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1977-78

Research and development

Government of Canada
Department of Communications

Gouvernement du Canada
Ministère des Communications

Research and Development

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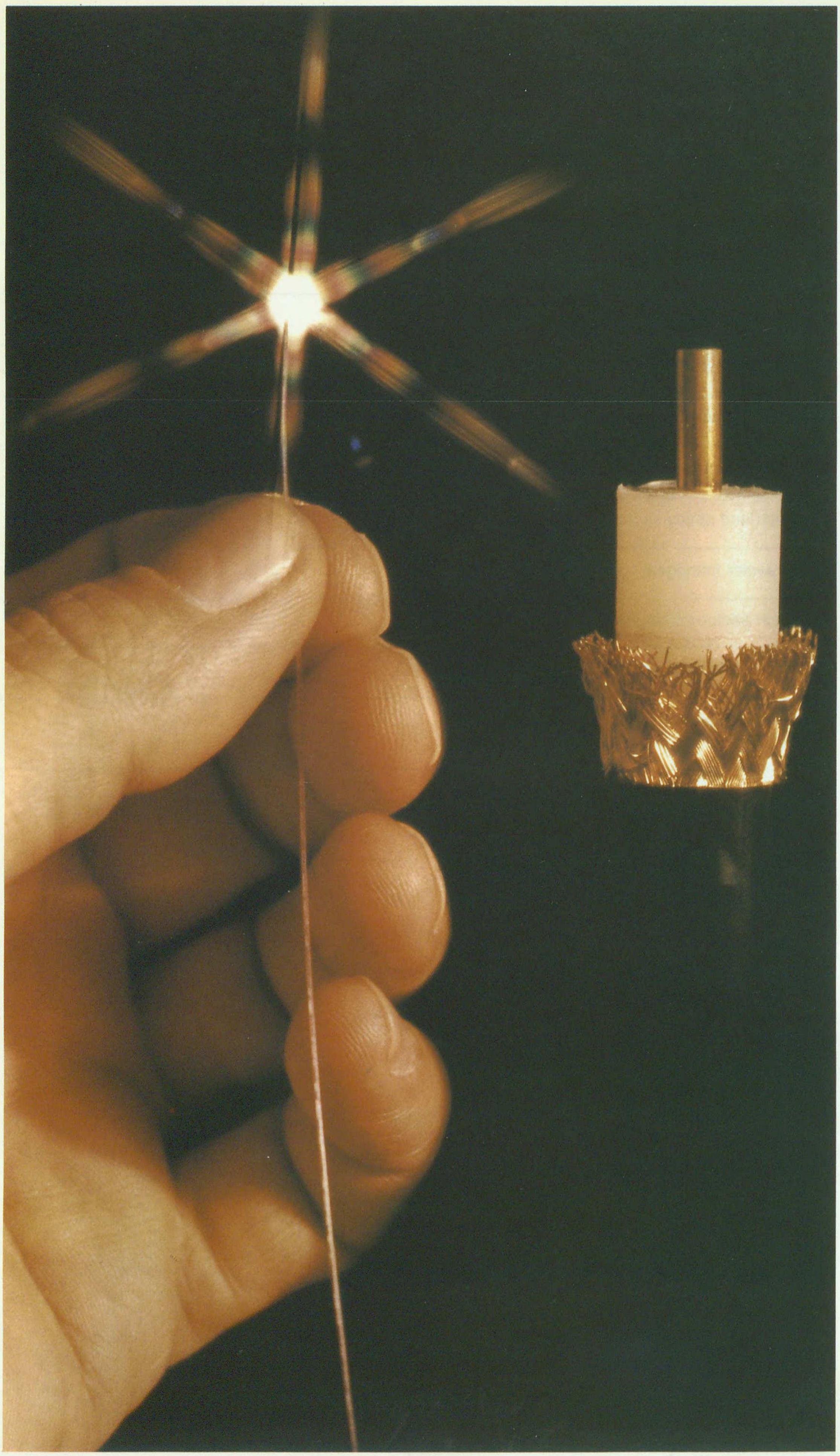
Contents



Hair-thin optical fibre waveguides provide many times the capacity of conventional coaxial cable.

Preface

Communications lie at the heart of new developments and sweeping changes in many industries.

The telecommunications industry has grown from virtually nothing at the turn of this century to a capital investment of $15 billion in 1977. Its growth rate is now about $2 billion a year and its revenues more than $3 billion a year. The industry employs more than 100,000 Canadians and has an annual payroll of $1 billion.

The telephone, broadcasting, cable distribution and mobile radio industries alone represent about four per cent of Canada's material wealth and a roughly similar proportion of her gross national product (GNP).

The federal Department of Communications (DOC) is charged with promoting the development and efficiency of communications in Canada, and with helping Canadian communication systems and facilities adjust to changing conditions. To help carry out this mandate, the department undertakes research in many aspects of communications.

Co-operation between government and industry helps Canadian industry maintain and improve its standing in a sector fundamental to our national social, economic and cultural health.

Technological research and development is also a vital part of the broader process of policy development within the department, since technological advances tend to have social, economic and institutional impact.

The aim of this review is to inform the general public, manufacturers, researchers and engineers about communications research performed by and through the department's Communications Research Centre, highlighting its industrial relevance and transferability. We hope this review will encourage contacts leading to more transfer of the department's research output to industry. Government, too, can benefit: public and industry feedback can help us set and adjust priorities. The ultimate purpose is to generate a useful dialogue between public and private sectors.

Many channels are available for this dialogue: readers may phone or write the managers and researchers listed in this publication - or they can go directly to responsible assistant deputy ministers, the deputy minister or the minister herself.

Transmission and delivery systems

by Dr. Martin Fournier
Director General, Technology and Systems Research and Development

More than 96 per cent of Canadian homes today have telephone, 97 per cent have television, and 98 per cent have radio service. Nearly 70 per cent subscribe to cable television. Satellite links give many northern Canadian communities access to national telecommunication networks.

Our technology has had to stretch and grow to allow us to send larger quantities of information reliably over long distances. We now have telecommunications systems capable of providing better, more reliable service, at lower cost. The most radical improvements have been in transmission and delivery systems technology.

In the first years of the telephone, when voice was transmitted over open wire lines, the search began for better and less costly means. Reliable, efficient high-frequency sources and amplifiers were developed, as were carrier systems using wire, multiconductor cable, coaxial cable and the radio spectrum. As higher portions of the spectrum were exploited, more information-carrying capacity became available at reasonable cost. Radio became increasingly attractive for both short- and long-distance communications. Its use spread, particularly as more reliable radio frequency sources and devices emerged to make long-haul wide-band communications more economic.

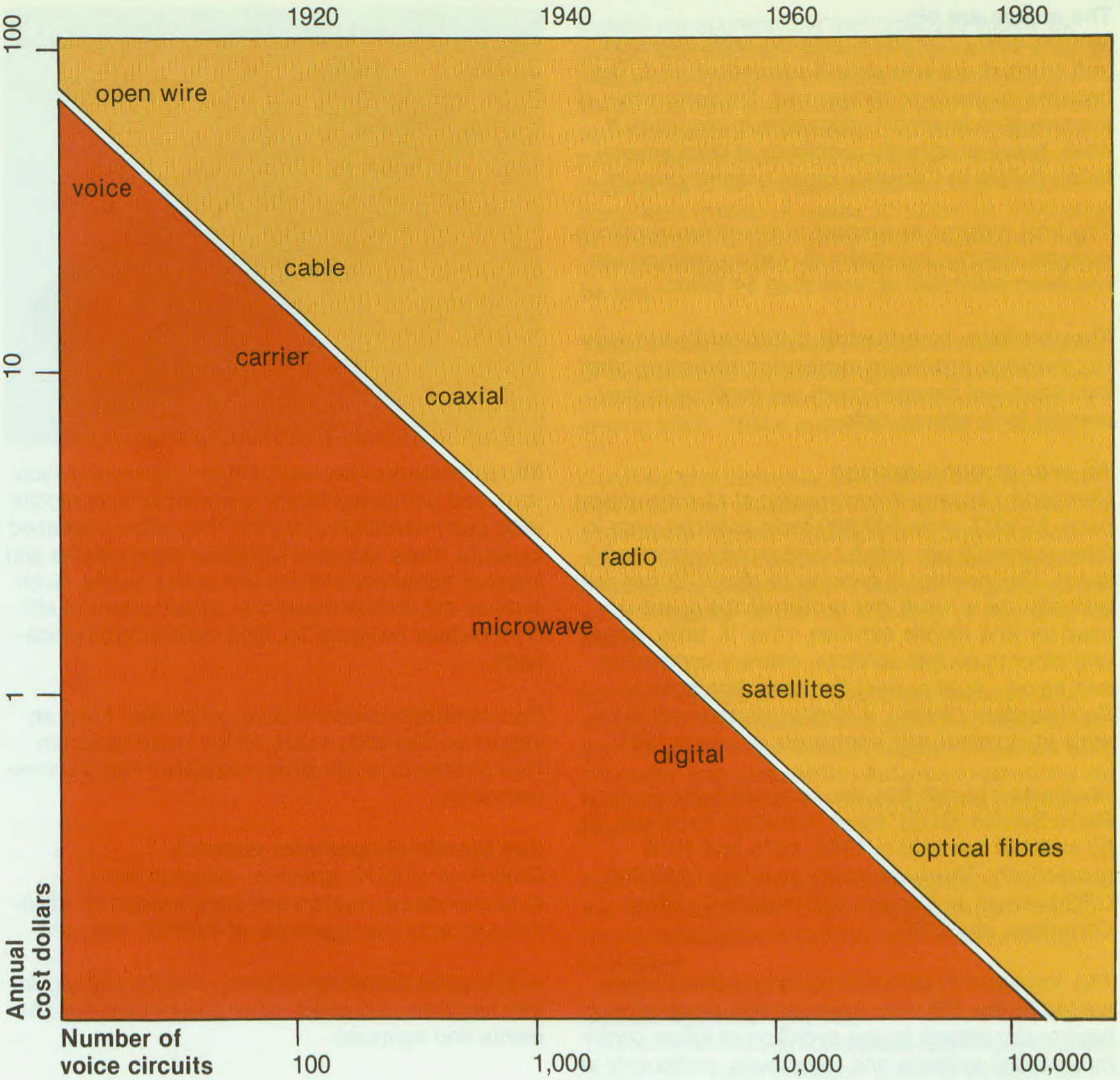
Development of space technology in the 1960s revealed new possibilities for long-distance telecommunications. Satellites came to be regarded as economically practicable repeater stations, and they proved a feasible means of providing reliable, low-cost communications across this vast country – especially for far northern communities. DOC continues to play an important role in assuring Canada's place in space communications.

