE POLICY

In April 1959 the National Research Council established its Associate Committee on Space Research. This Committee also serves the ICS as a Sub-Committee for the Scientific Aspects of Space Policy. Members for the Committee are drawn from industries, universities and government. Its functions are to:

- Advise the Interdepartmental Committee on Space on the scientific aspects of space;
- advise the National Research Council on matters relating to space research;
- act as the Canadian National Committee for the International Council of Scientific Union's Committee on Space Research (COSPAR);
- review and comment on space science programs and plans of the Space Science Coordination Office, and
- serve as a forum for exchanging and developing ideas in space science by people representing geographic and disciplinary interests all across Canada.

During 1979, the Sub-Committee held one meeting on 22 February. The Sub-Committee was instrumental in recommending that a popularized summary on space science be produced, that the Natural Sciences and Engineering Research Council (NSERC) consider facilitating attendance at IMS workshops, that Canada host COSPAR in Ottawa in 1982 and that the activity of the IMS coordinator be funded to the end of 1979.

International Magnetospheric Studies Program (IMS)

The IMS officially ended in 1979. Excellent cooperation existed between Canadian, USA, Japanese and Scandinavian scientists on various IMS projects.

A preliminary draft of a manual on IMS activities which have taken place on Canadian territory is under preparation. This manual will list the various campaigns, expeditions and other activities, the name and address of the project scientist, equipment used, dates, and kinds of data obtained. The manual is meant to be a convenient reference source for a space scientist seeking data complementary to a project for which he has data as well as a history of the activities which took place.

SUB-COMMITTEE FOR THE INTERNATIONAL ASPECTS OF SPACE POLICY

The Sub-Committee for the International Aspects of Space Policy was established by the ICS in February 1975. Its members are drawn from ICS member departments but representatives from non-member departments and agencies may be invited to participate in its activities from time to time, as the Chairman deems necessary. Its main functions are to:

- Advise the ICS on the international aspects relating to space;

- make recommendations concerning cooperation in the space activities of foreign and international entities in the best interests of Canada;

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

The Sub-Committee had an active year in 1979. While much of its activity focuses on the multilateral aspects of Canadian space policy, the Sub-Committee is also concerned with Canada's bilateral space cooperation relations.

As in past years, much of the work of the Sub-Committee involved Canada's participation in the UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS) and its two Sub-Committees (Scientific and Technical, and Legal). Of particular importance was the first session of the Working Group of Experts on the Use of Nuclear Power Sources, which was established following a Canadian-initiated effort. The session produced a report which described the conditions for the safe use of space vehicles carrying a nuclear power source and identified a number of areas requiring further study. The group will continue its work in 1980. Other areas of progress in the UNCOPUOS were the approval by the Committee, and subsequently by the General Assembly, of the Moon Treaty. In addition, the decision was taken to hold a 2nd UN Conference on the Exploration and Peaceful Uses of Outer Space in late 1982. Preparations for the Conference will begin early in 1980.

1979 was the first year of Canada's status as a cooperative member of the European Space Agency (ESA) and members of the Sub-Committee participated in meetings of the Agency.

The IASP also reviewed cooperation in space with the USA, Italy and Japan. The Sub-Committee prepared a Canadian position paper for submission to the USA Congressional hearings on satellite earth observation systems.

DEPARTMENTAL PROGRAMS AND FACILITIES

NATIONAL RESEARCH COUNCIL OF CANADA (NRCC)

General

The National Research Council of Canada (NRCC) undertakes and sponsors scientific and technological research in a broad range of disciplines, including aeronautics, astrophysics, biology, building, chemistry, mechanical engineering, physics and electrical engineering. In addition to extensive laboratories and other facilities, NRCC has its own computation centre, and manages the Canada Institute for Scientific and Technical Information (CISTI). The NRCC also provided administration for 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 NRCC 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 including the development of equipment and instruments for use in the severe space environment.

To carry out these responsibilities, the NRCC receives advice from its Associate Committee on Space Research, plans through its Space Science Coordination Office and manages and operates its scientific programs through its Space Research Facilities Branch. The Herzberg Institute of Astrophysics of NRCC

conducts scientific investigations and the National Aeronautical Establishment is responsible for the Remote Manipulator System, non-cartographic applications of photogrammetry and dynamic stability of aircraft.

Space Science

NRCC has continued its space science responsibilities in its rocket, balloon and ground-based programs and its developmental responsibility in the teleoperator remote manipulator system for the USA Space Shuttle.

Government funding approval is being sought for a $42M cooperative space science program with the USA. This program will enable the flight of a number of facility-type instruments in the Space Shuttle, will provide a network of ground stations in support of the "Origins of Plasmas in the Earth's Neighborhood" program, provide a Data Analysis Network, and aid in responding to scientific opportunities presented internationally, particularly by NASA.

Herzberg Institute of Astrophysics (HIA)

Members of the Herzberg Institute of Astrophysics are participating in the "Firewheel" satellite project which will be launched in May 1980 by the European Space Agency's Ariane rocket. This international collaborative project, headed by the Max Planck Institute of West Germany, involves major contributions from Canada, the USA and the UK. In the experiment, a main satellite will be used to detonate two explosives in space, some 60,000 Km from earth. These detonations, one involving lithium and the other barium, will enable scientists to measure the effects of disturbances in the earth's atmosphere and the electric fields around the planet. Four smaller sub-satellites will be ejected from the mother spacecraft to monitor the explosions. Scientific instruments for the Canadian sub-satellite are being supplied by the Herzberg Institute and NASA. Design, manufacture and integration of the sub-payload are being carried out by SED Systems Limited under contract to NRCC's Space Research Facilities Branch. The Canadian experiment will measure charged particles in the Van Allen radiation belts around the earth and their response to the chemical releases. Scientists will also monitor energetic particles closer to the earth which cause aurora or Northern lights.

NRCC is one of several groups participating in the preparation of support and experimental packages for the international solar polar mission, a joint effort by NASA and the European Space

Agency. The deep space mission will fly a pair of spacecraft over the poles of the sun via Jupiter and provide scientists with an entirly new view of the solar magnetic fields, the corona of the sun and the solar wind. This dual probe will be launched from one of the Space Shuttles utilizing the RMS designed by a Canadian industrial team under contract to NRCC. A particle telescope, to measure cosmic ray activity throughout the mission and provide a profile of the influence of outbound solar particles, incorporating new design characteristics, is being prepared by the HIA. Also, computer-based ground support equipment is NRCC's responsibility.

Space Research Facilities Branch (SRFB)

A significant change in the mode of support provided by SRFB for rocket, balloon and ground-based experiments occurred during 1979. The change shifts the emphasis towards a campaign mode of operation and coordinated scientific measurements to study specific phenomena, e.g. pulsating auroras, field-aligned currents, etc.

During 1979, a total of five rockets and four balloons were launched under SRFB auspices. In additiona, SRFB supported a large USA program of 34 rockets launched into the solar eclipse which occurred on 26 February 1979. One of the Canadian rockets was also launched into the solar eclipse. The program was conducted from sites near Red Lake in northwestern Ontario. An important feature of the successful program was the launch of 12 rockets in succession within a 36-minute interval centered on totality.

National Aeronautical Establishment (NAE)

Teleoperator Remote Manipulator System (RMS)

The Shuttle Remote Manipulator System, a major R&D program begun in 1974, is now in its final phases. The program is an example of both international cooperation and NRCC laboratory interaction with Canadian industry. The first flight unit is expected to be delivered to NASA in 1980.

In May 1979, NASA placed a contract through the Canadian Commercial Corporation with Spar Aerospace Limited for Remote Manipulator Systems to equip the Orbiter fleet. The spin-offs resulting from the establishment of this technology in Canada include manipulators in space, for underwater applications, wheelchair manipulators and manipulators to facilitate retubing of Candu reactors.

Dynamic Stability of Aircraft

A cooperative program with NASA aimed at determining certain dynamic stability parameters for modern fighter aircraft and the Space Shuttle Orbiter vehicle is in progress at the National Aeronautical Establishment in collaboration with the Goddard Space Flight Center.

Non-cartographic Applications of Photogrammetry

The National Aeronautical Establishment has also developed techniques of photogrammetry common to aerial mapping and surveying to be applied to non-cartographic uses. These techniques are now being considered for a variety of applications including Remote Manipulator Systems to facilitate grappling, manipulation and positioning of objects in space.

DEPARTMENT OF COMMUNICATIONS (DOC)

General

The role of the Department of Communications is to foster the orderly development and operations of communications for Canada in the domestic and international spheres. In DOC, these responsibilities are carried out by the Space Sector which is responsible for the planning, development, coordination and implementation of policies and programs to meet Canada's needs in the field of space telecommunications, development and coordination of plans and procedures to provide for optimum participation by Canadian industry in the design, development and construction of Canadian satellite systems.

Besides recommending policies and coordinating and supporting the development of space communications facilities and services in Canada, DOC explores and supports the development of new applications technology through activities at its Communications Research Centre (CRC) and through contracts to private Canadian companies. The latter are essential to maintain an effective industrial base to serve the domestic and export markets.

HERMES

The HERMES satellite resulted from a cooperative program between the Department of Communications and NASA, with the participation of the European Space Agency (ESA). The spacecraft was

launched in January 1976 for a planned two-year mission in geostationary orbit, 36,000 Km. above the Equator at 116° West longitude. The performance of the spacecraft was such that its operation was extended into a fourth year, well beyond the original two-year planned mission lifetime. Unfortunately, a satellite malfunction occurred on 24 November 1979. Efforts over a one-month period to recover control of the satellite were unsuccessful and all HERMES operations ceased on 23 December 1979.

HERMES Experimental Program

From the beginning of the experimental period in 1976 to the end of June in 1979, a total of 37 Canadian communications experiments were performed successfully using HERMES. Of these, 22 experiments were of a social nature demonstrating services for tele-education, telemedicine, community interaction, administration, and radio/TV broadcasts. There were 15 technical experiments involving terminal evaluation, data modems, multiple access communications, propagation, precision measurements and computer communications. Experiments were conducted by universities, hospitals, federal and provincial departments and agencies, native institutions and industry. Similar experiments were performed in the United States on alternate days.

In 1979 in Canada, the emphasis of the experimental program shifted toward demonstration and evaluation of TV transmissions to small low-cost television receive-only (TVRO) terminals in Eastern Canada and to international demonstrations in countries planning for the use of 12 GHz satellite systems. The remaining four of the originally-planned technical experiments were completed during the first six months of the year.

In the field of technical experiments, the Communications Research Centre (CRC) continued experiments in terminal evaluation and gathering statistical data on propagation effects. The University of Toronto, in cooperation with organizations operating radio-telescopes at Green Bank, West Virginia, Algonquin Park, Ontario, and Owens Valley, California, continued an experiment using HERMES to perform real-time correlation of broad-band signals, to investigate the structure and the variability of a number of extra-galactic sources. The National Research Council (NRCC) in Ottawa, in cooperation with the National Bureau of Standards in Denver and the United States Naval Observatory in Washington, D.C., used HERMES to measure the difference between time standards to an accuracy of 5 nanoseconds, complementing a similar measurement between NRCC and France using the Symphonie satellite.

