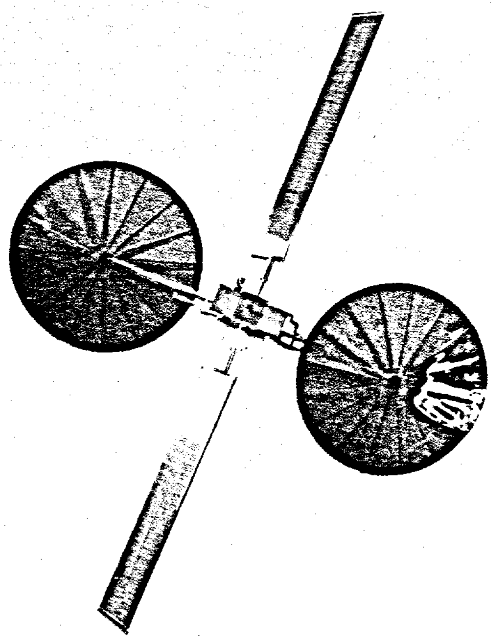
SATELLITES:

THE CANADIAN EXPERIENCE



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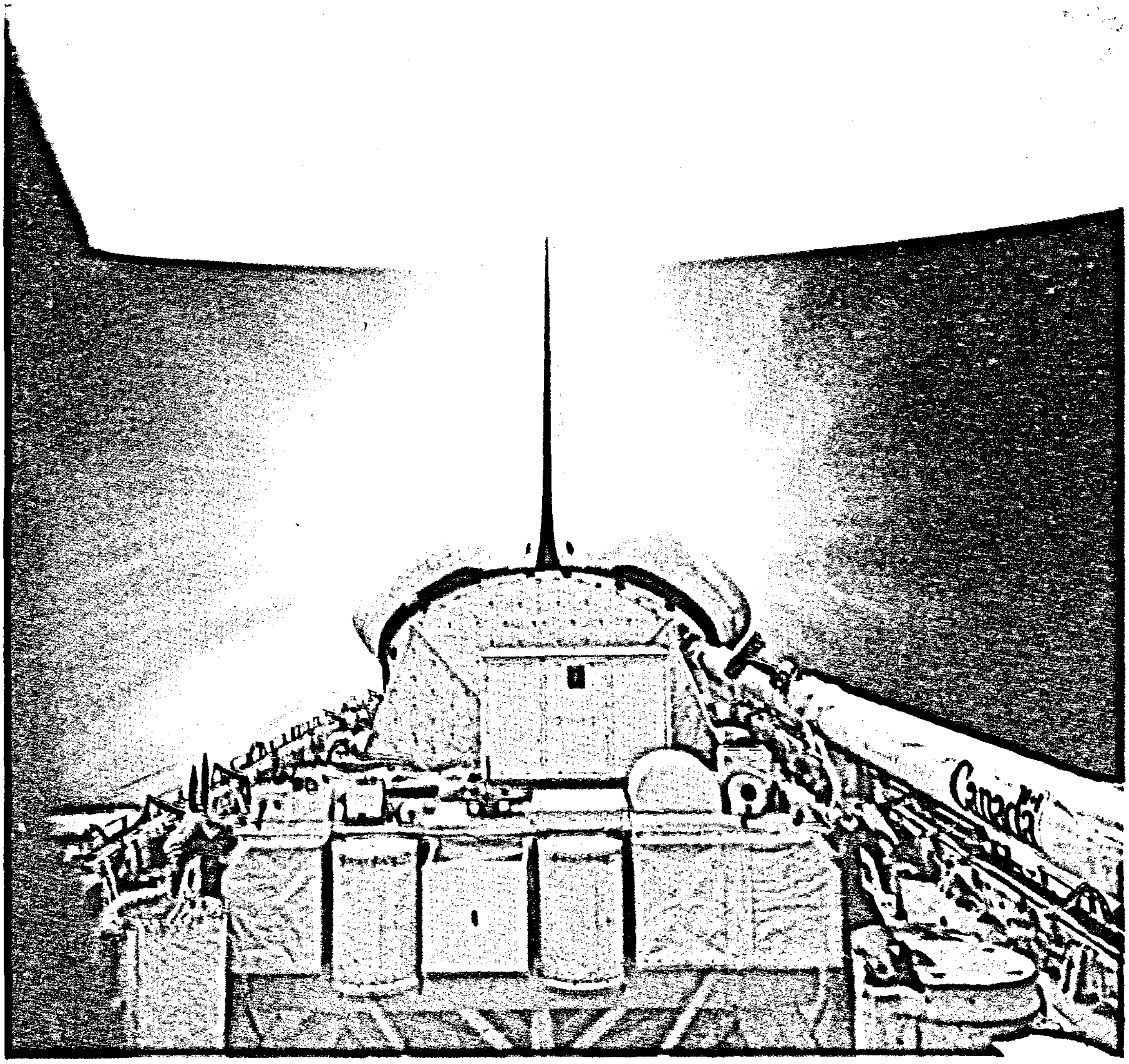
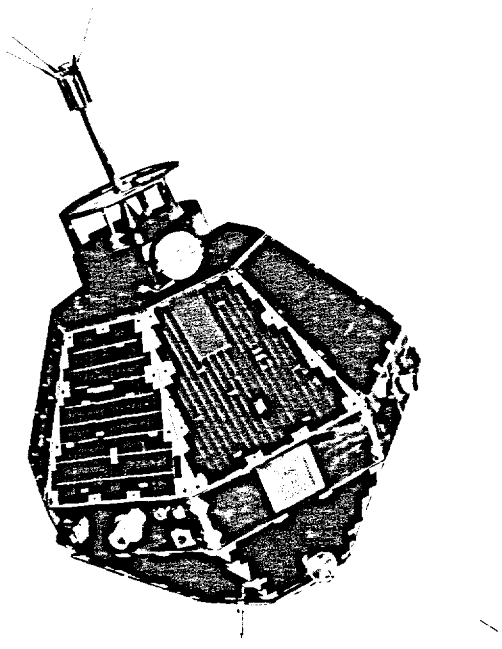


←
Proposed configuration of MSAT satellite, which is expected to be launched in 1988.

The purpose of the science and technology series is to inform readers of current trends in Canadian research and development. Only Canadian designs are discussed at length in this series, rather than designs of other countries which may be developed and produced in Canada.

Table Of Contents

Appendices



Canada always has had a keen—and active—interest in space. We were the third nation to design and build a satellite, following the Soviet Union and the United States. Our first spacecraft, Alouette I, was launched from a United States test range in September 1962.

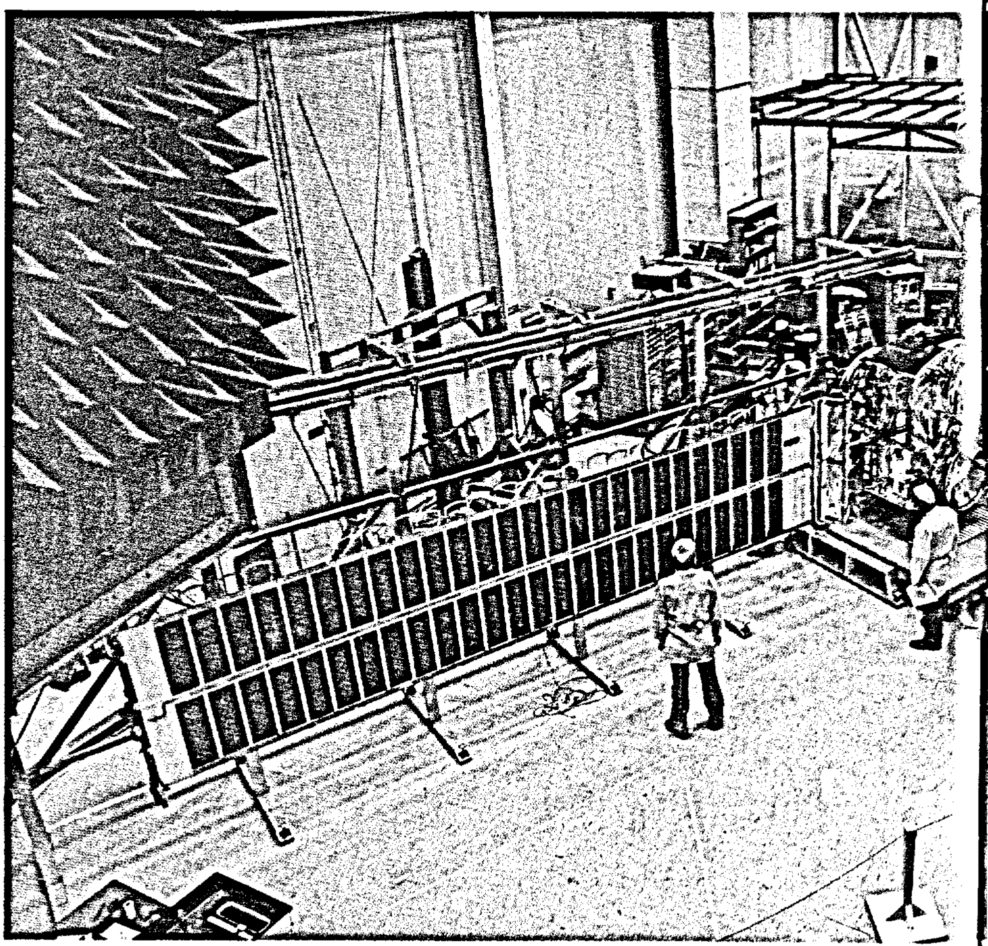
In the intervening 21 years, we have maintained our position as a world leader in space, and we have actually been the pioneer in several important areas of space technology. Some of our innovations, such as broadcasting by satellite directly to individual homes, have brought considerable practical benefits not only to Canada but to the world.

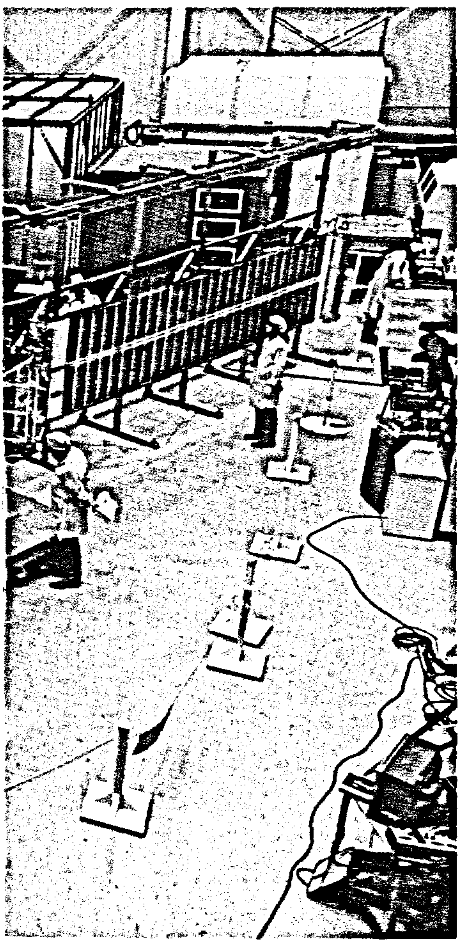
Canada's greatest contribution has been in the field of telecommunications. In this, as in so many other things, necessity has been the mother of invention. Canada is huge—the second-largest country in the world—but is sparsely populated. Most residents live along a relatively narrow strip adjacent to the US border, but about five million are scattered in small communities across the rest of the country, as well as in mountainous regions close to the border. Because of widely separated settlements, rugged terrain and atmospheric irregularities, particularly in the far North, conventional methods of communications are either impossible, unreliable or too expensive. Before the advent of communications satellites, many Canadians in remote areas were virtually isolated from the rest of the world.

This is no longer so. Our technological excellence in satellite telecommunications has given us the most efficient domestic satellite communications system in the world and one of the best networks for radio, television, telephone, data and facsimile transmission. Satellites allow people in remote regions to have more access to the advanced services enjoyed by city dwellers.

More than 100 countries have shared the benefits of our experience in the conception, design and operation of the world's first domestic geostationary communications satellite system. We have done everything from telecommunications consulting to the production of complete satellite systems for the United States and other Western nations. We have also co-operated extensively with developing countries and, to a limited extent, with Communist states, such as the People's Republic of China.

