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CANADA'S SPACE PROGRAM: A VOYAGE TO THE FUTURE

Report of The Standing Committee on Research, Science and Technology

William Tupper, M.P.
Chairman

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A picture of the ring of aurora around the north magnetic pole taken by the Canadian ultraviolet imager on the Swedish Viking satellite from about 10,000 kilometres above the pole.

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CANADA'S SPACE PROGRAM: A VOYAGE TO THE FUTURE

Report of the Standing Committee on Research, Science and Technology on the Study of Canada's Space Program

WILLIAM TUPPER, M.P.
CHAIRMAN

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HOUSE OF COMMONS

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Chairman: William Tupper

CHAMBRE DES COMMUNES

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Le jeudi 18 juin 1987

Président: William Tupper

Minutes of Proceedings and Evidence of the Standing Committee on

Research, Science and Technology

Procès-verbaux et témoignages du Comité permanent des

Recherche, de la Science et de la Technologie

RESPECTING:

In accordance with its mandate under Standing Order 96(2), a study of Canada's Space Program

CONCERNANT:

En conformité avec son mandat en vertu de l'article 96(2) du Règlement, une étude du programme spatial du Canada

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INCLUDING:

The Third Report to the House

Y COMPRIS:

Le Troisième Rapport à la Chambre

Second Session of the
Thirty-third Parliament, 1986-87

Deuxième session de la
trente-troisième législature, 1986-1987

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(Second Session, Thirty-third Parliament)

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The Standing Committee on Research, Science and Technology has the honour to present its

THIRD REPORT

In accordance with its mandate under Standing Order 96(2), on Monday, February 16, 1987, your Committee agreed to study Canada's science and technology policy, with special reference to the Space Program. Your Committee has heard evidence and considered policy with respect to the funding and the economic and technological benefits of the Space Program; the role and responsibility of the proposed Space Agency; and Canada's participation in the United States Space Station project.

Pursuant to Standing Order 99(2), your Committee requests that the Government table a comprehensive response to the Report.

ACKNOWLEDGEMENTS

The Committee acknowledges, with gratitude, the cooperation and support of all those who contributed to our study of Canada's Space Program. We extend our thanks to all of the witnesses who appeared and shared with us their knowledge and insight on this complex subject.

Many thanks, also, to David Berger M.P., who helped develop the nature and scope of the Committee's enquiry and took part in the hearings until May 22, 1987, but did not collaborate in the drafting of the report.

We acknowledge the assistance of two researchers from the Research Branch of the Library of Parliament, Dr. Thomas Curren and Mrs. Lynne Myers, and the expert guidance provided by our consultant, Dr. Ian McDiarmid.

The Committee expresses its appreciation for the essential services provided by Christine Fisher, Clerk of the Committee.

The Committee wishes also to acknowledge the valuable cooperation of the staff of the Committees and Private Legislation Directorate, the Translation Bureau of the Secretary of State, and the support services of the House of Commons and the Research Branch of the Library of Parliament.

SPECIAL ACKNOWLEDGEMENT

The Committee wishes to make a special acknowledgement to Dr. John H. Chapman who, at the time of his death in 1979, was the Assistant Deputy Minister for Space in the Department of Communications. Dr. Chapman played a key role in initiating and directing the Alouette/ISIS scientific satellite program. The 1967 "Chapman Report" shaped the future direction of Canada's space activities. Dr. Chapman was the principal architect of Canada's space program and its driving force for more than 20 years.

TABLE OF CONTENTS

CHAPTER 1

Introduction

It is appropriate that this Committee's study of Canada's Space Program should take place in 1987, inasmuch as this is the twenty-fifth anniversary of the launch of our first earth satellite, Alouette I, at Vandenberg Air Force Base in California on 29 September 1962. (In local California time, the date was 28 September; however, space activities are customarily recorded in Universal, or Greenwich, time.) With that successful endeavor, Canada became the third nation to establish a presence in space, after the Soviet Union's Sputnik in 1957 and the launch of the Explorer satellite by the United States in 1958.

It is important to recognize that Canada's space activities predated Alouette by many years. As early as the 1930s, Canadian scientists were studying the upper atmosphere using ground-based instruments. Because the North Magnetic Pole is located on Canadian territory, the Canadian north is the best place in the world to study phenomena produced by the interaction of particles from the sun (solar plasma) with the Earth's magnetic field. The effects of this interaction include the aurora, magnetic storms, ionospheric disturbances and probably changes in weather patterns.

Radio communications, particularly at high latitudes, can be disrupted during ionospheric disturbances; this became a critical problem during World War II and led to systematic studies of the ionosphere. Following the war, this work continued and expanded into rocket and balloon observations of the high atmosphere. The opening of the Churchill Research Range in Manitoba in 1957, and the development by Bristol Aerospace Ltd. in Winnipeg of the Black Brant series of rockets, allowed Canada to make major scientific contributions to the International Geophysical Year Program.

In 1958, the Alouette project was initiated by Canada in response to an invitation from the U.S. National Academy of Sciences. In 1959 a formal agreement was signed between Canada's Defence Research Board (DRB) and the U.S. National Aeronautics and Space Administration (NASA). Under that agreement, the DRB would design, build and finance the satellite and NASA would contribute a launch vehicle as well as pre-launch testing of the spacecraft. Further, Canada was to construct the ground stations (a technology in which Canada has since become a world leader) and NASA would make available its network of ground stations to receive the data. A third international partner joined the project when the United Kingdom agreed to provide telemetry stations in Singapore and the South Atlantic in exchange for access to satellite data.

Alouette I was an unqualified success. The spacecraft had been designed to operate in space for one year but a three-month period of operation was the criterion for a "complete success". In fact, Alouette I operated for 10 years, vastly exceeding even the most optimistic expectations.

Beyond the immense wealth of scientific data produced by Alouette I, there are a number of pertinent observations to be made that are germane to a consideration of Canada's present Space Program. First, the Alouette project was essentially science-based and dedicated to the generation of knowledge in a specific area which might eventually produce dividends in the form of an improved communications technology. Second, the project was an international collaborative effort, thus reducing individual costs while creating a broader network of scientific and technological expertise. Third, the project allowed Canada to develop a knowledge of space technology and the ability to design and build instruments and equipment that could operate for prolonged periods in the hostile environment of space.

Alouette I was followed in 1965 by Alouette II, a spacecraft which not only was a scientific success but also achieved a goal of perhaps equal significance: the successful transfer to Canadian industry of space technology developed by the Federal Government. This initiative was further enhanced with the ISIS satellites, the Canada-U.S. program of International Satellites for Ionospheric Studies. ISIS-1 was launched in 1969 and ISIS-2 in 1971. The latter spacecraft was constructed totally by private industry, with RCA of Montreal as prime contractor and Spar Aerospace Limited of Toronto as associate contractor.

The scientific returns from the early space experiments involving Black Brant rockets and the Alouette-ISIS satellites were very great indeed and, as a result, Canada developed a group of world-class space scientists in university and government laboratories. Much of our understanding of the electrically-charged particles that populate the ionosphere and the region beyond came from this work.

The experiments produced many scientific "firsts", including some of the first measurements of the Van Allen radiation belts at high latitudes and the first images of the aurora from space. Much of the knowledge gained from this early work is used today in the design of such technologies as space communications systems and over-the-horizon radar systems.

In 1967, the Federal Government made a decision to redirect Canada's space activities from purely scientific pursuits (exemplified by the Alouette and ISIS programs) to the applied. Specifically, this meant that Canada's principal objective in space would be the application of technology and science to domestic telecommunications and resource-survey problems. This decision terminated the Alouette-ISIS program with ISIS-2 and led to a serious decline in space-science activity in Canada in the late 1970s.

Following from this decision also, the Federal Government in 1969 created Telesat Canada, a government-industry corporation, to operate a commercial system of satellite-based communications throughout Canada. When the Anik A1 satellite was launched in November 1972, Canada became the first country to operate a domestic communications system based on a satellite in a geostationary orbit.

It is perhaps less well-known that the Anik A system was based on established technology which had been developed in the United States for the Intelsat IV satellites. The later series of Aniks would be derived from new technologies developed through a new scientific spacecraft, the Communications Technology Satellite (CTS), also known as Hermes.

The Hermes program was started in 1970 as a joint Canada-United States initiative to develop advanced technology in high-powered satellite communications. A formal agreement between the Department of Communications (DOC) and NASA was signed in April 1971. A month later, the European Space Research Organization (ESRO), formally agreed to participate in the program. Canada's role was to design and build the Hermes spacecraft and to operate it in a geostationary orbit.

Hermes was launched in 1976 and operated for almost four years. It was then the world's most powerful communications satellite and was used to carry out communications experiments which led to the powerful direct-to-home communications satellites of the 1980s, both in Canada and the United States.

By 1985, Telesat had launched nine satellites in the Anik A, B, C and D series and, at present, five orbiting Anik satellites in the C and D series are owned and operated by the company. In addition, Telesat maintains more than 230 earth stations. In 1990, Telesat will launch two new communications satellites in the Anik series, Anik E1 and Anik E2. These satellites, being constructed by Spar Aerospace Ltd. at a cost of $200 million, will replace the present Anik C and D satellites. The Anik E series will be the most powerful domestic communications satellites ever launched.[1]

In addition to communications, Canada has had an enduring interest in natural-resource surveys to provide the necessary data base for effective resource exploitation and management. In the late 1960s, sensors were being developed for inclusion on weather satellites to study the earth's surface and, in 1972, LANDSAT-1 was launched by the United States.

In 1972 also, the Canada Centre for Remote Sensing (CCRS) was established within the Department of Energy, Mines and Resources as the central agency in Canada's national program of remote sensing. The Centre uses both earth observation satellites and airborne systems to collect data on Canada's environmental mosaic. Remotely-sensed data have applications in forestry, agriculture, land use, water resources, mineral exploration, oceanography, Arctic ice reconnaissance and various types of environmental quality control.

The CCRS operates ground stations at Gatineau, Quebec and Prince Albert, Saskatchewan to receive remote-sensing data from LANDSAT (operated by the U.S. National Oceanic and Atmospheric Administration) and from the SPOT satellite, launched by France in 1985. The international collaborative character of Canada's satellite remote-sensing program will be broadened further in 1989 when the European Space Agency (ESA) launches its first remote-sensing satellite, ERS-1. Canadian ground facilities and data-handling programs are presently being upgraded to make use of data from the ERS-1, and also from the new U.S. LANDSAT-6 satellite.

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(1) For a more detailed history of Canada in space, see: Theodore R. Hartz and Irvine Paghis, *Spacebound*, Department of Supply and Services Canada, Ottawa, 1982, 188 pages.

Canada has developed a thriving remote-sensing industry, essentially a collection of more than 30 smaller companies who are among the world leaders in developing and manufacturing equipment for gathering and interpreting remote-sensing data. In 1985, some 1,400 Canadians were employed in these companies, producing and marketing remote-sensing services in Canada and in export markets. The value of these services in 1985 was approximately $120 million, of which some 60% was exported.

In 1969, Canada was invited by the United States to participate in the U.S. Space Transportation System (STS) program — the space shuttle. The National Research Council and NASA signed a formal agreement for a cooperative program to develop a Remote Manipulation System (RMS), a remotely-controlled space arm for the shuttle, now familiarly known as the CANADARM. The RMS has been used for a variety of manipulations in space, including the recovery and deployment of satellites. The prime contractor for the $100 million CANADARM project was Spar Aerospace Limited backed by an industrial team that included CAE Electronics, and more than 40 Canadian suppliers and subcontractors from Quebec to Alberta. The CANADARM was successfully tested in 1981 and 1982 on the space shuttle Columbia, and has added to Canada's reputation as a leader in space.