Over the first six months of 1979, a Program Delivery experiment was successfully conducted using the 9 m terminal at CRC as the uplink station. Educational programs from the Ontario Educational Communications Authority (OECA) were transmitted by HERMES to 1.2 m and 1.6 m TVRO terminals located in remote Ontario communities, while programs from the CBC Northern Service were transmitted by HERMES to 1.6 m TVRO terminals located in remote communities in Labrador, to test the capabilities of low-cost earth terminals to receive CBC network programs and educational school services and to evaluate the video quality and performance of the TVRO's when used by unskilled persons, in a range of climatic conditions.

After the completion of the extended experimental program, the satellite was moved in July 1979 to 142° West longitude for use in a series of demonstrations in Australia. For these, low-cost TVRO and telephony terminals were installed and used in 47 different locations in Australia. Video tapes of Australian programs were used for the TV demonstrations. Telephony demonstrations were conducted between the terminals in Australia and Canada and three video teleconferences were held on the subjects of fibre optics, telemedicine and tele-education. During this experimental period, the use of Telidon was demonstrated. At the conclusion of the Australian demonstration, a TVRO was installed in Papua - New Guinea for a brief TV demonstration similar to those provided to Australia. The demonstrations provided the Australians with an excellent opportunity to evaluate the use of satellite communications using the 12 GHz band. A final series of tests, which was planned to evaluate the effects of tropical rainfall in Australia on 12 GHz signals, was not completed due to the final satellite malfunction.

There were several other brief communications demonstrations to Canadian and foreign officials, experts and laymen throughout the year using HERMES. These demonstrations and teleconferences served to provide international and national visibility to the progress of communications by satellite in Canada and the services that this technology can provide.

ANIK-B Communications Program

In 1977, DOC signed an agreement with Telesat Canada to lease the 14/12 GHz portion of Telesat's ANIK-B satellite, launched in December 1978, for two years commencing in early 1979, with an option for a further three years. The lease provides facilities for DOC, in cooperation with other Canadian agencies, to conduct

communications pilot projects to follow on from the promising HERMES' experiments.

DOC invited proposals for pilot projects to test the provision of new services by communications satellites under close to normal operating conditions. The projects will continue for an extended period so that user agencies can determine how to make the most effective use of the satellite communications medium, and can evaluate benefits and limitations with respect to their particular operations. Seventeen pilot projects were accepted by DOC, categorized under the general headings of telehealth, tele-education, public telecommunications applications, advanced technology experiments and television program delivery.

The earth terminals used in ANIK-B projects were mainly provided by DOC. Antenna sizes, in addition to the 9-metre two-way terminal at CRC, included 1.2 metres, 1.8 metres, 3.0 metres and 3.7 metres for TV reception, interactive programs, TV transmissions, etc., as appropriate.

In 1979, in the field of telehealth, ANIK-B was used to provide a two-way video service for tests of medical diagnosis, treatment and continued medical education. The project involved Sacré Coeur and Hôtel Dieu hospitals (Montréal) as well as a hospital at LG-2 (James Bay Development Project) and the University of Montreal. In a separate audio phase of this project, the hospital at LG-3 was added into the network. This phase will continue in 1980.

In the field of tele-education, ANIK-B was used to demonstrate delivery of selected programs to remote communities in the provinces of Quebec, Ontario, British Columbia and the Yukon. In Quebec, the offices of the Ministry of Education of Quebec (MEQ) had a two-way video teleconferencing capability with the school at LG-2. A separate audio phase of this project, which was started late in the year, will continue in 1980. In Ontario, ANIK-B was used to transmit selected educational programs prepared by the Ontario Educational Communications Authority (OECA) to terminals in Geraldton, Marathon, Owen Sound and Manitouwadge to demonstrate a method for improved program delivery and to provide for tests of interactive programming. A terminal installed at the B.C. Institute of Technology in South Burnaby was used, via ANIK-B with interactive terminals at colleges in Cranbrook, Prince George, Dawson Creek, Whitehorse, Terrace and Port Alberni in a pilot project demonstrating education over large distances. TVRO terminals at Fort St. John, Fort Nelson, Prince Rupert, Gold River and Mackenzie also participated in this project which will continue in 1980.

ANIK-B was used for projects in public telecommunications in Quebec and Ontario. MEQ used interactive video and audio links between its offices and the school at LG-2 (as noted above) for administrative purposes. In Ontario, the Ministry of Government Services used terminals at Toronto, Thunder Bay and Sault Ste. Marie for teleconferences and administrative services using ANIK-B. This project will continue in 1980.

In the field of technology, the Communications Research Centre continued experiments in terminal evaluation, development of transmission methods and gathering information on propagation effects. The University of Toronto, in cooperation with the Algonquin Radio Observatory (Algonquin Park), Naval Research Laboratory (Washington) and the Dominion Radio Astrophysical Observatory (Penticton) performed an experiment using ANIK-B on phase-coherent long-baseline interferometry. The experiments will be continued with further tests planned in 1980.

In 1979, a Program Delivery Pilot Project (PDPP) using ANIK-B was begun in Ontario and British Columbia, the Yukon and Northwest Territories. In this pilot project, to test the broadcasting of TV signals to low-cost TVRO terminals, OECA programs were transmitted to terminal head ends, in 14 Ontario communities. Additionally, television programs were broadcast directly to a terminal located at the home of the King family in Macdiarmid. The project will continue in 1980 with the planned installation of up to 40 terminals. In the west, two programs supplied by the CBC and BCTV in British Columbia were broadcast via one transponder on ANIK-B to other TVRO terminals installed in British Columbia and Whitehorse and Yellowknife. More terminals are scheduled to be added to this project in 1980.

In addition to the formal pilot projects, ANIK-B was used, beginning in February 1979, once per week on the average to demonstrate 12 GHz transmission to a number of locations such as Montreal, Toronto, Ottawa, Saskatoon, and CRC. The audience for these demonstrations was both national and international and included officials from governments, industry, universities and various agencies involved with communications, science, regulation, broadcasting, etc. These demonstrations, which typically are of a 1-2 hour duration serve as a highly-effective method to give visibility to the Canadian work in the field. As such, it is expected they will continue in 1980 and a short period of each working day is set aside for this purpose as well as for tests and technical developments.

Experimental Use of SYMPHONIE Satellite

During 1979, the cooperative experimental program utilizing the Franco-German SYMPHONIE satellite was continued. There was a live transmission of the Radio Canada, French network coverage of the May elections to the Canadian Embassy in Paris. On the occasion of a UNESCO conference in Ottawa, there was a two-way video and audio connection between Ottawa and Paris. An extended experiment was continued in which clocks at the NRCC, Ottawa and B.I.H., Paris were compared. Teleglobe is responsible for providing earth terminal facilities to non-government users, while DOC is responsible for approving experiments and for providing facilities for government-sponsored experiments.

SARSAT

The experimental satellite-aided Search and Rescue System (SARSAT) is a joint Canada, France, U.S.A. project to provide a demonstration and evaluation of the use of satellites for the purpose of detecting and locating existing emergency radio beacons operating at 121.5 MHz and 243 MHz and experimental beacons at 406.1 MHz. In Canada, coordination of the joint project is being carried out by an Interdepartmental Review Board with DND being the lead department and with participation by the Departments of Communications, Fisheries, Transport, Supply and Services, and Industry, Trade and Commerce. A SARSAT project management organization is now operating.

European Space Agency (ESA) Agreement

An Agreement of Cooperation between Canada and the European Space Agency (ESA) came into force on 1 January 1979.

Within DOC, the identification and coordination of possible general studies contracts and new cooperative activities with ESA is an ongoing activity. Indeed, following review of the possibilities of cooperative projects with ESA in 1979, DOC proposed participation in the definition phase of ESA's Large Satellite (L-SAT) Communications Satellite program. Approval for Canadian participation in this program is expected in early 1980.

Mobile Communications Satellite Program

MUSAT is a new type of geostationary satellite system in planning in Canada to meet the needs of the military and of civil

government departments for UHF mobile satellite and other specialized communications services, especially in the Canadian North, in remote areas, and in coastal waters. The primary function of MUSAT would be to provide two-way voice and low-rate data communications to ships, aircraft and lightweight manpack stations for use in field operations.

MUSAT differs from the ANIK satellites in many respects. In its primary role, it would utilize frequencies in the 240-400 MHz band in comparison to the ANIKs which operate in the 4/6 GHz and 14/12 GHz bands. While different, the MUSAT and ANIKs are complementary in their functions. Where the ANIKs provide commercial fixed-satellite and broadcasting satellite services in the 4/6 GHz and 14/12 GHz band to act among a network of fixed earth stations, MUSAT would provide UHF mobile satellite service to ships, aircraft, and land mobile stations and military 7/8 GHz fixed satellite service. Other services which could be provided by MUSAT include UHF data collection from fixed and mobile meteorological and earth exploration sensors, monitoring of UHF emergency radio beacons and L-band maritime mobile-satellite service.

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

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

Earth station hardware feasibility studies have included the development of a prototype channel unit and a deployable antenna for the transportable terminal. Tests of the completed units have been made over the FLTSATCOM satellite. DAMA software for the unit is being written under a current contract. The antenna is being further developed mechanically and the gain is being reduced to 10 dB minimum as a result of new system design criteria.

Space Industry Development

In 1978 and 1979, landmark decisions were made by the government on the future of the Canadian space industry, which will lead directly to the establishment of a Canadian prime contractor for satellites. In particular, the government approved a program which was designed to support Canada's space endeavours by providing the required integration and test facilities at the David Florida Laboratory; by providing support to Telesat Canada in placing the prime contract for the ANIK-D satellites with SPAR Aerospace Limited; and by authorizing the Minister of Communications to enter into contracts to provide for the integration and partial test of the third ANIK-C spacecraft in Canada.

ANIK-D Prime Contract

Telesat's ANIK-D satellites will be needed for 1982 to continue and extend the 6/4 GHz service currently provided by the ANIK-A satellites. A contract was awarded to Spar Aerospace Ltd., by Telesat in early 1979, for the design, construction and supply of two ANIK-D satellites. This was the first prime contract for satellites awarded to a Canadian firm and was the culmination of earlier government decisions to establish a Canadian prime contractor capability.

ANIK-C Integration and Test

Telesat's three ANIK-C satellites will operate in the 14/12 GHz band, providing heavy-route message services, broadcasting to cable and head ends and other possible new services beginning in 1982. In 1979 the government also approved a plan whereby SPAR would integrate and partially test the third ANIK-C spacecraft in Canada (Hughes Aircraft Co. will be integrated and testing the first two ANIK-C spacecraft). This exercise is a valuable and necessary learning experience for the industry as it gears up to become prime contractor for the ANIK-D program.

Industrial Technology Development

DOC also administers a space industry technology development program, begun in 1976, to encourage industry to develop components and subsystems expected to be required for future Canadian and export satellite programs. About $2.0 million was contracted to Canadian firms during 1979/80, and the same amount is budgeted for 1980/81.

This program, which is consistent with the government's contracting-out policy, includes:

- an SHF space technology development effort, to help Canada maintain its competitive position in 14/12 GHz satellite components and subsystems; together with an extension of this work to higher frequencies (20-30 GHz) likely to be used in the future;

- development of new technology applicable to small SHF earth terminals for direct-to-home TV, CATV and radio and telephony applications;

- spacecraft power systems technology, including new electronic battery management systems;

- feasibility studies and development of advanced electronic components, including gallium arsenide (GaAs) field effect transistors (FETs), for use in satellite transponders, earth terminals, and emergency locator transmitters;

- work on dynamics and control systems technology required for future commercial communications satellites and other Canadian spacecraft.