The developments in space telecommunications are so numerous and occur so rapidly that no publication can be comprehensive and up-to-date. What this document offers is simply a September 1983 "freeze-frame" look at our activities in this exciting field.





ISIS II, a research satellite, launched in 1971, is still operating.

Hermes spacecraft during solar array deployment tests at the David Florida Laboratory, Communications Research Centre, Department of Communications near Ottawa.

Canada began its satellite program with a series of four research spacecraft that studied the ionosphere, the layer of the upper atmosphere which contains electrically charged atomic particles that affect long-distance radio transmission. The research satellites were followed by the Communications Technology Satellite, later named Hermes, which revolutionized space communications by proving that spacecraft could operate effectively at higher powers and higher frequencies than existing systems.

Alouette I

For Canada, a better understanding of the ionosphere was thought to be the key to bringing improved and dependable radio communications to the people of the far North. Ionospheric disturbances there, often visible as the aurora borealis (northern lights), make long-range radio communications difficult and sometimes impossible.

Alouette I, Canada's first satellite, was launched by the US National Aeronautics and Space Administration (NASA) in September 1962 and operated for ten years. It carried out four types of measurement, including sounding of the ionosphere with radio waves. Alouette I produced considerable data about the upper section of the ionosphere, including geographic details and information about the daily, seasonal and longer-term variations in that part of the atmosphere.

ISIS

The success of Alouette I led to an agreement between the United States and Canada to build and launch a series of International Satellites for Ionospheric Studies (ISIS). Canada designed, developed and constructed the spacecraft; the United States launched them.

Alouette II, originally intended as a back-up in case Alouette I failed, was modified to improve its performance, rebuilt and became the first of the ISIS series. It was launched in November 1965 and was used to perform experiments for almost ten years. Two far more sophisticated satellites followed. ISIS I, launched in January 1969, and ISIS II, launched in April 1971, are still operating today.

The broad aim of the ISIS program was to make a comprehensive study of the upper section of the ionosphere. Alouette II and the two ISIS spacecraft provided valuable data about the ionosphere throughout a complete 11-year solar cycle. (Changing levels of solar activity cause significant variations in the ionosphere.) Two new instruments on ISIS II enabled scientists to piece together the first pictures of the aurora borealis as seen from above. Interpretation of these data led to a better understanding of the effects of the ionosphere on communications.

Another ISIS research satellite was planned, but in 1969 the Canadian government decided to redirect its space activities. Space technology had advanced to the stage where we could begin to apply our knowledge to establish a much-needed domestic communications satellite system. On September 1, 1969 Parliament passed an act incorporating Telesat Canada, the world's first domestic communications satellite company. But even as the commercial Telesat network was being developed, planning for a new type of experimental satellite was beginning. In 1970, the Communications Technology Satellite project started.

Hermes *(Communications Technology Satellite)*

In January 1976, the Communications Technology Satellite, later known as Hermes, was launched. It was and will continue to be one of the milestones in Canadian space history. Hermes' innovations set a new course for domestic satellite communications systems in Canada and have had implications throughout the world. Experiments with the satellite paved the way for many now-common commercial services, including:

- 'tele-education';
- 'telehealth';
- direct broadcasting by satellite to individual homes (DBS);
- integrated digital telecommunications.

Despite the fact that some of these applications are carried by terrestrial networks (there is no commercial satellite telehealth system yet, for example), the Hermes experiments were undoubtedly the catalyst for these services.

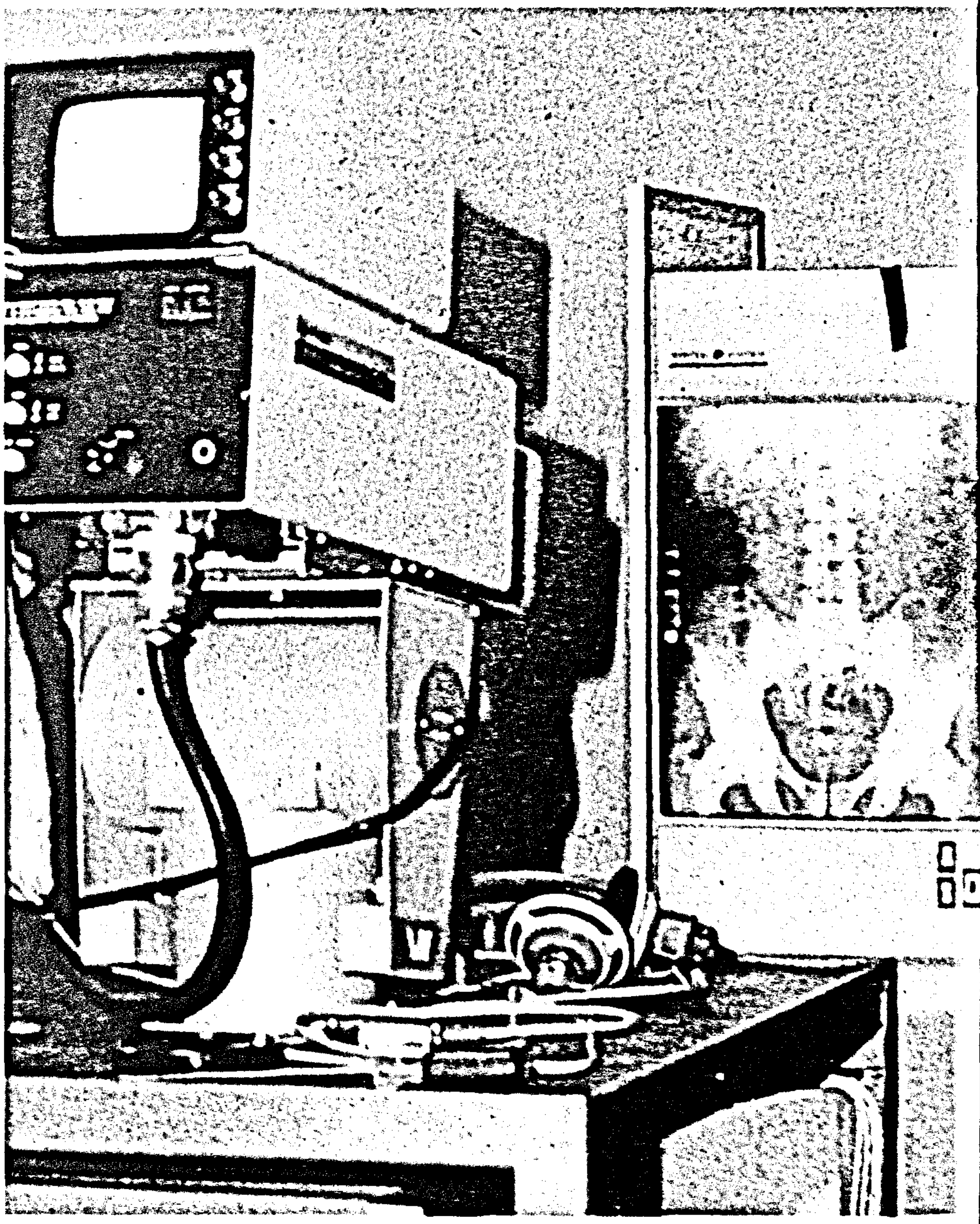
One of the primary objectives of Hermes was to test a system that used the super high frequency 14/12 GHz bands—reception of signals at about 14 thousand million cycles per second (14 gigahertz) and transmission back to Earth at about 12 GHz. These frequencies are reserved for satellite communications, unlike the 6/4 GHz bands used by previous satellites—and by the ground networks that carry telephone and other telecommunications traffic. By using 14/12 GHz, Hermes eliminated interference with ground-based transmissions and so could use earth stations with dish antennas measuring less than one metre wide (not even one-quarter the size of ones then in use) right in the centre of town.

The Hermes design had other technical innovations used on later spacecraft. It was powered by solar cells attached to retractable 'sails'. The delicate sails, with 27 000 solar cells, folded like an accordion inside the satellite during launch and were unfurled only when in orbit. For maximum efficiency an advanced tracking mechanism maintained the sails at right angles to the sun's rays. Hermes also had an improved stabilization system that kept the satellite fixed with its antennas pointing earthward within a minuscule margin of error.

Hermes had a design life of two years, but Canada and the United States were able to conduct experiments for almost twice that time—from April 1976 to November 1979, when the satellite finally stopped functioning. (US experiments ceased in June 1979.) Important technical experiments included digital TV transmission and a technique to send satellites separate bursts of information timed so accurately that they arrive within a few billionths of a second from one another. This permits maximum efficiency in the satellite since it can be accessed from multiple points in lightning-quick succession. Furthermore, different kinds of telecommunications information—voice, data and image—can be integrated within a single burst.

Social experiments explored potential uses of the 14/12 GHz technology to better serve residents of rural and remote areas in the fields of health, education, broadcasting and intercommunity communications. Some of the ground-breaking experiments in telehealth, tele-education and DBS are discussed in individual sections on those topics.

During its lifetime, Hermes was the most powerful non-military communications satellite ever put into space. To date, none more powerful has been launched.



In a typical situation in telemedicine, a surgeon and his patient are located in a remote location while a specialist surgeon and an anesthetist provide consultation support from a far distant city. The specialists can zoom in to examine in detail any areas of particular concern.

During telemedicine experiments via *Hermes, consultation services and the transmission of medical data included slow scan transmission of X-rays from Labrador City to St. John's, Newfoundland, some 1 200 kilometres away.*

Using Anik B link, Montreal radiologist advises on X-ray of patient at a site in northern Quebec, 1 500 kilometres away.

Telehealth—health care and health education *via* satellite and ground-based telecommunications—has the potential for narrowing the gap between the range of services provided to people in remote centres and those in large cities. In one Hermes experiment between the University Hospital in London, Ontario, and a small hospital in Moose Factory, Ontario, doctors operating on patients in the remote hospital could consult surgeons and other specialists in London. The specialists could remotely control a TV camera in the operating room and zoom in on the patient. X-ray images, electroencephalograms, electrocardiograms, fluoroscopy and other medical data could be relayed for immediate 'teleconsulting'.

Memorial University of Newfoundland has been one of the most assiduous in developing telehealth applications in Canada. It conducted several two-way voice/one-way video experiments with Hermes, including:

- connecting four remote medical centres with a hospital in St. John's, Newfoundland;
- continuing education programs for health professionals;
- 'televisits'—visits *via* satellite to patients hospitalized far from home by relatives left behind;
- community health education programs (nutrition, pre-natal care, diabetic diets, etc.).

In furthering the work done with Hermes, Anik B proved beyond a doubt that satellites are a reliable and efficient means of providing isolated communities with the best of medical care. In 1979, Memorial University used Anik B to link several remote hospitals and nursing stations to an earth-based audio teleconferencing system that connected hospitals and other educational institutions throughout the province. The number of similar regional teleconferencing networks keeps growing—there are now at least six—and a national system is being considered.

In the summer of 1983, the university, in co-operation with the Department of Communications (DOC) and the Newfoundland Telephone Company, began testing a system to provide medical support services (as well as direct dial telephone and data service) to offshore oil drilling rigs. DOC designed a small, low-cost stabilized terminal that compensates automatically for the roll and pitch of the rig. This has permitted audio consultations and the transmission of medical data *via* Anik B from the rig to the emergency department of the university's Health Sciences Centre.

Just as conventional educational television supplements school classes and home studies in urban areas, tele-education, long-distance instruction *via* satellite or terrestrial telecommunications, helps teach residents living in remote and rural parts of Canada. Tele-education can be one-way (either live or taped) or interactive, where students and teachers are in two-way audio or video contact.

Tele-education was the focus of several Hermes experiments and Anik B pilot projects. Two of these have developed into large-scale ventures that lease satellite time commercially.