Following the decline of space-science activities in the late 1970s, the Federal Government decided in 1980 to increase the space-science budget to allow Canadian scientists to participate in international cooperative space projects. The National Research Council was named the lead agency for space science and the Canada Centre for Space Science (now part of NRC's Space Division) was set up to manage the Space Science Program and to provide facilities for scientists in both university and government laboratories. As a result of the increased funding a number of major space-science projects were initiated with the U.S., Sweden, France and Japan.

Most of the projects have relatively long lead times and some have been delayed by the Challenger disaster. However, the instrumentation for a number of the projects has been completed and they are now making a substantial contribution to space science. One of these instruments is an ultra-violet auroral imager which was launched in 1986 on the Swedish satellite VIKING and has produced some of the best and most interesting auroral images yet received from space. Another result of the increased funding for space science was that a number of Canadian companies became involved in the construction of space instrumentation for the first time.

At the same time that funding was being increased for some parts of the Space Science Program, the general budget reductions announced in November 1984 resulted in the cancellation of NRC's rocket and balloon program. This has had a significant effect on the Space Science Program because it removed the only component of the program that had a relatively short time-frame between project initiation and launch, a feature that is necessary when graduate students are involved or when new instruments are being tested.

The Canadian Astronaut Program was started in 1983 in response to an invitation from NASA, and is managed by NRC's Space Division. Initial plans called for three flights by Canadian astronauts aboard the space shuttle. By the end of 1983 six astronauts had been selected and, in October 1984, Marc Garneau became the first Canadian in space. He carried out a number of experiments aboard shuttle flight 41-G and acted as proxy

investigator for scientists and engineers from 17 different agencies in Canada. A second flight was scheduled for March 1987, but this was postponed due to the Challenger disaster. A new date for this flight is still being negotiated with NASA.

The presence of humans in space serves very well to increase public awareness of the Space Program and its benefits. It is also hoped that the existence of an astronaut corps will encourage young Canadians to pursue careers in science and technology. The astronauts have already touched the public imagination in a way that no other part of the Canadian space program (except perhaps the CANADARM) has. To date over 1,400 requests have been received for astronauts to speak to various groups and some 300 of these requests have been accepted.

The Canadian space industry, although relatively small, is both innovative and productive. Industry sales in 1985 were about $320 million and some 3,500 people are presently employed. More than 70% of Canadian space products and services are sold in export markets. The industry has a growth record averaging 20% per year over the past decade. An important characteristic of the industry is the fact that it is 90% Canadian-owned, a remarkable achievement in a country where foreign ownership is often the rule.

International cooperation in space projects is an enduring and vital characteristic of Canada's Space Program. While our most active international partnership has been with the United States (Alouette-ISIS, WAMDII, WISP, LANDSAT, CANADARM, Space Station), Canada has enjoyed productive relationships with other countries, including Japan (remote sensing, rocket and satellite experiments), France (SPOT satellite, WINDII, SARSAT/COSPAS), the Soviet Union (SARSAT/COSPAS), Sweden (VIKING Satellite), as well as Australia, the United Kingdom, West Germany, and Brazil. This list does not, of course, include all of those countries with whom Canadian companies do business, including many Third World nations who are utilizing Canadian technology and expertise in communications and remote-sensing applications.

An important Federal Government activity is this country's relationship with the European Space Agency (ESA). Canada has had a formal agreement with ESA since 1978, and we are the only non-European country to enjoy that status. Our membership in ESA requires Canada to contribute to the Agency's general budget, albeit at a lower level than the European member states. In 1987, our contribution will be about $2.5 million. In addition to that, Canada contributes to, and participates in, a number of important space projects with ESA, notably the ERS-1 remote sensing satellite and the OLYMPUS telecommunications satellite.

The Federal Government's participation in space activities is presently scattered among a number of departments and agencies. The principal actors include the Department of Communications (DOC) which originally developed the Alouette-ISIS programs and the CTS-Hermes satellite. Personnel and technology transferred from DOC developed the Anik satellite series, now owned and operated by Telesat Canada. Although Canada's space communications system resides in the private sector, DOC retains an important reservoir of expertise in space communications systems, electronics, mechanics and applications in the department's Communications Research Centre (CRC) at Shirley's Bay near Ottawa. This establishment includes the David Florida Laboratory (DFL), a world-class facility for testing satellites and components prior to launch.

The Canada Centre for Remote Sensing (CCRS) of the Department of Energy, Mines and Resources is the lead agency in remote sensing in Canada. The Centre is an acknowledged international centre of expertise in this field.

The National Research Council, through its Space Division, and also through the Herzberg Institute of Astrophysics, is a major actor in Canada's Space Program. NRC's Space Division currently manages Canada's Space Science Program, the Canadian Astronaut Program, and Canada's major space project, the development of the Mobile Servicing System (MSS) for the U.S. Space Station Project. This includes the User Development Program which is being designed to maximize the economic benefits from Space Station.

Other departments with a role in space activities are the Departments of Regional Industrial Expansion (DRIE), Environment (Atmospheric Environment Service), and Fisheries and Oceans.

The Ministry of State for Science and Technology (MOSST) is the department responsible for space R&D policy, for coordinating Space Program activities, and for resource-allocation recommendations. The Interdepartmental Committee on Space (ICS), whose Chairperson is from MOSST, has an important coordinating role in the Federal Government's space activities. The ICS draws its membership from those federal departments and agencies with an interest in space. In the Speech from the Throne on October 1, 1986, the Federal Government stated its intention to establish, through legislation, a Canadian Space Agency. The Agency will act to promote international cooperation in the peaceful use of space and will work with Canadian industry, universities and provinces, "to ensure that the benefits of Canada's role in space will be shared by all Canadians."[2]

(2) Speech from the Throne, October 1, 1986.

CHAPTER 2

New Initiatives in Canada's Space Plan

In May 1986, the Federal Government announced a new Canadian Space Plan, with an emphasis on economic returns through job creation and increased industrial revenues. The Minister of State for Science and Technology stated that the new program "responds to the needs of Canada to manage our resources, enhance communications across the country, exercise national sovereignty, and build on our industrial strengths in all regions of the country."[3]

The principal element of the new program will be development of the Mobile Servicing System (MSS) for the U.S Space Station and the creation of a Space Station User Development Program. Other major elements include support for Telesat Canada's MSAT, a new communications satellite system for mobile users; the development of advanced technologies and applications for remote sensing, including continued planning for a new remote-sensing satellite, RADARSAT; expanded cooperation with Europe through our membership in ESA and participation in major European space projects; continued support for the Canadian Astronaut Program; and additional funding for the Space Science Program.

A. Space Station Program

The U.S. Space Station represents one of the most complex and ambitious technological undertakings ever conceived. This permanently-manned orbiting facility has an expected lifetime of 25 years and will serve as the base for a wide variety of functions.

Canada was invited, along with other nations, to participate in this massive endeavor and in 1984 the Prime Minister announced that Canada was indeed interested in taking part. Our proposed contribution is what is known as the Mobile Servicing System (MSS). The space-based part of the system, known as the MSC or Mobile Servicing Centre, will help in the construction of Space Station, giving Canada an early and highly visible role in the program. The MSC will also have an on-going part to play in the maintenance of the Space Station structure; in servicing attached payloads used for materials processing, remote

(3) Government of Canada, *Canadian Space Program*, News Release, Ottawa, May 12, 1986.

sensing or astronomy; in docking the space shuttle; in moving equipment and supplies around on Space Station; in supporting astronauts with their extra-vehicular operations; and in forming part of the emergency evacuation system for the manned modules.

The Space Station is planned to include several free-flying unmanned platforms. The U.S. and ESA will each have a co-orbiting platform and a platform in polar orbit. The platforms will be used for a variety of tasks such as experiments in space science, earth observations and materials processing.

The Canadian Mobile Servicing System clearly will be a critical component of the Space Station, both during construction and later during operation of the Station. The MSC is building on our CANADARM technology. It will be more flexible than CANADARM, with the addition of a seventh joint at the shoulder. It will also be five times as strong as the first-generation arm, so that it can handle heavier payloads such as the orbital maneuvering vehicle (OMV) which weighs 150,000 kilograms. A Space Vision System (SVS) will be added to permit accurate judgment of speed and distance in space where reference points are missing.

The MSC will be built in modular form and will likely require five shuttle flights to complete. If the Space Station Program is able to surmount its various problems, including questions of military use and inflating costs, it is now tentatively scheduled to have the first part of the MSC on the second or third Space Station flight of the shuttle, some time in the mid-1990s.

Development of the MSS is a Major Crown Project, to be managed by NRC. The prime contractor for the project is Spar Aerospace Limited. The other industrial team members are CAE Limited (Montreal), SED Systems Inc. (Saskatoon), and Canadian Astronautics Limited (Ottawa). The Federal Government has estimated the total cost of the development of the MSS at $697 million (1986 $) over 15 years, to fiscal year 2000/01. The estimated cost over five years (to FY 1990/91) is $169 million. The User Development Program has been estimated at $50 million over five years and $100 million over 15 years.[4]

B. MSAT

The Federal Government retains a significant interest in the development of satellite-communications technology. The Mobile Satellite, MSAT, will be owned and operated by Telesat Canada. The Federal Government's involvement includes market and technology development, and guaranteed lease of services once the system is operating in space. MSAT will provide voice and data services to mobile terminals in motor vehicles, trains, ships and aircraft operating in rural, offshore, and remote areas of Canada. Market studies have identified 60,000 to 100,000 potential Canadian users. The MSAT system is designed to complement, not compete with, the mobile cellular telephone system which serves principally urban centres.

MSAT was originally developed as a government demonstration project in mobile communications but its intrinsic economic value has converted it to a commercial enterprise

(4) Ministry of State for Science and Technology, *The Canadian Space Program: New Initiatives*, Ottawa, May 1986, p. 2.

of major significance. The eventual users of the system — fishermen, truckers, resource industries, law enforcement agencies, etc. — will derive economic benefits through increased efficiencies of operation. The hardware manufacturing industry and a new service industry will further distribute the economic gains. Telesat Canada anticipates an eventual doubling of its present revenue levels when MSAT is fully operative.

The MSAT program is not, however, a certainty at this time and some fundamental requirements must be met before the program can move ahead. First, to be viable, MSAT in Canada will have to be very closely coordinated with a similar (preferably identical) U.S. system. At present, there is no identified American operator and the U.S. Federal Communications Commission (FCC) is attempting to persuade a number of interested companies to form a consortium.

Second, the required frequencies in the radio spectrum must be allocated to MSAT and coordinated with other countries, particularly with the United States. Canada would prefer to use the UHF (ultra-high frequency) spectrum but the FCC is resisting this in the United States. An alternative spectrum is L-Band, but some South American countries are not at present sympathetic to this proposal. The issue of spectrum allocation will be discussed, and possibly settled, at the World Administrative Radio Conference (WARC) in Geneva in October of this year. Failure to resolve the problem at that time could place the MSAT program in serious jeopardy.

Estimated costs to the Federal Government for MSAT are $15 million over five years (to FY 1990/91) and $151 million over a 15-year period ending in FY 2000/01.

