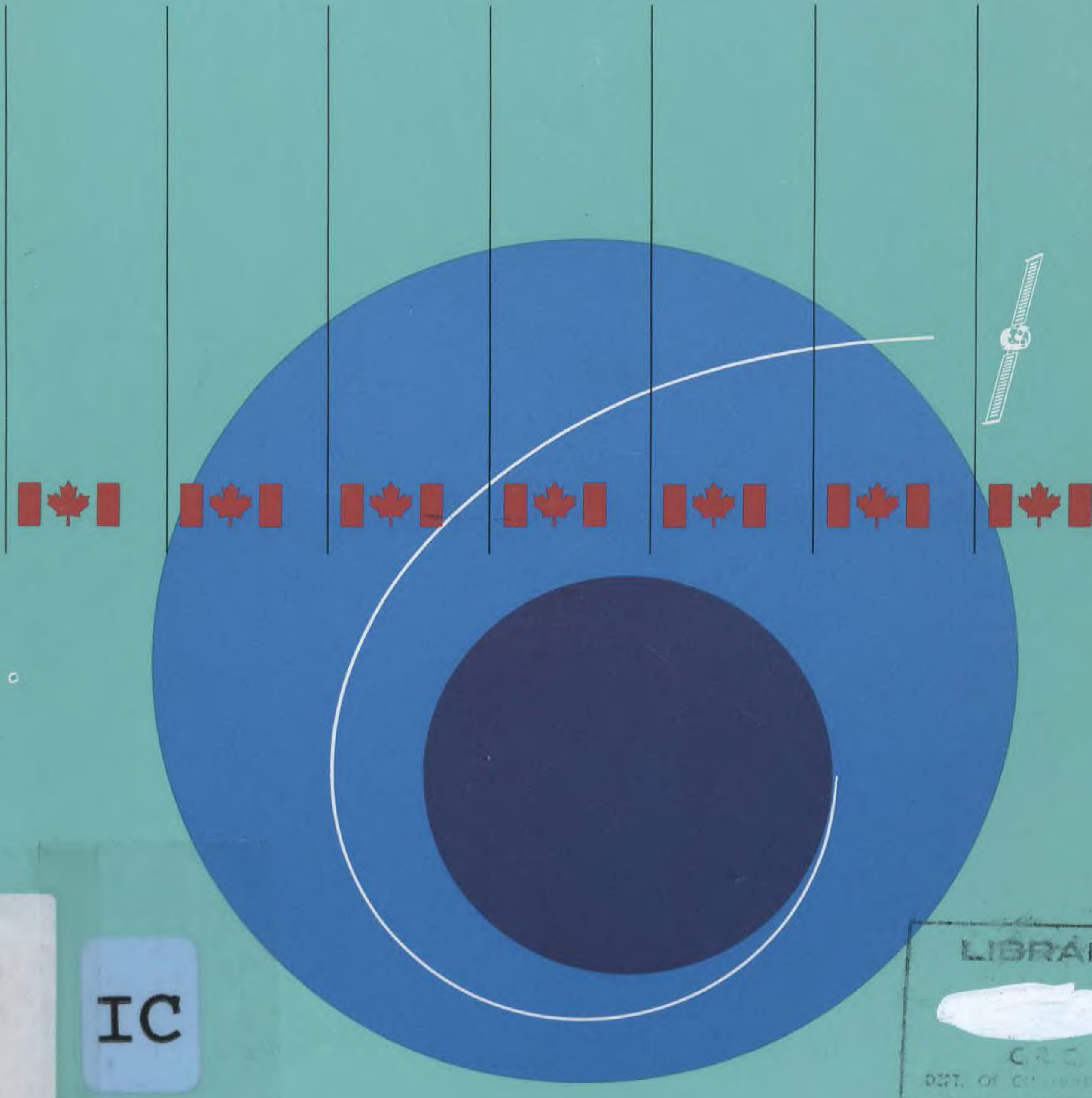
Canada in Space



Department of Communications

Little more than a decade has passed since Canada became the first nation to join the Soviet Union and the United States in the space club.

Six successful Canadian scientific and communications satellites have now earned this country's space scientists and engineers a performance and reliability record respected around the world.

Beginning with Alouette I, in 1962, and concluding with ISIS II, in 1971, four made-in-Canada scientific satellites established our place in space. They worked perfectly, providing science with tremendous amounts of data to further man's knowledge of the ionosphere and giving both Canadian government and industry invaluable experience in the design, manufacture and operation of satellites and their subsystems.

Our space program entered a new phase in 1972, when the launch of Telesat Canada's Anik I gave Canadians the world's first domestic geostationary telecommunications satellite system. Anik's twin brother, Anik II, was launched the following year.

Now, with these achievements behind us, we stand on the threshold of a new venture in space. Work is proceeding towards the late-1975 launch of the Communications Technology Satellite (CTS). Purely experimental, CTS will test the technology and applications of a new generation of high-powered satellites to meet the communications needs of the 1980's.