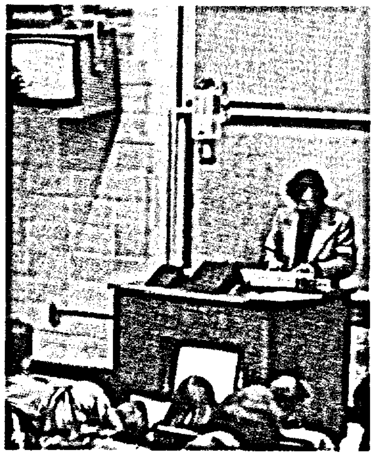
TVOntario (TVO), the broadcast service of the Ontario Educational Communications Authority, was a well-established educational television network providing programming free to some of the province's urban residents well before Hermes went into service. But TVO did not reach any remote communities; the cost of a ground-based communications network was prohibitive. In 1979, however, it used Hermes to extend its program distribution to four schools in remote locations. This was the first long-term trial of direct broadcast by satellite (DBS) to individual buildings equipped with low-cost receiving antennas as small as one metre wide. The experiment was so successful that TVO began regular DBS transmissions in an Anik B pilot project later the same year—another world first. TVO broadcast 94 hours a week of educational programming to 46 rural and remote communities. This service became commercial in September 1982.

TVO found program distribution by satellite so effective that it replaced its entire ground-based network as soon as the first Anik C satellite became available, in January 1983. It is continuing to expand its satellite operations, both to reach more remote communities—it now serves about 70 and reaches more than 90 per cent of Ontario residents—and to provide new services. Trials are under way to enable students at seven high schools in northern Ontario to obtain guidance information from TVO's Telidon data base. (Telidon is the Canadian-developed videotex technology.)

British Columbia is trying a new approach to education that combines the sophisticated technology of satellites with cable and other ground-based networks. The Knowledge Network, an educational authority formed in 1980 by the BC government, operates a system that links three universities, 15 community colleges and six provincial institutes with about 150 communities in the province, many of them rural. It is notable because it gives most of the residents of the mountainous province (which is almost the size of Western Europe) the chance for post-secondary school instruction in their own homes.

More than 85 per cent of BC residents, as well as many people in the Yukon and Alberta—can pick up telecasts seven days a week, 14 hours a day, *via* Anik C. Some are children's programs, but most are adult education courses. Interactive broadcasts give viewers the chance to respond by telephone during transmissions.

The system has been remarkably successful: though there are only 2.8 million residents in British Columbia, more than 8 000 people—who because of distance or disability would have otherwise been unable to go to classes—enrolled with educational institutions during the 1982-83 academic year and 'attended' school at home through the Knowledge Network.



Tele-education in Canada was the focus of several Hermes experiments and Anik B pilot projects. It can be either one-way (either live or taped) or interactive, where students and teachers are in two-way audio or video contact.

The ultimate application of satellite technology to broadcasting will be in "direct" broadcasting—the transmission of a satellite signal strong enough to be received directly by a low-cost ($500 or less) home receiver about one metre wide. There are no satellites dedicated solely to direct broadcasting yet, but by the late 1980s several countries will have them. By the turn of the century, DBS could well become the most important function of communications satellites.

Canada pioneered direct broadcasting in 1976 with demonstrations using the high-power, high-frequency experimental satellite Hermes. Because of its power, and because its 14/12 GHz transmissions eliminated interference with 6/4 GHz ground telecommunications networks, its signals could be picked up in city centres by antennas less than one metre in diameter. (To avoid interference, earth stations oriented to 6/4 GHz satellites often have to be located away from urban areas and require relatively large dish antennas—three metres wide and larger.)

In January 1979 Canada became the first country to use the scaled-down earth stations (0.6 to 1.6 metres) in a long-term trial during the six-month TVOntario DBS experiment using Hermes. Field trials continued with the moderately-powered Anik B satellite, which could broadcast in both the 6/4 and 14/12 GHz mode. The first regular direct-to-home broadcasts began in September 1979, when Anik B started transmission of 94 hours of TVOntario programs a week. Two months later, the satellite started carrying 150 hours weekly to residents of western Canada for British Columbia TV Ltd., a private broadcaster, and the Canadian Broadcasting Corporation.

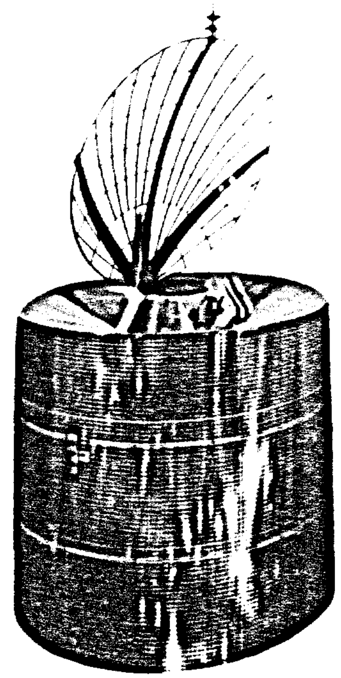
In 1981, the Department of Communications undertook a wide-ranging program of planning studies to assess all aspects of a full-fledged DBS system for Canada: technical and system requirements, as well as social, economic, regulatory and policy issues. These studies were completed in 1983 and indicated that a DBS system could be feasible to deliver a multichannel television package to the approximately 1.8 million Canadian households in rural and remote areas that have limited access to broadcast services. (Most have three television channels or fewer.) These households could pick up DBS signals with a small dish antenna installed on the rooftop or in the backyard. With mass production, these antennas could cost as little as $400.

None of the satellites now in operation is powerful enough to offer a 'true' DBS service, i.e. excellent reception on at least six channels using dishes smaller than one metre. However, the Anik C spacecraft, currently the strongest communications satellites, provide acceptable DBS home reception within certain limitations. Anik C channel capacity is being leased by an American company for the first commercial DBS system in the world. United Satellite Communications Inc. (USCI) delivers five television channels *via* Anik C to subscribers in the eastern United States who are not served by cable. The USCI service began in autumn 1983 and uses 1.2-metre dish antennas. In Canada, North Star Home Theatre Inc. plans in 1984 to market pay-TV *via* Anik C directly to homes with no access to a cable grid.

Anik C can provide a reasonably good interim DBS service in Canada until satellites specifically designed for that purpose are launched. However, systems using Anik C (or other satellites of similar power) and small receiver antennas suffer from occasional signal loss or degradation because of rain. To overcome this problem, true direct broadcasting satellites will be considerably more powerful than existing domestic communications satellites. Two such spacecraft would be needed to serve all Canada.

We lead the world in DBS technology, and are now poised to proceed with the final planning for our own system of satellites dedicated to direct broadcasting. At the July 1983 Regional Administrative Radio Conference, Canada was assigned the necessary six orbital positions for satellites that could be used in a full-fledged DBS system. Canadians are now awaiting Telesat Canada and the country's broadcasters to come up with a definitive proposal on how to set up an initial system. Whatever is proposed, it is certain to satisfy one of the principal objectives of the 1983 Broadcasting Strategy for Canada: "to provide a significantly increased choice of programming of all kinds in both official languages (English and French) in all parts of Canada".

A Canadian DBS service possibly would offer remote and rural users something besides the traditional commercial channels, pay-TV and public interest stations. It could also provide radio and many of the new services now being developed or considered for cable distribution: teletext, facsimile transmission, high-resolution TV and 'narrow-casting' services (specialized television programming aimed at small specific audiences, such as continuing education for professional groups).



Anik A1, the world's first domestic communications satellite was placed in geostationary orbit in 1972.

Model of Anik D spacecraft inside 7 m x 10 m thermal vacuum chamber.

Telesat Canada, the world's first domestic communications satellite company, transmits and distributes all forms of telecommunications by satellite in Canada. Though incorporated by an act of Parliament, it is neither a Crown corporation nor an agent of the government. It is a combined venture, controlled more or less equally by the federal government and several telecommunications companies. In 1976, Telesat joined the organization of major Canadian telephone companies, the Trans-Canada Telephone System, now known as Telecom Canada.

Telesat's first spacecraft, Anik A1, was launched in 1972. From 1973 to 1983 six more Anik satellites were sent into orbit. Five of these are still operational. Two more satellites will be launched from the NASA space shuttle during 1984. Hundreds of earth stations complete the Canadian domestic satellite system, and Telesat owns and operates more than 125 of them.

Telesat's purpose is to operate a commercial system of satellite communications to serve all Canada, from the sparsely populated far North to the industrial South. Its Anik network carries as broad and sophisticated a range of voice, video, data and facsimile services as any domestic satellite carrier in the world. There have been four generations of Anik satellites; almost every one, in some way, has been a world first.

Anik A

These were the first geostationary domestic communications satellites in the world—that is, they orbited above the equator at a speed matching the rotation of Earth. This makes them always visible from any point within their coverage area, and so they are able to provide 24-hour-a-day telecommunications services.

In the case of Anik A—and its successors—this coverage area included virtually all Canada. Anik A satellites were thus the first domestic communications satellites to use less-expensive non-tracking earth terminals. This was also made possible by Telesat's development of new mini-computer techniques to keep its satellites precisely on station.

Anik A1 was launched in November 1972. Its 12 microwave channels together could carry the equivalent of 11 520 one-way telephone circuits, or 12 colour television programs. It operated on the 6/4 GHz frequencies—reception of signals from Earth at about six thousand million cycles per second (6 GHz) and transmitting back to receiving antennas at about four thousand million cycles per second (4 GHz). Anik A2 was launched in April 1973 and was joined by Anik A3 in May 1975. All three satellites were designed to last seven years; all were identical.

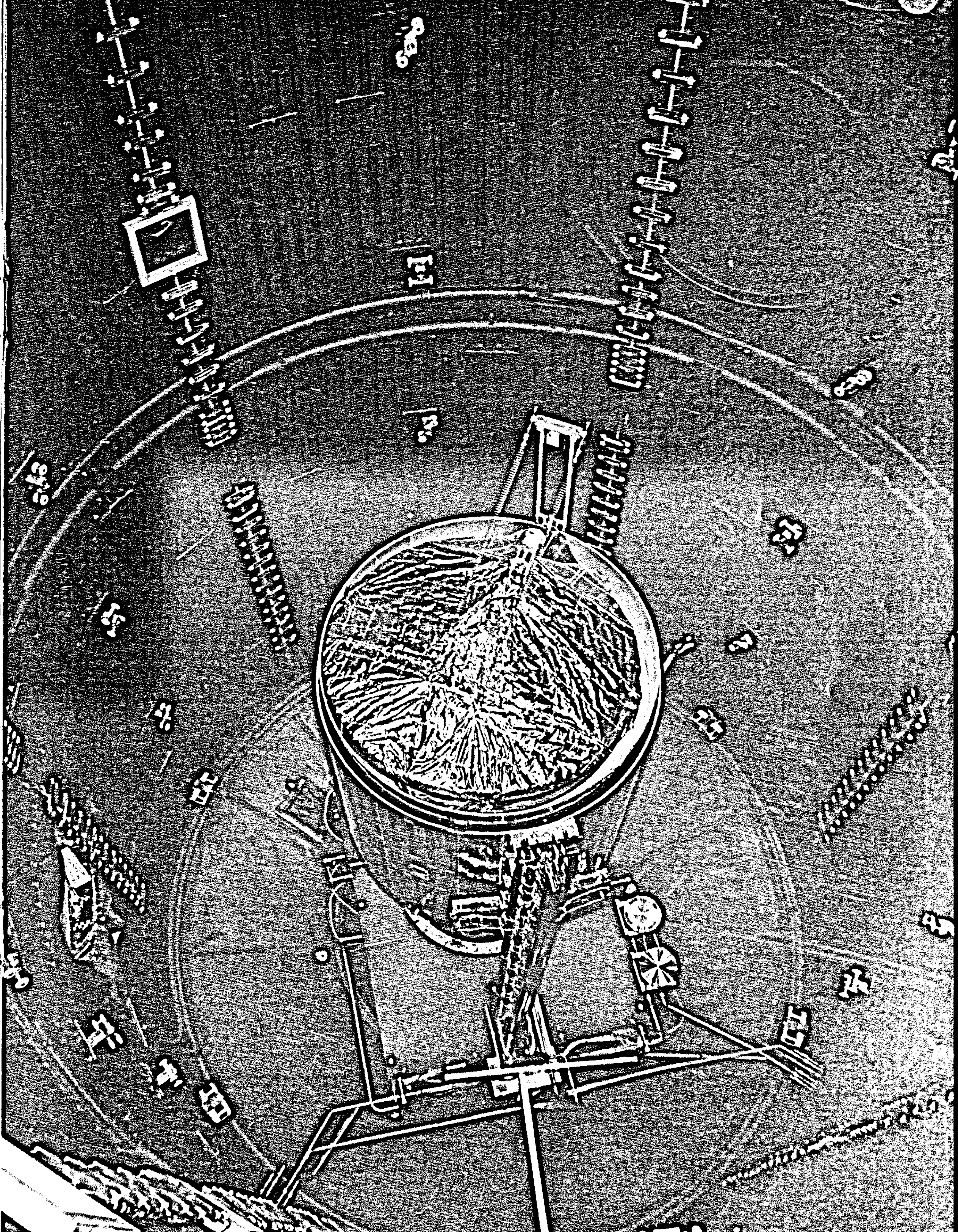
Both Anik A1 and A2 were 'retired' in 1982 after almost ten years in space. In 1981 Telesat accomplished another world first with Anik A2 and A3. The two satellites were co-located in the same orbital position, permitting the still usable channels on each to be operated as if they were aboard a single spacecraft. Anik A3 is scheduled to be retired in late 1984.