C. Remote Sensing and RADARSAT

Canada is an acknowledged world leader in the reception, processing and analysis of remote-sensing data from satellites and aircraft. Both the Federal Government's Canada Centre for Remote Sensing (CCRS) and private industry will continue to be supported by funding from the Space Program.

The remote-sensing program of most interest to the Committee is RADARSAT, a Canadian satellite equipped with a new Synthetic Aperture Radar (SAR) system. RADARSAT is a Canadian-led international collaborative project involving the United States and the United Kingdom. The satellite was originally scheduled for a shuttle launch in 1990, but the proposed launch date has now been put back to at least 1993.

The SAR designed for RADARSAT is superior to any other presently developed. This microwave sensor will penetrate cloud and darkness to "view" the land and oceans underneath. RADARSAT will have a polar orbit and would therefore cover the entire globe. Canada's northern regions would be covered every 24 hours and southern Canada would be covered every three days.

The satellite would provide extensive data on agriculture because it can discriminate between fallow land and land under cultivation. Moreover, the radar responds to the structure of a plant and can indicate its moisture level, information which would permit a forecast of eventual crop yields. RADARSAT will also provide data in geology, and on non-renewable resources, mapping data for hydrology and detailed information on sea-ice

conditions in northern areas, including information on different ice types. The radar will also provide data on ocean wave spectra, including wave height, direction and frequency. Additional sensors have been proposed for RADARSAT and these would provide a variety of data, including weather information based on ocean surface temperatures. An important aspect of RADARSAT is the fact that it will monitor the North on a daily basis, and should therefore enhance Canada's claim to sovereignty over the Arctic regions.

There will be substantial economic benefits for all regions of Canada if RADARSAT is launched and operates successfully, and these potential benefits have been documented by the Department of Energy, Mines and Resources. First, there will be industrial expenditures for the hardware which will provide employment and revenue. Second, there will be economic gains from the use of the resource-management data generated by the satellite. Third, there will be economic benefits from the expansion of the remote-sensing service industry in both domestic and export markets. However, although these benefits are real and significant, there will have to be a net expenditure by the Federal Government to make the project feasible.

The RADARSAT program in its present form has been reduced in scope, principally through deletion of an optical sensor and reduction of the satellite's life span from ten years to five by eliminating a planned in-space servicing capability using the space shuttle. These modifications have reduced the total cost of RADARSAT from $978 million to $635 million; the Federal Government's net contribution has been similarly reduced from $635 million to $236 million. Canada's two international partners will contribute most of the balance of RADARSAT's total cost, with three Canadian provinces and private industry making smaller contributions.

Although the Federal Government has stated that the remote-sensing program of CCRS will be continued, the future of the RADARSAT project itself is in serious doubt at this time. Funding for the satellite has not been approved and a positive Cabinet decision is needed for the project to go ahead.

D. European Space Agency (ESA)

Canada maintains a continuing commitment to industrial collaboration with European partners in space activities. A formal arrangement with ESA is the central feature of this cooperative effort. Canada's participation in ESA's communications and remote-sensing satellites was noted earlier in this Report. Canada is also participating in the study phase of the French spaceplane program, Hermes. This effort has the potential to enable Canadian industry to capitalize further on investments in the CANADARM program.

Over a five-year period to FY 1990/91, Canada will spend an estimated additional $27 million on cooperation with ESA; estimated additional expenditures to FY 2000/01 are $123 million.

E. Canadian Astronaut Program

The Astronaut Program, with a description of its goals and objectives, was discussed earlier in this Report. Under the 1986 Space Plan, the program will continue, partly in anticipation of Canadian astronauts working on Space Station to support those experiments

originating from industry, government and universities which benefit from human intervention in space.

Estimated funding for the Astronaut Program over five years to FY 1990/91 is $15 million. Over the 15-year period to FY 2000/01, estimated costs will be $55 million.

F. Space Science

The definition of space science is necessarily very broad and includes study of the space environment, the solar system, and the physical and biological processes which occur in space, including those associated with manned space flights. One way of defining space science is to divide the subject into three categories: (1) science *on* space, essentially studies of the space environment; (2) science *in* space, including experiments, such as those planned for Space Station, in life sciences and materials processing in a microgravity environment; and (3) science *from* space, which can include space observations of the Earth's surface and atmosphere, and of astronomical phenomena. (Canada's Space Science Program excludes research in remote sensing and in communications which are organized and funded as separate activities.)

The Canadian Space Plan which was announced in May 1986 included a Space Science Program as a major component. Specifically, four areas of space science were chosen: space physics, upper atmospheric research, microgravity sciences, and space astronomy. Canadian activity in space science has traditionally been concentrated on space physics and upper atmospheric research, and our researchers have achieved international recognition in these disciplines. Canada's major achievements in space science occurred in the 1960s and early 1970s, particularly with the four major scientific satellites in the Alouette-ISIS programs, and also with the sub-orbital rocket experiments launched from Fort Churchill, Manitoba.

The Space Science Program, as articulated by the National Research Council, has the following objectives:

> First is to ensure Canada maintains a position of excellence in a world-wide context in the exploration of space.
>
> Second, particularly through the program activities with NRC, is to provide opportunities for Canadian scientists to participate in both national and international space science missions.
>
> Third is to provide the major facilities and instruments required for Canadian scientists to perform space science experiments, to train young scientists and engineers to meet the future needs of the program and to strengthen ties and cooperation between industry and universities.[5]

The May 1986 announcement stated that additional funding would be made available for space science: $20 million over five years to FY 1990/91, and $70 million over 15 years to FY 2000/01.

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(5) National Research Council, Space Division, *Minutes of Proceedings and Evidence of the Standing Committee on Research, Science and Technology*, Issue No. 18, March 12, 1987, p. 18:7. (Further references to Proceedings and Evidence will only be identified by issue number and date).

Although these appear to be substantial sums of money, the Committee has received evidence that the funding for space science in Canada is actually shrinking, both in relative and absolute terms. The proportion of Federal Government expenditures devoted to space science in the five-year period 1981/82 to 1985/86 was 14.2%; for the period 1986/87 to 1990/91, the proportion will decrease to 9.6%. In absolute terms, funding will decline from $21.5 million in 1984/85 to $16 million in 1990/91. Moreover, there is no allowance for inflation over this period.

CHAPTER 3

Discussion and Recommendations

A. Program Objectives

The Committee has received extensive testimony on all aspects of Canada's Space Program. We have heard from those Federal Government departments and agencies that are most actively involved in space, from Canada's leading space-technology companies, from academic scientists and administrators, from Provincial Governments and from concerned members of the Canadian public. The Committee has been impressed by the variety and complexity of Canada's activities in space. It is appropriate, then, to consider the Federal Government's objectives in space.

In May 1986, MOSST listed four objectives for the Space Program:

(1) to build on Canada's expertise in space;

(2) to maintain Canada's position in international cooperation;

(3) to ensure maximum economic and social benefits;

(4) to ensure that Canada maintains a position of excellence in the worldwide scientific exploration of space.[6]

The Committee believes that these are admirable and practical objectives for the Space Program and it is appropriate that we should frame our evaluation of the program within the context of those objectives. Canada has been successfully involved in space activities for more than 25 years and we have achieved a notable expertise in certain areas. However, this country has limited financial, scientific and technological resources and we must employ those resources in the most economical and effective way.

B. Program Balance

In the Committee's view, *the most important issue to emerge from our hearings is that of an appropriate balance between the various components of the Space Program. The Committee feels that the 1986 Space Plan fails to strike an appropriate balance.*

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(6) Ministry of State for Science and Technology, *The Canadian Space Program: New Initiatives*, Ottawa, May 1986, p. 1.

Canada's projected civilian space expenditures over five years, in 1986 $, from FY 1986/87 to FY 1990/91 are estimated to be $824 million. Three major activities — remote sensing, Space Station, and communications — will account for the bulk of those expenditures. The proportional distribution of expenditures as defined in the 1986 Space Plan is as follows:

Remote Sensing	29.1%	($240 M)[7]
Space Station	26.6%	($219 M)
Communications	24.5%	($202 M)
Space Science	9.6%	($79 M)
Other projects	10.2%	($84 M)
	100.0%	$824 M[8]

The Committee has received testimony and documentation on three major individual projects in which Canada is, or could be, involved. These are RADARSAT, MSAT and Space Station. *The Committee believes that RADARSAT should have the highest priority of the three because it best fulfills the stated objectives of Canada's Space Program.*

Canada has been involved in satellite remote sensing since the launch of LANDSAT-1 in 1972 and, as noted earlier, we have achieved a position of world leadership in remote-sensing technology and in the collection and processing of remotely-sensed data for domestic and export markets. The world market for this technology and expertise will continue to expand into the next century and Canada has an excellent opportunity to capture a major share of this business.

The Committee has received extensive testimony on RADARSAT, from within the Federal Government and from outside. The witnesses we have heard were essentially unanimous in their support for the RADARSAT project.

RADARSAT fulfills all of the relevant objectives of the Canadian Space Program. First, it will build on, and substantially expand, Canada's expertise in space-based remote sensing. Second, because RADARSAT is a Canadian-led project in partnership with the United States and the United Kingdom, it maintains Canada's position in international cooperation on the peaceful uses of space. Third, the project provides substantial economic and social benefits for Canadians through exploitation of domestic and export sales, generating both employment and revenue.

All regions of Canada will benefit from RADARSAT. Industrial expenditures for the construction of the hardware for the RADARSAT project will be concentrated in Ontario and Quebec. However, the resource-management data produced by the satellite will generate benefits more evenly across the country. The Prairies, particularly, will benefit from the agricultural and non-renewable resource data while Atlantic Canada will be well-served by data on ice- and sea-state conditions.

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(7) Does not include RADARSAT.

(8) Ministry of State for Science and Technology, *The Canadian Space Program: New Initiatives*, Ottawa, May 1986, p. 5.

An important aspect of RADARSAT, less readily quantifiable but very significant in the Committee's view, relates to the issue of Arctic sovereignty. RADARSAT will over-fly the Canadian Arctic every 24 hours, providing detailed information on sea-ice and sea-state conditions, on surface-ship movements in the region, and on the geology of the Arctic land areas. This continuous flow of high-quality information, which has resource-management value, will enhance this country's claim to sovereignty over the Arctic.

Canada's resource industries are, and will remain, vitally important to this country's economy. As we move towards the 21st century, there will develop a growing reliance on information technologies and the economic benefits that will be derived from them. In this Committee's opinion, the RADARSAT project effectively bridges the gap between our traditional reliance on resource industries and our concurrent need to develop high-technology industries to move our economy towards the information society.

The Committee has been informed that a positive decision must be made soon on RADARSAT or the project may have to be abandoned, because our two international partners will direct their attention to other projects. An additional constraint on the United States is their current difficulties with their launch schedule in the wake of the space shuttle disaster. *The Committee believes there is an urgent need for an early and positive decision on RADARSAT by the Federal Government.*

Recommendation 1

The Committee recommends that the RADARSAT project, in its revised version, be approved and funded by the Federal Government, with funding to commence in fiscal year 1987-88.

It is this Committee's view, also, that the RADARSAT project should go ahead in addition to, not at the expense of, the presently-approved activities of the Canada Centre for Remote Sensing of the Department of Energy, Mines and Resources.

Recommendation 2

The Committee recommends that the remote-sensing program (exclusive of RADARSAT) of the Canada Centre for Remote Sensing continue to be funded at the level described in the 1986 Space Plan.