Teleglobe

Teleglobe presently owns and operates four Standard "A" (INTELSAT type) earth stations: two at Mill Village in Nova Scotia, one at Lake Cowichan on Vancouver Island, British Columbia, and the Laurentides earth station located near Weir, Quebec.

The Mill Village I and II earth stations were built in 1965 and 1968 respectively. They are presently providing the satellite telecommunications traffic to and from countries of the Atlantic Ocean region.

The Lake Cowichan earth station, which was completed in 1972, is providing satellite telecommunication traffic to countries of the Pacific Ocean region. The Lake Cowichan site is jointly shared by Teleglobe Canada and Telesat Canada.

The Laurentides earth station was brought into service in mid-August 1979. This station, located in the Laurentide region of Quebec, just north of Montreal, was established to access the third operational Atlantic Ocean Region satellite.

The antenna at this earth station is 32 metres in diameter and is a wheel and track design utilizing a beam waveguide technique to pass the signal from the base mounted feed to the antenna

subreflector. It is also capable of operating in a dual polarization frequency re-use mode compatible with the future INTELSAT V satellites.

To meet the forecast traffic requirements, the Laurentides earth station was initially equipped with fourteen operational and two standby receive chains, and four operational and one standby transmit chains. This station is linked to the Montreal and Toronto switching gateways via the domestic microwave network. SCPC (single channel per carrier) type operation is scheduled for December 1979. Initially, this system will consist of six voice channel units with the intention of expanding it to a total of twenty-two voice channel units by early 1980.

During the early part of 1979, the monopulse tracking systems for Mill Village I and II were modified for step tracking systems, a new thermoelectrically-cooled low noise amplifier system (40° K) and a new feed were installed in Mill Village II. These modifications to the Mill Village operations were part of Teleglobe's refurbishing and betterment programs to maintain a high standard of operational reliability and service.

Propagation studies in the 14/12 GHz band have continued in 1979. These studies were originally scheduled to end in 1980, however they have now been extended to 1981 in order to acquire as much statistical propagation data as possible. The data collected from these radiometer installations in Quebec and Ontario will be used to determine the need for space diversity earth stations when Teleglobe decides to implement such operations in the 14/12 GHz band.

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 area maintains a sufficient level of expertise to be able to provide advice, keeps abreast of international

developments in satellite communications and associated technical fields, carries out studies in support of planning and policy development, and manages contracts to industry and universities.

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

Space Electronics

The Space Electronics directorate is concerned with the development and reliability assessment of advanced electronic technology and hardware to meet future space communications requirements. Some areas of current concern are small earth terminals for TV receive only and two-way telephony applications; satellite antennas, transponder components, solid state power amplifiers and satellite switched time division multiple access hardware; and satellite power subsystem components including high reliability battery management systems.

During 1979, the directorate was involved with many activities among which one can mention:

- the continuation of in-house and industrial studies on the development of new and advanced spacecraft transponder elements;

- the start of new in-house work on component development for the application of direct RF modulation/demodulation techniques to communications spacecraft at microwave frequencies;

- the completion of the DOC-funded industrial development of a demonstration transponder for Direct Broadcast Satellite applications at 12/14 GHz. This unit uses a passively-cooled (-100° C) all-FET receiver front-end;

- the start of in-house development of a 14 GHz solid-state TWTA replacement amplifier with 1W output, for application to two-way telephony terminals. DOC-funded contracts were awarded to Canadian industries for the development of advanced components to increase the efficiency and reduce the cost of small television receive-only terminals (TVROs).

In-house studies on lightweight spacecraft lens antennas have resulted in the development of a model with improved cross-polarization properties, for which a patent application has been filed. A DOC-funded contract was let to SPAR Aerospace Ltd., to develop the use of dichroic surfaces for spacecraft antennas.

In the area of spacecraft power systems technology, a DOC-funded contract was awarded to Canadian Astronautics Ltd., to develop a high-reliability battery management system to engineering model standards. In-house work was concentrated on the development of a high-efficiency 250W DC/DC power converter.

In the areas of Ultra High Frequency (UHF) and digital communications, development and fabrication of the RF/IF portion of a Slim-TDMA terminal for use with ANIK-B was completed. Design and fabrication of a laboratory test unit (LTU) 406 MHz Emergency Locator Transmitter (ELT) was also completed and made available for incorporation into the SARSAT simulation test facilities. Approval has been obtained to proceed with the industrial development of ELT electronics starting in 1980 using DOC funds.

An essential component of ELTs and EPIRBs (emergency position indicating radio beacon) is an ultra-stable frequency source (oscillator) which exhibits high stability with temperature changes, low power consumption, and is low cost. A technique was developed to realize these requirements and a digitally temperature-compensated crystal oscillator was designed and fabricated.

Steps were taken to establish a Canadian Industrial source for Gallium Arsenide field-effect transistors (GaAs FET's). Optotek Ltd. submitted a proposal to DSS in November 1978 to develop power GaAs FET technology. However, this proposal was not immediately supported because no single Government department appeared to have the mandate to establish the creation of such a capability. However, during 1979, a study paper was written and a phased development proposal involving DSS, DND and DOC funding was presented for Senior Management approval. This approval has been granted in principle by all concerned departments, and a May 1980 contract start date is expected. The value of the first 2 phases of the contract is $2.2M and will run until 1983. The CRC contribution will be in the areas of device design, some fabrication support, RF testing and reliability studies.

Investigations of other device technologies of interest to the Space Program were also carried out in 1979. This included I^2L logic, surface acoustic wave (SAW) devices, VMOS power devices and microprocessors.

Space Mechanics

The Space Mechanics directorate is concerned with spacecraft system design, attitude and orbit determination, prediction and control, and mission dynamics. These tasks require a capability in spacecraft thermal materials and mechanical design, control system design, propulsion technology, and analysis of mission dynamics and orbital operations.

During the past year, a high power solar array structure (developed by SPAR Aerospace Ltd., of Toronto) has been fabricated and assembled in-house. In addition to successful preliminary tests already accomplished, extensive qualification tests will be completed in 1980.

An advanced attitude control system intended for spot-beam communications satellites has been developed in industry, through the conceptual design and analysis phases. In addition to the unique demands of the spot-beam, this control system will maintain gain control as well as low susceptibility to flexible structure influences present in large spacecraft. During the next year, components will be selected or developed for this control system; also, its application to specific satellite programs such as the ESA L-SAT Program will be studied. This work is supported by a system simulation facility at CRC, using a hybrid computer and a precision inertial test simulator.

The thermal control of complex spacecraft with high power payloads presents critical thermal problems to the satellite in its space environment. The first phase of design for an advanced heat pipe system intended for advanced spacecraft was successfully completed in industry. During the next year, the design concepts will be applied to new requirements typical of future spacecraft such as MUSAT and L-SAT.

CRC continues to be active in the development of computer programs for the determination and prediction of spacecraft orbit and attitude, especially in subsynchronous, inclined orbits. These programs are needed for future Canadian space programs for communications, search and rescue, and remote sensing. CRC continues to provide technical assistance to, and membership in, the working group of the United Nations Committee on the Peaceful Uses of Outer Space, in assessing the unforeseen risks of nuclear-powered satellites.

Space Systems

The Space Systems directorate is concerned with concept development and design of communications systems and major subsystems and with proof-of-concept experiments. In 1979, the directorate continued its studies to support applied research and development related to communications processing techniques, including voice codecs, channel modems, and security subsystems for small terminals and mobile satellite communications systems. The techniques studied are applicable to a variety of systems including ANIK, MUSAT and military satellites. In addition, non-satellite applications, such a mobile communications, are served by developments in these studies.

For mobile communications, such as to aircraft, ships and transportable stations, it is impractical to use the large steerable high-gain antennas of conventional earth terminals. A basis is being developed for the design of systems for such programs as MUSAT, maritime mobile systems, and navigation systems such as NAVSTAR. Methods are investigated for using lower frequencies and modulation techniques capable of operating at low signal-to-noise ratios. With the recent WARC 79 allocation of the 806-890 MHz band for public mobile satellite use as well as land mobile, studies have started on the potential applicability of satellite systems to satisfying future public needs for mobile communications.

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

Within Space Systems, a SARSAT technical office (STO), has been established to carry out the technical tasks which DOC has undertaken under the DND/DOC SARSAT agreement. The technical tasks being carried out by the STO include:

a) System design and implementation coordination with NASA and CNES;

b) Preparation of specification and procurement documentation and test documentation for hardware being developed and supplied by Canada;

c) Monitoring of contracts for development and delivery of three SARSAT repeaters, ground support equipment, three life-tested L-band transmitters, a SARSAT ground station, and a mission control center;

d) Pre-launch simulation and tests, and post-launch system performance verification tests;

e) Assistance to DND in planning and implementing the demonstration and evaluation phase after the first SARSAT launch in April 1982.

Digital and analog techniques to provide voice privacy are being investigated at CRC. Voice coding, security, and modem subsystems were developed, tested and reduced to LSI. Successful field trials of a digital voice privacy technique were conducted during 1979. Final design iterations are underway with pre-production model trials scheduled for late FY 80/81.

David Florida Laboratory (DFL)

The DFL is maintained by DOC as a national facility for the environmental testing and integration of satellites and space hardware. In 1978 the decision was taken to expand these facilities to permit complete integration and testing of the large communications satellites which will be carried in the Space Shuttle. As a result, the building has been extended by 1700 square metres and new items of equipment are being added which include a vibration tester with a capacity of 178 KN sinusoidal and 160 KN random and a large thermal vacuum chamber with dimensions 6.7 x 10.7 m. This expansion program will be completed by January 1981.

The capabilities of the future facility when completed will be:

Thermal vacuum chambers

- 6.7 m dia. x 10.7 m high
- 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
- 1 m dia. x 1 m long
- Vacuum to at least 10^{-7} torr in all chambers

- Temperature range -195° to +150°C in all chambers
- Automated temperature scanning, monitoring and recording (digital format) for 300 channels of data.

Vibration equipment

- 178 KN sinusoidal system
- 164 KN random system
- 53.8 KN sinusoidal system
- 44.8 KN random system
- 27 KN sinusoidal/random system
- Systems can monitor up to 54 accelerometer channels simultaneously
- Real-time analyser available for data analysis

RF facilities

- Screened room for RFI/EMC testing to MIL STD 461/462
- 6 m x 6 m x 7 m and 12 m x 12 m x 12 m shielded anechoic chambers with -50 dB reflector coefficient from 1 GHz to 20 GHz and associated 410 m antenna range

High bay area

- 30 m x 12 m x 10 m high (each of two areas)
- overhead cranes
- air-cleaning equipment
- Ground support facilities

During 1979, the environmental testing laboratory was used almost exclusively in support of the Space Shuttle Remote Manipulator System (SRMS) Program, for which NRCC is the lead agency. Precise scheduling of activities, however, permitted other testing to be performed for the Tracking and Data Relay Satellite System (TDRSS) transponder system and other research projects. The RF facilities of the DFL were heavily used during 1979 in support of projects for Canadian Marconi Company and the Departments of Communications and National Defence.

High Reliability Laboratory (HRL)

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

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

In the past, extensive use of the facility has been made in pioneering work on the reliability of GaAs FETs for space use. These devices are now rapidly displacing travelling wave tubes in satellite and earth terminal subsystems such as SHF amplifiers and oscillators. During the past year, a considerable number of destructive physical and failure analyses were undertaken on components and devices for the Shuttle Remote Manipulator System in support of NRCC and the Canadian prime contractor, SPAR. Support was also provided to SPAR and Telesat Canada in the assessment of devices for the ANIK-B spacecraft, and there will be a significant increase in the level of activity as work proceeds with the ANIK-C and D programs.