Anik B

As it became apparent that the experimental 14/12 GHz Hermes satellite would be very successful, Anik B, originally conceived as a 6/4 GHz commercial satellite to replace the Anik A series, was designed in 1973-74 and built to include six 14/12 GHz channels as well. When it was launched in December 1978, it was the world's first dual band commercial communications satellite.

The 14/12 GHz capacity was leased by the Department of Communications (DOC) so that the promising Hermes experiment could be continued over longer-term pilot projects in cooperation with industry, provincial government agencies, native groups, and other organizations. Some of these are mentioned in the sections on Telehealth, Tele-education and Direct Broadcasting by Satellite (DBS).

One of the aims of the Anik B program was to help Canadians to use new satellite technology to improve health, educational and broadcasting services. For this reason, one of the six 14/12 GHz channels was leased in 1980 to La SETTE, the Quebec cable consortium, to distribute videotaped programs across the province. In September 1982 all the remaining 14/12 GHz capacity was turned over to Telesat for commercial use, except for a small portion that DOC retained for technology trials. In January 1983, the 14/12 GHz commercial Anik B users transferred to the new Anik C3 satellite.



Anik C

Some of the most advanced technology in the world went into the construction and launch of the three high-capacity Anik C satellites. They are Canada's first commercial spacecraft operating solely at 14/12 GHz and will remain the most powerful communications satellites available to North Americans until the mid-1980s.

Anik C3 was launched during the first space shuttle mission to send satellites into orbit, in November 1982. Its 16 channels can carry the equivalent of 32 colour television signals, or 21 504 voice circuits—twice the capacity of an Anik A satellite. The combination of its greater power and higher frequency means that the satellite can use smaller earth stations—about one-third the size of 'conventional' receiving dish antennas. Further, because the 14/12 GHz frequency is so far removed from the ones at which ground-based communications systems operate, the antennas can be placed in city centres without fear of radio interference.

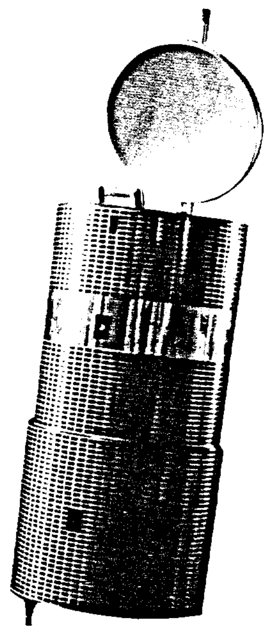
Anik C2 followed Anik C3 into space *via* the space shuttle in June 1983. (The satellites were numbered in the order they were built.) Anik C1 is scheduled for shuttle launch in the spring of 1984. All three Anik C satellites are expected to last ten years in space.

The Anik C satellites are already delivering high-quality TV pictures to antennas only 1.2 metres in diameter. Among Anik C2 users are viewers in the eastern United States who are part of the world's first commercial direct-to-home satellite broadcasting system. The Anik C series of satellites is also providing a wide range of voice, TV and other video, data and facsimile services to Canadian business across the country and residents in rural Canada.

Anik D

The two Anik D satellites were the first to be built by a Canadian prime contractor (Spar Aerospace Limited). They are the biggest Telesat has yet sent into orbit and have the greatest capacity. They are intended to be the backbone of Canada's domestic satellite communications system until the early 1990s.

Anik D1 was launched by Delta rocket in August 1982. It has 24 6/4 GHz channels, together capable of carrying the equivalent of 24 colour TV signals, or 23 040 voice circuits. Anik D2 will be put into space in autumn 1984 from the NASA shuttle. The two satellites will replace the Anik A and Anik B series both in function and position. Anik A1, which is no longer used, was moved into a higher orbit to make room for Anik D1; another non-operational satellite will be moved to make room for Anik D2.



Anik C-1

Major users and applicators of our commercial domestic communications satellite system include:

Educational Broadcasting

TVOntario, the broadcasting service of the Ontario Educational Communications Authority, and British Columbia's Knowledge Network are carried to terrestrial transmitters, cable and other distribution facilities.

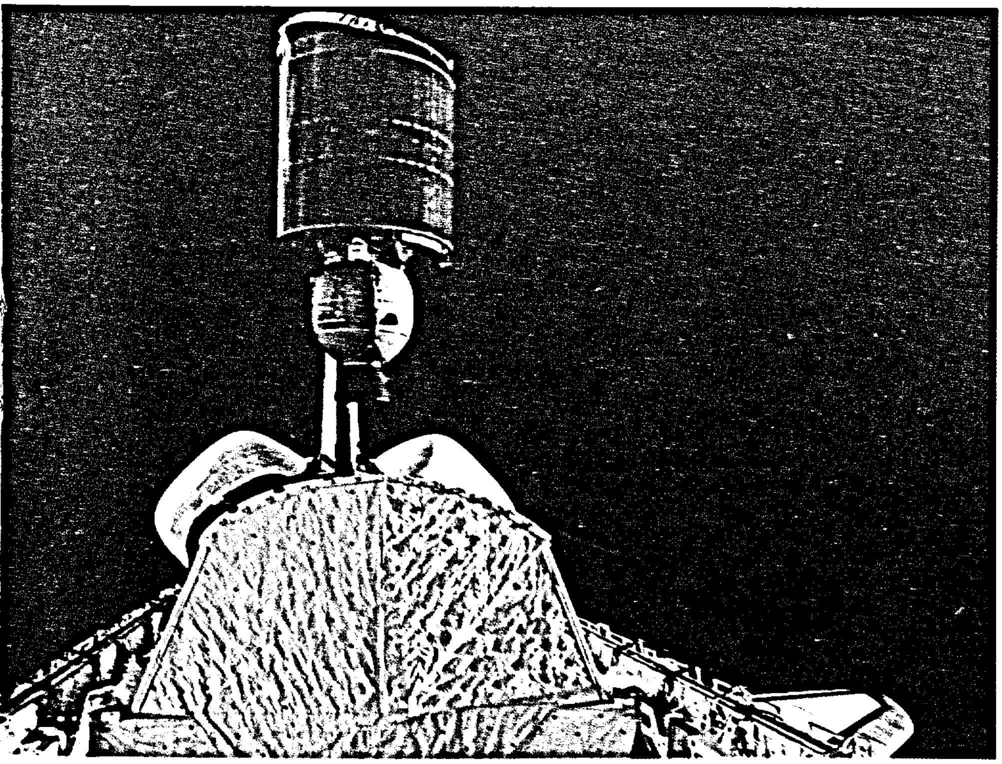
Canadian Broadcasting Corporation (CBC)

Telesat, the first satellite carrier of national network TV signals, today carries the CBC's English and French radio and television network services. The CBC uses Anik not only to distribute finished programs for live or delayed broadcast but also to assemble program material transmitted from one city to another, to extend its coverage to the North and to provide special regional services.

House of Commons

Live coverage of House of Commons proceedings, with commentary and interpretation in both English and French, is carried across the nation to cable television systems. Canada was one of the first countries to offer this basic form of 'teledemocracy'.

Spinning at about 50 revolutions per minute, Telesat Canada's Anik C-3 communications satellite rises gently out of the cargo bay of the US space shuttle Columbia, *November 12, 1982.*



Telephone Companies

Canada's major telecommunications carriers use a dozen or more satellite channels for long-distance telephone, data and other services. Satellites have become such a common, integral part of the telecommunications network that their use has become 'transparent' to Canadians. People dialling long distance, for example, hear 'blips' as their calls are being connected, but are largely unaware of how the connection is being made.

Cable Television Distribution

Delivery of television programs to cable systems is one of the most popular applications of Canadian satellites. One of the most remarkable networks is La SETTE, a consortium of Quebec cable operators that provides recorded programs —mostly cultural—from France to more than 50 cable systems throughout the province. The programs are delivered *via* Anik C (except to networks within 50 kilometres of Montreal). La SETTE, which began operations in 1980, was the world's first commercial application of the 14/12 GHz technology. A similar system, the Atlantic Satellite Network, serves Canada's Atlantic provinces.

Pay Television

All but one of Canada's new pay-TV networks are transmitted from their origination points to hundreds of local cable companies, which sell the services to consumers. Together, the networks use eight satellite channels.

Television in Remote Locations

Canadian Satellite Communications Inc. (CANCOM) puts together a package of television signals from four independent Canadian broadcasters and four US networks. Telesat delivers the transmissions to remote and previously underserved communities.

Integrated Digital Communications Service
(Stratoroute 2000)

Stratoroute 2000, introduced by Telecom Canada, brings about the true integration of voice, data and image telecommunications. Signals travel by terrestrial means to Stratoroute 2000 earth stations where they are blended into a digital stream and transmitted to an Anik

C satellite in a sequence of high-speed bursts timed almost to the billionth of a second. The signals are retransmitted back down to receiving earth stations where the system interconnects with the standard telephone network.

The service is aimed at large businesses, such as financial institutions and resource companies, that operate all over the country, generate huge volumes of voice, data and image traffic and require high-speed transmission. Costs are relatively low, because rates are based on satellite capacity, not distance.

Newspaper Publishing

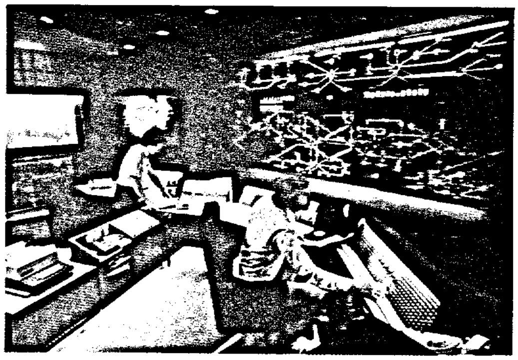
The text of a major Canadian daily, *The Globe and Mail,* is transmitted by Telesat every night from *The Globe's* Toronto news headquarters to 'satellite' printing plants in Vancouver, Calgary, Ottawa and Moncton. This eliminates the transportation time lag and makes *The Globe* a national publication.