In contrast to the RADARSAT project, the testimony we have received on Canada's participation in the U.S. Space Station has been contradictory and often controversial. Indeed, much of the testimony we have received accurately reflects the continuing debate carried by the popular news media. A project of the scope and magnitude of the U.S. Space Station, with its almost infinite complexity and enormous cost, cannot easily avoid controversy. Beyond that general statement, there are a number of issues of significant concern which the Committee has attempted to address.

The Committee accepts the essential validity of the following statement, which was made by MOSST in May 1986 when the new Canadian Space Plan was announced:

> For industry, Space Station provides the opportunity to enhance technical and managerial capabilities, to maintain and forge new links with domestic and foreign industry and for

> securing new markets through participation in technical areas of strategic importance, such as automation and robotics, and materials processing in space. [9]

Additionally, there is a real and substantial return on our investment in Space Station in terms of national prestige, and from scientific and industrial linkages to be established through participation in a major international project.

The Canadian Institute for Advanced Research (CIAR) supports Canada's participation in Space Station:

> We feel that the prime objective of a Canadian Space Station Program would be to stimulate the development and diffusion of advanced technology that will strengthen the competitiveness of the Canadian economy. In other words, we view the Canadian Space Station Program as a technology driver program.[10]

Very positive comments were also made about Space Station by the Canadian Prime Contractor, Spar Aerospace Limited:

> Our role in building the Mobile Servicing Centre is much more than constructing a mission-critical integral component of this exciting project. It is in a very real sense a beacon for our best intellectual talents —in attracting them to where the action is, here at home in Canada...[11]

To a degree, this Committee shares in the excitement of Space Station and the strong sense of national purpose that is associated with our participation. But we have also received a substantial body of testimony expressing serious concern about this project.

The most obvious concern is about the possible military uses of Space Station by the United States. The Federal Government has rightly expressed concern about this issue. Canada agreed to participate in Space Station on the understanding that it would be designed, developed, operated and used as a civil space station in a manner consistent with international law. The Committee supports this position.

There may be certain uses of Space Station, however, which some observers would define as "military" but which the Committee believes should not be rejected outright. One such possible use of Space Station could be for testing of arms-control verification technologies. The Committee believes that the use of Space Station for such a purpose would be acceptable.

Overt military use of the Space Station is unacceptable to the Committee. To the degree that basic scientific research in space can be accurately categorized as military or non-military, we believe that experimentation dedicated to the development of weapons systems, including the Strategic Defense Initiative (SDI), should not be performed on Space Station.

Canada's investment in Space Station will only pay acceptable dividends if the managerial and technological expertise gained in the development of the MSS can be transferred to terrestrial applications[12]. Canada needs adequate access to the Space Station's working areas — the pressurized modules — to pursue experiments in space science, particularly materials science, in a microgravity environment.

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(9) Ministry of State for Science and Technology, *The Canadian Space Program: New Initiatives*, Ottawa, May 1986, p. 3.
(10) Canadian Institute for Advanced Research, Issue No. 17, March 9, 1987, p. 17:23.
(11) Spar Aerospace Limited, Brief to the Standing Committee on Research, Science and Technology, March 9, 1987, p. 4.
(12) For an interesting discussion of the link between space and terrestrial applications in the use of hydrogen, see the testimony of the Hydrogen Industry Council, Issue No. 34, June 12, 1987.

The Canadian Institute for Advanced Research (CIAR) has recommended to the Federal Government that the designated funding for the MSS be apportioned as follows:

> ...about half the program [funding] should be devoted to the production of the Space Station hardware, an eighth ... to the Space Station user development, about a quarter to the technology development program, and the remaining eighth as the seed money for the technology exploitation program.[13]

The CIAR raised another important point when it further recommended that a dramatic increase in the cost of the space hardware should not come at the expense of the other elements of the program. The same concern was expressed to us by Canadian Astronautics Limited, a designated sub-contractor for the MSS and other space projects.[14] The Committee shares their concern. *Based on past experiences with major projects, we doubt that the expenditures for the MSS will be confined to the estimated funding of about $700 million.* Our fear is substantiated by the fact that the initial U.S. estimate for Space Station of $8 billion (U.S.) has now ballooned to $14 billion (U.S.). Moreover, Canada's share of annual operating costs for Space Station could be as high as $30 million.

A number of witnesses were opposed to Space Station because they felt it was an inappropriate project for Canada to participate in. There is an essential difference between the Space Station Program and previous space projects, such as those dedicated to communications and remote sensing. In those instances, we went into space for a specific purpose, using the space platform (satellite) to achieve a definitive result; e.g. a superior system of communications. In the case of Space Station, the space platform itself is the focus of the activity and the potential uses of the Station are a secondary consideration.

The President of Telesat Canada discussed this point with the Committee, at some length:

> I am not an advocate of Canadian involvement in the space station. I think it corners too much of our available financial resource and concentrates it on our hardware development program which is unlikely to have much ongoing benefit for Canada.
>
> Projects such as our involvement in the space station are often sold on the basis that they will produce great technical spinoffs in our economy, but I think we should be dubious of claims of spinoffs from hardware-based space projects. For example, if the real benefit of hardware development in the space station is the boost and spinoff effect it gives to robotics, why do we not spend our money on robotics that work here on earth and can be applied to terrestrial needs where there is an ongoing market; not to a space station which somebody else may or may not build later on?[15]

Several witnesses suggested that a succession of smaller projects with defined goals would be preferable to Space Station.[16]

The Committee is also concerned that Canada lacks sufficient depth in basic scientific research to use effectively the microgravity environment of Space Station. We acknowledge that there is considerable potential to develop useful industrial processes but we believe that this potential has been greatly exaggerated by the more enthusiastic proponents of the project.

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(13) Canadian Institute for Advanced Research, Issue No. 17, March 9, 1987, p. 17:24.
(14) Canadian Astronautics Limited, Issue No. 16, March 4, 1987, p. 16:7.
(15) Telesat Canada, Issue No. 30, May 21, 1987, p. 30:7.
(16) Canadian Astronautics Limited, Issue No. 16, March 4, 1987, p. 16:6; Bristol Aerospace Limited, Issue No. 32, May 27, 1987, p. 32:87.

The Committee has considered the evidence and, on balance, we accept the validity of the statement by Dr. J.S. MacDonald of MacDonald Dettwiler and Associates that "Man-in-Space is something in which [Canada] should participate because it is clearly going to be part of the future of mankind, and as an advanced nation we cannot afford not to be part of it."[17] Although we share reservations about the size of the return on our investment in Space Station, we feel that Canada should continue to participate in the project, provided some specific conditions are met.

Recommendation 3

The Committee recommends that Canada proceed with its participation in the Space Station Project, provided that:

a) agreement be reached with the United States on military use of Space Station. A minimum acceptable agreement would be the exclusion of weapons or weapons prototype testing from Space Station;

b) a satisfactory agreement be negotiated with NASA on Canada's use of Space Station facilities, including polar platforms for Canadian research, Space Station access time, and Canada's share of operating costs;

c) acceptable assurances be given by the Federal Government that cost increases (overruns) for the MSS will not be met at the expense of other parts of the Space Program.

The 1986 Space Plan establishes the Canadian Astronaut Program on a continuing basis, confirming Canada's belief in the value of manned space flight. As currently planned, the successful continuation of the Canadian Astronaut Program depends on participation of Canadian astronauts in future shuttle flights and their eventual access to Space Station.

Recommendation 4

The Committee recommends that Canada's agreement with NASA on participation in the Space Station Project should include access of Canadian astronauts to Space Station.

Canada's investment in the science and technology of satellite communications has been a notable success and Telesat Canada is now a profitable private corporation. The Committee views the Canadian experience in space communications as a true success story of basic science, initially funded by government, maturing into a practical and profitable applied technology with widespread benefits for Canada.

Given the profitability of the satellite communications industry in Canada, *the Committee believes it is now appropriate for the private sector to provide most of the funding for research and technology development in satellite communications. Concurrently, the Federal Government's funding for the communications component of the Space Program should decrease.*

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[17] MacDonald Dettwiler and Associates Ltd., Brief to the Standing Committee on Research, Science and Technology, June 12, 1987, p. 4.

Recommendation 5

The Committee recommends that the Federal Government's funding for the communications component of the Space Program be gradually decreased and that the principal responsibility for research and technology development in this field be assumed by private industry.

The Committee views the MSAT program as having great value for Canada and we believe the Federal Government should continue to provide funding for technology and market development for that project, as indicated in the Space Plan. The Federal Government has stated that it will be a major user of MSAT services when the system is operating. This, however, is an operational decision by those departments and agencies of government which will use the service and the Committee does not believe that such leasing arrangements are appropriate for inclusion as part of Canada's Space Program.

Recommendation 6

The Committee recommends that the Federal Government continue to support the MSAT project but that funds for leasing MSAT services should be drawn from the budgets of user departments and not be charged against the Space Program budget.

The Committee has received a considerable body of disturbing testimony on the decline of space-science funding in Canada. As noted earlier, funding has declined from approximately 15% of the Space Program budget to less than 10%. This level of funding is significantly lower than that provided in the space budgets of other Western countries. In the United States, for example, NASA spends 20% of its total budget on space science.

The Committee is aware that there is generally insufficient funding for basic scientific research in Canada. The situation which exists in space research is perhaps instructive in indicating the severe negative effects that may accrue to a science program when research funding is inadequate.

Canada's initial, and very successful, ventures into space were science-based and by the early 1970s the Canadian space-science community included almost 100 researchers in government laboratories and universities. Since then, however, the situation has gradually, but markedly, deteriorated. Since 1971, not a single Canadian scientific satellite has been launched. Moreover, there has been a lack of hiring of space scientists over the last fifteen years and the physical infrastructure supporting the activity has deteriorated. This decline in support for space science has discouraged many high-calibre graduate students from seeking a career in space research. As a consequence, Canada is facing a critical shortage of space scientists and engineers in the years ahead.

The Committee is convinced that a substantial increase in funding for space science is needed if Canada is to be able to participate effectively in international space projects in the future. Professor R.P. Lowe of the University of Western Ontario has summarized the situation in succinct terms:

> Canada is not only unique in having a space science budget that is small by both absolute and proportionate standards; it also is unique in not having an independent launch capability to which it has guaranteed access on a continuing basis. This handicap is a continual constraint in the formulation of Canadian activities in space although it potentially could provide some advantages. It forces our space scientists to seek out

international partners who have an infrastructure of launch vehicles, spacecraft, tracking and data acquisition stations and all of the centres of expertise that these imply. But a partnership implies that each partner must contribute something of value that the other does not have. In Canada's case, this must be scientific expertise both in the field of knowledge itself and in the state-of-the-art instrumentation required to further advance that knowledge. Therefore, for Canada more than other nations, it is even more important to support the space science activity at a healthy level.[18]

Recommendation 7

The Committee recommends that the Space Science component of Canada's Space Program should be funded at the level of approximately 15% of the total Program budget and that the Program content should be determined through consultation with the Space Science community in Canada.

One of the reasons advanced in support of Canada's participation in Space Station is the prospect of using the space environment, and particularly the microgravity environment, to develop industrial processes for the production of novel and useful products. In the Committee's view this is a valid approach, but we question whether Canada has a sufficient reservoir of basic expertise in such areas as materials science to allow us to capitalize effectively on the opportunity. From the testimony we have heard, it is our considered opinion that microgravity research, for example, is at a very basic level at this time and that the designation, "User Development Program", is not appropriate to the reality of the situation. We believe that this aspect of our participation in Space Station should be re-classified as space science and that funding and management of this research should be included in the Space Science component of the Space Program.