International Satellites for Ionospheric Studies (ISIS)

Operations of ISIS-I and ISIS-II continued successfully throughout 1979. With these satellites in their eleventh and ninth years of operation respectively, ionospheric data were obtained for an average of 3 to 4 hours per day during the year.

Two additions of an international nature were started during the year. In the first, data were collected at the CRC ground satellite control centre from the Japanese ISS-b satellite beginning in April and shipments of data to Japan began in the following month. In the second, ISIS-II was operated to obtain specifically-relevant data for the American MAGSAT program which began in November.

The DOC satellite data acquisition facility in Resolute

Bay was closed down in August. In October, the number of operating staff at the CRC satellite ground centre was reduced. As a consequence, the number of weekly shifts available to obtain data from the ISIS and ISS-b satellites was reduced to 10 from 21. The data acquisition support by the NASA Space Tracking and Data Network terminated in October 1979, thus suspending collection of ionospheric data using the ISIS satellite over European and the North-West areas of North America. However, because of the continuing interest of DND, NRCC and the international scientific community, it has been decided to continue operation of the ISIS satellites and collection of the data for worldwide use will continue in 1980. DND and NRCC are contributing to the funding of the continued operation.

DEPARTMENT OF ENERGY, MINES AND RESOURCES (EMR)

General

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

The Canada Centre for Remote Sensing (CCRS)

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

effort through the working groups of the Canadian Advisory Committee on Remote Sensing (CACRS).

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

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

To carry out its mandate, CCRS has two earth receiving stations, one in Prince Albert, Saskatchewan, and the other in Shoe Cove, Newfoundland, both capable of receiving, recording, reproducing and distributing LANDSAT and NOAA satellite data to Canadian users. The stations provide "quick-look" black and white imagery of Multispectral Scanner (MSS) data, near real-time data through facsimile transmission, computer compatible tapes and microfiche. The Prince Albert station also provides high resolution black and white or colour imagery and Return Beam Vidicon (RBV) imagery from LANDSAT.

CCRS facilities also feature:

a) an Image Production System for satellite data capable of generating high resolution black and white film from bulk tapes, of making radiometric and geometric corrections and of generating colour composites;

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

c) digital and visual analysis systems to allow users to analyse remote sensing imagery from satellite and aircraft sensors;

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

e) a sensor and systems development laboratory providing for the engineering and of onboard computer and data acquisition systems, sensor interfaces, navigation systems and aircraft modifications.

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

LANDSAT

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

The Centre has been receiving and processing LANDSAT data since the first satellite in the series was launched in 1972. The currently-active spacecraft are LANDSAT-2 and LANDSAT-3. The two satellites together provide complete coverage of Canada at least once every nine days.

Data on Canada is received at two ground stations located in Prince Albert, Saskatchewan, and Shoe Cove, Newfoundland. These stations received and processed 1,800 LANDSAT orbits during 1979, resulting in the reproduction and sale by private industry of over 15,000 satellite image prints as well as 300 computer compatible tapes. In addition, following the launch of LANDSAT-3 in March 1978, the Centre started receiving and processing RBV data from this satellite. RBV data have a ground resolution of 30 m in panchromatic mode, as opposed to the 80 m resolution of the multispectral data, thus opening new possibilities in the area of thematic mapping at larger scales. Finally, as part of a continuing effort to meet user requirements, a laser beam image recorder was put in operation at Prince Albert, allowing the entire processing of standard LANDSAT data to be done on-site, thus reducing turn-around time to all users working on dynamic phenomena, ranging from hydrological systems to vegetation monitoring.

SURSAT

The Canadian Surveillance Satellite (SURSAT) Program, originating in 1977, was largely completed in 1979, aside from detailed documentation of results. The program investigated the value of microwave devices, space and airborne, for a number of applications principally oriented to oceans, ice, and human activities off-shore and in the Arctic. It involved the use of data acquired by SEASAT-A, a proof-of-concept NASA satellite, as well as underflights using the EMR long-range Convair 580. Both the

satellite and aircraft were equipped with Synthetic Aperture Radars and other microwave devices. Within the design restrictions imposed by the SEASAT-A characteristics (L-band operation and 20° angle of incidence), the program was extremely successful, providing a wealth of hard facts and information to the research and operational agencies involved, pointing out the technological options to be included in future systems in order to meet user requirements. Important industrial spin-offs were also achieved in the areas of radar development, operations and processing.

It was concluded in the final report on the SURSAT Program that a further period of development and experimentation with the Synthetic Aperture Radar would be in Canada's interests. The experiments undertaken demonstrated promise that the images from this all-weather sensor could provide information required by operational agencies for monitoring of ice coverage and drift, detection and location of human activity in coastal and ocean areas, and could aid surveillance of ocean pollution as well as monitoring land resources.

The SURSAT Program also explored the capabilities of spaceborne radiometers, scatterometers, and altimeters to monitor weather, sea state, and ice parameters. In particular, the abilities of these sensors to measure ocean surface wind speed and direction, and ocean wave height to desired accuracies were demonstrated.

A report to the Cabinet on the results of the experimental program was prepared for submission in late 1980.

DEPARTMENT OF NATIONAL DEFENCE (DND)

General

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

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

a) with the USAF in its development of a world-wide satellite navigation system, the NAVSTAR Global Positioning System;

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

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

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

Base

Research on military communications, including satellite communications, is carried out for DND by the Communications Research Centre (CRC) of the Department of Communications, and is monitored by the Defence Research Establishment Ottawa, which adjoins the former on the same site. Space-oriented development projects are managed within DND, but technical support frequently is provided by CRC on a cost-recoverable basis.

NAVSTAR Global Positioning System

NAVSTAR/GPS is a multi-billion dollar research and development program initiated by the United States to satisfy the position - location and navigation requirements of the U.S. armed services. When it becomes operational in 1987/88, NAVSTAR/GPS will consist of 24 satellites continuously broadcasting position data to users with special receivers. Three-dimensional accuracies of better than 10 m have been demonstrated in the concept validation phase of the program. The U.S. Department of Defense received approval in July 1979 to proceed with the second phase of the program, full-scale development and testing. Contracts have been let to Rockwell for satellite production and to Magnavox and Collins for development and construction of a variety of prototype, operational receivers for users.

It is expected that NAVSTAR/GPS will become the primary navigation aid of the future causing the gradual phasing out of such systems as LORAN, OMEGA, DECCA, TACAN and TRANSIT. With this in mind, DND has entered into a bilateral understanding with the U.S. for the development of military receiver equipment in Canada. Another understanding has been signed with nine other NATO countries to foster widespread use of the system and effect standardization and interoperability in NATO.

Canadian Marconi Company (CMC) is under contract to DND to design and develop receivers for use with NAVSTAR/GPS. After prototype delivery, an extensive test and evaluation will be carried out to verify and refine the design before follow-on procurement.

CRC has also been carrying out studies for DND in connection with the NAVSTAR Global Position System (GPS) being implemented by the USAF. Activities at CRC include GPS performance evaluation at high latitudes and support of contract studies for user terminals.

The technology being developed at CMC will place this company in a strong position to market their receivers world-wide, thereby maintaining their present reputation as a world leader in navigation systems. The benefit for DND and Canada will be a Canadian source for procurement and life-cycle support.

The Departments of Transport and Energy, Mines and Resources are actively monitoring the progress being made with a view to participating in the development of receivers for civil aviation and geodetic use. CMC, itself, is expected to expand their activity to marketing a broad line of NAVSTAR/GPS equipment.

Search and Rescue Satellite (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. Satellites offer the possibility of monitoring Emergency Locator Transmitter (ELT) transmissions throughout the Canadian search and rescue area of responsibility.

A memorandum of understanding was signed by NASA (USA), CNES (France) and DOC (on behalf of the Canadian interdepartmental participants, DND, DOC, DFE and MOSST) in August 1979, to cover cooperative development of a satellite-aided detection and location system. DND is the lead department. Negotiation of an understanding with the Soviet Ministry of Merchant Marine (MORFLOT) was initiated for joint demonstration and evaluation of the SARSAT system and a compatible MORFLOT system, COSPAS.

Canada will supply repeaters for installation on three TIROS weather satellites to be operated by NOAA. CNES will supply onboard processors which will permit ELT signals to be recorded and stored over the oceans, and subsequently retransmitted to a ground station at the first available opportunity. The three participants will be responsible for provision of their own ground stations. First SARSAT launch is scheduled with NOAA-E early in 1982. A 15-month demonstration and evaluation will follow in cooperation with operational user agencies. The Memorandum of Understanding was signed on 27 August 1979.

Surveillance Satellite Experiments (SURSAT)

The Department of National Defence participated with various other federal government departments in this project designed to examine the use of satellite data to assist in meeting Canadian surveillance requirements. The project, which officially terminates on 31 March 1980, involved experiments with NASA SEASAT-A satellite data and an airborne synthetic aperture radar (SAR) flown on an EMR Convair 580 aircraft. The experiments were largely a success in that they whetted the appetite of those involved to pursue further work on the use of satellite surveillance for a rather diverse list of surveillance requirements.

For DND, results from SEASAT-A were inconclusive. The SAR was not designed to monitor the type of human activity that is of particular military interest. Enough evidence was gathered though to suggest that a satellite SAR designed for that purpose would be very useful. Further study has been recommended.

Of greater immediate applicability to military surveillance was the potential shown by the airborne SAR portion of SURSAT. With its ability to penetrate weather and darkness and operate in a stand-off mode, SAR may be very useful for both tactical and strategic purposes as a supplement to present methods. Significant follow-on effort is planned for developing a DND airborne SAR capability.

Spacelab

The joint proposal by the Massachusetts Institute of Technology (MIT), the Defence and Civil Institute of Environmental Medicine (DCIEM) and McGill University to NASA to carry out studies in vestibular physiology on Spacelab has progressed satisfactorily. Tentative launch for Spacelab I is now April 1982. The flight crew for Spacelab I visited DCIEM for four days in February 1979 for training in the Space Sled linear acceleration experiment, the orientation experiment and the motion sickness experiment. A second training session is planned to familiarize the crew with the gradual onset of motion sickness by exposure to head movement by wearing special spectacles. DCIEM scientists visited NASA, Houston to participate in some zero "G" parabola flights to measure the astronauts' susceptibility to motion sickness and to attend the NASA Critical Design Review for equipments to be built for the DCIEM experiment by SPAR Aerospace. Contracts for these equipments have been let and delivery is expected shortly. Procurement problems with the Space Sled, which is being supplied by the European Space Agency, have been solved.

SPADATS (Space Detection and Tracking and Identification)

Canada participates in SPADATS through its involvement in NORAD which has operational responsibility for the system. There are two NORAD monitoring systems in Canada equipped with Baker 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.

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

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

Canadian Shipborne Satellite Terminal (CSST)

A versatile experimental UHF shipborne terminal capable of operating over the US FLTSATCOM system and the potential Canadian MUSAT was assembled at the Communications Research Centre and tested on two Canadian naval vessels. As part of the technical evaluation a double-hop voice circuit was established with the Weapons Research Establishment in Australia in an effort to demonstrate the flexibility and interoperability of the Canadian experimental naval satellite communications equipment. The results were so successful that the maritime environment of DND is planning to implement shipborne satellite communications, primarily to provide interoperability with the US Navy. The initial step will be a contract to Canadian industry for a development prototype terminal for extensive test and evaluation followed by eventual fleet fitment of production units.