Alouette I launched September 29, 1962

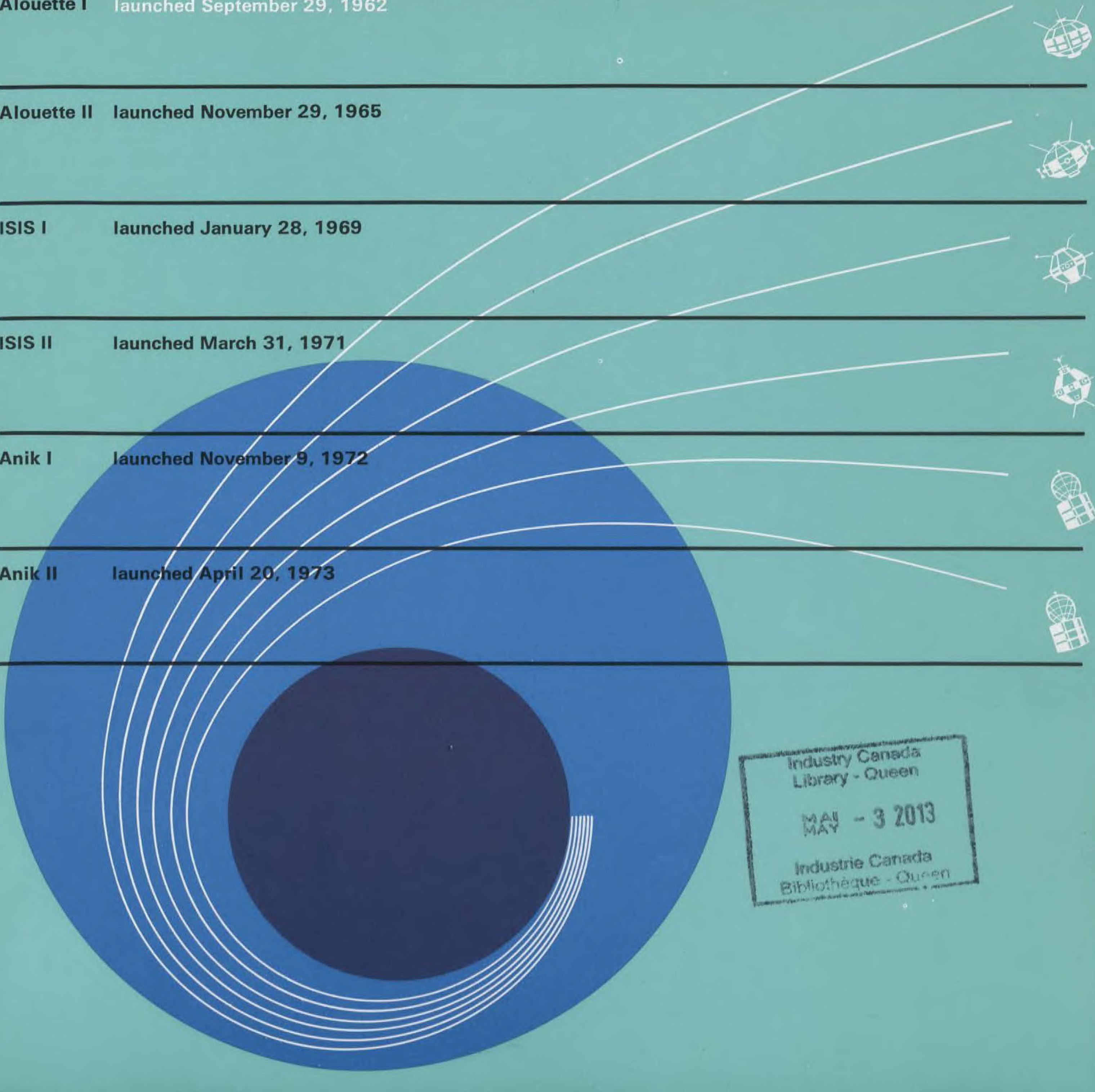
Alouette II launched November 29, 1965

ISIS I launched January 28, 1969

ISIS II launched March 31, 1971

Anik I launched November 9, 1972

Anik II launched April 20, 1973

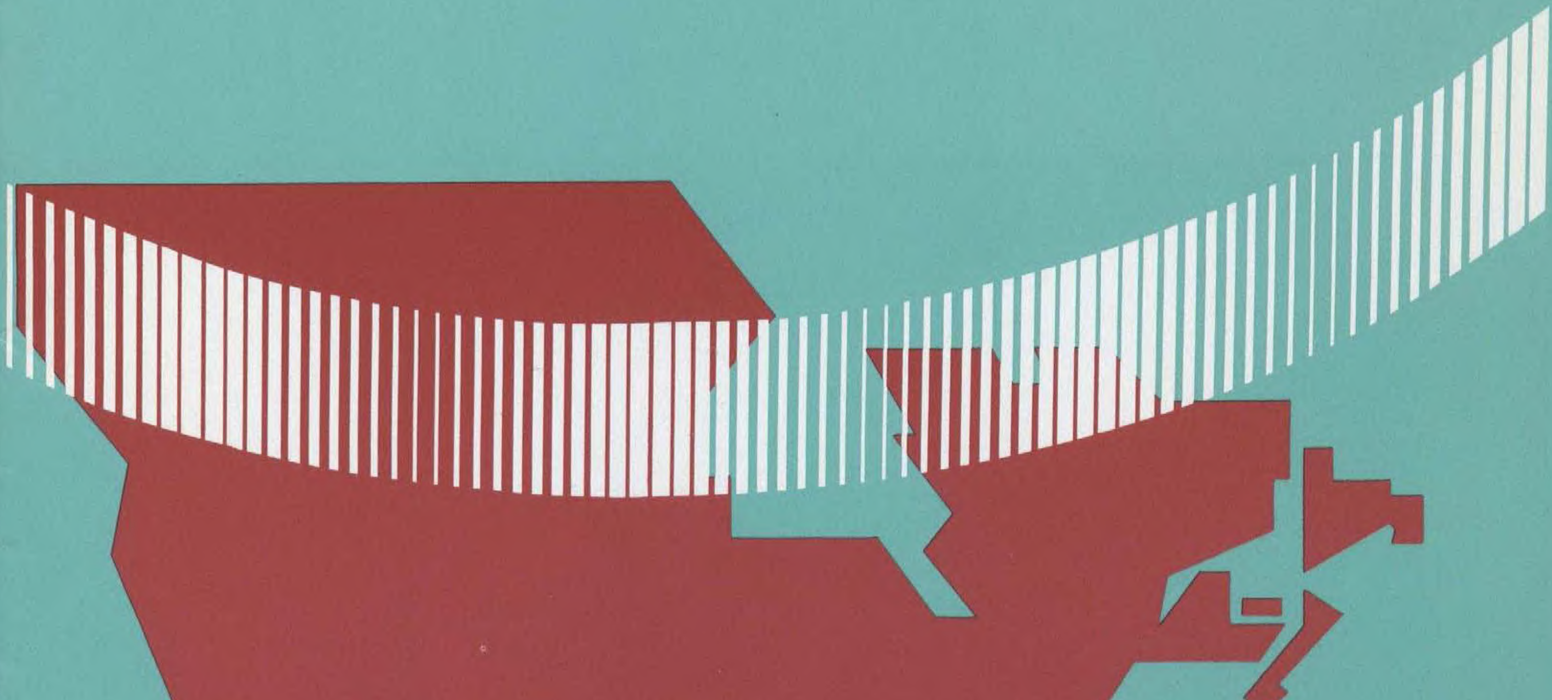


Canada's second decade in space has already begun to bring her people practical benefits of knowledge, experience and confidence gained in the first. While Anik beams TV programs and high quality telephone service to the previously remote north, the Department of Communications and Canadian industry have designed and are now building the Communications Technology Satellite, which could pave the way for development of more powerful, more flexible communications satellites.

The space program to date has fulfilled completely the original Canadian commitment to seek peaceful ways of participating actively in space research, despite the limited resources available. This commitment was made by two prime ministers — John Diefenbaker and Lester Pearson — in quick succession after the launching of Sputnik began the space race in 1957. As a result, Canada has probably conducted more successful space research per dollar than any other country. Though sometimes short on glamour, this space research has been long on knowledge — scientific knowledge of the "inner space" above us and practical knowledge of the design and construction of spacecraft.

Because of their knowledge of electronics, radio physics and communications systems, scientists at the Defence Research Board's Defence Research Telecommunications Establishment (DRTE) were given responsibility for the first Canadian satellite projects. This establishment, located at Shirley Bay at the western outskirts of Ottawa, was transferred to the new Department of Communications in 1969 and became the Communications Research Centre (CRC). Many of those at DRTE who worked on the first Alouette are still at CRC working on new satellite programs.

Their northern geography has given Canadians a particular interest in the ionosphere, which can be at its most disturbed in the region above Northern Canada. The phenomenon has provided the beauty of the *aurora borealis* or "northern lights", but has also led to special communications problems. In the past, the Canadian space program emphasized a search for improved understanding of the ionosphere as the medium for our often unreliable short wave radio links. Now we are seeking new solutions to old problems of keeping in touch, by putting the skills acquired building scientific satellites to work in a communications satellite program.



Alouette I, the first satellite designed and built by a nation other than the United States or the Soviet Union, was put together at a time when most satellites had a useful lifespan of a few months. That it could still send back useful data after 10 years — the longest run of any satellite so far — seems an almost incredible feat. Its builders expected it to operate for a year; their most optimistic prediction was five years of declining usefulness.