Recommendation 8

The Committee recommends that the Space Station User Development Program should be integrated into the Space Science component of the Space Program.

The Committee believes that Canada's Space Program should have a specific component dedicated to the development of space technology. This component would be separate from the Space Science component but would build upon the basic scientific research carried out and coordinated by that group in government and university laboratories. Examples of successful Canadian space technology programs in the past are the satellite-communications technologies developed by the Department of Communications (DOC) and adapted by Telesat Canada in the Anik satellite series, and the development of the CANADARM Remote Manipulator System by Spar Aerospace Limited in collaboration with the National Research Council and DOC.

Major opportunities for technology development are implicit in Canada's participation in Space Station and in remote sensing. We believe that these activities should be managed in a single program with a funding level approximately equal to that recommended above for the Space Science component of the Space Program.

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(18) Professor R.P. Lowe, University of Western Ontario, Brief to the Standing Committee on Research, Science and Technology, April 30, 1987, p. 9.

Recommendation 9

The Committee recommends that the Space Program should have a Space Technology component which would include the technology development activity currently part of the Space Station Project, and appropriate parts of the Remote Sensing activity of the Canada Centre for Remote Sensing. Funding for this component should be at the level of about 15% of the total Space Program budget.

The foregoing discussion centres on those space projects in which Canada is presently involved and recommends certain changes in the balance of activities in our Space Program which we feel will improve that program. Since there is a realistic concern that a major component of the Space Program, our participation in the U.S. Space Station, may not ultimately go ahead, it is appropriate for the Committee to suggest an alternative course of action which would provide challenging opportunities for our space scientists and at the same time be consistent with Canada's concept of its position in the world community.

Canada is a strong proponent of world peace and comprehensive multilateral arms-control measures. The Arms Control and Disarmament Division of the Department of External Affairs, through its Verification and Research Unit, has commissioned research on space-based verification of arms-control measures. This process has been developed by External Affairs as the PAXSAT Concept, the application of space-based remote sensing for verification of multilateral arms control.

The PAXSAT Concept has two potential applications. The first is designated as PAXSAT 'A' and involves space-to-space remote sensing and deals with the verification of agreements involving space objects. The second, PAXSAT 'B', focuses on the verification of agreements involving conventional forces through space-to-ground remote sensing.

Canada's expertise in satellite remote sensing, combined with our dedication to verification of multilateral arms-control agreements, eminently qualifies us to take the lead in an international collaborative program of the PAXSAT type. Canada's declared interest in this activity was reiterated in the Speech from the Throne on October 1, 1986:

> Arms control and disarmament are essential elements of Canadian policy. We are in the forefront of multilateral discussions concerning conventional arms control and confidence-building in Europe. In the nuclear field, both the verification of existing agreements and the conclusion of new accords are vital elements in Canada's efforts.[19]

At the Committee's public hearing in Toronto, the Working Group on International Surveillance and Verification presented the following testimony:

> Canada possesses outstanding technical capabilities in remote sensing and surveillant instrumentation which, with a certain amount of political will, could be put to excellent use in the fields of international airborne and satellite surveillance for peace-keeping and arms verification.
>
> The need for this technology is now coming into international prominence as more arms limitation treaties are expected to be made and as the United Nations is being called upon more and more to undertake peace-keeping and arms-verification activities.
>
> In forming a new Canadian space agency there is an opportunity for Canada to be able to provide more international technical expertise in these areas.[20]

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(19) Speech from the Throne, October 1, 1986.

(20) Working Group on International Surveillance and Verification. Brief to the Standing Committee on Research, Science and Technology, May 13, 1987, p. 3.

The Committee has reviewed the testimony and evidence we have received on this issue, and we consider the surveillance and verification role an appropriate one for Canada. Therefore, if for any reason, Canada does not proceed with the Space Station Project, we propose the following recommendation for an alternative program:

Recommendation 10

The Committee recommends that, should an alternative to the Space Station Project become necessary, the Federal Government should consider expanding the RADARSAT program to incorporate an arms-control surveillance and verification role in collaboration with other interested and appropriate countries.

Professor Ursula Franklin of the University of Toronto and Professor William Fyfe of the University of Western Ontario presented testimony on the *International Geosphere-Biosphere Programme (IGBP): A Study of Global Change*, more popularly known as the Global Change Project. The IGBP was unanimously adopted by the International Council of Scientific Unions (ICSU) at the 21st General Assembly in Berne, Switzerland in September 1986.[21]

The objective defined for the IGBP is as follows:

> To describe and understand the interactive physical, chemical, and biological processes that regulate the total Earth system, the unique environment that it provides for life, the changes that are occurring in this system, and the manner in which they are influenced by human actions.[22]

The IGBP will be developed as a research program to provide the fundamental information basic to an assessment of likely future changes on the Earth in the next 100 years.

The dominant influences on the earth's environment are of natural origin and include volcanism, the shifting courses of rivers, the turbulent dynamics of the atmosphere and oceans, and changing energy inputs from the sun. Superimposed on these natural forces are the activities of humans, particularly our use of fossil fuels for energy generation, intensive agricultural practices, major construction projects, and our almost infinite capacity to produce waste materials. The more serious effects of human activities include acidic precipitation, the rise in atmospheric concentrations of greenhouse gases such as carbon dioxide, desertification, water pollution, and the widespread degradation and erosion of agricultural soils.

To understand, and hopefully modify, these destructive processes will require a more complete knowledge than we now have of the physical and biological components and dynamics of the total Earth system. A major international transdisciplinary research effort is required: hence the motivation to develop the International Geosphere-Biosphere Programme.

Among the technologies needed for this complex understanding is the ability to examine the Earth as a planet from space. It is in this context that the RADARSAT program was cited as a valuable technology for providing some of the earth-resource data that will be

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(21) Dr. Ursula Franklin, Issue No. 23, March 30, 1987, p. 23:8. Dr. William Fyfe, Issue No. 26, April 30, 1987, p. 26:7.

(22) International Council of Scientific Unions (ICSU), Ad Hoc Planning Group on Global Change, *The International Geosphere-Biosphere Programme: A Study of Global Change*, April 4, 1986, p. 3.

needed for the IGBP. In its present revised configuration, the radar sensor (SAR) will provide data on ice coverage and dynamics in polar regions; ocean dynamics; geological information; data on soil moisture and changes in water bodies; and vegetation dynamics on land.

Another sensor, which was part of the original RADARSAT design, is an advanced very high resolution radiometer (AVHRR), a multispectral scanner operating in the visible and infrared bands. The AVHRR would provide global information on vegetation dynamics, including data on soil moisture and crop conditions, and sea surface temperatures. Inclusion of this additional sensor would increase the cost of RADARSAT by $12 million.

The Committee believes that the Global Change Project is an important initiative and Canada's active involvement is both appropriate and desirable.

Recommendation 11

The Committee recommends that studies be undertaken, or supported, by the Federal Government to determine how the RADARSAT project, either in its revised form or in an appropriately expanded form, could be used as part of the International Geosphere-Biosphere Programme (the Global Change Project), as adopted by the International Council of Scientific Unions.

C. Program Budget

In 1985/86, the estimated expenditures in the Canadian Space Program were $158 million. Space Program expenditures for the five-year period 1986/87 to 1990/91 are, in $ million (1986 $):

1986/87	1987/88	1988/89	1989/90	1990/91
148	160	170	166	180

The Federal Government's annual investment in space activities has been, and is, surprisingly small, but it is an investment that has paid handsome dividends. Space technologies have been successfully transferred to Canadian private industry. Canada is unique in the world in that the value of our industrial exports of space products and services, now some $200 million per year, exceeds by a large margin the government's total annual expenditures on the Space Program.

It is an acknowledged fact that Canada's total investment in Science and Technology is lower than it should be for this country to remain competitive in the international marketplace and, arguably, to retain our status in the world's science community. The Committee is persuaded, based on the evidence that we have received, that the Federal Government's investment in space is presently too low to achieve an optimal return on those dollars that are committed to the program. Canada presently stands eighth in the world in space expenditures as a percentage of Gross National Product, just behind the Netherlands and just ahead of the United Kingdom. The leading actors in space in the Western World are the United States and France, each of whom spends far more on space, proportional to Gross National Product, than does Canada.

The Committee believes that the Space Program budget should be increased by approximately 25%, to effect a better balance of components (as recommended earlier) and more appropriate funding levels for individual activities. The Committee believes that an increase in funding for the Space Program is essentially an investment in Canada's economy of the 21st century and can readily be defended on that basis.

Recommendation 12

The Committee recommends that funding for Canada's Space Program should be increased to approximately $200 million per year (1987 $) for each of the next five years.

In Table 1, below, we present a summary of cash flows to each of the components of the Space Program, necessary to carry out the various activities in the balanced program recommended earlier. These cash flows are based on funding information supplied to the Committee by federal departments and agencies during the course of our study.

TABLE 1

CANADIAN SPACE PROGRAM
SUGGESTED CASH ALLOCATIONS
1987/88 — 1991/92
($ million 1987)

Program Component	1st year	2nd year	3rd year	4th year	5th year	Totals
Space Station	21	31	43	48	50	193
RADARSAT (modified)(1)	38	42	46	50	54	230
Remote Sensing	38	40	18	18	18	132
Communications (2)	34	20	20	10	6	90
Space Science (3)	30	30	30	30	30	150
Space Technology (4)	30	30	30	30	30	150
Other (5)	12	12	12	12	12	60
TOTALS	203	205	199	198	200	1,005

(1) Funding for RADARSAT not included in 1986 Space Plan.
(2) Decreasing support with time.
(3) Includes the funding for the Space Station User Development Program.
(4) Includes sensor development, new software, etc.
(5) Includes expenditures for European Space Agency and the Canadian Astronaut Program.

D. The Canadian Space Agency

The Federal Government's Space Program is presently coordinated by the Interdepartmental Committee on Space (ICS). We have no wish to denigrate or criticize the efforts and dedication of the members of the ICS, but that body has lacked decision-making and funding authority over the departmental and agency programs represented by its members. The Aerospace Industries Association of Canada (AIAC) has commented on the shortcomings of the ICS:

> The Interdepartmental Committee on Space (ICS) is expected to coordinate Canada's efforts. It is not expected to manage them. In fact, nobody in Canada manages a truly national space program. Each department involved in space looks after its own projects. This fragmentation is demoralizing to the space industry, because government, after all, is not only its partner, but also one of its biggest customers. And it is confusing to Canada's international partners and customers, who must deal with several different government departments which damages Canada's image in the world community.[23]

We have taken note also of the testimony of Dr. L.W. Morley, the founding Director of the Canada Centre for Remote Sensing, and presently at the Department of Physics, York University:

> I would like to say that I am delighted that Canada has chosen to create a space agency. For 10 years I suffered as a member of the Interdepartmental Committee on Space, and I do not think there was a more ineffectual committee in the whole government.[24]

In the Speech from the Throne on October 1, 1986, the Federal Government stated its intention to create, through legislation, a national Space Agency:

> My government's commitment to high technology as a motive force in Canada's economic growth will be expressed in legislation to establish a Canadian space agency. International cooperation in the peaceful use of space is essential to the development of key technologies. Working in cooperation with industry, universities and provinces, the new agency will help to ensure that the benefits of Canada's role in space will be shared by all Canadians.[25]

There was essentially unanimous support from witnesses who appeared before the Committee for the creation of a Space Agency. *The Committee strongly endorses the creation of a Canadian Space Agency to integrate and manage Canada's Space Program to ensure that our limited resources are invested in the most effective manner possible. We anxiously await the introduction of the enabling legislation for the new agency.*

For the new Space Agency to be effective, based on the testimony we have received, the Committee believes that the Agency must have operational control over all of the Federal Government's space activities. This includes the relevant parts of DOC's Communications Research Centre, the Canada Centre for Remote Sensing of EMR, and the Space Division of NRC.