A new frontier

Fibre-optics technology is the newest frontier in telecommunications transmission and delivery systems. Considerable progress has been made in reducing the cost of optical fibres, while increasing their information-carrying capacity. Fibre-optic systems have big advantages over conventional coaxial cable links, including wider bandwidths, smaller diameters, lower weight, lack of crosstalk, complete immunity to inductive interference, and ability to deliver many more signals at much lower cost.

Because of their potentially low costs and wider bandwidth, fibre-optic technologies are particularly well suited to digital techniques now in wide use. Plans are already afoot to implement operational systems in the early 1980s. DOC is actively trying to stimulate development of a strong Canadian fibre-optics industry.

Substitution of electrons for paper and ink in communications (based on revenue).



Spectrum management

Although fibre optics offer the promise of dramatically increased wide-band transmission at lower costs, radio communications will retain a major role in Canada for a long time. A variety of applications will continue to exist for radio transmission through the atmosphere, including broadcasting, land mobile communications, microwave relay systems and satellite communications.

The radio spectrum is a valuable natural resource. It is public property, to be administered in the public interest in accordance with international agreements to which Canada is a party. DOC is responsible for the administration and management of the spectrum.

This responsibility entails:

- licensing the use of specific frequencies by individual users, in such a manner that the spectrum is equitably shared and efficiently utilized;
- promulgating the rules and regulations under which licences are granted;
- enforcing these rules and regulations; and
- ensuring the harmonious introduction of new services.

To perform these functions effectively, the department must keep continually abreast of new developments in the field. This means having people on staff who are knowledgeable on all matters pertinent to the allocation of spectrum so the department can accommodate various national services within an international framework, and effectively represent the Canadian interest abroad in international negotiations.

In the dynamic and rapidly expanding field of communications, knowledge must be continually augmented and updated. The DOC research sector helps meet this continuing, ever-growing information need. Spectrum research is essential to DOC policy-making and spectrum management functions.

The stakes are big

Virtually every Canadian uses the radio spectrum and much of our economy is dependent on it. But because its use is so widespread, the dollar value of the spectrum is almost impossible to measure. It does, however, directly contribute at least several billion dollars to Canada's gross national product.

The total national investment in telecommunications systems directly dependent on radio spectrum use has been estimated at more than $4 billion.

Transportation, broadcasting, public safety and security, fisheries, petroleum exploration and many other industries and services could not continue in their present form without radio.

An ever-growing demand

Demand for spectrum is increasing at an accelerating pace. In 1977, over 500,000 radio licences were in force (some 50 per cent for land mobile communications). This number is growing by about 12 per cent annually. As a result, the portion of the spectrum used by land mobile services - that is, taxis, police and other municipal services, delivery companies and so on - is at or near the saturation point in Southwestern Ontario. A similar situation will likely arise in Montreal and Vancouver by about 1981.

Spectacular growth has also occurred in the General Radio Service (GRS)* band. Permits in force rose 30, 50 and 120 per cent in 1974, 1975 and 1976 respectively. There are today more than 800,000 GRS licences in Canada and close to 2 million Canadians use GRS.

The revolution in personal communications represented by the CB radio boom seems destined to have major impact on the evolution of future communications systems and techniques, particularly in areas such as the cordless telephone.

Recent advances in solid-state technology have already spurred evolution of new, more reliable telecommunications services. Large scale integration (LSI) techniques have resulted in enormous reductions in the size and weight of electronic components. These techniques have led to more sophisticated circuits with better performance and lower cost.

Cordless telephone

Microprocessors may well transform telecommunications and permit significant improvements in mobile radio communication systems. They afford increased capacity, make selective signalling more reliable and improve frequency stability and audio quality. Such devices will be fundamental in development of efficient cellular networks for land mobile communications.

Recent developments in fibre optics may have an impact on demands made on the radio spectrum. New strategies of spectrum regulation may become necessary.

Key thrusts of spectrum research

Objectives of DOC spectrum research are:

- to provide information and tools needed for effective spectrum management, at minimal cost; and

- to support departmental policy-making and regulatory functions and assist other government departments and agencies.

The program has three main areas: radio propagation research, radio environment studies, and systems studies.

The first focuses on the interaction between radio waves and the propagation medium, as well as the effect of this interaction on the performance of communications systems.

The second examines problems of radio noise and interference, attempting to characterize noise sources and assess their effects on communications systems.

The last touches all aspects of communications systems, including their technical, economic and social implications. The focus is on the economic and social value of the spectrum, alternatives to its use, demand analysis, future requirements and utilization strategies.

* Widely known as CB from the U.S. designation, Citizens' Band.

Optical communications systems

by Dr. Ken Hill
Manager, Optical Communication Applied Research

Optical communications technology is widely expected to precipitate big improvements in the capabilities of many kinds of telecommunications systems. This new technology may well transform our communications environment. Its introduction will have to be carefully planned. Equally important, projections of an annual optical communications equipment market of nearly $2 billion by 1990 offer an unparalleled opportunity for the Canadian telecommunications industry. This opportunity must not be lost.

Today's telecommunications systems use a variety of well established technologies - twisted-wire pair, coaxial cable and microwave radio being chief among them. These systems are well in place.

Carefully and intricately connected, they form networks carrying messages within and across national boundaries. Social, regulatory and powerful economic pressures have moulded Canadian telecommunications systems into a network which leads the world in quality, efficiency, and level of service to the public.

But this network is now reaching economic and physical limits: available and economic communication bandwidths are in short supply. There are also economic and geographic obstacles to providing the rural population with the same services as urban people.

New optical communications technology may break this impasse. There is growing excitement in the telecommunications industry over its impending introduction.

Optical systems very near

Telecommunications companies may begin installing optical-fibre communication systems as soon as the early 1980s. The first such systems are now being field-tested. Along with more advanced systems still at the conceptual stage, they will likely find application throughout the Canadian telecommunication system.

Use of this new technology, in everything from subscriber lines to high-capacity, long-range trunks, will enhance both network efficiency and ability to provide new services in an increasingly information-oriented society. It will also encourage secondary activity in the electronics industry.

Priority will be placed on development and manufacture of terminal devices which can take advantage of the additional information-carrying capacity of optical fibre. All sectors of the telecommunications industry are expected to feel the impact of fibre optics.

A revolutionary change
It is no small step to substitute light for electrical current and glass fibres for metal conductors in communication systems. Considerable developmental effort and massive retraining of personnel will be necessary - but the benefits will be commensurate. A gradual changeover will result in increasingly cost-effective national networks, with greater flexibility and capacity. These attributes will be essential in tomorrow's world.

New services will help bridge geographic distance and the social and cultural chasms in our society. Even improvements in a simple domestic telephone system increase the efficiency with which we use human resources, while enhancing our quality of life.

Introduction must be planned
A primary responsibility of DOC is to foster the orderly development of new communications systems and networks, including the well planned introduction of optical communications. The department, therefore, maintains a growing information base and a high level of competence in the technology of optical communications. Departmental efforts fall into two broad, mutually supportive categories:

- government support of projects by Canadian industry and universities, in areas related to optical communications; and
- in-house research and strategic planning for regulatory and policy-making purposes.