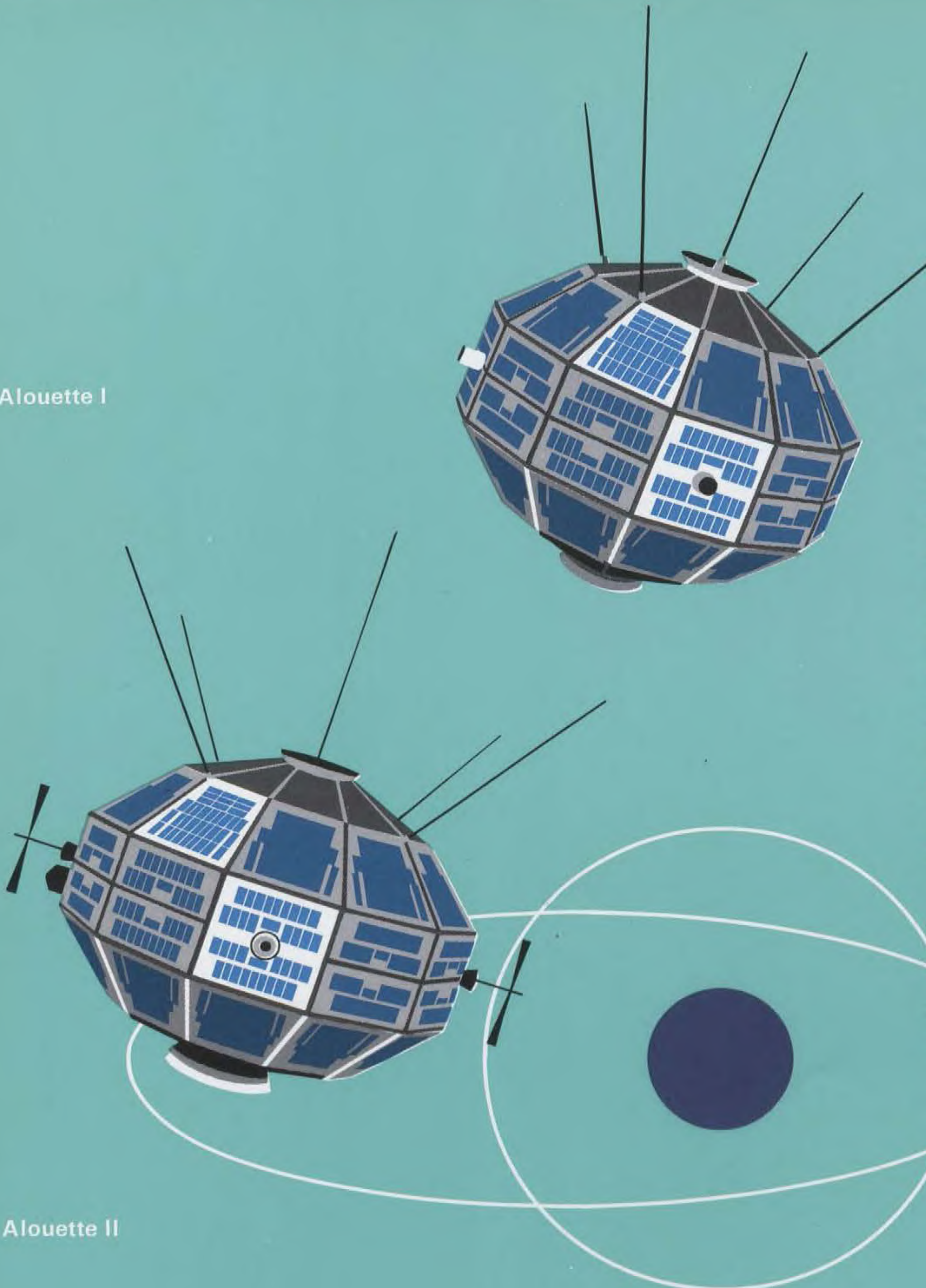
The original outlines of the Alouette satellite were contained in a paper presented by DRTE to a U.S. conference in the fall of 1958. The purpose of the conference was to hear proposals for satellite studies of the ionosphere — the region of electrically charged particles beginning at an altitude of about 35 miles which plays an important role in radio communications. The Canadian proposal was recognized as the most advanced at the conference, but no immediate action was taken. However, Canada was ready with a detailed proposal for a few months later when the newly-formed U.S. National Aeronautics and Space Administration (NASA) decided to put up such a satellite. An agreement with NASA was signed in the spring of 1959 and Canada entered the space age.

Three years of hectic activity followed for the scientists, engineers and technicians at Shirley Bay. With only a 50 per cent chance that the first satellite would even get into orbit, they had to build two flight-ready "birds" so the second could be sent up if the first one did not make it. They had to predict every part's performance under conditions like weightlessness, radiation and direct sunlight that simply could not be simulated on the ground. Equipment to conduct four scientific experiments, to transmit the data back to earth, to control the satellite's operations and to provide it with power for all this had to pack into a package weighing only 325 pounds.

One unique Canadian contribution to space technology emerged from this work — the long, extendible antennas which have become standard elements of nearly every nation's satellites since then. Spar Aerospace Ltd. of Toronto, which subsequently developed the antenna concept commercially, has sold more than $12 million worth of them to foreign space programs.

The main experiment on Alouette involved sending radio waves at various frequencies into the ionosphere and measuring their reflection by the layers of charged particles, giving a sort of radar map of the ionosphere from above which would complement similar studies from the ground. This required far longer antennas than had ever before been put in space — 150 feet from tip to tip for one, 75 feet for the other. The idea of an antenna stored rolled up like a carpenter's steel tape and formed into a tube as it unrolled had been developed 20 years earlier by the National Research Council for use in tanks. It was just the thing for Alouette.

Alouette I



Alouette II

Once the design had been worked out, assuring the satellite's reliability became the biggest concern. This sometimes meant ordering hundreds of samples of a part so that they could be tested under many different conditions and the very best one chosen. Solar cells, batteries, regulators and controls had to be put together so that power would be supplied when and where it was needed, in a form that could be used. Equipment was designed so it could not accidentally run down the batteries so much they would not recharge. Components had to be insulated from the sun's heat, from the vibration of the launch, from electrical interference. Changes were still being made in the final days before launch, but the satellite went up on schedule at 11:06 p.m. (PDT), Sept. 28, 1962 (2:06 a.m., September 29, Ottawa time). And it worked. A wave of relief passed through the tired crews at NASA's Western Test Range and Shirley Bay when ground stations in South Africa and Alaska confirmed Alouette was in orbit and operating.