Recommendation 13

> **The Committee recommends that the Canadian Space Agency should incorporate all personnel, budgets and facilities of the Federal Government's departments and agencies presently engaged in space activities, including all in-house space Research and Development (R&D) capability.**

It is important that the Space Agency have a stable budget, including funding for all the Federal Government's R & D activities in space. Because space projects tend to be long-term in nature, the budget should be approved for at least a five-year period.

Recommendation 14

> **The Committee recommends that the Canadian Space Agency have a stable five-year budget that includes funding for all space R&D activities of the Federal Government.**

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(23) Aerospace Industries Association of Canada, *SPACE - An Opportunity for Canada*, January 1985, p. 15.
(24) Dr. L.W. Morley, Issue No. 28, May 12, 1987, p. 28:97.
(25) Speech from the Throne, October 1, 1986.

The Science Council of Canada has recommended that an advisory council on space, separate from the Space Agency, should be created. The advisory council would be representative of the general public and all sectors involved in space activities, and would report directly to the Minister responsible for the Space Agency. The Committee concurs in this recommendation.

Recommendation 15

The Committee recommends that an Advisory Council on Space, comprised of representatives from industry, university and government, be established to advise on space policy. The Advisory Council should report to the Minister responsible for the Space Agency.

A critically important part of Canada's Space Program is the international collaboration on space activities. As we have discussed earlier, Canada perhaps is more dependent on international collaborative space projects than most other countries, principally because we lack an independent launch capability. Examples of current international projects are Space Station, MSAT, and the search-and-rescue system SARSAT/COSPAS.

International space projects vary considerably in character and complexity and Canada's involvement may be negotiated on an inter-agency basis, or require an intergovernmental agreement (IGA). Where Canada's involvement is essentially technical in nature, as in the case of our contribution to Sweden's VIKING satellite, an agency-to-agency agreement is sufficient. In a more complex project, as in the case of Space Station, an IGA is required since important foreign policy issues may be involved. An inter-agency agreement, dealing with the technical issues, can be developed under the umbrella of the IGA.

The Committee believes that the Canadian Space Agency should be responsible for negotiating agreements with the space agencies of other countries. When a specific project involves issues bearing on Canada's foreign policy, and an IGA is required, the Department of External Affairs will be responsible for negotiations.

Recommendation 16

The Committee recommends that the Canadian Space Agency have the authority to negotiate agreements on international space projects with its counterparts in other countries.

A recurrent theme in the Committee's hearings on the Space Program was the emerging crisis in the training and supply of space scientists and engineers to carry Canada's space effort into the next century. We alluded to this problem earlier in our discussion of the effects of the cancellation of the sounding-rocket program and its dual impact on Canada's Space Science Program and on research opportunities for graduate students.

Professor Gordon Rostoker of the University of Alberta made the following statement on this issue:

> ...the picture I am painting is one of an aging, over-committed group of researchers who have, in the past, served Canada and their science well. They are, however, being asked to

do all the tasks they have done in the past plus many others and are lacking the infrastructure of support so necessary to the successful discharge of their responsibilities. The lack of career positions in the space sciences over the past 15 years has led to a significant drop in the number of young people prepared to pursue a research career in that area. We do have some soft money postdoctoral positions available within our community, but there are no qualified applicants to be found in Canada. In short, it is my opinion that the scientific community of space researchers in Canada is in no position to effectively participate in major new initiatives such as Space Station.[26]

The problem in Canada of an insufficient supply of scientists and engineers is multi-faceted and long-standing and is not confined to the field of space science and research. As frequently noted by the Minister of State for Science and Technology, part of the difficulty stems from Canada's lack of a "science culture", a societal problem which results in too-few qualified candidates entering university programs in science and engineering. In the past, Canada has relied heavily on imported technical and scientific expertise, but this is an option of diminishing relevance in an increasingly competitive world.

The Committee views the situation with concern. We make the following recommendation.

Recommendation 17

The Committee recommends that the Canadian Space Agency, in consultation with the Natural Sciences and Engineering Research Council (NSERC), carry out a comprehensive study of the training and supply of space scientists and engineers and develop mechanisms to ensure an appropriate supply of qualified personnel for future years.

We were also informed by a number of witnesses that the funding policies of NSERC, while invaluable to the university Space Science community, are often not conducive to productive interaction between university and government scientists, and industry. The situation is not helped by the current level of investment in R & D by Canada's major space contractors. The Committee believes that the new Space Agency, established with the comprehensive authority that we have recommended, should seek ways to increase the level of interaction. The *Centre d'adaptation de la main-d'oeuvre aérospatiale au Québec* made the following statement which is pertinent to this discussion:

We believe that the Space Agency must have a mandate, in addition to its co-ordination of space programs, to promote, whenever possible, closer ties between university researchers and private enterprise. This agency must serve as a catalyst, and create multiple links of cooperation and joint action between the representatives of these two milieux.[27]

Recommendation 18

The Committee recommends that the Canadian Space Agency, in consultation with NSERC, develop mechanisms to fund university space research that would be complementary to NSERC funding and that would encourage greater interaction between university and government scientists, and industry.

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(26) Dr. Gordon Rostoker, Brief to the Standing Committee on Research, Science and Technology, May 27, 1987, p. 8.

(27) *Centre d'adaptation de la main-d'oeuvre aérospatiale au Québec*, Brief to the Standing Committee on Research, Science and Technology, June 1987, p. 5.

The Federal Government has stated its intention to ensure that the industrial benefits from the overall Space Program are equitably distributed across Canada. Particular emphasis has been placed on the distribution of benefits to eastern Quebec and Atlantic Canada. The government's proposed distribution of new Space Program expenditures over the five-year period is as follows:

Atlantic Canada	10%
Quebec	35%
Ontario	35%
Prairies	10%
British Columbia	10%[28]

At the present time, Canada's space industry is concentrated in Ontario and Quebec with significant, but smaller, centres of activity in the Prairies, particularly Saskatchewan, and in British Columbia. There is little space activity in Atlantic Canada at this time. The Committee received the following testimony from the Department of Regional Industrial Expansion (DRIE) on the outlook for Atlantic Canada:

> ...we believe it will be very difficult. We do believe it is reasonable to expect that we will achieve some development of industrial activity in the Atlantic provinces as part of the next five-year space plan. I do not want to leave committee members with the impression that Atlantic Canada is a wasteland of technology and technological capability. This simply is not true. There are small emerging companies in various places in Atlantic Canada; Fredericton Process Technologies and a number in Halifax could possibly take advantage of some of the activity associated with the Canadian space plans. We believe some progress can be made. I must say frankly, though, that our evaluation of 10% is a very ambitious target during the period of time we are talking about here.[29]

The question of regional development is a sensitive and difficult issue in Canada, particularly for high-technology industries which will increasingly form the foundation for continued economic prosperity in the decades ahead. The Committee is sensitive to the needs of such areas as Atlantic Canada whose citizens wish to participate in the benefits of advanced technology industries.

We question, however, if it is practical, at least over the short term, to attempt to distribute the limited resources of Canada's Space Program to areas lacking the appropriate industrial infrastructure to participate efficiently. Where the real benefits of the Space Program can be shared regionally without compromising the overall thrust of the Program's activities, the Committee sees no difficulty whatever.

In this context, both the RADARSAT and MSAT programs will confer substantial benefits on Canada's regions. Both programs, the first a Federal Government initiative and the latter a government-supported Telesat Canada enterprise, have substantial value for the fisheries and natural-resource industries, for example. Another alternative might be to encourage the construction of earth stations or other space-activity support facilities in those regions lacking the industrial infrastructure to participate directly in the manufacture of space hardware.

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(28) Ministry of State for Science and Technology, Issue No. 15, March 2, 1987, p. 15A:13.
(29) Department of Regional Industrial Expansion, Issue No. 19, March 18, 1987, p. 19:13.

The Committee believes that the Canadian Space Agency should explore these various possibilities with DRIE to devise acceptable regionalization initiatives that will be compatible with the goals of the Space Program.

Recommendation 19

The Committee recommends that the Canadian Space Agency, in cooperation with DRIE, should reassess the feasibility of the proposed regional distribution of space hardware contracts and determine if alternative approaches would be more appropriate in regions where no space hardware manufacturing capability exists at the present time.

If the Committee's recommendations are enacted, the Space Agency will have an important role in funding space research at various levels. Again, because Canada's resources for space activities are limited, it is essential that research funded by the Agency be strictly controlled as to quality and purpose. *Long-term research projects, which frequently are international in character, must adhere to world-class standards; short-term research must be driven by the specific requirements of the individual client.*

Recommendation 20

The Committee recommends that the Canadian Space Agency should establish formal procedures, including peer-review mechanisms where appropriate, to evaluate new proposals for research as well as the results of R&D supported by Agency funding.

E. Launch Services

Canada does not have, and has never had, the capability to launch satellites. In past years — and the four satellites in the Alouette-ISIS series are examples — Canada procured launches through collaboration with other countries, principally the United States, on space projects of various kinds. As was discussed earlier in this Report, Canada had a productive sounding rocket launch program at Fort Churchill, Manitoba.

Since the cancellation of the Fort Churchill program in 1984, the space science community has suffered from the lack of a domestic sounding rocket launch capability. The shuttle disaster has further complicated the situation because NASA itself now has a diminished launch capability for the U.S. civilian space program and has instituted restrictions on launches for foreign countries.

The Committee has addressed the issue of whether Canada should re-institute a domestic launch program. Several witnesses, including Professor Ralph Nicholls of York University, have recommended that consideration be given to re-establishing the launch program at Fort Churchill, as well as the balloon program at Gimli, Manitoba.[30]

The Committee also received testimony from Bristol Aerospace Limited of Winnipeg on this issue. Bristol is the manufacturer of the Black Brant series of sounding rockets which were used extensively at the Fort Churchill facility. The Black Brant is also used extensively by NASA and is, in fact, widely used around the world for space science projects.

(30) Dr. Ralph Nicholls, Brief to the Standing Committee on Research, Science and Technology, April 13, 1987, p. 26.

Bristol Aerospace further informed the Committee that the company is prepared, conditional on the receipt of appropriate funding from the Federal Government, to study the feasibility of developing a Canadian Expendable Launch Vehicle (ELV) for launching small satellites into orbit. The technology for an ELV is available in Canada. It was suggested to us that an international market might exist, or be created, to make the ELV project economically viable at some point in the future.[31]

The Committee has considered the evidence received. We do not feel that the development of a Canadian ELV capability is affordable. The Committee feels that Canada should rely on other countries for a satellite-launching capability, through participation in international projects.

We believe it is desirable for Canada to have a sounding rocket capability for space science projects but we question whether the financial resources are available from the Federal Government at this time to develop a launch facility. We believe, however, the feasibility of such a program should be reassessed. For space science projects requiring sounding rockets, we recommend that the Black Brant rockets should be used when required. If a Canadian launch facility is not re-established, launch services should be purchased from other countries or arrangements made for cooperative projects.