The department is actively planning or already carrying out several projects involving support to Canadian industry in this field. They are aimed at helping Canadian manufacturers gear up to meet huge domestic and foreign demand expected to emerge in the near future.

DOC's optical communications program undertakes major pilot projects involving the Canadian manufacturing and telecommunications industries. These projects are now in advanced system planning.

Original equipment manufacturers, in full partnership with user organizations and several federal and provincial government departments, will carry out these projects in both urban and rural settings. Their purpose will be to test the technology in harsh operating environments. Industry is already participating in several contracts for development of optical communications cable and devices. Some of these contracts involve direct transfer of technology from the department.

The Canadian public, Canadian manufacturers, operating companies, and users like the Department of National Defence must themselves be able to assess this technology, because of its potentially radical impact on their telecommunications systems and services. They must have access to an independent body of opinion on the state of this technology and the direction of its development. Forecasts of alternative applications in our telecommunications networks would also be useful.

These needs must be met now.

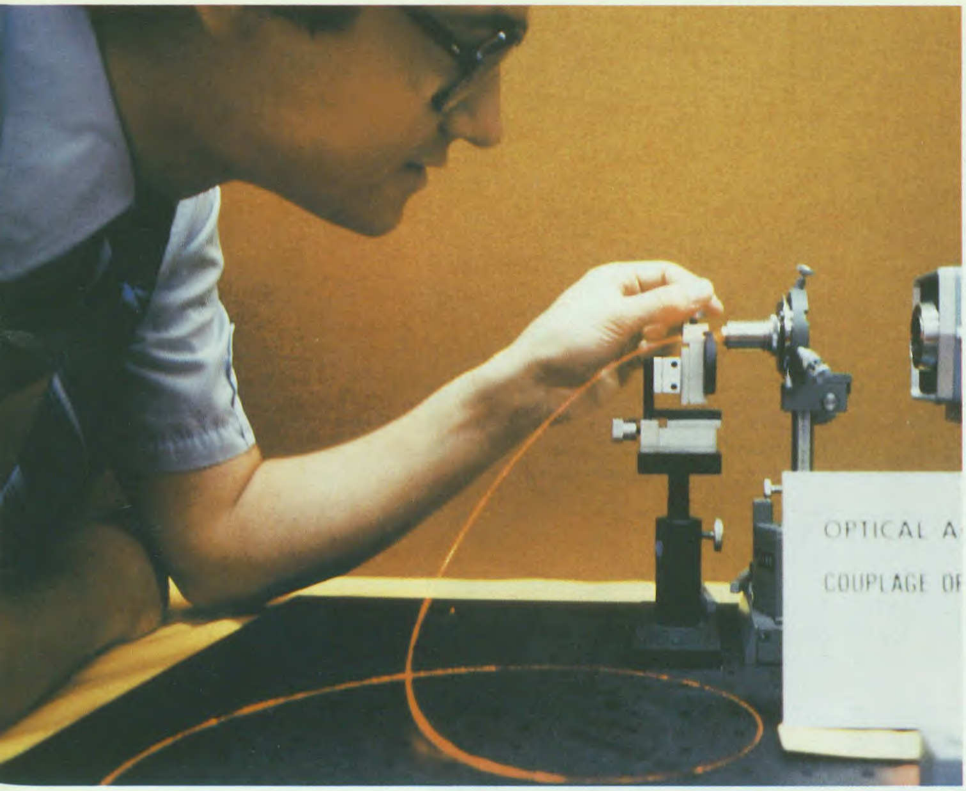
First-generation optical communications technology is rapidly evolving from a laboratory curiosity to the systems implementation stage.

Present choices, especially when they affect the existing infrastructure, limit future options open to the department in ensuring that the telecommunications system evolves in the public interest. Choices must be informed and impartial. The DOC optical communications program gathers and evaluates information in light of this imperative.

In-house research and strategic planning performed by the optical communications program provide the basis for advice to the department on technological trends and their implications for future network topologies. Partly to ensure that program personnel retain their expertise, the Communications Research Centre also conducts applied research. Its major goal is to make direct, original contributions to understanding this technology. Efforts involve fibre-optic devices and systems work. Results of this research are available to all Canadian companies, including those unable to support an in-house technology capability.

The program enjoyed notable succes in 1977. Staff published 16 scientific papers in international journals and delivered several presentations at international conferences. Invention notices were also submitted to Canadian Patents and Development Limited (CPDL).

Optic fibre coupler



Publications discussed both device and systems elements; they have been well received by the technical community. Subjects include:

- use of isotopic glasses for waveguide fabrication;
- non-linear effects in fibre waveguides;
- degradation mechanisms in semiconductor laser sources;
- modulation formats, including analog intensity modulation, pulse position modulation, pulse code modulation and pulsed FM;
- wavelength-division multiplexing;
- optical access couplers, power combiners and duplex links;
- photo-sensitivity phenomena in optical-fibre waveguides and applications;
- systems technology for lightwave communications by pulse code modulation at a data rate above one Gigabit per second; and
- conceptual design and projections of the cost of centrally and remotely switched television distribution systems.

Some of these topics merit special mention. Work on the centrally switched fibre-optic broadband distribution system was particularly novel and timely, being the first in open literature to document fully the advantages of using a distributed-switching network topology in conjunction with fibre optics. Cost projections agree in essence with those independently formulated by major private sector organizations.

Program staff were first to discover an important photosensitivity phenomenon in certain types of optical-fibre waveguides, which may be useful in fabrication of high-resolution optical waveguide filters and in controlling laser source wavelength. These are important considerations in high-capacity wavelength-division multiplexed systems. Equally imperative is the need to know whether such photosensitivity will cause degradation in characteristics of an optical-fibre waveguide in use for a long period.

DOC optical access-coupler technology is also meeting the rigid requirements of industry. DOC staff, in an extension of that technology, demonstrated a power-combiner action useful for joining signals derived from several sources for point-to-point transmission through a single fibre waveguide. Such a device would reduce the fibre needed to meet telecommunications traffic demands. The access-coupler technology allowed the first demonstration of a fully bidirectional fibre-optic link - a significant advance in lowering network implementation costs.

Summary

Introduction of fibre optics (one form of electro-optical technology), expected to begin in the early 1980s, will likely have major impact on the evolution of our national telecommunications networks. DOC, responsible for fostering new communications systems, is helping Canadian industrial concerns and users to maximize the resulting benefits. This support takes three forms:

1 contracting out substantial quantities of development work to industry;

2 advancing the state of the art, through applied research; and

3 supporting major pilot projects to determine the capabilities and limitations of a technology that may be the most important development in telecommunications since the transistor.

Market opportunities in electro-optical systems

Electro-optical systems are hybrid twinnings of electronic and optical components to perform a desired function. Optical-fibre communication systems fall into this category. From the user's viewpoint, these systems, in comparison with viable alternatives, become attractive only if they can provide competitive performance at a lower price or improved performance at a competitive price. But comparison of an electro-optical system to available conventional systems is not straightforward.

Impact area / Contracts	Program Definition Study	BNR System Study	ADL Study	CCS-280 Project	RCA Detector	University of Manitoba	McMaster University	CRC/CWC Coupler	BNR NRC/IRAP	CWC DITC/DIP	MPB Technologies	RCA DITC/DIP	
DOC/CRC Data Base	H	H	H	—	L	L	L	—	L	M	L	—	12%
New Technology Development	—	L	L	M	H	M	M	H	H	H	H	H	26%
Canadian Industry	H	H	—	H	H	M	L	H	H	H	H	H	30%
Communications Policy	M	H	M	—	—	—	—	L	L	L	L	—	8%
DND	—	—	M	H	M	—	H	H	M	H	M	H	24%
Value ($1000)	200	333	33.5	186	143.3	30	74	156	557	1500	160	800	4172.8

Impact is judged to be high (H), medium (M), low (L) or non-existent (-) to estimate the impact of the various contracts on the five impact areas.

Requirements are generally stated in terms of experience gained in repeated past use of conventional systems approaches. When faced with an essentially radical departure, business analysts must be very careful to examine the end use of the electro-optical system. Only then can they forecast the benefits possible through use of electro-optical technology. Many valid applications of electro-optical systems will hinge on "additional benefits" - more specifically, on improved performance.

When searching out electro-optical business opportunities, analysts must also be familiar with performance characteristics and costs of devices and subassemblies required for any given system configuration. They must fully grasp the changing constraints imposed on systems design by evolving technology. They must completely understand the beneficial attributes of such systems design.

Recent market analyses have identified major business opportunities for manufacturers of electro-optical systems. Projections indicate these markets will develop and expand with increasing speed over the next decade and continue strong growth thereafter.

The transmission equipment market will be most dramatically affected. This market comprises devices and systems which transmit and receive information in various forms; it is a major segment of the total communications and data-processing equipment market. Electro-optical transmission equipment could penetrate up to 12 per cent of the market by 1985 and be worth about $670 million in sales within industrial countries.