Transportable Satellite Ground Terminal (TSGT)

Yet to be approved, but under serious consideration, is a project to produce a development prototype SGT in the 7/8 GHz frequency band for use in a transportable mode by Canadian Forces deployed in Northern European and peacekeeping roles.

Facilities

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

DEPARTMENT OF THE ENVIRONMENT (DOE)

General

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

Among those areas in which the Department of the Environment has been active in a lead role is the development and demonstration of space technologies for gathering of meteorological data, and inventory of forest, water and land resources. Some of the work is done in cooperation with the Canada Centre for Remote Sensing on one hand and provincial agencies on the other. In addition to satellites, aircraft provide data particularly for programs of ice reconnaissance and forest inventory.

Remote Sensing

During 1979, the GEMS 300 image analysis system was installed at the Pacific Forest Research Centre. This new system complements the Canadian Forestry Service's (CFS) ARIES*

* Applied Resource Image Exploitation System

capability already functioning at the Petawawa National Forestry Institute. Both systems were used by CFS scientists and scientific personnel from other government departments and agencies. The software from ARIES, which can be accommodated by GEMS 300, was provided to remote sensing centres in Ontario and Quebec.

Within the Canadian Forestry Service, remote sensing projects include the generation of forest statistics, forest classification, and the detection of clear-cuts, regeneration and insect damage. The LANDSAT images are enhanced for assistance in forest fire management, especially where they provide information on forest roads and fuel types.

The Water Survey of Canada utilized both the LANDSAT and the Geostationary Operational Environmental Satellite (GOES) data collection and distribution systems. The Prince Albert Satellite Station (PASS) was operated by a contractor for the Water Survey of Canada to receive and disseminate data from one channel on the eastern GOES satellite located over the equator at longitude 90° W. A study concluded that retransmission of data from remote hydrometric stations using satellites is cost-effective even without consideration of the increased benefits of a shorter delay in making data available to the user. Development by industry was completed of a convertible GOES-ARGOS data collection platform.

The Lands Directorate developed methods for the applications of remotely-sensed data for ecological land surveys and land use monitoring programs. Satellite imagery was operationally used in Ecoregion, Ecodistrict and Land Use Systems Mapping mapping projects. Linkages were developed between the Canada Land Data system and automated satellite image analysis systems. Operational use of LANDSAT images for ice reconnaissance continued.

DOE scientists participated in the experimental and program management aspects of the SURSAT program. Results indicated that there is considerable potential for use of microwave sensors for environmental monitoring. Supporting studies were conducted on the optics of fresh water as related to interpretation of remotely sensed data of fresh water bodies.

Stratospheric Studies

Experimental and theoretical studies of the stratosphere and ozone layer continued in order to assess the depletion of the ozone layer by chlorofluoromethanes. Data from rockets, balloons and satellites were acquired and analyzed.

In February a STRATOSPROBE/York payload was flown at the Canadian Forces Base (CFB), Cold Lake, Alberta, in support of the "ground truth" program for the Link Irridesence Measurement of the Stratosphere (LIMS), Stratosphere and Mesosphere Sounder (SAMS) and Scanning Backscatter Ultraviolet (SBUV) Experiments on the NIMBUS VII satellite. The balloon measurements included HNO_3, NO_2, O_3, H_2O and CH_4.

As part of a joint program with the Commonwealth Scientific and Industrial Research Organization (CSIRO) and Federal Aviation Agency (FAA), in March and April, two experiments from AES were flown in Alice Springs and one in Mildura, Australia. These two experiments were the NO_2 spectrophotometer and HNO_3 radiometer. The objective was to obtain background stratospheric profiles of nitrogen constituents in the southern hemisphere. Two additional flights of these experiments were carried out at Mildura, Australia, in October.

Theoretical simulations of the constituent data sets from the STRATOSPHERE flights were carried out in collaboration with York University. Comparisons indicate that hydroxyl densities in the 18 to 30 km region are smaller than current models predict. The consequences of low hydroxyl densities on ozone depletion by chloro flouro methanes (CFM's) were evaluated with a scenario model. The projected depletions of ozone by freons at the 1973 usage rate are about a factor of three smaller than predicted by models with current photochemistry and injections of NO_x from high altitude aircraft could cause significant ozone depletions.

An industrial study of a Space Shuttle get-away-special instrument, funded by DSS as an unsolicited proposal, gave promising results for a future satellite instrument.

Meteorological Satellites

Conversion of two ground receiving stations operated by the Atmospheric Environment Service (AES) to receive data from the new TIROS-N/NOAA series of polar-orbiting meteorological satellites was completed in 1979. Reception and distribution of GOES data continued in Toronto with improvement in the photo facsimile circuits making possible transmission of image sectors suitable for regional use. A start was made for procurement of a second GOES receiver for Vancouver in preparation for putting into place systems to replace in part the data that will be lost when the weather ships on the NE Pacific are decommissioned. Drifting buoys transmitting temperature and pressure by use of the ARGOS system on

polar-orbiting NOAA satellites will also form a part of the alternative data system and were procured for testing in 1980.

The major emphasis of the meteorological satellite research and development program within the AES is towards the combination of satellite radiances with conventional meteorological data. These programs include machine-assisted analysis of aircraft and HRPT (High Resolution Picture Transmission) data in support of sea ice forecasting, combination of Visual and Infrared Spin Scan Radiometer (VISSR) and weather radar data for short range precipitation forecasting and the combination of radiosonde and TOVS data. Progress was also made under the SURSAT Program, on experiments to assess the impact of scatterometer wind data from SEASAT on the ocean surface pressure analysis and marine forecasts. In addition, AES personnel in the DND Meteorological and Oceanographic Centre participated in evaluation of the SEASAT altimeter wave-height data.

DEPARTMENT OF FISHERIES AND OCEANS (DFO)

This is the first year that a separate Fisheries and Oceans program has been reported. The Department of Fisheries and Oceans continued to participate in the national SURSAT, SARSAT, and MUSAT program level committees and internationally, in the SEASAT SAR team. The Canada-France Ocean Optics Experiment (CFOX) was organized as a joint project of the Institute of Ocean Sciences, Sidney, British Columbia and the University of Paris (Villefranche). During 1979, field observations consisted of air and shipborne optical and water productivity measurements designed to be correlated with the Coastal Zone Colour Scanner (CZCS) on NIMBUS-7.

Phases of the Grand Banks Experiment took place in May and November 1979 with organizational responsibility shared between the principal investigators at the Institute of Ocean Sciences and U.S. Navy's NORDA facility in Bay St. Louis. The experiment is designed to test detectability of fronts and ocean current boundaries by microwave remote sensors. It was originally designed around the SEASAT sensors, however, with the demise of SEASAT, the 1979 operation made use of NIMBUS-7 and NOAA satellites as well as airborne equipment including the synthetic aperture radar equipped Convair 580 operated by the SURSAT project.

DFO, in conjunction with the National Defence Meteorology and Oceanographic Group, were responsible for the evaluation of the SEASAT altimeter for wave analysis. Comparisons were based on Waverider buoys wherever possible, and elsewhere were based upon ships of opportunity reporting within 30 minutes of a SEASAT pass

and within 140 km of the satellites' ground radar. Results obtained from the relatively small amount of data available during the operational lifetime of SEASAT suggest the satellite data are at least as accurate as ship-based observations and could make a significant contribution to wave height analyses and forecasts. The comparison with Waverider buoys showed excellent agreement between the SEASAT $H_{1/3}$ and the "ground truth".

Use of satellite infra-red imagery continues at both the Bedford Institute of Oceanography, Dartmouth, Nova Scotia and the Institute of Ocean Sciences. Surface water thermal patterns visible during cloud-free periods can provide information on dynamic processes in the ocean and digitally-processed images have been compared with ship data off the west coast.

In one of the most successful special observing systems established for the First GARP Global Experiment (FGGE), 368 drifting buoys were deployed during 1979, of which 301 were in the southern hemisphere south of 20° south. These buoys reported barometric pressure and sea surface temperature via the ARGOS system carried on board the TIROS-N and NOAA-A spacecraft. Canadian participation included a contribution of 74 buoys, coordination of the buoy deployment by 41 ships.

DEPARTMENT OF TRANSPORT

General

The Department of Transport is responsible for the formulation and implementation of federal policy for all forms of land, sea and air transport.

DOT operates air traffic control facilities for all international flights using the North Atlantic routes, and has similar responsibilities with regard to national and international shipping in Canadian coastal and inland waters. DOT is also responsible for fulfilling certain international responsibilities that have been assigned to Canada by the intergovernmental Maritime Consultative Organization (IMCO) and the International Civil Aviation Organization (ICAO).

As a present and future customer of space services, DOT is participating in several space projects aimed at improving the safety and efficiency of air and marine operations. These include the international AEROSAT program, to be used in evaluating the use of satellites for air traffic control; the INMARSAT preparatory committee concerned with improved maritime communications; the trials of a MARISAT terminal installed on one of its icebreakers; the study for the use of a Multipurpose UHF Communications Satellite (MUSAT), and a Search and Rescue Satellite (SARSAT).

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. However, due to funding difficulties, this program was radically revised. It is now charged to provide for a feasibility study which will be coordinated by a committee set up by the Aerosat Council in 1978.

The Committee for Review of Application of Satellites and Other Techniques to Civil Aviation (ARC) met once in 1979. The feasibility study is continuing with contributions by the ARC participants and working groups. It is planned to have a final report for review by the ARC by May 1981. It is expected that the ARC will report to the Aerosat Council after review of this report.

International Maritime Satellite (INMARSAT)

The International Maritime Satellite Organization (INMARSAT), a new international organization which will provide satellite capacity to improve maritime communications, came into existence in July 1979. Twenty-nine countries (including Canada) are already parties to the INMARSAT Convention. Canada has played a major role in the establishment of INMARSAT. It is believed that the use of satellites, which are already employed on a large scale for intercontinental telecommunications traffic, is the only practical means for the successful future development of safe and efficient maritime communications. The INMARSAT plan for maritime communications satellites is expected to lead to considerable improvement in communications with vessels (including oil exploration rigs) operating at sea which have become subject to congestion as a result of the continuing increase in maritime traffic in general, radio frequency limitations and other technical constraints.

There are three main parts of the INMARSAT structure: an Assembly, a Council and a Directorate. The Assembly, which will meet every two years, is responsible for governmental aspects of INMARSAT's activities. It will consider general policy and long-term objectives, and express views and make recommendations on these matters to the Council. Each Government has one vote. The Council, which will meet at least three times a year, is composed of representatives of the signatories of the Operating Agreement, each with a vote in proportion to the investment share represented (subject to a limit on any one signatory of 25 per cent). It has

the responsibility for providing and managing the INMARSAT system, having regard to the views and recommendations of the Assembly. The Directorate, run by a Director General, is responsible for the detailed running of INMARSAT under the direction of the Council. INMARSAT's permanent headquartets will be located in London. It is intended that INMARSAT shall operate on a sound economic and financial basis.