Recommendation 21

The Committee recommends that Canada not develop a capability to launch satellites but, instead, continue to participate in international projects with countries which have a satellite-launching capability.

Recommendation 22

The Committee recommends that Black Brant sounding rockets and balloons be used when required as part of Canada's Space Science program. If the numbers required do not warrant re-establishing a launch capability in Canada, arrangements should be made with other countries for launch services, either through direct purchase or through cooperative projects.

Canada has enjoyed a long and productive association with the United States through NASA. In the opinion of some witnesses, however, our Space Program became excessively reliant on launch services provided by the United States, a situation which has produced serious difficulties in the aftermath of the Challenger explosion. In recent years, other countries have become more active in space activities and a number, including France and Japan, have developed, or are developing, reliable launching capabilities. Historically, Canada's space activities have had a notable international character, including, more recently, some cooperation with the Soviet Union and the People's Republic of China. The Committee feels it is appropriate that Canada continue to develop international linkages to ensure that our space researchers have both continuity and flexibility in obtaining launch services.

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[31] Bristol Aerospace Limited, Issue No. 32, May 27, 1987, p. 32:84.

Recommendation 23

The Committee recommends that Canada not rely too heavily on any one country for launch services but, instead, explore possibilities for cooperative projects with a number of countries, including European nations, Japan, the Soviet Union, China, and the United States.

Although not specifically confined to the issue of launch services, Canada's relationship with the European Space Agency (ESA) may usefully be discussed at this point. This country has had a long and fruitful relationship with ESA. We have, however, received testimony suggesting that the "overhead costs" of our formal ties with ESA are not justified by the return Canada receives on the investment. Both Canadian Astronautics Limited and Telesat Canada expressed this view, and we quote the former in this context:

> In our view, the Canadian involvement in ESA has not been quite so successful, the main flavour difference there being that the way the ESA involvement works is that Canada contributes money to ESA, which is then spent back in Canada, except that not all of it gets spent in Canada. Canada has had kind of a dual mode approach to ESA. One is in the study area where basically roughly half of the money we put into ESA comes back into Canada. We think we can get far more bang for the buck, as it were, by spending that money right at home. If we want to participate in ESA programs we think there are better ways to do it than by being associate members of ESA.[32]

The contrary view, essentially expressing present Canadian policy, was articulated by the Department of Energy, Mines and Resources:

> ...when the government enters into an agreement with the European Space Agency, the arrangement is such that all countries that partake in that agreement share in the industrial benefits in proportion to their investment in the project. But there is an overhead that is kept back by the agency itself. The result is that on many programs it would be typical that for a $3 program, $1 would be required for the agency and its organizational units to operate, and only $2 would be shared back to participating countries in proportion to their investment. So some industrialists would argue that it would be better for the government to invest the Canadian dollars directly in these companies and avoid the loss of some of the overhead in Europe. Other companies would argue that, indeed, the overhead is worthwhile because it associates us, to our advantage, with larger projects that we cannot afford alone. Secondly, it opens the market up for Canadian products, and, thirdly, it opens up the possibility for some of our companies to cooperate in Europe.
>
> I know many of the people who appear before your committee, and I am sure that some industrialists would take the same view as [Canadian Astronautics Limited]. Others would take a different view and say no, there is a net benefit in the Canadian government's participating in the European Space Agency. But the issue really is the fact that some money does go to the overhead.[33]

The Committee acknowledges the various opinions expressed to us. We have considered the issue and, on balance, we believe that it is appropriate that Canada continue our formal relationship with ESA.

Recommendation 24

The Committee recommends that Canada continue our formal cooperative arrangement with the European Space Agency.

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(32) Canadian Astronautics Limited, Issue No. 16, March 4, 1987, p. 16:7.
(33) Department of Energy, Mines and Resources, Issue No, 21, March 18, 1987, p. 21:29.

LIST OF RECOMMENDATIONS

Recommendation 1

The Committee recommends that the RADARSAT project, in its revised version, be approved and funded by the Federal Government, with funding to commence in fiscal year 1987-88.

Recommendation 2

The Committee recommends that the remote-sensing program (exclusive of RADARSAT) of the Canada Centre for Remote Sensing continue to be funded at the level described in the 1986 Space Plan.

Recommendation 3

The Committee recommends that Canada proceed with its participation in the Space Station Project, provided that:

a) **agreement be reached with the United States on military use of Space Station. A minimum acceptable agreement would be the exclusion of weapons or weapons prototype testing from Space Station;**

b) **a satisfactory agreement be negotiated with NASA on Canada's use of Space Station facilities, including polar platforms for Canadian research, Space Station access time, and Canada's share of operating costs;**

c) **acceptable assurances be given by the Federal Government that cost increases (overruns) for the MSS will not be met at the expense of other parts of the Space Program.**

Recommendation 4

The Committee recommends that Canada's agreement with NASA on participation in the Space Station Project should include access of Canadian astronauts to Space Station.

Recommendation 5

The Committee recommends that the Federal Government's funding for the communications component of the Space Program be gradually decreased and that the principal responsibility for research and technology development in this field be assumed by private industry.

Recommendation 6

The Committee recommends that the Federal Government continue to support the MSAT project but that funds for leasing MSAT services should be drawn from the budgets of user departments and not be charged against the Space Program budget.

Recommendation 7

The Committee recommends that the Space Science component of Canada's Space Program should be funded at the level of approximately 15% of the total Program budget and that the Program content should be determined through consultation with the Space Science community in Canada.

Recommendation 8

The Committee recommends that the Space Station User Development Program should be integrated into the Space Science component of the Space Program.

Recommendation 9

The Committee recommends that the Space Program should have a Space Technology component which would include the technology development activity currently part of the Space Station Project, and appropriate parts of the Remote Sensing activity of the Canada Centre for Remote Sensing. Funding for this component should be at the level of about 15% of the total Space Program budget.

Recommendation 10

The Committee recommends that, should an alternative to the Space Station Project become necessary, the Federal Government should consider expanding the RADARSAT program to incorporate an arms-control surveillance and verification role in collaboration with other interested and appropriate countries.

Recommendation 11

The Committee recommends that studies be undertaken, or supported, by the Federal Government to determine how the RADARSAT project, either in its revised form or in an appropriately expanded form, could be used as part of the International Geosphere-Biosphere Programme (the Global Change Project), as adopted by the International Council of Scientific Unions.

Recommendation 12

The Committee recommends that funding for Canada's Space Program should be increased to approximately $200 million per year (1987 $) for each of the next five years.

Recommendation 13

The Committee recommends that the Canadian Space Agency should incorporate all personnel, budgets and facilities of the Federal Government's departments and agencies presently engaged in space activities, including all in-house space Research and Development (R&D) capability.

Recommendation 14

The Committee recommends that the Canadian Space Agency have a stable five-year budget that includes funding for all space R&D activities of the Federal Government.

Recommendation 15

The Committee recommends that an Advisory Council on Space, comprised of representatives from industry, university and government, be established to advise on space policy. The Advisory Council should report to the Minister responsible for the Space Agency.

Recommendation 16

The Committee recommends that the Canadian Space Agency have the authority to negotiate agreements on international space projects with its counterparts in other countries.

Recommendation 17

The Committee recommends that the Canadian Space Agency, in consultation with the Natural Sciences and Engineering Research Council (NSERC), carry out a comprehensive study of the training and supply of space scientists and engineers and develop mechanisms to ensure an appropriate supply of qualified personnel for future years.

Recommendation 18

The Committee recommends that the Canadian Space Agency, in consultation with NSERC, develop mechanisms to fund university space research that would be complementary to NSERC funding and that would encourage greater interaction between university and government scientists, and industry.

Recommendation 19

The Committee recommends that the Canadian Space Agency, in cooperation with DRIE, should reassess the feasibility of the proposed regional distribution of space hardware contracts and determine if alternative approaches would be more appropriate in regions where no space hardware manufacturing capability exists at the present time.

Recommendation 20

The Committee recommends that the Canadian Space Agency should establish formal procedures, including peer-review mechanisms where appropriate, to evaluate new proposals for research as well as the results of R&D supported by Agency funding.

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The Committee recommends that Canada not develop a capability to launch satellites but, instead, continue to participate in international projects with countries which have a satellite-launching capability.

Recommendation 22

The Committee recommends that Black Brant sounding rockets and balloons be used when required as part of Canada's Space Science program. If the numbers required do not warrant re-establishing a launch capability in Canada, arrangements should be made with other countries for launch services, either through direct purchase or through cooperative projects.

Recommendation 23

The Committee recommends that Canada not rely too heavily on any one country for launch services but, instead, explore possibilities for cooperative projects with a number of countries, including European nations, Japan, the Soviet Union, China, and the United States.

Recommendation 24

The Committee recommends that Canada continue our formal cooperative arrangement with the European Space Agency.

Appendix I

GLOSSARY

Alouette — Canada's first space satellite, Alouette-1, was launched in 1962; Alouette-2 was launched in 1965. Both were used to study the ionosphere.

Anik — The name for the communications satellites of Telesat Canada. Anik is an Inuit word meaning brother.

CCRS — Abbreviation for the Canada Centre for Remote Sensing, part of the Department of Energy, Mines and Resources.

CIAR — Acronym for the Canadian Institute for Advanced Research.

CRC — The Communications Research Centre of the Department of Communications.

DFL — Abbreviation for the David Florida Laboratory at Shirley's Bay near Ottawa; a world-class satellite-testing facility and part of the CRC.

ERS-1 — The Earth Resources Satellite of the European Space Agency (ESA), scheduled to be launched in 1989.

ESA — Acronym for the European Space Agency, headquartered in Paris. Canada has a formal agreement with ESA.

Hermes — A manned spaceplane being designed by France. The project is being managed by ESA.

Hermes/CTS — A Canada-U.S. Communications Technology Satellite launched in January 1976. This spacecraft was the forerunner of today's advanced communications satellites.

ICS — The Interdepartmental Committee on Space which coordinates Canada's federal space activities. The ICS is chaired by the Ministry of State for Science and Technology.

Ionosphere — A region in the upper atmosphere which can have profound effects on radio communications.

ISIS — The International Satellites for Ionospheric Studies, a Canada-USA program. The two satellites were launched in 1969 and 1971.

LANDSAT — A series of earth resources, remote-sensing satellites launched by the United States.

MSAT — A mobile communications satellite being developed by Telesat Canada with support from the Department of Communications.

MSS/MSC — Respectively, the Mobile Servicing System and Mobile Servicing Centre, Canada's contribution to the U.S. Space Station.

NASA — National Aeronautics and Space Administration (U.S.A.).

OLYMPUS — A telecommunications satellite being developed by ESA for launch in 1989. The satellite will be tested at the DFL.

Plasma — A gaseous collection of electrons and positive ions.

RADARSAT — An earth resources, remote-sensing satellite which uses radar sensors, being planned by CCRS. It is a joint Canada-U.S.A.-U.K. project.

RMS — The Remote Manipulator System, or CANADARM, built for the U.S. Space Shuttle by Spar Aerospace Limited of Toronto.

SAR — Synthetic Aperture Radar, a sensor being developed by CCRS for use on RADARSAT.

SARSAT/ COSPAS — An international satellite search and rescue system, partially developed in Canada. The system is jointly operated by Canada, France, the U.S.A., and the Soviet Union.

SPOT — Acronym for the French remote-sensing satellite "Système pour l'observation de la Terre".