Market estimates for 1990 predict an increase to $1.7 billion. But these estimates only describe markets in developed countries where telecommunication services are already good and where electro-optic technology will be gradually introduced into national networks and data processing facilities. The worldwide market may well be significantly larger. Developing countries, anxious to use their human resources and to encourage and attract foreign investment, will try mightily to upgrade their communication networks. They will look, in particular, for high ratios of performance to cost when purchasing telecommunications equipment. They may well choose to leapfrog outdated technologies and turn to electro-optical solutions. (A significant correlation exists between foreign investment in any given country and the grade of service provided by its telecommunications network.)

Prospects for electro-optics systems in the transmission equipment market during and beyond the next decade look excellent. Optical systems appear likely to displace conventional equipment in six broad areas of the transmission equipment market: telephone, cable television, satellite ground terminal, industrial automation, computer and military transmission systems. In the near term, it can be stated with confidence that one of these will emerge to offer the biggest market prospects for electro-optical systems. Large-volume sectors of the market will generally be served by high-technology intensive companies that quickly develop the capability to deliver and market electro-optic systems with high ratios of performance to cost. Opportunities for smaller enterprises will likely arise later in the custom-system, low-volume market. This specialty market will appear as larger enterprises, concentrating on high-volume products, become more selective in the systems they choose to manufacture.

A competitive new market

The market for electro-optical transmission systems is international. Canadian companies preparing to serve this market can expect strong competition at home and abroad. Business thrusts into a growing high technology market like electro-optics must follow one precept: to reach the product development stage as far in advance of the competition as possible - and to stay ahead.

Through contracts, the federal government is investing significant funds in the private sector to ensure that Canadian suppliers of electro-optical transmission equipment achieve as large a competitive edge as possible. Details of these contracts are available from the department.

Satellite communications and related applications

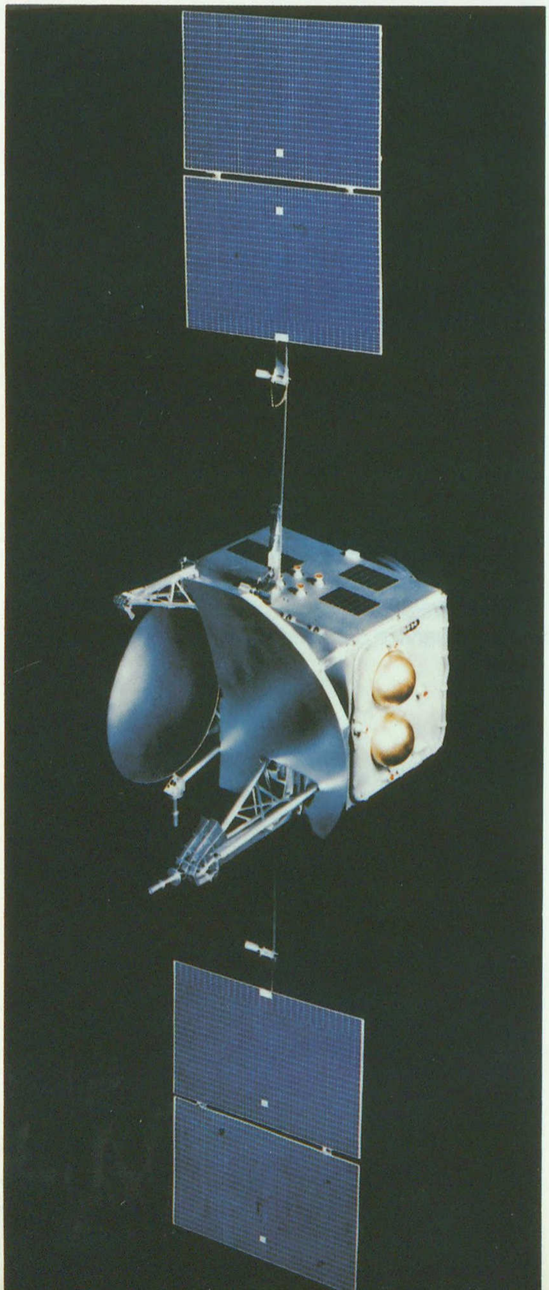
by T.A. Eastland
Consultant, Space Programs Management

Background
Communications satellites were first developed almost two decades ago. Since then satellites have been used to augment terrestrial communications systems and have had an increasingly favorable impact on the quality and cost of global telecommunications.

During the last 10 years, operational commercial communications satellites have become cost-effective substitutes for existing terrestrial systems. There are now about 70 operational or pre-operational communications satellites in orbit; their estimated total capacity is equivalent to about one million telephone circuits.

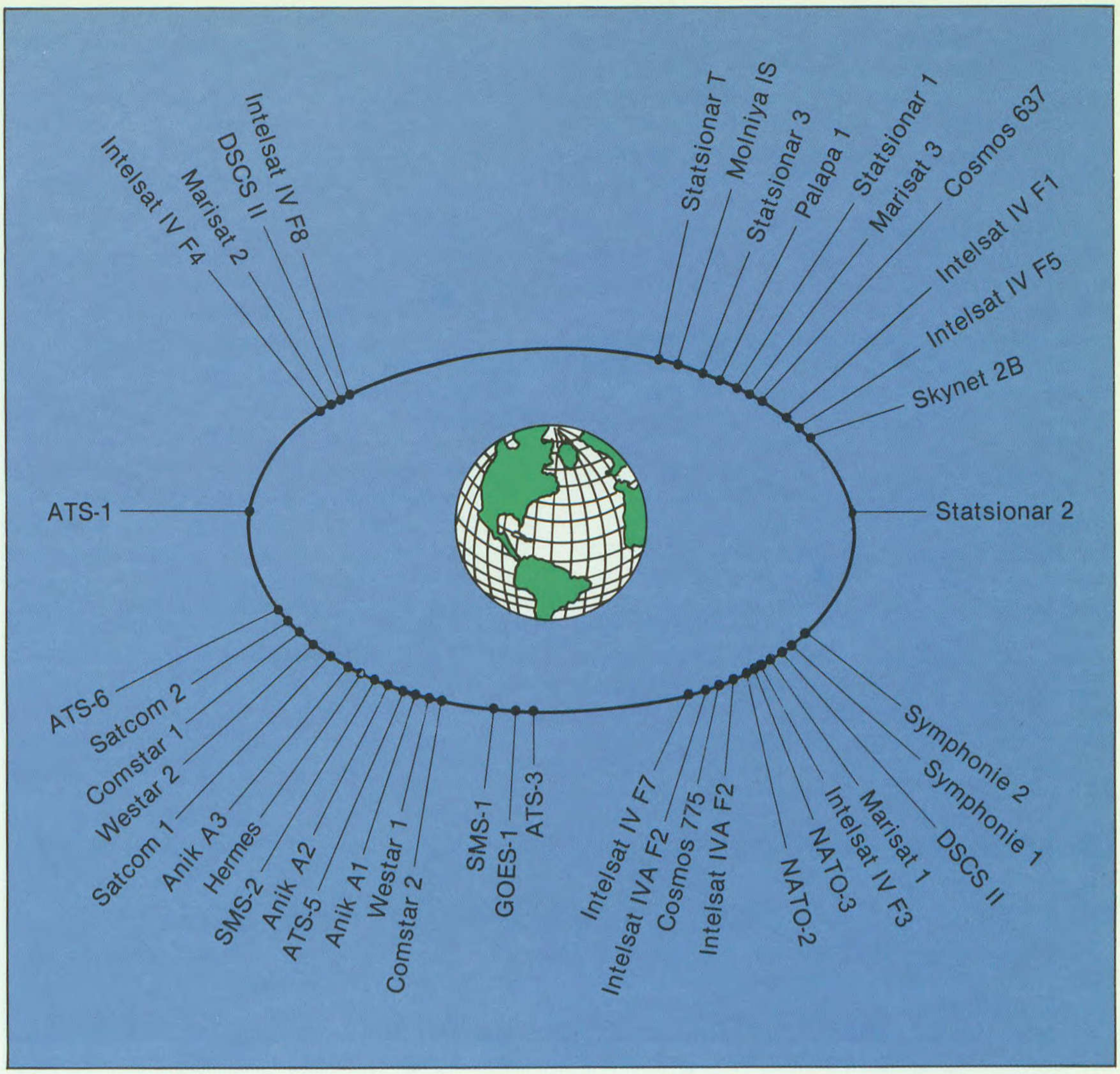
With a harsh climate and scattered population centres, Canada is reaping particularly useful benefits from space-aided communications. In the mid-1960s, a government-industry task force recommended the kind of space communications system it thought could best serve Canadian needs. After a government White Paper on the subject, Parliament created Telesat Canada in 1969.