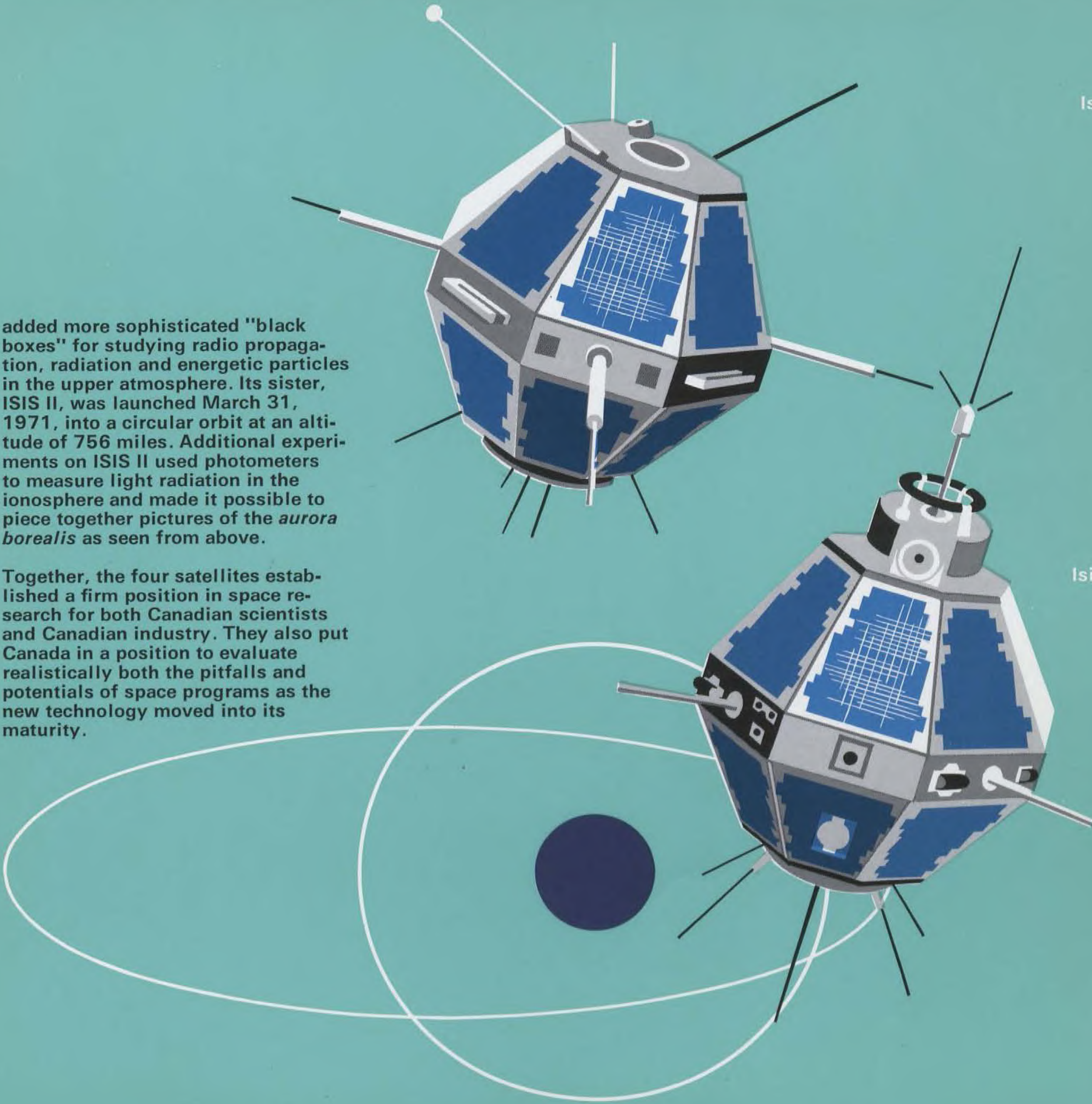
The four experiments, three from DRTE and one from NRC, were equally successful — resulting in some 400 scientific papers, more than those made possible by any other satellite. Sounding the ionosphere with radio waves from above, measuring cosmic noise, listening to very low frequency radio signals, counting the charged particles around the satellite — they gave the first global information about the upper regions of the ionosphere. Previously, knowledge had been largely limited to the region below about 200 miles. Combining Alouette data with studies from the ground, scientists now had a more complete picture of the whole ionosphere. They could determine better how plasma particles and radiation from the sun react with the earth's atmosphere and magnetic field, how this "solar wind" affects radio transmission and causes phenomena such as the *aurora borealis*. Alouette's unexpected long life provided the added bonus of comparable measurements of ionospheric behaviour over almost all of an 11-year cycle of solar activity.

With the success of Alouette I, the Canadian team was left with the question "what next?". It still had a carbon copy of the satellite in orbit — the backup model that would have been launched had the first try failed. The answer was not long coming. The United States and Canada agreed to build a series of International Satellites for Ionospheric Studies (ISIS). The government, seeing a golden opportunity to involve Canadian industry in advanced space technology, agreed to the joint program. Alouette I had been almost entirely an "in-house" project, but a major part of the following satellites was designed and built by Canadian industry with government providing management supervision, setting specifications and contributing special technical knowledge. The main subcontractors for the three ISIS satellites, as well as for the current Communications Technology Satellite, were RCA Ltd. of Montreal for electronics and Spar Aerospace Ltd. of Toronto for structure.