STS — The U.S. Space Transportation System, otherwise known as the Space Shuttle.

VIKING — A Swedish space science satellite to which Canada contributed an ultraviolet imager to study the aurora.

WAMDII — The Wide Angle Michelson Doppler Imaging Interferometer, a Canadian instrument for the study of winds of atomic oxygen at high altitudes.

WARC — The World Administrative Radio Conference, where radio bands are allocated to users, including communications satellites. The next meeting of WARC is scheduled for the fall of 1987.

WINDII — The Wind Imaging Interferometer, an instrument derived from WAMDII, scheduled to be flown on the shuttle-launched upper atmosphere research satellite. A Canada-U.S.A.-France project.

WISP — Acronym for Waves in Space Plasma, a study designed to characterize the nature of the Earth's ionosphere by observing the behaviour of electromagnetic waves transmitted into it. A Canada-U.S.A.-Australia project.

Appendix II

WITNESSES AND SUBMISSIONS

Issue No.	Date	Organizations and Witnesses
15	Monday, March 2, 1987	**Minister of State for Science and Technology:** The Honourable Frank Oberle. **Interdepartmental Committee on Space:** Dr. D.I.R. Low, Chairman. **Space Agency Transition Team:** Dr. Arthur Collin, Head. **Ministry of State for Science and Technology:** Dr. Mac Evans, Director, Space Policy Sector.
16	Wednesday, March 4, 1987	**Canadian Astronautics Limited:** Michael Stott, Executive Vice President. **Aerospace Industries Association of Canada:** C.A. Bishop, Vice President.
17	Monday, March 9, 1987	**Spar Aerospace Limited:** Larry Clarke, Chairman of the Board. **Canadian Institute for Advanced Research:** Morrel P. Bachynski, (President, MPB Technologies Inc.); Peter Munsche, Executive Director.

Issue No.	Date	Organizations and Witnesses
18	Thursday, March 12, 1987	**National Research Council, Space Division:** Dr. Gary Lindberg, Executive Director; Dr. K.H. Doetsch, Director, Space Station Projects Office; Dr. A.L. Vankoughnett, Director, Space Research Operations Office; Dr. Clive Willis, Associate Vice-President, Science.
19	Wednesday, March 18, 1987	**Department of Regional Industrial Expansion:** Cliff Mackay, Assistant Deputy Minister; Tim Garrard, Director General, Aerospace and Defence Branch; Raj Dayal, Officer, Space and Specialist Firms Division, Aerospace Directorate.
20	Friday, March 20, 1987	**Department of Communications:** Richard Stursberg, Assistant Deputy Minister, Telecommunications and Technology; Dr. Robert Breithaupt, Director, Space and Telecommunications Industry Development and Director, MSAT Program; Dr. Jack Chambers, Director of Space Systems; Michael Binder, Assistant Deputy Minister, Corporate Management.
21	Monday, March 23, 1987	**Department of Energy, Mines and Resources:** Dr. Ken Whitham, Assistant Deputy Minister, Research and Technology;

Issue No.	Date	Organizations and Witnesses
		Dr. E. Shaw, Director, RADARSAT Project, Canada Centre for Remote Sensing.
22	Thursday, March 26, 1987	**Department of External Affairs:**
		R.J.L. Berlet, Director General, Technology and Investment Development Bureau;
		Ton J.M. Zuijdwijk, Economic Law and Treaty Division;
		Ron E. Stansfield, Head, Nuclear Affairs and MBFR Section, Defence Relations Division;
		Peter McRae, Deputy Director, Legal Operations Division;
		Brian Buckley, Director, United States Transboundary Division;
		Victor G. Bradley, Science, Technology and Communications Division.
23	Monday, March 30, 1987	**Individual presentations:**
		Gordon McNabb;
		Dr. Ursula Franklin.
24	Monday, April 6, 1987	**Canadian Centre for Arms Control and Disarmament:**
		John Lamb, Executive Director;
		John Barrett, Deputy Director.
26	Thursday, April 30, 1987	**The Royal Society of Canada:**
		Dr. William Fyfe, Chairman, Global Change Project;
		Pierre Garneau, Executive Secretary.
28	Tuesday, May 12, 1987	**York University, Centre for Research in Experimental Space Science (CRESS):**
		Dr. Ralph W. Nicholls, Director;
		John Bird, Graduate Student.

Issue No.	Date	Organizations and Witnesses
		University of Waterloo:
		T.A. Bruzustowski, Vice President, Academic;
		G.E. Schneider, Mechanical Engineering;
		F.J. Burkowski, Computer Science.
		Resonance Limited:
		W.H. Morrow, President.
		University of Toronto:
		Dr. Geraldine Kenney-Wallace, Chairman, Research Board; Member, Science Council of Canada.
		Canadian Association of Physicists, Division of Aeronomy and Space Physics:
		Dr. R.P. Lowe, Chairman;
		Dr. G. Shepherd, Member.
		Working Group on International Surveillance and Verification:
		Professor Eric Fawcett;
		Dr. L.W. Morley;
		Dr. Stanley J. Townsend.
		Proposed Institute for Space and Terrestrial Sciences (ISTS):
		Dr. K.A. Innanen, Astrophysicist and Dean of Science, York University;
		Dr. R.C. Tennyson, Director, University of Toronto Institute for Aerospace Studies;
		Dr. E. LeDrew, Department of Geography, University of Waterloo;
		Dr. R.P. Lowe, Department of Physics, University of Western Ontario.

Issue No.	Date	Organizations and Witnesses
		University of Toronto Institute for Aerospace Studies (UTIAS):
		Dr. R.C. Tennyson, Director.
30	Thursday, May 21, 1987	**Telesat Canada:**
		Eldon D. Thompson, President and Chief Executive Officer.
		QUESTS, Queen's University:
		Dr. R.W. Smith.
32	Wednesday, May 27, 1987	**University of Saskatchewan:**
		Dr. D.J. MacEwen, Chairman, Institute of Space and Atmospheric Studies.
		SED Systems Inc., Saskatoon, Saskatchewan:
		Dr. D.H. Kjosness, Chief Operating Officer.
		Saskatchewan Research Council:
		Jim Hutch, President;
		Jeff Whiting, Manager, Remote Sensing.
		University of Alberta:
		Dr. Gordon Rostoker, Director, Institute of Earth and Planetary Physics;
		Dr. John Samson, Associate Professor, Department of Physics.
		Canadian Astronomical Society:
		Dr. E.R. Seaquist, President;
		Dr. James E. Hesser, Chairman, Joint Subcommittee on Space Astronomy.
		Government of Saskatchewan:
		Ray Meiklejohn, Minister, Science and Technology.
		ITRES Research Ltd., Calgary, Alberta:
		Dr. Clifford D. Anger.

Issue No.	Date	Organizations and Witnesses
		Bristol Aerospace Limited, Winnipeg, Manitoba:
		W. Ralph Bullock, Vice President, Engineering and Quality.
		University of Calgary, Alberta:
		Dr. Sun Kwok, Professor, Department of Physics.
		Lawyers for Social Responsibility:
		Tim Quigley;
		Stuart Bailey.
		First Merchant Equities Inc., Saskatoon, Saskatchewan:
		Mike Smith, President;
		Charles J. Hodgins, Vice Chairman and Chief Executive Officer.
33	Wednesday, June 10, 1987	**Laval University:**
		Dr. François Tavernas, Dean of Science and Engineering.
		L'Association montréalaise d'Aéronautique:
		Gilles Desharnais, Member.
		BOMEM:
		Jean-Noël Bérubé, Vice-President, Marketing.
		GENTEC:
		Jean-Luc Giroux, President.
		La Ville de Montréal La Communauté urbaine de Montréal:
		Michel Hamelin, Chairman;
		Serge Langford, Economist.

Issue No.	Date	Organizations and Witnesses
		l'Ordre des Ingénieurs du Québec:
		Gilles Dauville, President;
		Laurent Martineau, Member;
		Thomas Welt, Member.
		l'Association des Ingénieurs—conseils du Québec:
		Robert Ménard, Member.
		Concordia University:
		Charles Giguère, Vice Rector.
		l'École Polytechnique de Montréal and the University of Montreal:
		Jean-Louis Houle, Professor.
		McGill University:
		Tom Pavlaseck, Professor.
		Montreal Chamber of Commerce:
		Luc Lacharité, Executive Vice-President.
		Montreal Board of Trade:
		Kevin Saville, Assistant Director-General.
		Centre d'Adaptation de la main-d'oeuvre aérospatiale au Québec (CAMAQ):
		Serge Tremblay, Director-General.
		Government of Quebec, Department of External Trade and Technological Development:
		The Honourable Pierre MacDonald, Minister;
		Pierre Coulombe, Assistant Deputy Minister.

Issue No.	Date	Organizations and Witnesses
		Laval University:
		Dr. K.P.B. Thomson, Professor, Department of Geodesy and Remote Sensing, Faculty of Forestry and Geodesic Sciences;
		Dr. R.J. Slobodrian, Professor, Department of Physics.
34	Friday, June 12, 1987	**MacDonald Dettwiler and Associates Ltd., Richmond, B.C.:**
		Dr. John MacDonald, President.
		Hydrogen Industry Council:
		Richard D. Champagne, President and Chief Executive Officer;
		Robert D. Murray, Chairman.

A copy of the relevant Minutes of Proceedings and Evidence of the Standing Committee on Research, Science and Technology *(*Issues 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26, 28, 30, 32, 33, 34 and 35, which includes this Report*) is tabled.

Respectfully submitted,

WILLIAM TUPPER,
Chairman.

NOTE

*Copies can be obtained from the Clerk of the Committee, Room 517, 180 Wellington Street, Ottawa, Ontario, K1A 0A6, Telephone: (613) 992-6312.

MINUTES OF PROCEEDINGS

THURSDAY, JUNE 18, 1987
(42)
[*Text*]

The Standing Committee on Research, Science and Technology met *in camera* at 9:15 o'clock a.m., this day, at the Speaker's Residence, Kingsmere, the Chairman, William Tupper, presiding.

Members of the Committee present: David Daubney, Suzanne Duplessis, Guy Ricard, William Tupper.

In attendance: Ian McDiarmid, Research Consultant. *From the Library of Parliament, Research Branch*: Thomas Curren, Research Officer; Lynne Myers, Research Officer. *From David Orlikow's office*: Angus Ricker, Legislative Assistant.

In accordance with its mandate under Standing Order 96(2), the Committee commenced consideration of the draft report on Canada's Space Program.

At 12:25 o'clock p.m., the sitting was suspended.

At 1:20 o'clock p.m., the sitting resumed.

It was agreed, — That the Committee authorize the expenditure of funds from the Committee budget to pay the costs incurred for the working session held at Kingsmere.

It was agreed, — That the draft report, as amended, be adopted as the Committee's Third Report to the House and that the Chairman be authorized to make such typographical and editorial changes as may be necessary without changing the substance of the report and that the Chairman be instructed to present the said report to the House.

It was agreed, — That the Committee print 3,000 copies of its Third Report to the House in tumble bilingual format with a distinctive cover.

It was agreed, — That pursuant to Standing Order 99(2) the Committee request that the Government table a comprehensive response to its Third Report.

It was agreed, — That the title of the Committee's Third Report to the House shall be, "Canada's Space Program : A Voyage to the Future".

At 2:30 o'clock p.m., the Committee adjourned to the call of the Chair.

Christine Fisher,
Clerk of the Committee.