Resource Exploration

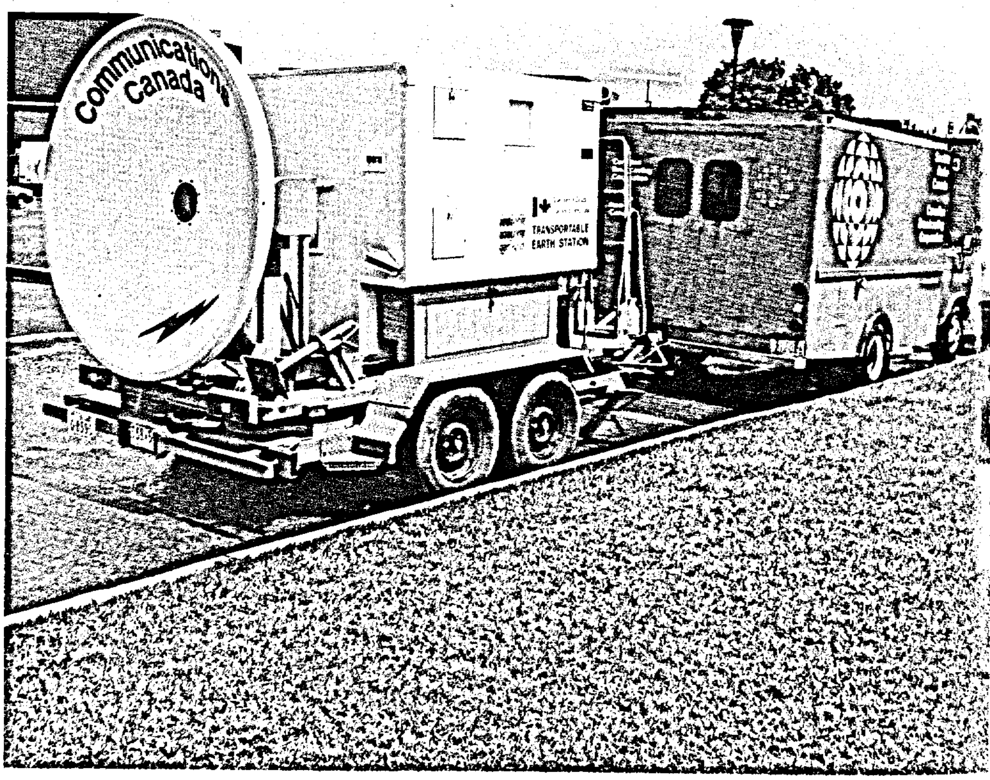
Oil and gas company crews in remote locations can have reliable voice and data links with their headquarters through the use of small air-transportable earth stations, such as AEL Microtel Ltd.'s Spacetel system, and Telesat's satellite system.

Satellite News Gathering Terminals

Telesat's satellites provide TV broadcasters with a reliable, "go-almost-anywhere" means of covering fast-breaking news stories, elections, sports and special events. The satellite news gathering terminal, first developed by the Department of Communications, uses a portable earth station mounted on a truck to send signals *via* satellite to earth stations at network news headquarters. Events at remote locations can be transmitted live and appear instantaneously on television screens across the country.



Telecom Canada's operations management centre in Ottawa monitors the performance of its major transmission routes and switching locations ensuring the efficient operation of its national telecommunications network.



The satellite news-gathering terminal (SNG) uses a portable earth station mounted on a truck to send electronic signals to the Anik B satellite.

About 100 Canadian companies are involved in the space industry. The largest is Spar Aerospace Limited, a diversified technological company owned by Canadian shareholders. It has steadily acquired its competence in the design and production of satellites and related systems to the point where it now acts as prime contractor in the development of complete satellite systems.

Spar and its predecessor companies have been involved in the Canadian space program since Alouette I was designed in the late 1950s. They contributed to the design and manufacture of all 14 Canadian satellites and about 35 spacecraft for other countries. In 1979 Spar was named the prime contractor for the two Anik D satellites, a $78-million contract from Telesat Canada. It was the first such prime contract awarded to a Canadian firm.

Spar's customers in recent major satellite contracts include:

- *EUROPEAN SPACE AGENCY* $65-million major subcontract to produce solar array systems and to carry out spacecraft assembly, integration and testing of the Olympus satellite, earlier known as L-SAT (April 1983);
- *INTELSAT* $33-million subcontract to supply subsystems for five INTELSAT VI spacecraft (December 1982);
- *GOVERNMENT OF BRAZIL* $161-million (US) prime contract to provide two telecommunications satellites and a related ground control system for the Sistema Brasileiro de Telecomunicaçoes por Satélite project (June 1982).

Canadarm

In 1974 work began on Canada's most famous space product, Canadarm—the Remote Manipulator System for NASA's Space Transportation System (the space shuttle).

Canadarm enables shuttle astronauts to take satellites from the cargo bay and place them accurately in space. It can also pluck satellites already in orbit and put them in the cargo bay for servicing or for their return to Earth. Canadarm retrieved its first satellite in June 1983, and has since manoeuvred a payload of about 4 000 kilograms. Its capacity is 30 000 kilograms—the equivalent of a loaded bus.

The National Research Council of Canada was the contracting agency for Canadarm, which was designed, developed and built by Spar in collaboration with the Council. System testing was also done in Canada: the federal Department of Communications arranged to have Canadarm components undergo rigorous examinations at its David Florida Laboratory. The first Canadarm was delivered to NASA in 1981, the second in 1983; another two are to follow in 1984.

David Florida Laboratory

The testing of systems like Canadarm or of very large satellites, such as the European Space Agency's Olympus, is highly specialized. The David Florida Laboratory is one of the few facilities in the world that can perform simulated launch and space environment tests on large satellites (up to 4 500 kilograms) and on subsystems and components for spacecraft.

Several countries and international space agencies rely on the David Florida Laboratory as follows:

CANADA

- **Anik D** virtually all the building and testing, as well as the assembly, of both satellites; Anik D1 successfully launched; Anik D2 in storage at the laboratory awaiting launch in late 1984.

UNITED STATES

- **Canadarm** testing of subsystems for first remote manipulator system and three follow-on units for the NASA space shuttle program.
- **SARSAT** testing of subsystems for the US spacecraft in this satellite search-and-rescue project developed jointly by Canada, the United States and France.
- **Other** testing of subsystems manufactured by the Canadian company Com Dev Ltd. for several American satellites, some of which have already been sent into space.

EUROPEAN SPACE AGENCY

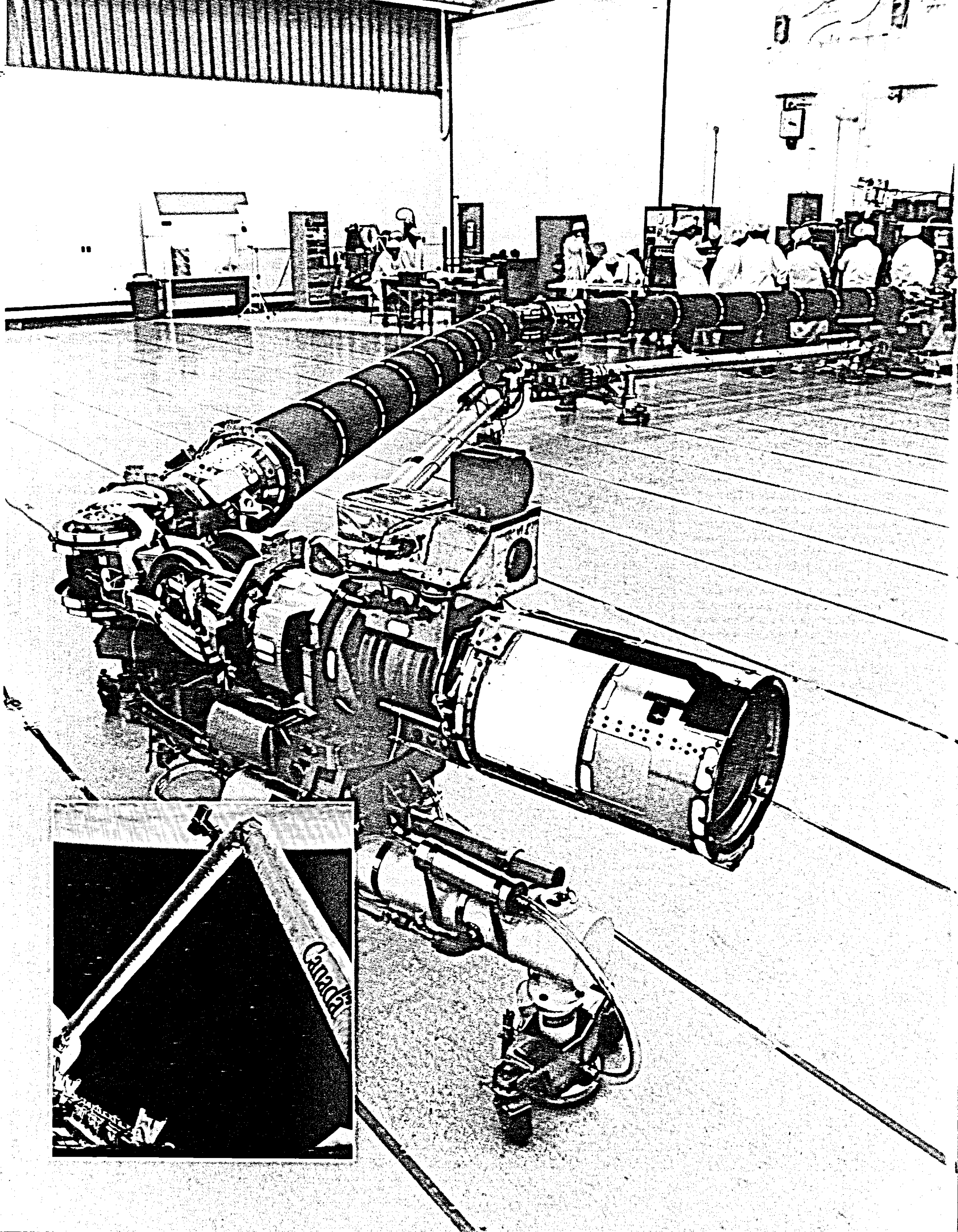
- **Olympus** testing of thermal and structural models set to begin in 1984; testing and assembly of final prototype spacecraft, scheduled for launch in late 1986, also to be done at the laboratory.

BRAZIL

- **Brazilsat** almost all the building and testing, as well as the assembly of the two spacecraft to be completed at the laboratory; first satellite expected to be launched in 1985.

SWEDEN

- **Viking** testing of subsystems under way for this experimental satellite.


Canada

The facilities in the laboratory include:
- two high-bay spacecraft assembly areas, with appropriate dust and contamination control, for assembly of aerospace components and systems—sufficient space for up to five Delta class spacecraft—such as Anik C—at one time;
- two RF anechoic (no radio wave reflections) test chambers;
- three vibration machines with control and measurement instrumentation for launch simulation;
- five thermal vacuum chambers that simulate conditions of outer space;
- data reduction facilities to display, record, and analyse thermal vacuum, vibration and RF test data.

The laboratory was built in the early 1970s to support the design, assembly and test of Hermes. It was greatly expanded in 1979-80 to accommodate complete satellites to be launched by expendable rocket or by the space shuttle. The laboratory has recently been upgraded for testing of large satellites, such as Olympus and the two Brazilian communications spacecraft. By autumn 1983, more than 20 complete satellites and subsystems had been tested.

The laboratory is part of the Communications Research Centre and its facilities are available to Canadian industry and government agencies on a cost-recoverable basis. It was named in recognition of C. David Florida, a leader of Canada's early space effort, who died in 1971.