The first of the ISIS series was Alouette II, the standby model of Alouette I, which was modified and rebuilt for its new mission. Alouette I was in circular orbit 625 miles above the earth, but Alouette II was placed in an elliptical orbit ranging from 320 miles to 1,800 miles. It also carried an additional scientific experiment, provided by NASA, and was launched simultaneously with a U.S. satellite, Explorer XXXI, to provide for measurements that could not be made by a single satellite. The two satellites went up November 29, 1965, and again the results more than lived up to expectations. Combined with data from Explorer XXXI, Alouette II gave scientists valuable new information about behaviour of the ionosphere over a range of altitudes.

Experience gained from the two satellites permitted the next ionospheric satellite to combine in one craft the experiments carried separately in Alouette II and Explorer XXXI. This satellite, named ISIS I and launched January 28, 1969, was literally an orbiting laboratory for studying the upper atmosphere. Weighing 580 pounds, ISIS I carried 10 experiments and had antennas extending 240 feet and 62 feet from tip to tip. Its elliptical orbit ranged from altitudes of 2,160 miles to 360 miles — covering most of the important areas of the ionosphere. The experiments included those on the earlier satellites and added more sophisticated "black boxes" for studying radio propagation, radiation and energetic particles in the upper atmosphere. Its sister, ISIS II, was launched March 31, 1971, into a circular orbit at an altitude of 756 miles. Additional experiments on ISIS II used photometers to measure light radiation in the ionosphere and made it possible to piece together pictures of the *aurora borealis* as seen from above.

Together, the four satellites established a firm position in space research for both Canadian scientists and Canadian industry. They also put Canada in a position to evaluate realistically both the pitfalls and potentials of space programs as the new technology moved into its maturity.