This unique public-private corporation was given the mandate to own and operate Canada's commercial satellite communications. Three years after its birth, it



Artist's conception Anik B

Operational geostationary satellites as of 1978

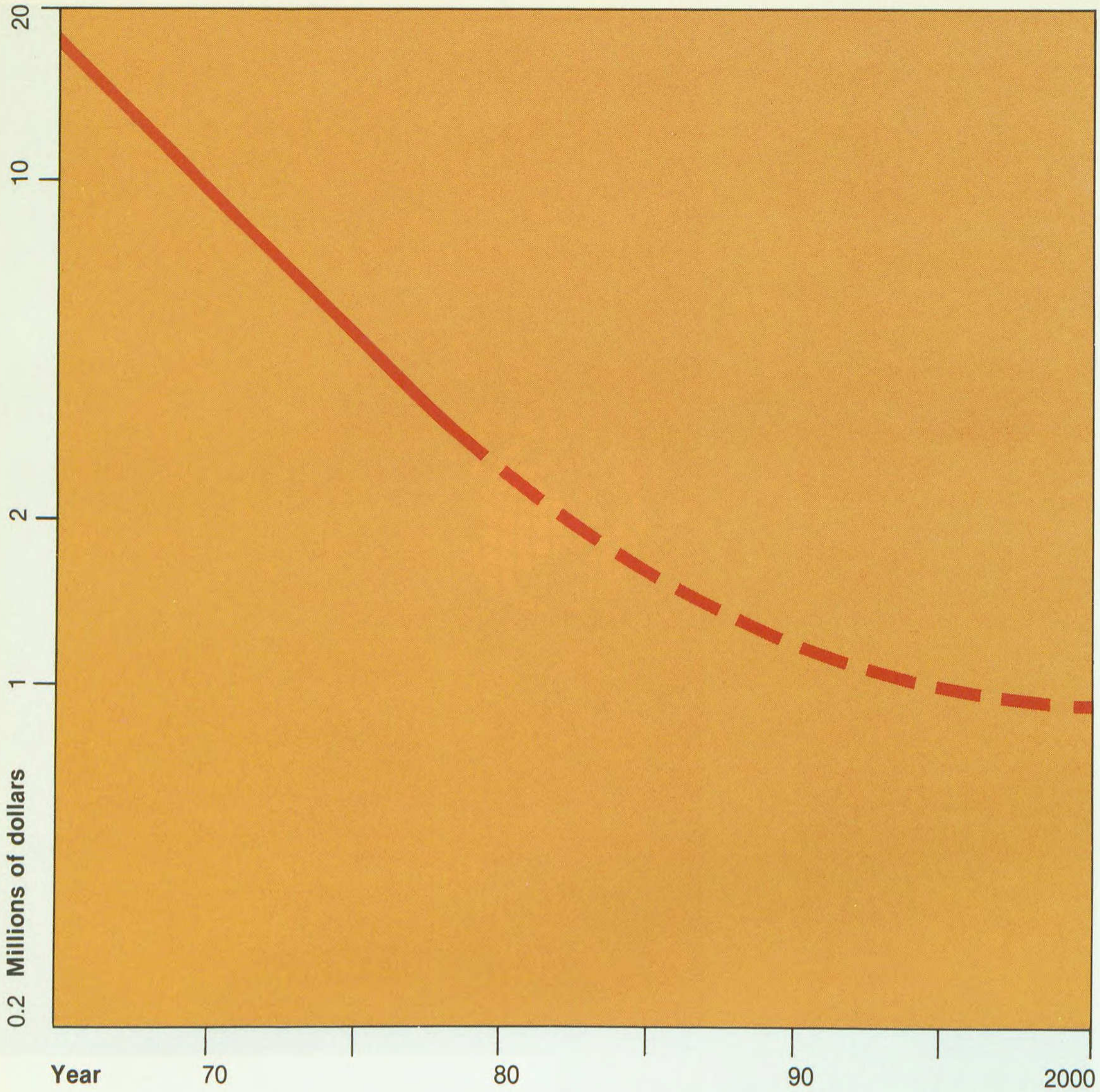


Artist's conception of Anik A

established the world's first domestic geosynchronous communications satellite system. Launches of Telesat Anik A series spacecraft gave Canadians a complete point-to-point system in the 6/4 GHz range.

The Anik satellites will continue to play an important role in Canada's communications services, with the planned launches of Anik B in 1978 and the first of three Anik C spacecraft in 1981. These satellites will carry transponders operating at 14/12 GHz - powerful enough to be used with modest-sized earth stations in a downtown-to-downtown configuration. They will be ideally suited for heavy-route digital and telephone traffic and for transmitting television programs direct into community distribution systems.

Recent experiments using Canada's advanced Hermes satellite and more intensive pilot projects planned for the Anik B spacecraft have been designed to demonstrate the efficacy of 14/12 GHz service in meeting Canadian needs.



Leasing cost per wide-band transponder channel

The role of the department

The objective of DOC is to foster the orderly development and operation of communications for Canada in both the domestic and international spheres. The department's mandate includes responsibility for ensuring optimum use of space technology to meet Canadian telecommunications needs.

DOC seeks development of a viable industrial base and has responsibility for transferring space technology to Canadian industry and helping maximize participation of that industry in fast growing domestic and foreign space markets.

The department works with other government departments to ensure maximum industrial participation in space activities, consistent with industry capabilities and desires. There are, for example, ongoing efforts to foster a spacecraft prime contractor capability in Canada and a program is underway to expand DOC's David Florida Laboratory to include facilities for integrating and testing complete, large satellites. In addition, negotiations with Telesat Canada helped provide Canadian industry with the highest practical level of subcontract business for construction of the Anik C series.

Another method of insuring participation by Canadian industry is the application of the government's "make-or-buy" policy. This contracting-out principle is applied to the widest degree possible in DOC programs. Industrial contracts totalled over 65 per cent of the 1977/78 DOC space program budget. The corresponding figure for 1978/79 is 85 per cent, amounting to some $33 million.

DOC also administers an industrial contract program, begun in 1976, to encourage industry to develop components and subsystems expected to be required for future Canadian satellite programs. Industry participation during the first two years of the program has been highly successful. More than $700,000 was contracted to Canadian firms during 1977/78, with program funds budgeted at $2 million for 1978/79.

While DOC has contributed directly to a continuing program throughout the federal government to support Canada's industrial base (particularly in high-risk areas of advanced research), it has also provided various departments with expert advice in the evaluation of ongoing industrial assistance programs in the aerospace field.

A look at the future

Developments during the next decade in use of satellites for communications and related purposes promise to be dramatic. New applications are made possible by advances in technology and, conversely, advancing technology is being fuelled by demand inherent in new applications.

Some specific advantages of satellite communications which will continue to lead to both more widespread and new applications are listed below.

- System indifference to geography and distance which, in terrestrial systems, introduce both additional cost and noise. Satellite communications easily reach remote and mountainous regions where reliable communications have been either non-existent or prohibitively expensive.

- The plummeting cost of the new technology. In 1975, the price of a trans-Atlantic telephone call had been reduced to about one third of the cost prior to introduction of the Intelsat system. A recent U.S. study shows the cost of leasing a wide-band transponder channel will decrease by another two-thirds during the next 20 years.

- The unique efficiency of satellites for certain advanced communications applications. Satellites are more efficient than alternative terrestrial systems for point-to-multipoint services, and even more so for direct broadcasting. For mobile services requiring wide-band links, no alternative seems feasible.

- The greater information-carrying capacity, the greater flexibility inherent in the higher bandwidth and the lower noise in satellite systems.

All these advantages are, of course, particularly outstanding in the Canadian geographic and demographic context.

New applications

Fields covered in developing applications of satellite communications include:

1 Electronic mail

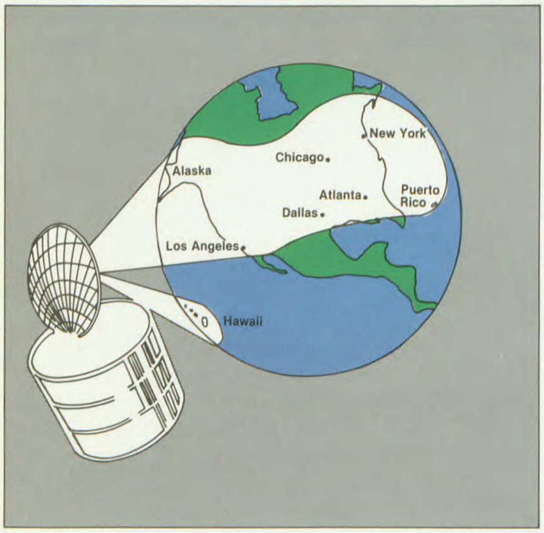
Substitution of electronic communications for type-written and other "pen-and-ink" type messages continues at an accelerating rate. Estimates say 70 per cent of all messages sent in North America will be "electronic" by the year 2000. Telemail is already well envisioned by both U.S. and Canadian postal planners. The U.S. has conducted telemail experiments via Hermes, and Canadian authorities are planning a pilot project employing Telesat's Anik B satellite.

2 New business systems

Financial institutions, stock exchanges and computer bureaus will all be sending huge amounts of data through far-flung networks via satellite. Other industrial applications foreseen include pipeline control, and remote monitoring of field stations and sensors.