International Consulting and Sales

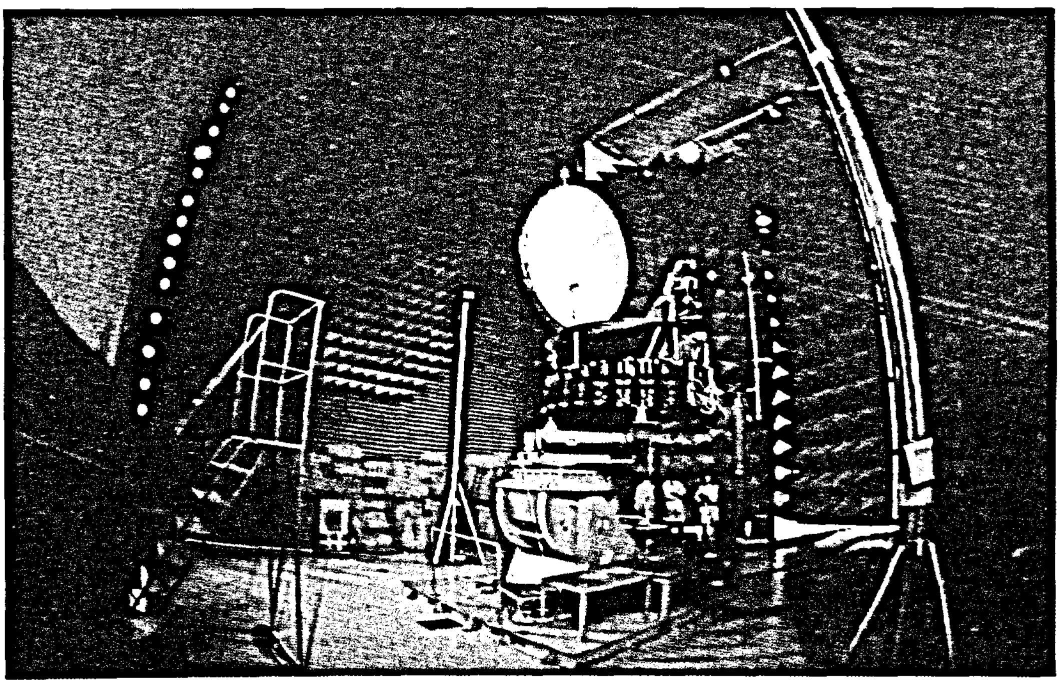
Canadian engineers and technicians travel the world as consultants in the design, procurement and operation of satellite systems. Canadian companies have advised and sold to governments and private companies in Canada, the United States, Europe, Asia, Africa, South America and Australia. Among the Canadian companies prominent in space-related consulting services are:

• AEL Microtel Limited • Canadian Astronautics Limited • Com Dev Ltd. • Miller Communications Systems Ltd. • Raytheon Canada Limited • SED Systems Inc. • Spar • Telesat.

In 1982, the Canadian industry's 48 largest companies—which accounted for more than 95 per cent of space-related sales—had total sales of $196 million, $128 million (65 per cent) outside Canada. The estimated 1983 figures for these same companies are $276 million total, $194 million (70 per cent) in exports. Just over 40 per cent of the total sales were, and are projected to be, related to the ground segment of satellite communications systems (earth stations, antennas, etc.).

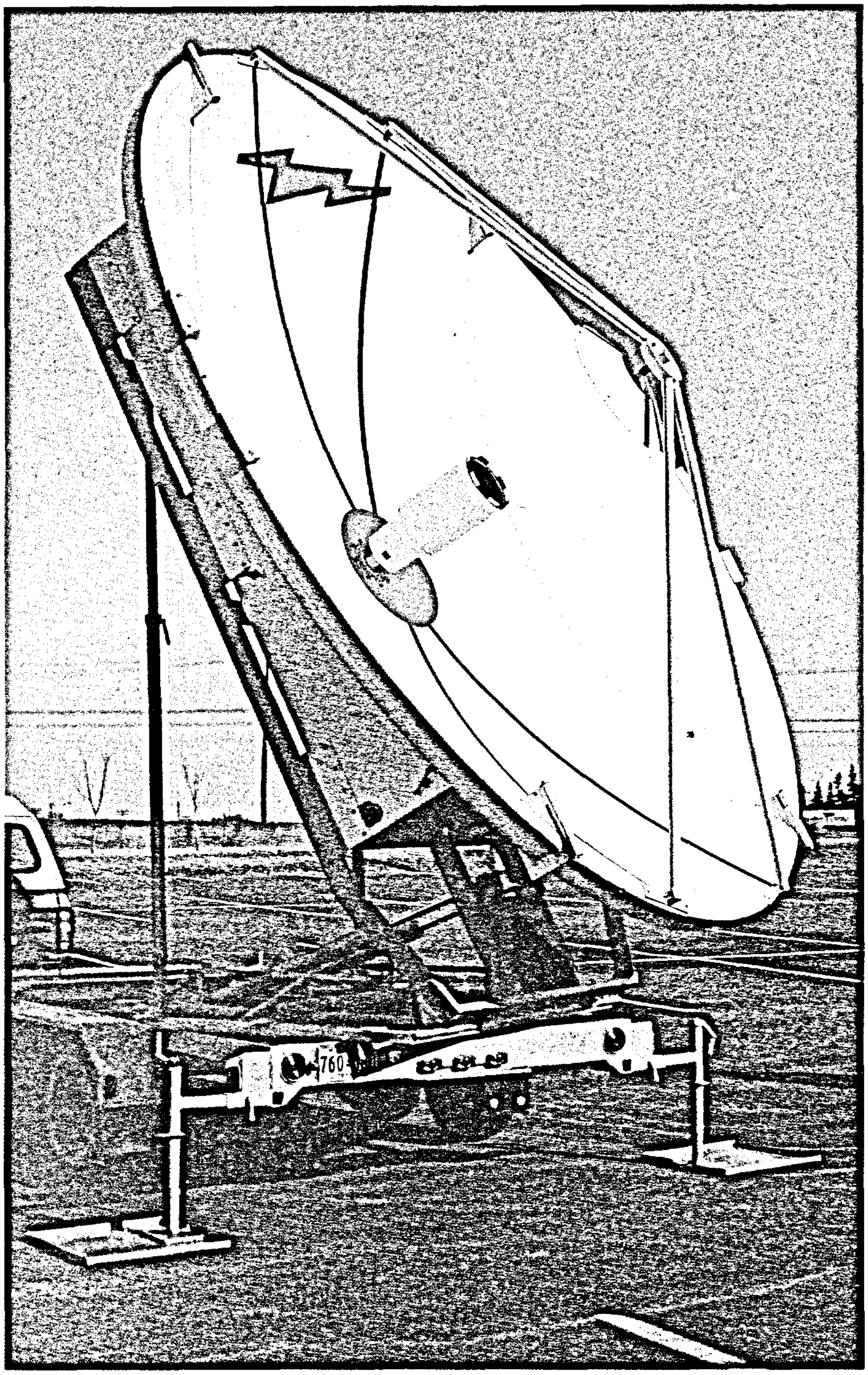
Major products of important Canadian space industry firms include:
- *SATELLITES* Spar;
- *SATELLITE SUBSYSTEMS* Canadian Astronautics, Com Dev, Fleet Industries, SED Systems, Spar;

Canadarm undergoes tests and (inset) *is seen in flight on the* Columbia *space shuttle.*



The enlarged anechoic chamber, an environmental testing facility, which opened in 1980, at the David Florida Laboratory at the Communications Research Centre.

- *14/12 GHz and 6/4 GHz PERMANENT AND TRANSPORTABLE EARTH STATIONS AND COMPONENTS* AEL Microtel, Andrew Antenna Company Ltd., Canadian Astronautics, Com Dev, Digital Telecommunications Ltd., MacDonald Dettwiler & Associates Ltd., MPB Inc. Raytheon Canada, SED Systems, Spar and many other smaller companies;
- *SATELLITE TRACKING ANTENNAS* TIW Systems Ltd.;
- *REMOTE SENSING SURVEILLANCE SYSTEMS AND COMPONENTS* Moniteq Ltd., MacDonald Dettwiler, Spar;
- *REMOTE MANIPULATOR SYSTEMS AND COMPONENTS* CAE Electronics Ltd., Spar.



Andrew Antenna's 4.5 metre 4/6 GH_3 transportable earth station.

Satellites now provide Canadians with many important daily services, but one of their most dramatic and exciting roles has been in helping to rescue accident victims. The SARSAT program is literally saving lives.

SARSAT is a satellite system developed by Canada, the United States and France to improve marine and aviation search and rescue operations. SARSAT is a unique international joint space venture because it works in co-operation with a similar and technologically compatible Soviet system, COSPAS. The result is an excellent example of how well satellite technology can be applied for peaceful purposes: in the first 13 months of its demonstration phase (September 1, 1982–October 1, 1983), COSPAS/SARSAT contributed to the rescue of 87 people.

The COSPAS/SARSAT system uses polar-orbiting satellites that provide world coverage every few hours. The satellites, acting as communications relays, receive radio distress signals from Emergency Locator Transmitters (ELTs) in aircraft and Emergency Position Indicating Radio Beacons (EPIRBs) in ships and retransmit them to ground stations. (In the event of an accident, the ELT or EPIRB is activated automatically and can also be switched on manually.) Ground stations detect the distress signals, determine the location of each to within a 20-kilometre radius and notify a rescue co-ordination centre—all within 20 minutes after a satellite pass.

Four SARSAT ground stations have been sold to the US and one to France. Further sales are expected.

This kind of service is particularly important in Canada, where search and rescue operations have always been difficult and expensive because of the vast size of the country. Before COSPAS/SARSAT, several days might elapse before a rescue centre would even be aware that a ship or aircraft was missing.

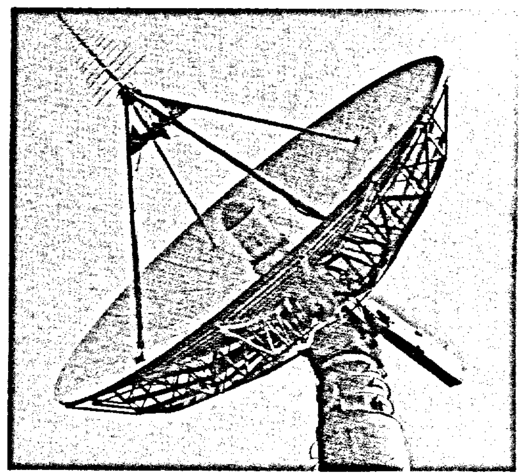
There are now in orbit two Soviet COSPAS satellites and an American one carrying SARSAT equipment. With these three satellites, the signal pick-up delay from an ELT or EPIRB anywhere in the world is four hours or less; when a second US satellite goes into service, the delay will be no more than three hours. The fourth SARSAT-COSPAS satellite (SARSAT 2) will be launched after the demonstration period is over (June 1984). When it is launched, perhaps as early as October 1984, there always will be two COSPAS and two SARSAT satellites in orbit at the same time.

Canada has been involved with SARSAT since 1973, when the first feasibility studies were conducted. Since then, the federal Department of Communications and Canadian contractors have made major technological contributions, specifically:

- development of 406 MHz ELTs and other emergency beacons operating at that frequency (Bristol Aerospace Limited);
- ground station software to operate at all three international distress frequencies: 121.5 MHz (commercial), 243 MHz (military) and 406 MHz, the band reserved for satellite-aided search and rescue (Canadian Astronautics Limited);
- spaceborne repeaters for the US satellites to accommodate the three frequencies (Spar Aerospace Limited);
- mission control centre (SED Systems Inc.).

To date, Canada has spent about $14 million on SARSAT.

The ground stations are fully automated units that can receive and process data at all three frequencies from all SARSAT and COSPAS satellites. A computer-controlled, three-metre



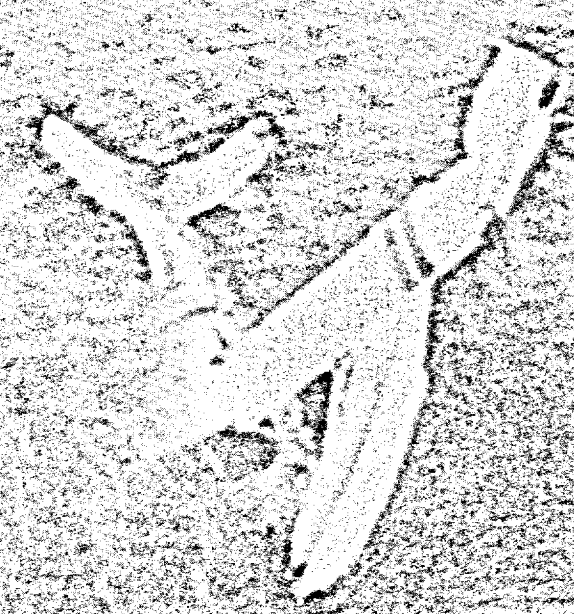
tracking antenna follows each satellite pass. During the demonstration phase, one unit is operating in Canada; three will be needed to cover the whole country once the system is fully operational. Four ground stations have been sold to the United States and one to France. Further sales to other countries thinking of joining SARSAT are expected.