Isis I

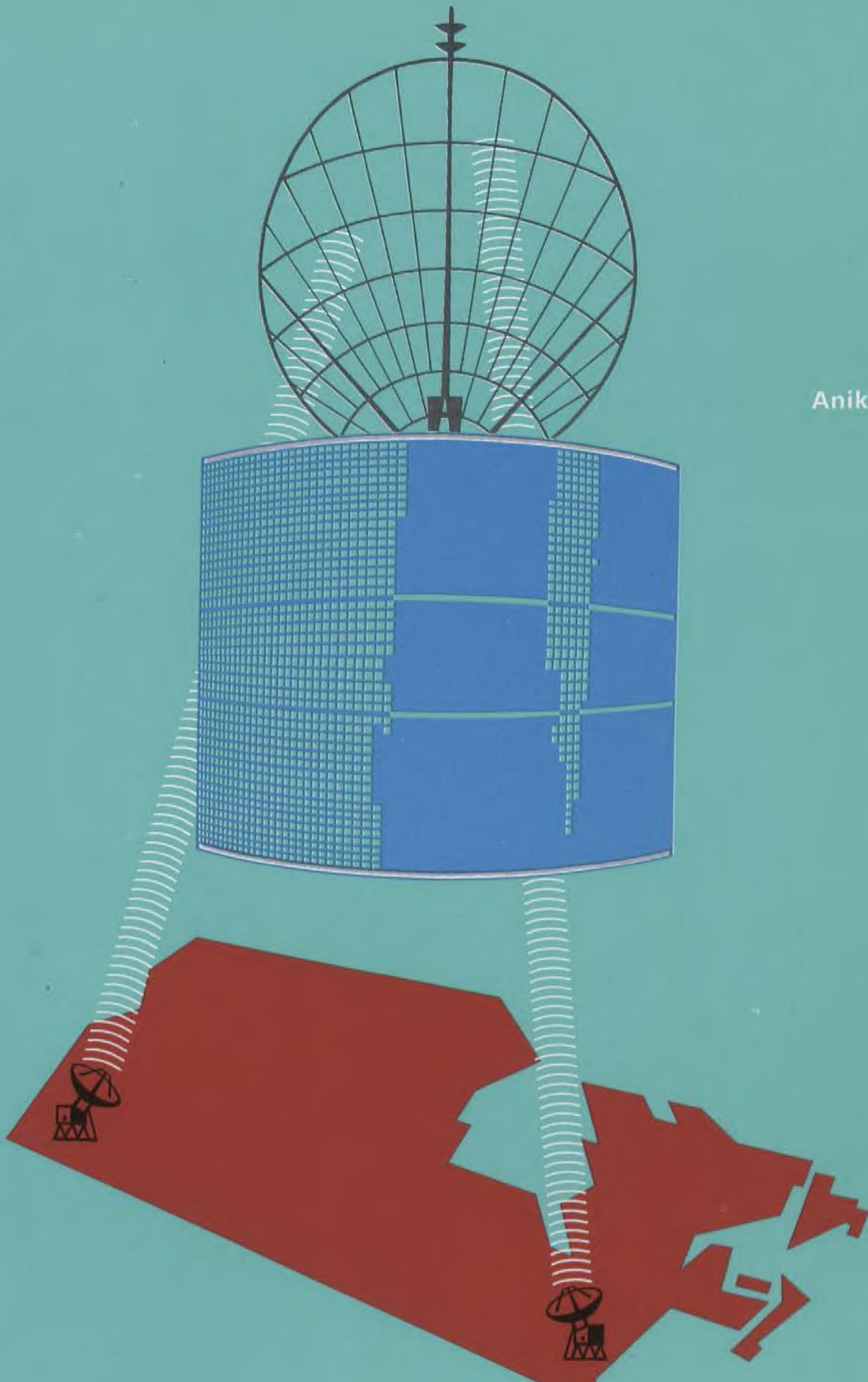
Isis II

With Canada's well-known problems of severe climate, vast distances, and sparse population, the most obvious and most immediate application of space technology is for communications. Canada actively supported from the start the program of international communications satellites now bridging all the world's oceans. The government decided in 1968 that Canada should also use satellites to extend the coverage and capacity of domestic communications. At that time, only the Soviet Union had domestic satellite communications — a system requiring multiple satellites and complicated tracking stations. Parliament created Telesat Canada — an independent corporation in which the government is a shareholder — to run a domestic system.

Its first satellite, Anik I, was launched on November 9, 1972, into a geostationary orbit 22,300 miles over the equator at about 114° W. longitude. The first domestic geostationary communications satellite in the world, it provides a high capacity for east-west television, telephone and data transmission, and has made possible the introduction of modern communications to many areas of the country for the first time. A second, identical satellite, Anik II, was launched April 20, 1973. Intended primarily as a back-up for the first Anik, it provides Telesat with spare channels, some of which are being temporarily leased to American users. Spar Aerospace Ltd. of Toronto and Northern Electric Co. Ltd. of Lucerne, Que., received major subcontracts from Hughes Aircraft Co. of California, which built the spacecraft for Telesat.

In its first year, Anik I linked together two "heavy route" ground stations near Toronto and Vancouver, six network TV stations to send and receive television signals from major urban centres and 24 remote TV stations to receive signals in larger communities in the North. In early 1973, the first stations of a "thin route" network bringing smaller, isolated northern communities telephone and radio services were inaugurated. The network, using ground stations that can be upgraded to provide additional services, was scheduled to grow to 19 stations by 1975.