Telecommunications services available via the INMARSAT system will include telephone, telex, data transmission, recorded information and facsimile services. INMARSAT is also considering the provision of distress services, and other services available for telecommunications users on land. INMARSAT has yet to make a decision on the "space segment" to be utilized. Discussions which took place before the coming into force of the Convention indicated that the majority of the INMARSAT parties were in favour of a space segment known as "3 + 3". This consists of the use of three maritime transponders on board three INTELSAT V satellites of the International Telecommunications Satellite Organization and the use of three MARECS satellites provided by the European Space Agency. The three MARECS satellites are due to be launched in late 1980 and in 1981.

The Canadian operating entity for INMARSAT is Teleglobe Canada. The Department of Transport will pay Teleglobe Canada on a user basis only, plus an agreed upon payment, if necessary, for a priority requirement for safety.

Marisat Terminal

The test and evaluation program was completed in 1979 and the terminal has become a part of the operational equipment of the Coast Guard icebreaker John A. MacDonald.

NAVSTAR/GPS

The developing satellite system is being considered for civilian use. Studies of the system parameters and capabilities will be undertaken, prototype receivers will be purchased and evaluated under field conditions. The data collected will permit standards and regulations to be formulated by the time the system is utilized by civil aviation. The first phase project definition has been delayed until FY 82/83 due to resource limitations and delay in the U.S. military program.

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

General

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

Industrial Support

RMS Base Technology

The original RMS base technology development project at SPAR Aerospace Ltd. was completed in mid-1978. This project, which was supported under the Defence Industry Productivity Program (DIPP), was a stepping-stone which enabled the company to obtain the Shuttle RMS Project. A new DIPP-supported RMS base technology project has been approved and contracted to Spar. Its prime objectives are to develop base technologies in the following areas:

a) Systems for the assembly of large space structures;

b) Remotely-controlled systems for use in hostile ground-based environments;

c) Emergency robot vehicle systems;

d) Shuttle RMS modifications and improvements.

This project is scheduled to run to June 1, 1980, and the Crown and the company will equally share the eligible costs to a maximum Crown contribution of $3.5 million.

Satellite Subsystems and Earth Stations

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

INTERNATIONAL RELATIONS

The nature and scope of space activities is increasingly leading most countries with space programs to look for foreign partners with which to carry out activities and projects. For a country such as Canada, international cooperation is an integral component of its space activities. The section of the report dealing with departmental programs illustrates the extent of this involvement.

United States of America

For many reasons, the United States is, and will likely remain, Canada's main foreign partner in space activities. The two countries have developed close relationships at both the working and official levels with frequent visits and contacts.

European Space Agency

Canada is increasingly becoming involved with other partners. The most important is the ten member European Space Agency, in which Canada became a cooperative member effective 1 January 1979. Under the terms of the agreement, Canada contributes on a GNP basis to the General Studies of the Agency, this represents 9.15% of the General Studies costs. In addition to participating in the General Studies program of the Agency and attending meetings of Council, Canada is also able to attend meetings of the program boards and participate in the Agency's optional programs. Towards the end of the year, the Canadian Government indicated its interest in joining both the Remote Sensing Preparatory Program (RSPP) and the L-SAT Program.

Japan

In 1979, Canadian-Japanese cooperation in remote sensing continued. Areas of common interest were defined and contact points established.

Italy

During the year there were several exchanges of delegations with Italy and areas for cooperation in space activities were identified.

Others

As well, liaison for effective international cooperation exists with a number of countries on both institutional and individual levels. Canada continues to be involved in the transfer of space technology, particularly its applications to developing countries. One such example is a cooperative project among Canada, France and the U.S.A. to establish a regional remote sensing centre for West Africa in Ouagadougou, Upper Volta, which includes a training program for students of the area.

FINANCIAL SUMMARY

The financial summary data for the member departments, covering FY 1979/80 and FY 1980/81, 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, both in 1979 constant dollars and in current dollars, from 1969/70 until today. Unless specified, all expenditures are given in current dollars.

Table 1 summarizes the government's actual expenditures in 1979/80 and budgeted expenditures for 1980/81, broken down into types (IN-HOUSE or INTERNAL, INDUSTRY and UNIVERSITY) on the one hand, and, on the other hand, into categories (A: space systems; B: ground stations and earth terminals and C: data processing and analysis). Table 2 provides similar data but broken down into Departments and categories.

During the period 1969/70 - 1979/80, the government's total space expenditures, in real terms, fluctuated according to a 5-year average cycle with peaks in 1969/70, 1972/73 and 1978/79. This frequency seems to reflect quite well the life-span of definite space projects. However, one must point out that due to yet undefined reasons, this pattern will likely be broken in FY 1980/81. Since 1969/70, space expenditures have increased at an average annual rate of approximately 20% (1979/80 over 1969/70). Nevertheless, notwithstanding this long-term trend, the total space expenditure of $70 million in FY 1979/80 is 26% lower than that of FY 1978/79, which indeed represents the highest peak of the period. In FY 1980/81, the trend will be reversed again and the budgeted space expenditure will increase by 27.7% ($19.5 million, more than in FY 1979/80). The FY 1979/80 lower level of expenditure was caused by a reduction of activities in the RMS project which is coming close to completion and the appearance in FY 1978/79 of one-shot payments made to Telesat Canada for ANIK-B. This reduction of expenditure will be compensated in FY 1980/81 by: the DFL extension and operations for ANIK C/D support and payment of premiums to Telesat Canada for ANIK C and D satellites by DOC; the Space Science program undertaken by NRCC in cooperation with NASA; and, the LANDSAT follow-on and Synthetic Aperture Radar (SAR) development undertaken by EMR.

It is interesting to note that after having jumped from $13 to $22 million per annum from FY 1977/78 to 1978/79, IN-HOUSE expenditures, after having shown a slight decrease in FY 1979/80, increase slightly in FY 1980/81 to show a relatively modest increase (11% in real terms) over the period considered (1980/81 over 1978/79). During the same periods, the government expenditures directed to Canadian industry have first decreased by 42.5% (FY 1978/79 to 1979/80) and then increased by 32% (FY 1979/80 to 1980/81). In the two fiscal years covered by this report, 58% and

60% respectively of the total government spending in space has been or is budgeted to be realized in Canadian industry. This is slightly less than in the previous years. This may be due to the fact that the existing projects are coming to an end and feasibility studies are undertaken within government to prepare for future projects.

During FY 1979/80, we witnessed the reversal of the downward trend that has been prevailing since the last few years in expenditure in Canadian universities in the form of grants or research contracts. In fact, these expenditures were representing 0.4% of the total spending in FY 1978/79 in contrast to 0.7% and 0.8% (in real terms) in 1979/80 and 1980/81 respectively. However, it is still too soon to determine whether this new trend will continue or not in the future and if it reflects new Government's attitude towards space R&D in the universities. NRCC and DOE are the two main contributors to the increase.

The following briefly discusses the attached tables and figures.

Tables 1 and 2 show the space expenditures for FYs 1979/80 and 1980/81 broken down by departments and by categories (A, B and C). In Table 1 the expenditures in Canadian industry are also highlighted.

Figure 1 shows the predominance of NRCC and DOC as the most active deparments in the area of space for FY 1979/80 and 1980/81. This predominance is seen to exist since 1969/70 as shown in figure 4. These figures also show the emergence of EMR in FY 1980/81. The figure also shows that almost 50% of the total government space expenditures are based on three projects, the RMS, ANIK-B and DFL extension operations for ANIK C/D support. However, 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 undertaking significant changes. In the time interval considered, there is a constant shift from Space Systems (category A) to Ground Stations & Earth Terminals (category B). Indeed, the former passes from 74.3% in FY 78/79 to 60.6% in FY 80/81 and the latter from 19.2% to 29.5%, while these years, category C increases from 6.5% to 9.9%. After having experienced all time highs in FY 1978/79, government expenditures in space decreased by 26.5% or about $25 million in FY 1979/80. However, the FY 1980/81 budgeted figure of $89.3 million is coming back very close to the FY 1978/79 record figure of $95.2 million.

Even though IN-HOUSE expenditures decrease in real terms from FY 1978/79 to FY 1979/80 and 1980/81, their relative importance increases from 23% to 29% during this time. INDUSTRY expenditures show the same monetary pattern but their relative importance decreases instead from 77% to 70%. In FY 1979/80 and 1980/81 the relative importance of each type stabilizes. Figure 2 shows also that most of the fluctuations in the three categories have been absorbed by Canadian industry whose share of the expenditures goes from 74% in FY 1978/79 to 58% in FY 1979/80 and to 60% in budgeted FY 1980/81. It is very important to note that during these years the non-Canadian industry expenditures have steadily increased from $24.5 to $29.3 and to $35.7 million.

Finally, it might be important to note that expenditures in foreign industry (U.S.A. and other) increased considerably both in monetary and relative terms from 2.3% ($2.2 million) in FY 1978/79, to 10.7% ($7.5 million) in FY 1979/80 and 8.1% ($7.2 million) in budgeted FY 1980/81.

Figure 3 shows the government IN-HOUSE and INDUSTRY expenditures from 1969/70 until 1980/81. 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 63% of all government space expenditures occurred in INDUSTRY. Moreover, one can see that in FY 1976/77 these expenditures increased considerably (from 55.1% in FY 1975/76 to 68.5% in FY 1976/77), to finally stabilize around 70% in FY 1979/80 and 1980/81. Figure 3 also shows total expenditures in both current and constant 1979 dollars. The latter clearly indicates that from FY 1972/73 to FY 1976/77 expenditures in the space sector declined. The apparent steady increase shown by the graph in current dollars is due to inflation.

Finally, Figure 4 shows the expenditures, since FY 1969/70 broken down by departments. It also shows total expenditures in 1979 constant dollars for these years.

ANNEX

TABLE 1

TOTAL GOVERNMENT SPACE EXPENDITURES
(CURRENT DOLLARS)

($ MILLIONS)

	1979/80				1980/81			
	A	B	C	TOTAL	A	B	C	TOTAL
IN-HOUSE								
CAPITAL & G&S	4.97	1.02	.54	6.53	5.10	4.79	1.23	11.13
SALARY	6.15	4.93	2.74	13.82	6.42	5.48	3.04	14.94
SUB-TOTAL	11.12	5.95	3.28	20.35	11.52	10.27	4.27	26.06
INDUSTRY								
CANADA	31.27	7.37	1.97	40.61	36.02	13.75	3.84	53.61
USA	5.68	1.48	.31	7.47	4.54	2.10	.56	7.21
OTHERS	1.02	-	-	1.02	1.58	.07	-	1.65
SUB-TOTAL	37.97	8.85	2.28	49.10	42.14	15.92	4.40	62.46
UNIVERSITY	.35	.10	.05	.50	.49	.13	.14	.76
GRAND TOTAL	49.44	14.90	5.61	69.95	54.15	26.32	8.81	89.28

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

TABLE 2

TOTAL GOVERNMENT SPACE EXPENDITURES
(BY DEPARTMENT)
(CURRENT DOLLARS)