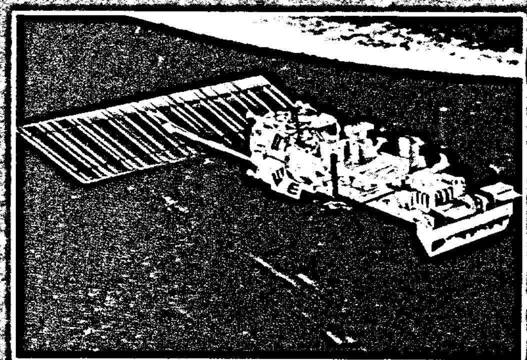
COSPAS/SARSAT has already played a major role in 36 rescues in its first year of testing. Accident victims have been saved not only in Canadian and American territory and waters, but also in the Alps, the Canary Islands and at the North Pole.

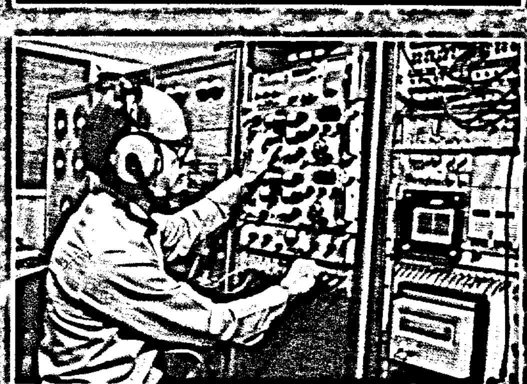
Advantages of 406 MHz include:

- *FEWER FALSE ALARMS*—Almost 96 per cent of ELT/EPIRB alarms are false alarms caused by a variety of reasons, including incorrect use. The digital identification code that can be accommodated on the 406 MHz band allows searchers to first check if a plane is, in fact, in the air (or a ship at sea).
- *MORE INFORMATION FOR SEARCHERS*—The digital code can give searchers quite specific information about what they are looking for: size, markings and other important characteristics of a missing aircraft or vessel.
- *GREATER ACCURACY*—The ELT/EPIRB signal can be pinpointed to within five kilometres.
- *WORLD-WIDE COVERAGE*—The information received by a satellite at 406 MHz can be stored in the spacecraft memory. Thus, when the satellite transmits data to Earth, all receiving ground stations can know what has happened throughout the world. (With 121.5 MHz and 243 MHz, ground stations receive only those emergency signals a satellite picks up while it is within their range.)

SARSAT planners hope the 406 MHz frequency will be phased in by the late 1980s.





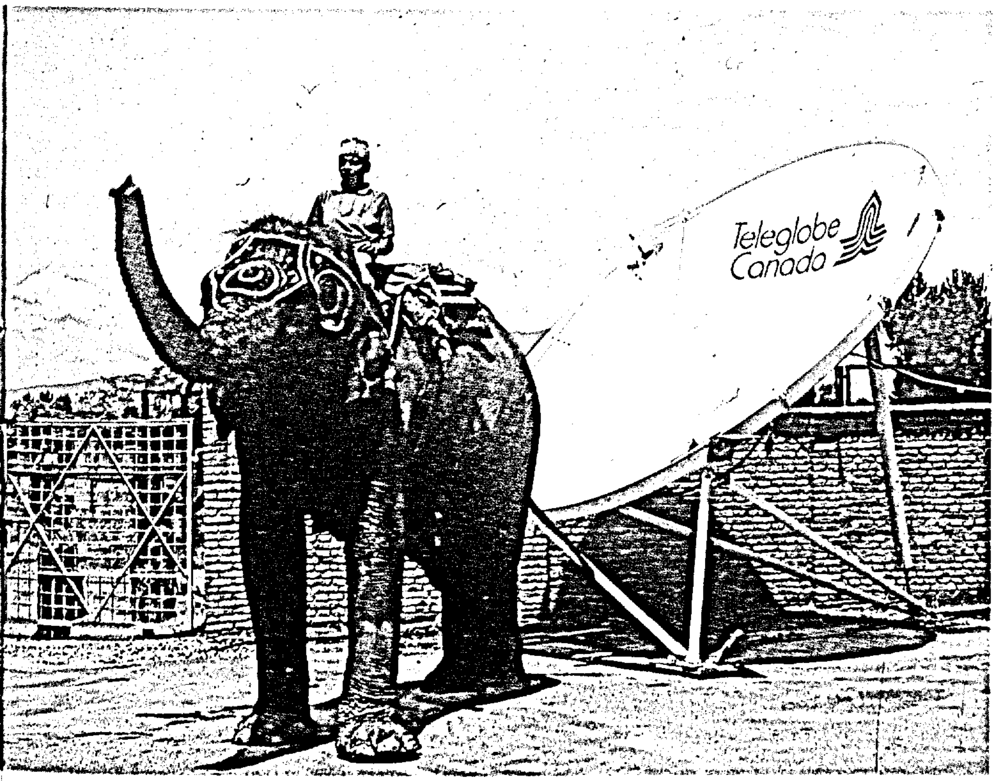


If a plane crash occurs, the craft's emergency locator transmitter (ELT) is set off automatically. The signals are received by the satellite and relayed to a ground station.

Information from the satellite is used to estimate the location of the accident. In Canada, the ground station sends the information on the accident to the mission control centre at Trenton, Ontario.

Canada is playing a key role in an international demonstration of a satellite-aided search and research system (SARSAT). The program, which began in September 1982, helped to save 36 lives during its first seven months of operation. Canadian-built SARSAT equipment was carried aboard the US NOAA-E weather satellite, when it was launched in spring 1983.

Telesat Canada's 3.7 metre, 12/14 GHz antenna was used during the successful climb of Mount Everest by a Canadian team in October 1982.



Teleglobe Canada, a federally owned corporation responsible for international telecommunications, represents Canada on major international satellite organizations and offers their services throughout the country. The company has been acclaimed world-wide for its reliable, cost-efficient network.

International Telecommunications Satellite Organization (INTELSAT)

Teleglobe's four earth stations link Canada to the world *via* satellite through the INTELSAT system. (Teleglobe also has an extensive submarine cable network.) INTELSAT was formed in 1964 when Canada and ten other nations signed the first agreement for an international satellite telecommunications system. It has since grown to 108 members and owns and operates 15 satellites—nine over the Atlantic Ocean and three each over the Pacific and Indian Oceans. Together, these spacecraft carry about two-thirds of the world's international telephone calls, Telex and telegram messages, television broadcasts and data transmissions.

Though its major need for INTELSAT satellites is for international telephone calls—which account for about 80 per cent of its daily telecommunications volume—Teleglobe has also used them to televise special events including:

- *The 1976 Olympic Games in Montreal.* Teleglobe's efforts made them the most widely viewed event in history at that time. It transmitted about 800 hours of coverage to Asia, Europe, Latin America and Africa.
- *The 1982 Economic Summit at Montebello, Quebec.* Proceedings were broadcast back to participating nations: France, Italy, Japan, United Kingdom, United States and West Germany.

The Canadian space industry will help build the next generation of INTELSAT satellites. Spar Aerospace Limited and Com Dev Ltd. are the Canadian subcontractors to Hughes Aircraft Corporation for the development of subsystems for at least five, and potentially as many as 12, INTELSAT VI spacecraft scheduled to be launched starting in 1986.

International Maritime Satellite Organization (INMARSAT)

Canada was one of the founding members of INMARSAT established in 1979 to improve global commercial maritime satellite communications and marine distress and safety communications for ships and offshore drilling rigs. INMARSAT, now with 39 member countries, operates six satellites over the three ocean regions. Through this system, Teleglobe brings Canadians in touch with vessels anywhere in the world by telephone and Telex.

Canada's program has become an integral part of the country's culture and economy. Every year we find new applications for existing satellite technology, and because of increased spending on research and development by government and industry, we will, without doubt, continue to develop new technologies to work with in the years to come.

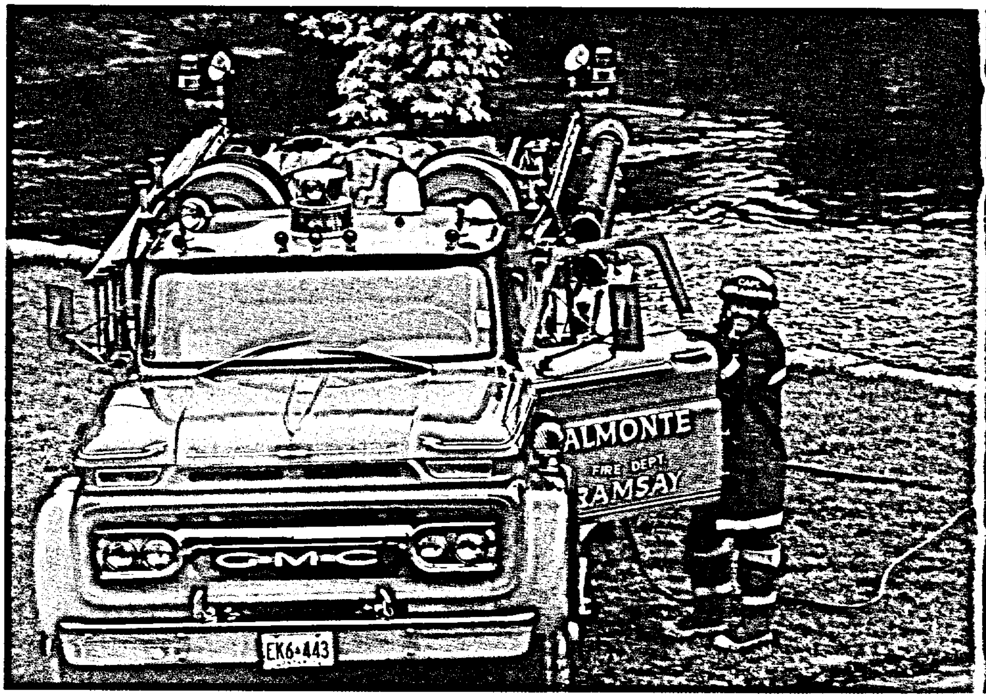
Some of the projects on the drawing board include:

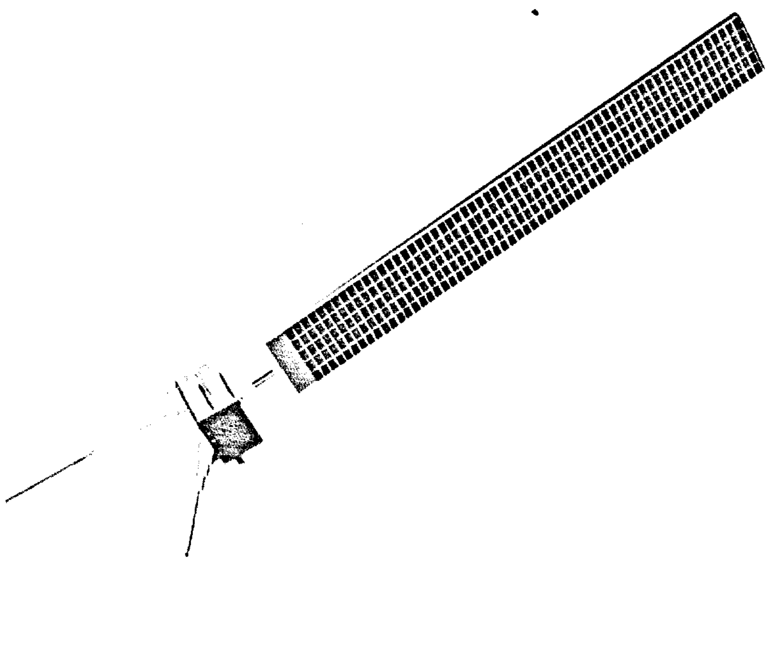
Mobile Satellite (MSAT)

Because of Canada's vast territory, much of it remote, there is a real and often urgent need for effective communications by mobile radio users who live and work outside metropolitan centres. At present, mobile communications are usually limited to a maximum effective range of 40 to 60 kilometres from a base station. Workers on a remote construction or exploration site, for example, have to travel 50 kilometres or more to reach the nearest phone—or even to be able to use their existing mobile radiotelephones.

MSAT is a proposed satellite system that would link mobile radio users with the rest of Canada—and the world. If a demonstration spacecraft is approved for launch in the late 1980s, Canada would become the first country with a mobile communications satellite. Preliminary feasibility studies on MSAT proved encouraging, and plans are proceeding on spacecraft design, market identification and an examination of the economic viability of the project. A final decision on MSAT is expected from the government in late 1984.