3 Broadcasting

CBC use of Telesat satellites for both radio and TV program distribution and production is well established. In the U.S., the Public Broadcasting System (PBS) is switching its nation-wide network from terrestrial systems to a domestic satellite which will feed 160 individual earth terminals sited at member stations. Canadian cable TV operators are interested in similar distribution (particularly for pay TV) and a trend to "community station" distribution by Anik C type satellites can be easily foreseen. Some forecasts predict Canada may some day have direct-to-home broadcasting via satellite, providing television to any household that wants it, almost anywhere in the country.



The PBS footprint

4 Medical, educational and social services

Several promising new applications of satellite communications in such fields as medical services, education and community interaction have recently been demonstrated by Hermes and some will be further refined through Anik B pilot projects. The viability and rapid acceptance of satellites in these fields has been proven.

5 Musat

New mobile service requirements for ships and aircraft have spurred interest in a multi-purpose UHF satellite communications system for Canada.

6 Other applications

Sarsat experiment

Communications-related applications of satellites include those envisaged for the proposed search and rescue satellite program, SARSAT, a Canada/U.S./France project that would use Canadian-built transponders on U.S. polar-orbiting satellites to pinpoint locations of emergency locator transmitters (ELTs). An operational system could find crash sites with accuracy and speed vastly better than that possible with conventional air search and rescue methods.

A surveillance satellite program, SURSAT, is also in the planning stages. Uses would include resource-cataloguing, border mapping, crop and environmental studies.

Yet another application, under study by DOC and the defence department, involves participation in a joint program with the United States Air Force for development of a global positioning system for aircraft navigation.

Technology trends

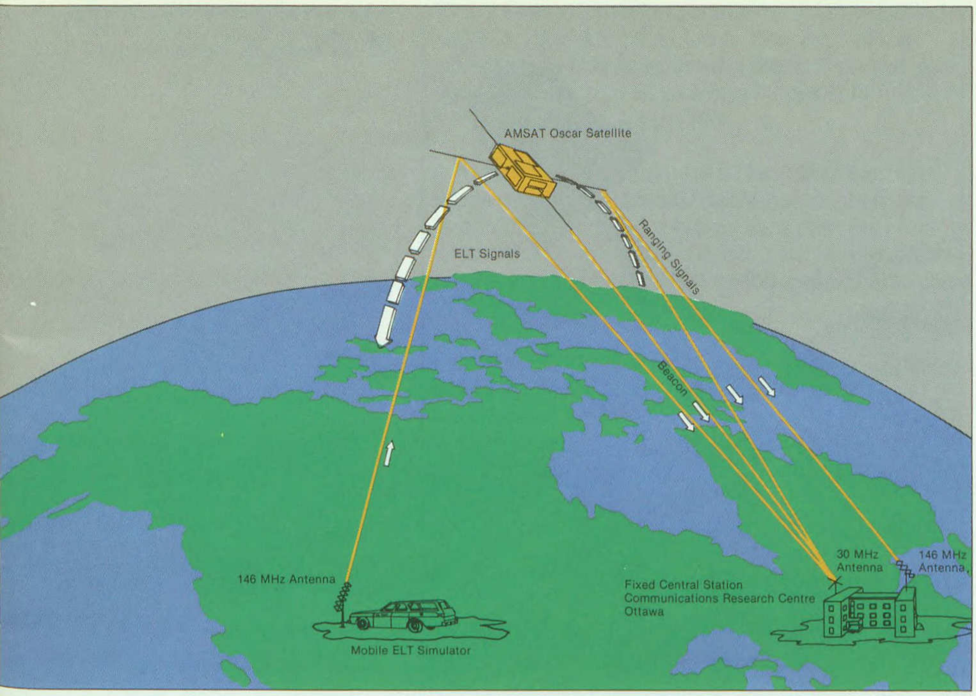
Technology developments have accelerated the general shift towards increased use of satellites for communications and other applications. Advances in both systems and earth terminal technology will affect Canadian industry.

Satellite systems

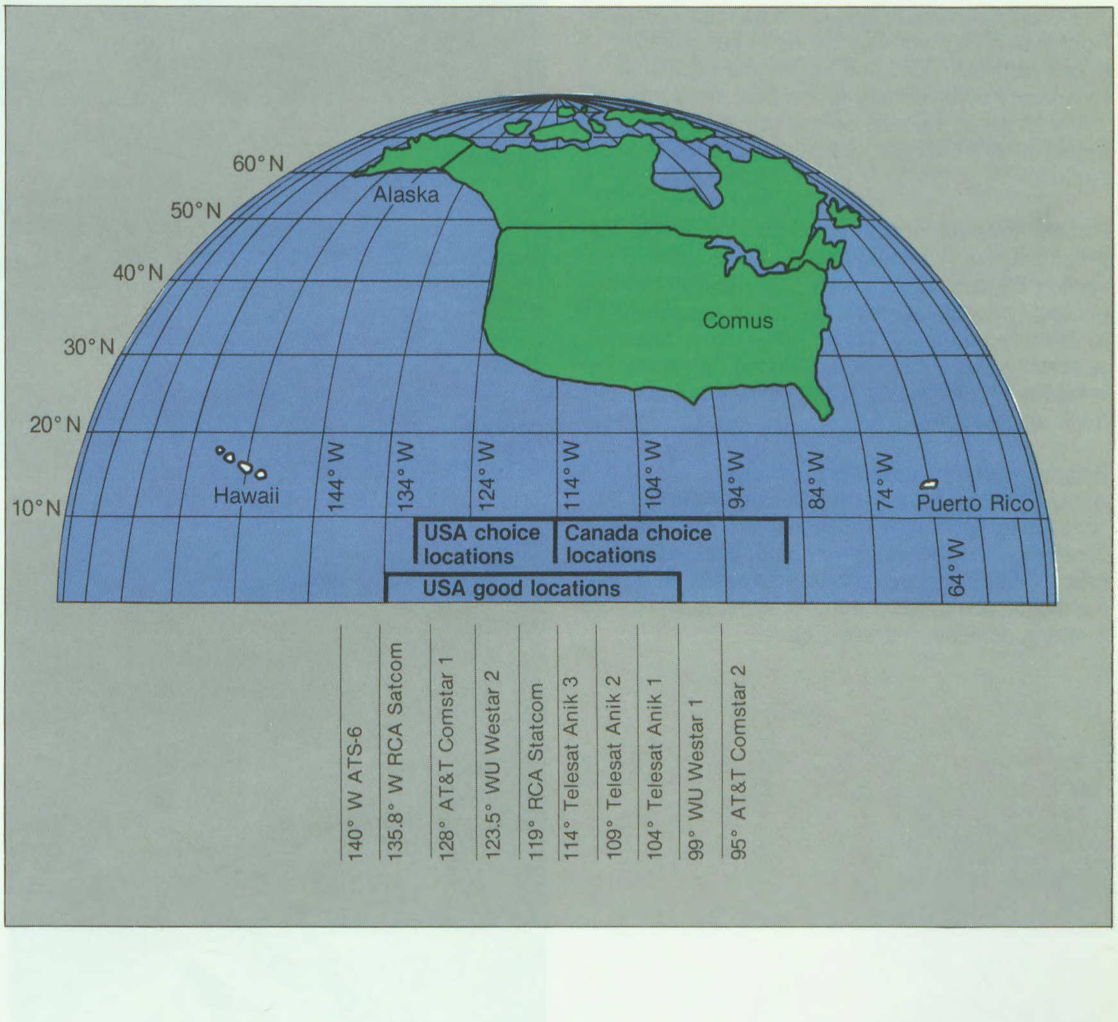
Of particular importance to the growth in satellite applications is the marked increase in the capacity of the spacecraft itself.

Since NASA's first geosynchronous satellite launch two decades ago, some 70 such satellites have been inserted into synchronous orbit. Sixteen of them are parked along the North American orbital arc. Even with 4 degrees of longitudinal separation between them, these spacecraft have almost exhausted the ability of the near-saturated 6/4 GHz band to meet U.S. and Canadian needs in commercial space communications.

New services and expanded capacity in this high-demand arc segment will be provided through use of higher frequencies, such as the 14/12 GHz band (pioneered by the Canada/U.S. Hermes program).



Geostationary communications satellites over North America



Other measures will include:

- frequency re-use, a cross-polarization technique developed by Canada's Spar Technology Ltd. to inexpensively double channel capacity within the same bandwidth;
- use of tightly-focused spot beams (perhaps in a scanning mode, employing TDMA techniques); and
- development of satellites with more power, improved stability and greater accuracy in antenna pointing.

All such developments will tend to lower system costs and broaden potential markets.