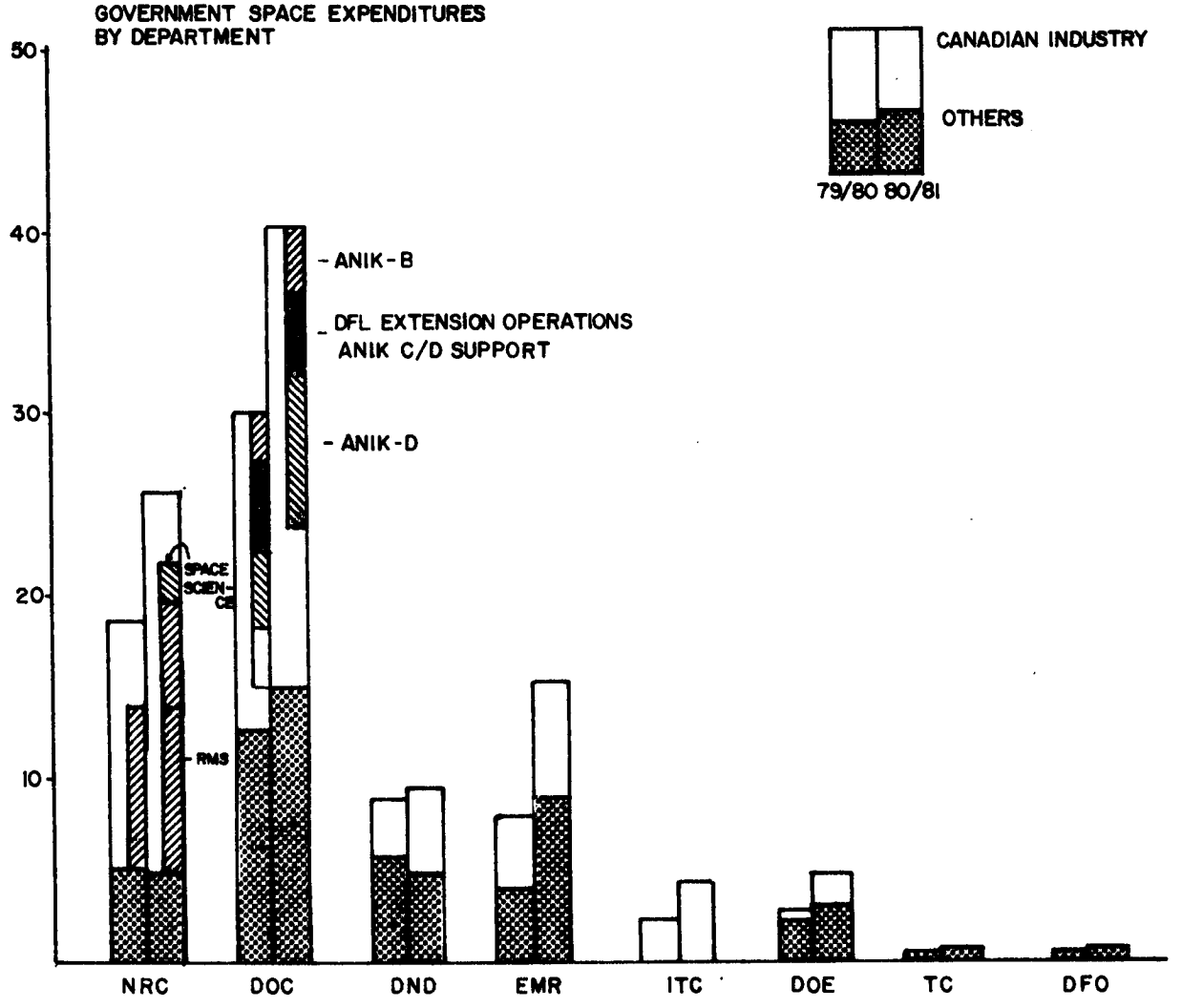
($ MILLIONS)

	1979/80				1980/81			
DEPT.	A	B	C	TOTAL	A	B	C	TOTAL
DOC	24.40	5.28	.25	29.92	31.86	8.09	.32	40.28
NRC	17.93	-	.50	18.43	14.61	-	.70	15.31
DND	5.07	3.12	.64	8.83	3.34	5.51	.55	9.40
EMR	.55	4.58	2.53	7.66	1.86	8.89	4.28	15.03
ITC	1.16	.90	.22	2.28	2.10	1.64	.60	4.34
DOE	.33	.85	1.25	2.43	.36	1.94	2.06	4.36
DFO	-	-	.22	.22	-	-	.30	.30
DOT	-	.17		.17	.02	.25	-	.27
TOTAL	49.44	14.90	5.61	69.95	54.15	26.32	8.81	89.28

FIGURE I

1979/80, 1980/81

GOVERNMENT SPACE EXPENDITURES BY DEPARTMENT



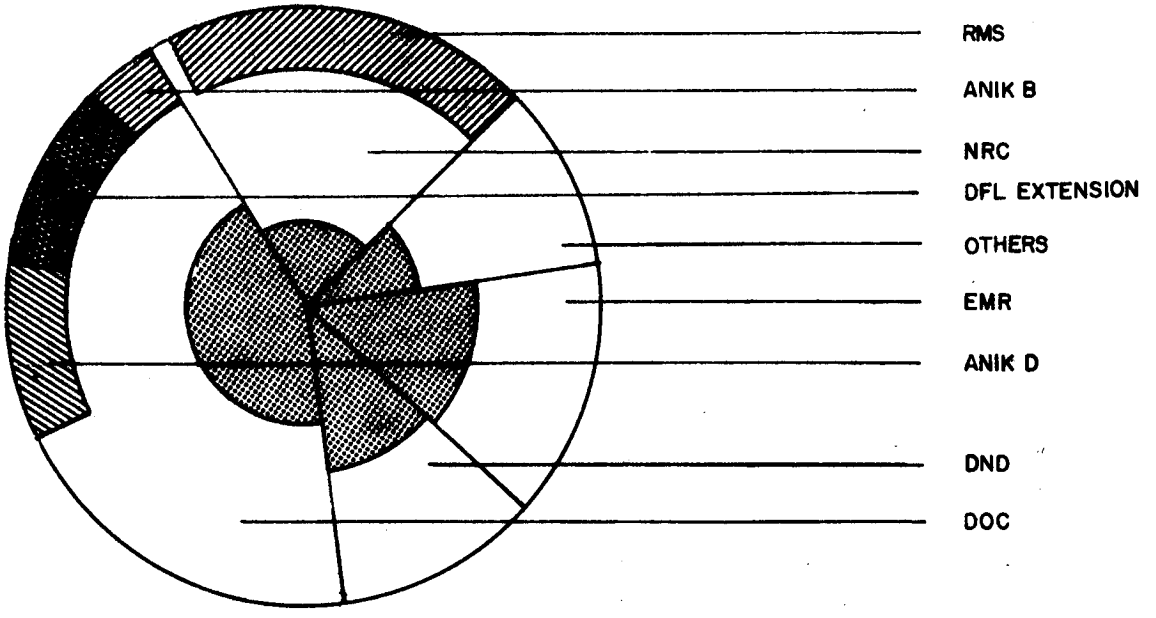
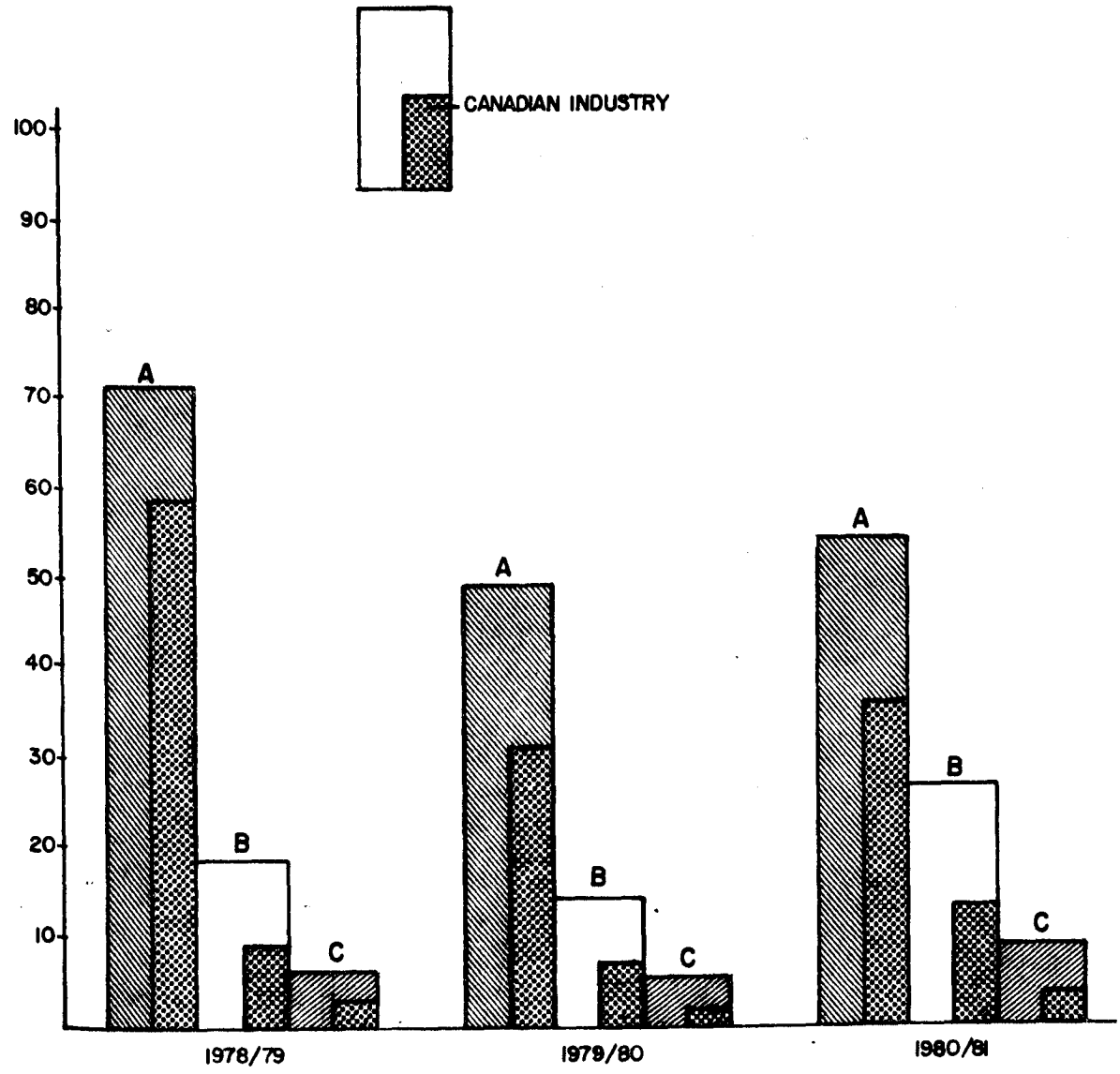