The Aniks represent the current "state of the art" in satellite building, and are an important step towards the goal of equal access to communications for all Canadians. To move closer to that goal, the Department of Communications is now assembling the Communications Technology Satellite, which will be launched in 1975. The project is experimental — designed to answer questions about future satellite communications and not intended to provide a service for present needs. The satellite is a test vehicle for high-powered orbiting transmitters that could bring sophisticated communications services, now available only in and around developed areas, to every corner of the nation in the 1980s. Such satellites could help wipe out regional disparities in radio, television, telephone and data communications by linking together a vast network of small, even portable earth terminals, simpler and much less costly than those required by today's lower-powered satellites. As the cost of ground stations comes down, the numbers of people served by satellite communications can rise.



Anik I

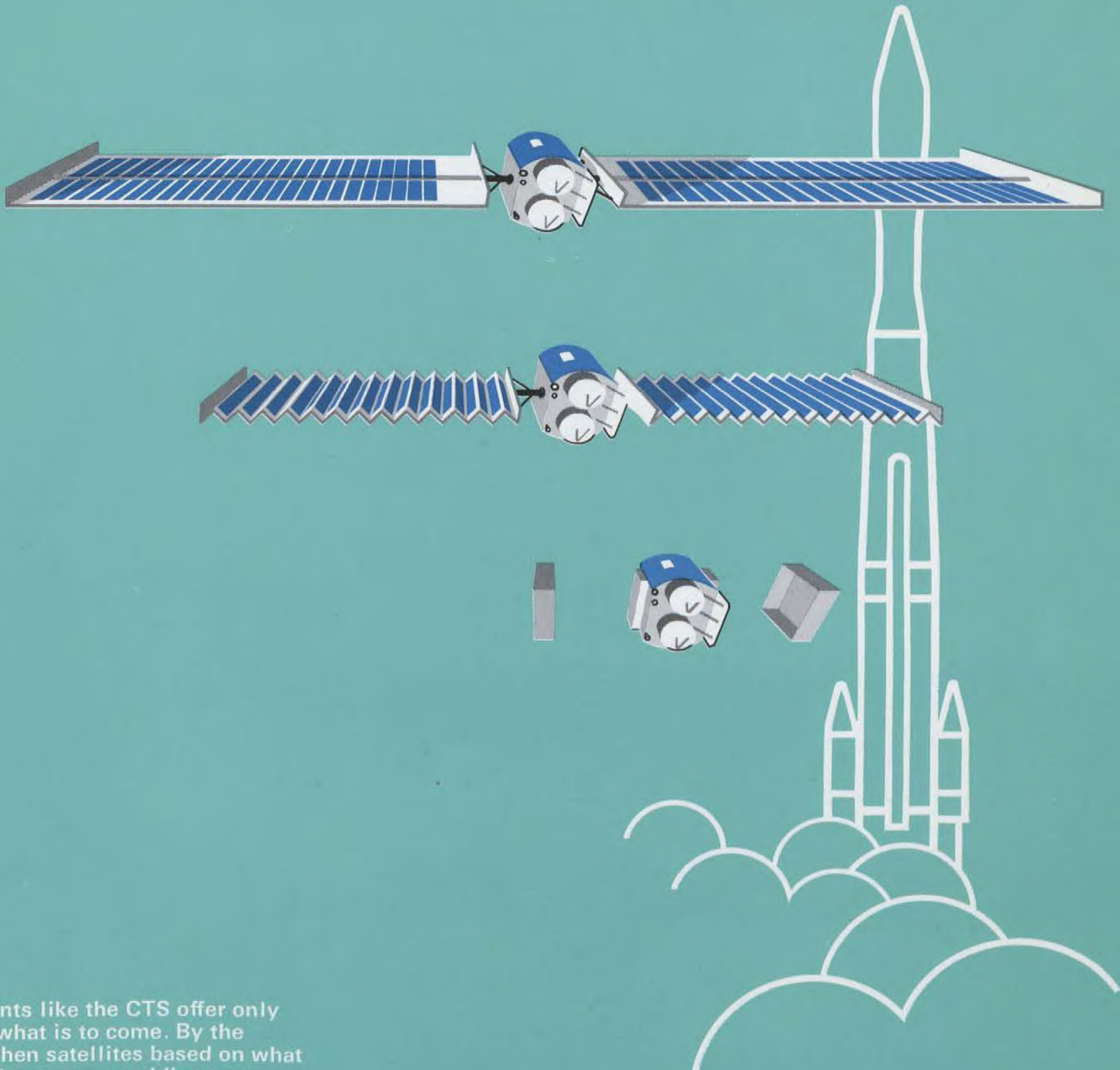
The approach to the CTS program has many similarities to that of the ISIS projects. It is a cooperative effort of the Department of Communications with NASA. No funds cross the border. Canada designs and builds the spacecraft; the United States provides some advanced components and pre-launch testing and performs the launch. Government experts at the CRC manage the construction program, with the main subcontractors RCA Ltd. for electronics and Spar Aerospace Ltd. for structure. One new feature is the modern Spacecraft Assembly and Test Facility at the CRC, where the actual satellite assembly will occur.