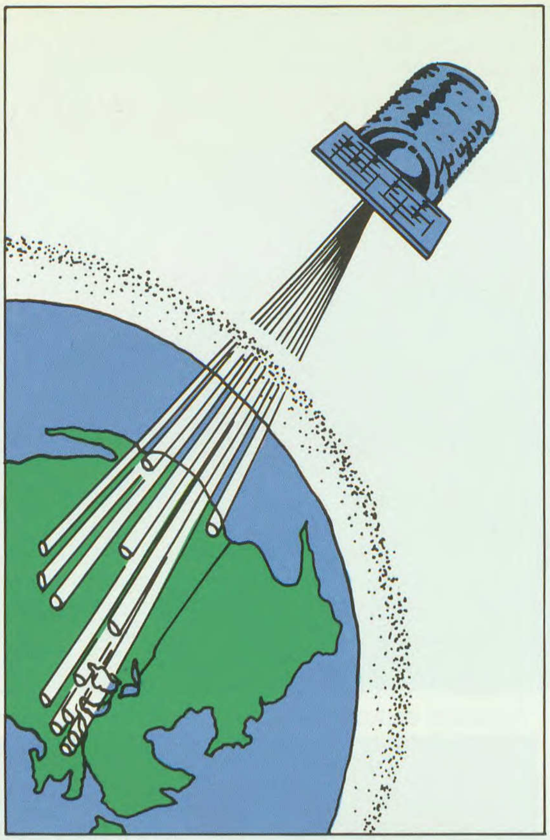
Ground segment
Small, portable earth terminals are a dynamic new development. Of Telesat Canada's existing 75 to 100 earth stations, the smallest is a 3 m model, costing about $20,000.

But there is an emerging demand for multi-point receiving stations as small as 1 m, costing under $1,000. This demand will be partly met through dramatic performance improvements in inexpensive low-noise receiver front ends.

The Gallium Arsenide field effect transistor amplifier, flight-tested on Hermes, has led to co-operative efforts between DOC and industry to exploit the technology commercially in low-cost earth stations. The efficacy of the new device coincides with a reduction in production costs through improved techniques.

Recent developments in peripheral equipment for ground stations - wide-band modulators, digital converters, demand access units and time division multiplexing systems, for example - are of special interest to Canadian industry. These advances in channel accessing and utilization techniques guarantee new reliability and efficiency in both thin- and thick-route traffic applications.

Space industry market projections
About the time Telesat Canada was awarding the contract for its Anik A spacecraft to a U.S. prime contractor, the federal government decided to re-orient Canada's space program towards development of an advanced communications capability with a strong domestic industrial base.



Artist's conception of the scanning spotbeam concept

This objective is still being pursued. It was Canadian industry which developed and built the advanced Hermes communications satellite, and which has received the nod as a major supplier for Telesat Anik B and C spacecraft. Indeed, it is DOC's aim to continue to develop a capability in Canada to build, as a prime contractor as well as major supplier, future Telesat satellite systems, including both ground terminals and peripherals.

The capabilities of today's Canadian space industry in a burgeoning world market, which some say will exceed half a billion dollars in annual sales by 1980, create important export opportunities for this country.

A 1975 report saw 1980 markets like this:

Type of system	*$ millions*
Satellite systems	235
Earth terminals	330
Peripherals	80

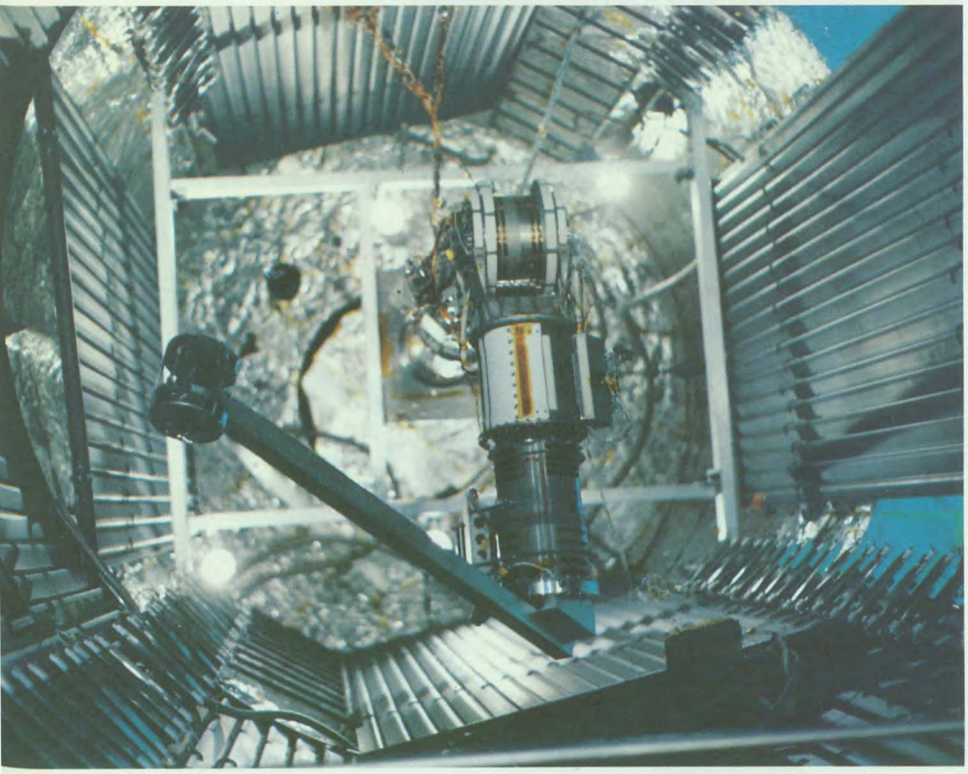
With a mere five per cent of this world market, Canadian industry could gain annual sales of $30 million.

World sales of small earth terminals in the period 1976 to 1986 are expected to total $1.1 billion, working upwards from around $30 million two years ago, to increase at an average 20 per cent a year to $150 million a year by 1986.

A recent unofficial analysis of the Canadian aerospace scene indicated possible space segment needs of around $50 million a year over the next 10 years. During the same period, earth station business (currently around $10 million a year) could grow to $16 million.

Export potential was an average $15 million for space segment business and $7 million for ground terminals.

Remote Manipulator System being tested in vacuum chamber at the Communications Research Centre



Peripheral equipment sales (expected to reach about $50 million by 1986) and a potentially enormous market for low-cost, portable earth stations would be additional.

Canada currently has a cumulative foreign trade deficit in the space industry of $60 to $75 million. Aggressive pursuit of a viable industrial base could turn this deficit into a surplus, contributing vitally to Canada's economic strength. In addition, it has been estimated that, for every job in a high-technology industry like aerospace, from three to seven jobs exist in support industries.

In the U.S., experience has amply demonstrated the spinoff benefits that a successful aerospace industry can offer other industrial sectors.

Federal support for space industries

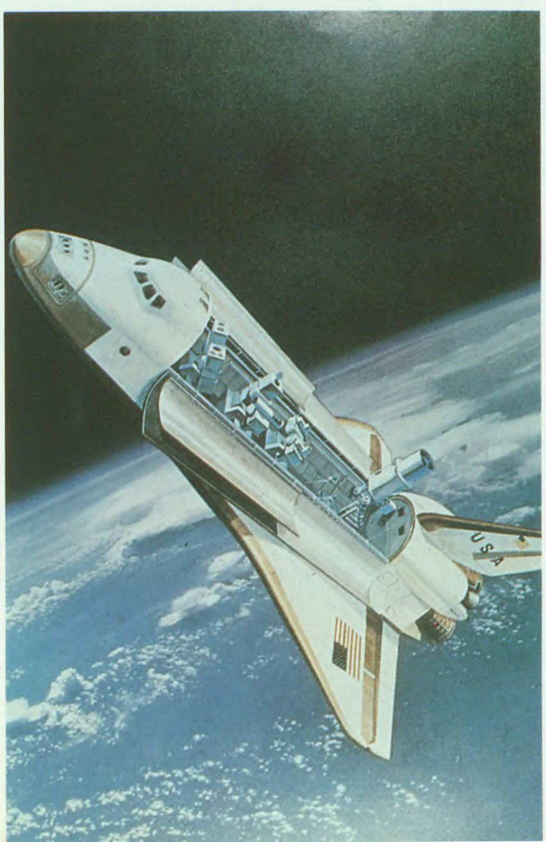
The federal government is committed to doing all in its power to foster development of a strong domestic space industry.

Canadian suppliers for DOC's $60 million Hermes (communications technology satellite) program have become much better qualified to participate in new programs, such as the U.S. space shuttle.

Spar Aerospace Products Ltd. of Toronto is supplying the remote manipulator system (RMS) for the shuttle orbiter, while Spar Technology Ltd. (formerly RCA) has supplied the transponder and antenna systems for both Canada's Anik B satellite and NASA's tracking data relay satellite system.

Canadian content in the Anik C procurement program will be about 32 per cent, running to some $22 million (including $5 million in guaranteed offset contracts).

Artist's conception of the U.S. Space Shuttle Orbiter



Successes like these reinforce Canada as a major world user and potential supplier of communications satellite systems, know-how and hardware.