FIGURE 2

GOVERNMENT SPACE EXPENDITURES
BY CATEGORY



AVERAGE 1978/79 TO 1980/81

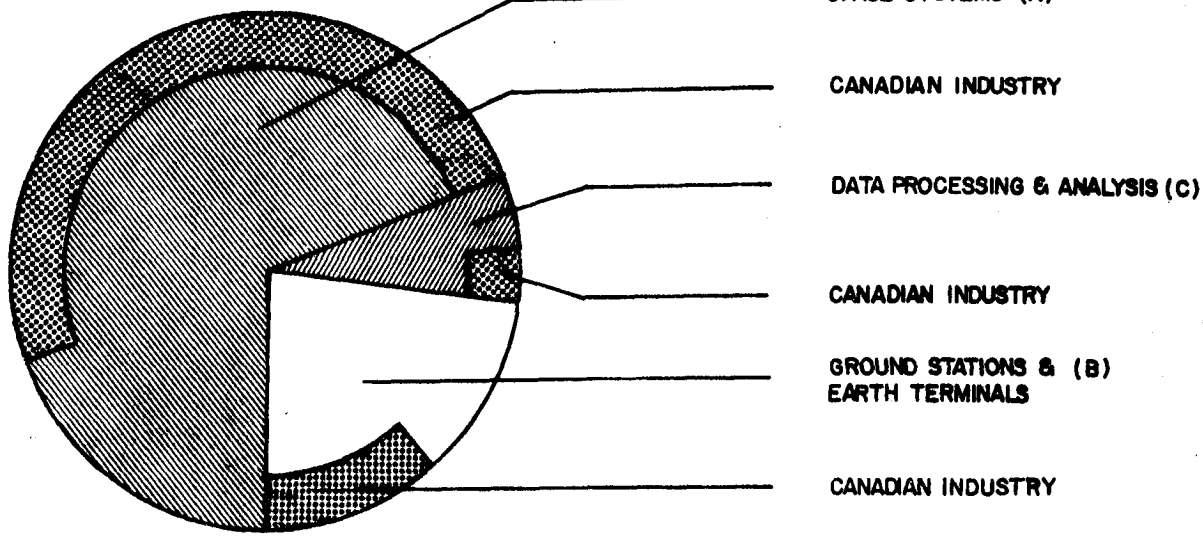


FIGURE 3

1969/70 TO 1980/81
GOVERNMENT SPACE EXPENDITURES
IN-HOUSE/INDUSTRY

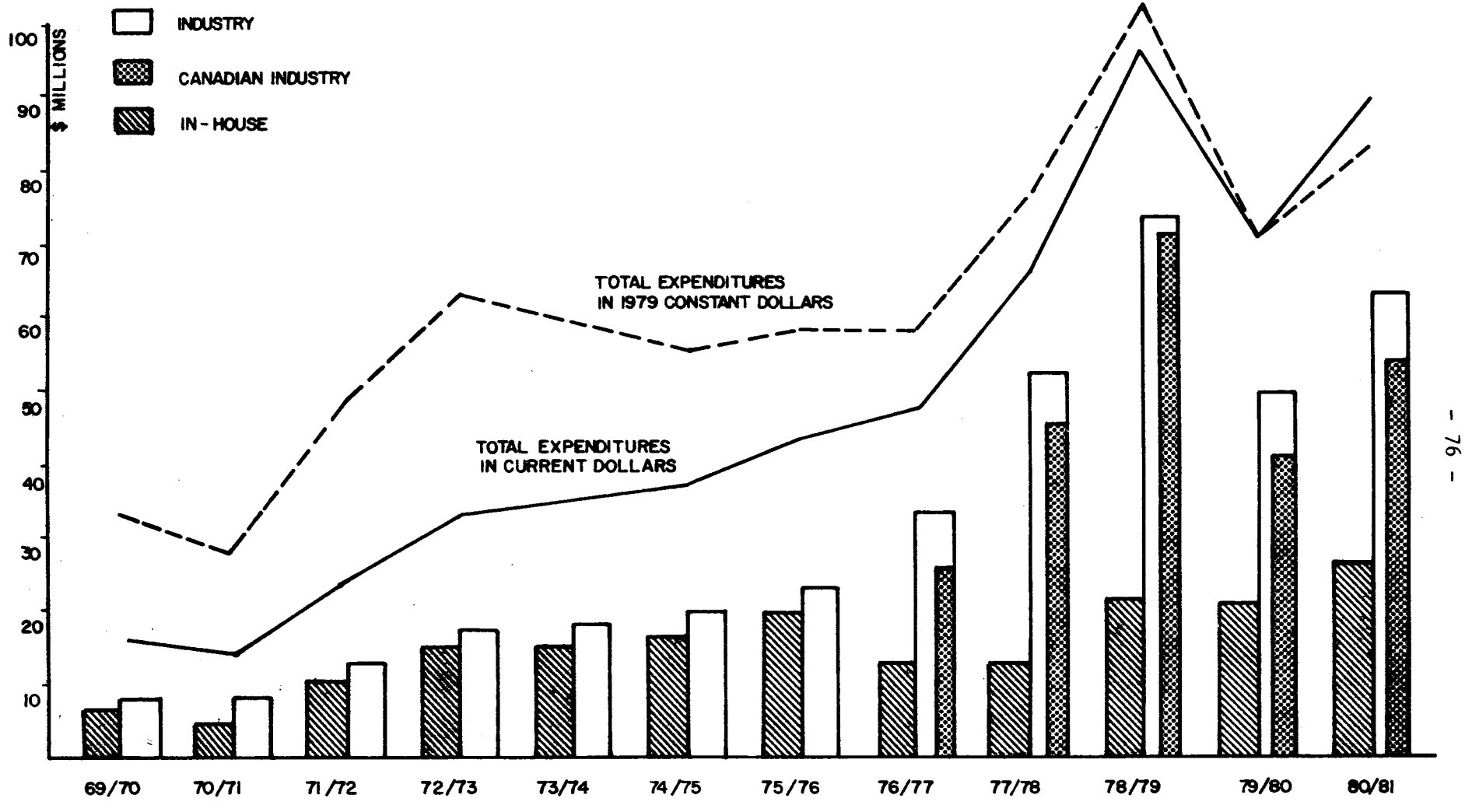
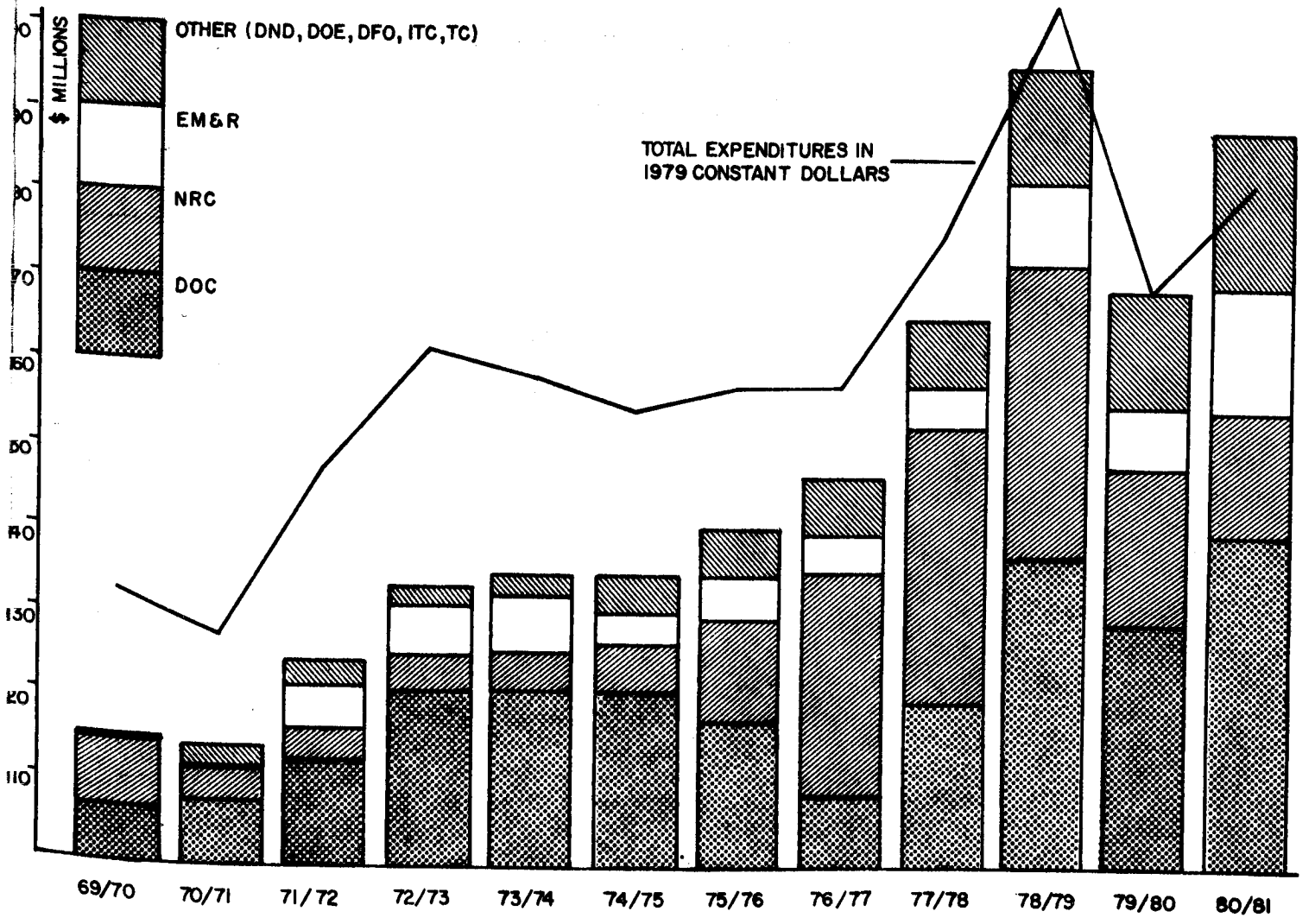
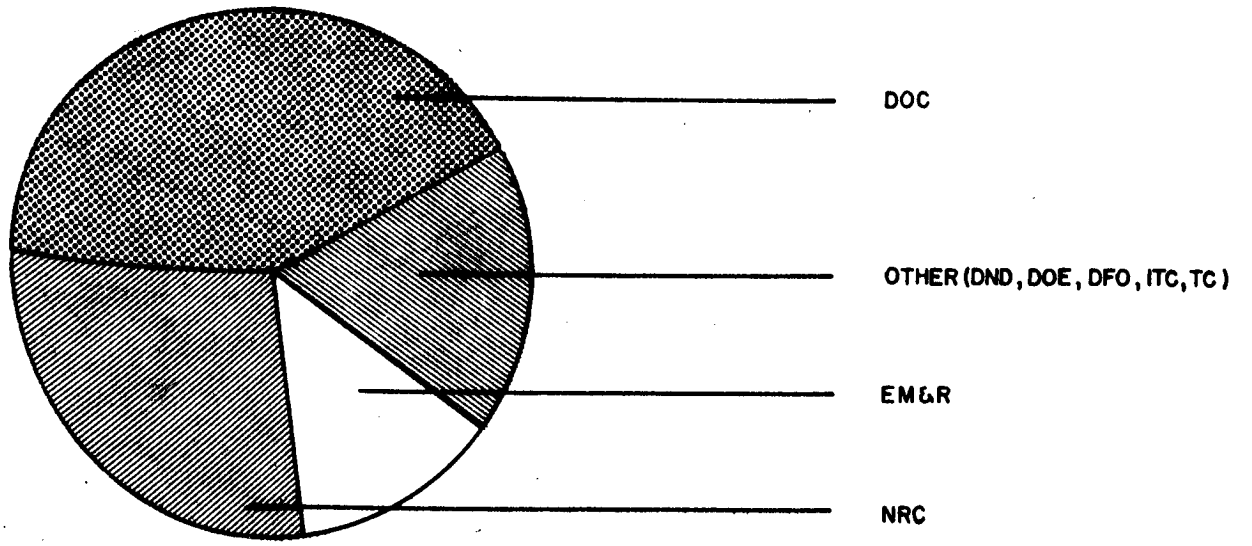


FIGURE 4
1969/70 TO 1980/81
GOVERNMENT SPACE EXPENDITURES
BY DEPARTMENT



AVERAGE 1978/79 TO 1980/81



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