Major users of an MSAT system would include: emergency and medical workers; forest fire fighters; the Royal Canadian Mounted Police and other law enforcement agencies; oil and gas exploration crews; truckers and travelling salesmen; fishermen; environmental data collection platforms.





Users of MSAT include emergency workers such as firefighters.

Radarsat is expected to be launched in the late 1980s.

In this satellite scan of some 100 kilometres of range land in Brooks, Alberta, the deeper red tones denote denser vegetation. A digital image analysis system called Aries II was used to enhance the picture.

An operational MSAT spacecraft would create a nation-wide system of mobile communications. Drivers travelling from coast to coast, for example, would be able to make calls from their cars' mobile radiotelephones to any point that can be reached from their home telephone. MSAT could even be used for phone calls from passengers aboard airplanes.

The market for an MSAT system is expected to grow at a rapidly accelerating rate well into the twenty-first century. The ultimate goal is a commercially viable communications system in which one MSAT satellite could serve several thousands of low-cost terminals outside major centres. Reliable voice and data communications would be provided to places, people and machines now unserved, at costs comparable to present rates for mobile services in large cities.

RADARSAT

Data from US remote sensing satellites have been used by Canada since the early 1970s for crop inventory, forest and wildlife management, land use studies, ocean mapping, ice reconnaissance and mineral and petroleum exploration. Canada has so far concentrated on the ground-based segment of remote sensing satellite systems. However, because of the vital importance of remotely sensed data to effective resource management, especially navigation through ice-filled seas in the North, we are considering the development of our own spacecraft to serve Canada's special interests.

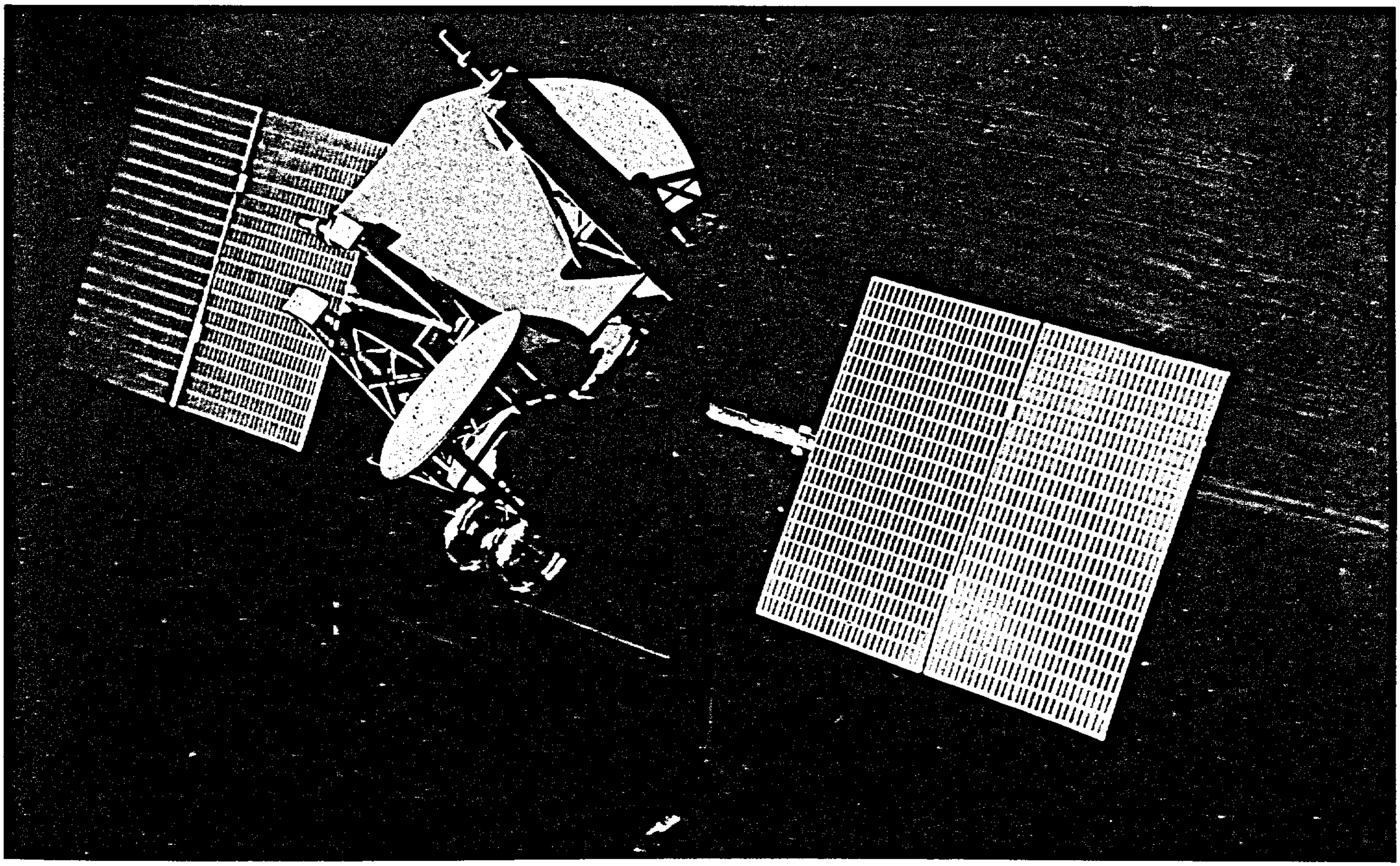
Radarsat, if approved for launch in the late 1980s or early 1990s, would improve on current remote sensing satellite systems by using a special radar sensor that could operate day or night, regardless of weather conditions, and produce high-resolution, map-like images of the earth and oceans. Information derived from Radarsat would assist not only Arctic navigation, but also Arctic energy exploration, agriculture and the fisheries.

NOTABLE CANADIAN ACHIEVEMENTS

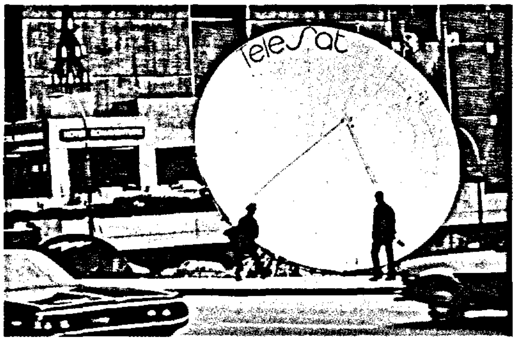
- Third country with its own satellite in space—Alouette I (1962).
- World's first domestic communications satellite company —Telesat Canada (incorporated 1969).
- World's first geostationary domestic communications satellite—Anik A1 (1972).
- World's first domestic communications satellite to use non-tracking earth stations—Anik A1 (1972).
- National network television signals carried by satellite—Canadian Broadcasting Corporation (1973).
- Construction of facilities to build and test spacecraft and spacecraft subsystems—David Florida Laboratory (1973).
- World's first satellite to test the super high frequency 14/12 GHz bands—Hermes (1976).
- Most powerful non-military satellite in the world—Hermes (1976).
- World's first demonstration of direct broadcasting by satellite (DBS) to earth stations small enough to be situated on or near individual homes—*via* Hermes (1976).
- World's first dual band commercial communications satellite (6/4 GHz and 14/12 GHz—Anik B (1978).
- World's first regular DBS programming—TVOntario, *via* Anik B (1979).
- World's first commercial 14/12 GHz service—La SETTE, a consortium of Quebec cable operators, *via* Anik B (1980).
- Manoeuvring satellites into same orbital position so that the usable channels on each could be operated as if they were aboard a single spacecraft—Anik A2 and A3 (1981).
- World's first remote manipulator system for space—Canadarm, first tested aboard second flight of the space shuttle *Columbia* (1981).
- Satellites used for world's first commercial DBS system—Anik C series (1983).
- First commercial satellite system combining voice, data and image telecommunications to be fully integrated with the ground-based network run by telecommunications companies—Stratoroute 2000 and the Telecom Canada network (1983).

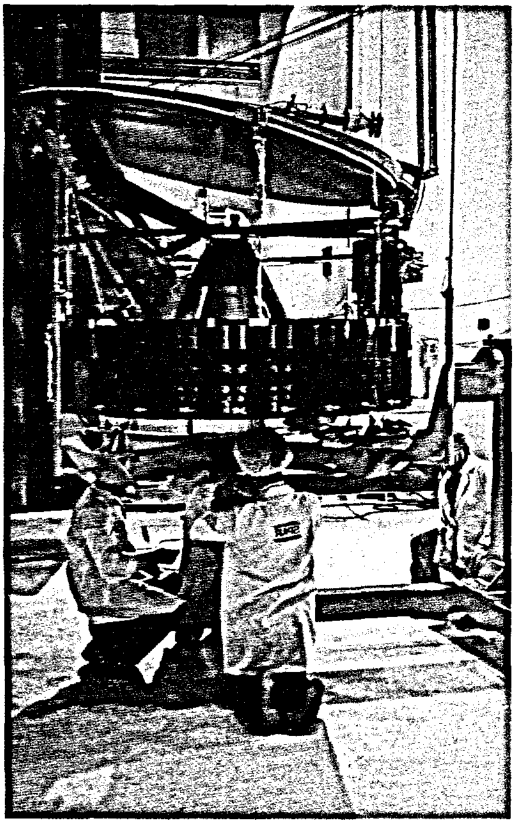
Name	Launch Date	Purpose
Alouette I	September 29, 1962	ionospheric research
Alouette II	November 29, 1965	ionospheric research
ISIS I	January 30, 1969	ionospheric research
ISIS II	April 1, 1971	ionospheric research
Anik A1	November 9, 1972	commercial
Anik A2	April 20, 1973	commercial
Anik A3	May 7, 1975	commercial
Hermes	January 17, 1976	experimental
Anik B	December 15, 1978	experimental/ commercial
Anik D1	August 26, 1982	commercial
Anik C3	November 12, 1982	commercial
Anik C2	June 18, 1983	commercial
Anik C1	(scheduled 1984)	commercial
Anik D2	(scheduled 1984)	commercial

Anik B, the world's first hybrid communications satellite operating in 6/4 GHz and 14/12 GHz bands.



GLOSSARY





Alouette — The name of the first Canadian satellite. It is a French word for a high-flying bird, the lark.

Anik — The name of Canada's commercial domestic communications satellites operated by Telesat Canada. The word means 'brother' in the Inuit language.

Beam — Directional pattern of an antenna. Beams for communications satellites are very narrow—only a few degrees wide.

Canadarm — The Remote Manipulator System for NASA's Space Transportation System (the space shuttle) that enables astronauts to take satellites from the cargo bay and place them in space and to retrieve satellites already in orbit and put them in the shuttle's cargo bay for servicing or return to Earth.

CBC — Canadian Broadcasting Corporation, Canada's government-owned radio and television networks (English and French).

DBS — Direct broadcasting by satellite (to low-cost earth stations small enough to be located on or near a single home).

Earth station — Facility equipped with dish antenna that transmits and/or receives satellite signals.

Geostationary orbit — The circular orbit about 36 000 kilometres above the equator, where satellites have an orbital period of 24 hours and therefore appear stationary from the Earth.

GHz — Gigahertz, a unit of frequency equal to one thousand million cycles per second.

Hermes — The name of the experimental Communications Technology Satellite. In Greek mythology, Hermes was the messenger of the gods.

MHz — Megahertz, a unit of frequency equal to one million cycles per second.

NASA — National Aeronautics and Space Administration (USA).

Orbital positions — Positions in the geostationary orbit assigned to specific satellites.

RF — Radio frequency.

SARSAT — Search and Rescue Satellite-Aided Tracking.

A Telesat Canada earth station at a demonstration in Montreal.

Scientists work on Anik C at the David Florida Laboratory, Communications Research Centre.

Satellite channel	The radio frequency channel of a satellite driven by one amplifier.
Solar cells	Semiconductor devices that generate electric current when illuminated by sunlight.
Videotex	An interactive communications system for displaying alphanumeric and graphic information on a video screen. Telidon is the Canadian-developed videotex system.