The European Space Research Organization (ESRO) is also participating by providing several vital components of satellite subsystems.

Three kinds of experiments will be conducted with CTS during its expected two-year lifespan, to test new satellite design and components, ground station technology, and the social and economic implications of such systems. A key to the satellite experiment is the advanced travelling wave tube being provided by NASA. It should be capable of producing a 200-watt signal at 50 per cent efficiency, as compared with the six watts at 30 per cent beamed to earth by the present generation of communications satellites. Because CTS will be so much more powerful, it will need more power from the sun which will be soaked up by concertina-type, extendible arrays or "sails". Instead of being kept stable by spinning, the satellite will be stabilized on three axes by hydrazine jets and a momentum wheel.

It is one thing to build such an advanced satellite — quite another to determine the wisest uses for it. The social significance of the non-technical experiments planned for CTS cannot be over-emphasized. Interested groups across Canada have proposed ways the satellite could be used and many will be participating directly by carrying out experiments chosen for inclusion in the program by an independent evaluation committee. Proposals include demonstrations of remote medical diagnosis, community interaction and tele-education. Thus, even before it is launched, CTS has at least one major accomplishment to its credit. It has started people thinking about new ways to solve their old communications problems by acting as a catalyst for groups which might never have dreamed of using a communications satellite if the government had not offered to put one at their disposal.

Ionospheric studies and satellite communications are two major parts of Canada's space effort. But experts at the Department of Communications and in other government departments are also participating in international satellite programs for resource-mapping, navigation, military communications and meteorology. This expert knowledge and involvement put Canada in the best possible position to exploit space technology.



Experiments like the CTS offer only a hint of what is to come. By the 1980s, when satellites based on what is learned now are providing new sorts of services across the country, other experiments undoubtedly will be under way to develop systems that cannot even be imagined today.

EXPERIMENTAL TECHNOLOGY SATELLITES

will use the most advanced concepts and technology to determine their usefulness in future commercial operational satellites.

Communications Technology Satellite
scheduled for launch in 1975 into a geostationary orbit over the equator at about 116° W. Longitude at an altitude of about 22,000 miles. It will be used for experiments in satellite design and components, ground station technology, and the social and economic implications of such systems.

COMMERCIAL OPERATIONAL SATELLITES

give a reliable service to users with the best available proven technology.

Anik I
launched in November 1972 into a geostationary orbit over the equator at 114° W. Longitude at an altitude of 22,300 miles. The first such domestic commercial system in the world, it is improving communications in all regions of Canada.

Anik II
launched in April 1973, into a similar orbit, as a back-up satellite.

SCIENTIFIC SATELLITES

provided valuable knowledge about the ionosphere, the environment through which radio waves travel. Designing and building them gave Canadian scientists and industry practical experience in space-age technology.

ISIS I
launched January 28, 1969 into an elliptical orbit ranging from 360 to 2160 miles, carried 10 ionosphere experiments.

Alouette II
launched November 29, 1965 in an elliptical orbit ranging from 320 to 1800 miles altitude, carried five ionosphere experiments.

ISIS II
launched March 31, 1971 in a circular orbit at 756 miles altitude, carried 12 ionosphere experiments.

Alouette I
launched September 29, 1962 into a circular orbit 625 miles up, carried four experiments to study the ionosphere.