Current government programs that will aid application of domestic technology and industrial development include:

1 *Musat, the multi-purpose UHF satellite system,* which would provide a variety of mobile telecommunications services to remote areas of Canada. In the planning for several years, Musat would supply high-quality, 24-hour-a-day service to such users as the defence department, the coast guard and the environment department, in applications involving portable manpack stations, remote data platforms and voice, data and facsimile services for potentially hundreds of ships, aircraft and other mobile stations. The system proposed would use a UHF-SHF transponder aboard a three-axis stabilized satellite (with a second spacecraft as back-up). With development and testing of a technically feasible transponder, earth terminal channel unit and various systems studies all but complete, the program is expected to enter the project definition phase later this year.

2 *SARSAT, the search-and-rescue satellite project.* The defence department, with DOC technical support, is examining possible use of a satellite-aided search and rescue system. SARSAT would be a joint Canada/U.S./France project to provide early, highly-accurate position data, derived from sophisticated computer processing of emergency locator transmitter (ELT) signals, received by polar-orbiting satellites.

Major impetus for the current project came with successful proof-of-concept demonstrations two years ago, during which the Communications Research Centre achieved accuracies as good as 2.5 km, using simulated "crash" signals and the Radio Amateur Satellite Corporation (AMSAT) Oscar-6 satellite.

The system will feature Canadian-built transponders aboard U.S. satellites. Current activity includes systems definition work, development of a signal processor and curve-fitting algorithms for ground-based position detection, a look at a possible scanning receiver to process signals from more than one source at the same time and negotiations towards a Memorandum of Understanding.

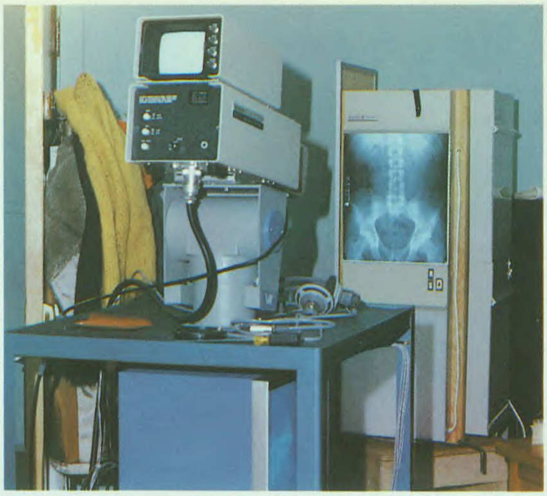
The Canadian electronics industry would benefit from the system through expenditures on space-borne repeaters and ground stations required to implement the system in Canada.

3 *Hermes,* the world's most powerful communications satellite. Hermes was developed in a Canada/NASA program to demonstrate feasibility of a high-powered 14/12 GHz transponder working with small earth terminals. During the last three years, some 30 Canadian groups - in fields as diverse as telemedicine, tele-education, community interaction, provision of government services in remote areas and broadcasting - have successfully demonstrated possible new services with this precursor of Anik C and similar operational 14/12 GHz satellites. The U.S. has had equal time on the satellite for social and technical experiments.

4 *Anik B communications program.* DOC's Anik B pilot projects program will refine exploratory work begun with Hermes to develop new operational telecommunications services. It will involve 14 carefully selected pilot projects to test new communications satellite services under near-normal operating conditions. Several "user-oriented" projects are planned in such areas as telehealth, television distribution, tele-education and community communications. Other technical experiments will investigate or assess technical questions in remote sensing, data communications and propagation measurement.

Emergency Locator Transmitters

A large hospital in London, Ontario, receives X-rays relayed by the Hermes satellite from a small northern community hospital in Moose Factory, Ontario.



Portable earth station receives signals from Hermes at Moose Factory Hospital.

International co-operation
DOC is responsible for promotion and protection of Canadian telecommunications interests on the international scene. The departmental space program participates in several multi-national satellite communications projects, such as INMARSAT (International Maritime Satellite Organization) whose purpose is to deploy and operate satellites intended to improve maritime communications.

Relations with Europe
DOC is negotiating possible Canadian participation in a variety of European Space Agency (ESA) programs. Such co-operation with Europe would benefit Canadian industry, because procurement contracts placed by the agency in Canada would be proportional to this country's contribution. And a long-range objective of Canada/ESA negotiations is establishment of industrial links to permit reciprocal arrangements for supply of components and subsystems.

The ESA telecommunications program includes plans for an operational 14/12 GHz satellite system (OTS/ECS), a maritime satellite program (Marecs), a direct-broadcast program (Heavy Communications Platform - H-Sat, for short), an advanced systems and technology program (ASTP) and an aeronautical satellite program. During 1977, a detailed proposal was developed for Canadian industry to build a complete transponder and antennas for a high powered 12 GHz satellite. Conditions of a possible Canada/ESA agreement are still under discussion.

Industrial technology development
DOC has several projects under its "make-or-buy" policy and industrial contract fund program of special interest to Canadian industry. These include:

- an earth terminal technology development effort, aimed at stimulating technological advances and assuring highest possible levels of Canadian industrial participation;
- studies of digital communications systems for both low- and high-rate applications in advanced satellite systems;
- an SHF space technology development effort, to help Canada maintain its competitive position in 14/12 GHz satellite components and subsystems;
- definition of future requirements for devices and components for high-speed digital communications via satellite;
- work on spread spectrum modems, to improve reception of signals under poor signal-to-noise ratio conditions;
- a project to evaluate the feasibility of application of advanced devices in such circuitry components as band pass, programmable and coded filters, discriminators, demodulators and stable oscillators;
- provision of support to the military in advanced communication satellite studies;

- assessment of the technical and economic feasibility of unattended data retransmission platforms (DRPs) to transmit sensor-collected data through a satellite to a central ground facility;
- a project, aimed at establishment of a competitive Canadian industrial producer, to further the technology required for the highly-accurate antenna control and pointing capabilities future advanced satellites will need;
- a satellite and antenna structures development effort to help maintain Canadian capabilities in mechanical systems, satellite structures and related fields; and
- a spacecraft power sources project to develop new electronic battery-management systems, with the actual studies involved undertaken by industry.

Special facilities in support of Canadian industry
Two unique facilities, each situated at the department's Communications Research Centre, just west of Ottawa, can assist industry in space systems research and development, including the design, testing and fabrication of satellite circuit components, subsystems and even the integration of entire spacecraft:

- The David Florida Laboratory is well equipped for environmental testing and assembly of satellite and space hardware. It has thermal/vacuum chambers of varying sizes and a range of systems for vibration, electromagnetic frequency, and RF interference testing.

- The High Reliability Laboratory (HRL) is a unique national centre of expertise in development and application of techniques for assessing the reliability of electronic subsystems, components, devices and materials for space communications systems. A brochure detailing its facilities is available from the manager of the High Reliability Laboratory.

Scanning electron microscope with integral microprobe analyser used for reliability assessment of electronic materials and devices in the High Reliability Laboratory, at the Communications Research Centre.

Rural and remote communications

Closing the urban-rural gap

The telecommunications services enjoyed by Canadians are among the world's best.

Canada's basic telephone system, for example, is second to none and possibly the most reliable and efficient anywhere. Single-party phone service is the urban norm, and installation in Canada (unlike that in many other parts of the world) is usually both fast and efficient.

Most city dwellers have access to signals from dozens of domestic radio and TV stations and a host of imported U.S. signals delivered by cable. Canadian cities are the most heavily-cabled in the world, with 82 per cent of urban households having access to CATV service and close to 60 per cent actually subscribing. Cable operators are moving beyond mere retransmission of broadcast signals to offer a wider range of services, in the fields of education, information and entertainment.

Outside the cities: a different story

But what of the six million Canadians who live in rural areas?

Recent surveys indicate that between a third and a half of all rural telephone users are unhappy with their phone service, while all but three per cent of urban subscribers are satisfied with it.

A basic reason for this profound difference in attitudes is the fact that, while demand for single-party service in rural Canada is rising sharply, some 35 per cent of rural subscribers still share their lines with more than three other users. Where improvements are made, four-party service is the norm in most areas.

A large proportion of country-dwellers has at best spotty reception of AM radio signals; 20 per cent are beyond the reach of the nearest TV station; and only 35 per cent are able to get FM radio broadcasts.

Cable systems, with their wide choice of programs, do not usually serve rural customers, because they need 12 to 18 customers a kilometre to be profitable.

Why the gap?

The main obstacle to equalizing the telecommunications service enjoyed by rural and urban-dwelling Canadians is financial - involving the economics of the operating telecommunications industry and plant designed for the economies of scale offered by the city.

Telephone companies make a profit in cities and lose money on rural service. They spend about $120 million a year upgrading and expanding rural service. But it still costs the carriers around 10 times as much to service the average rural customer as it does his urban counterpart.

Roughly 90 per cent of this capital cost differential arises from the greater length of local loops - the copper wire pair extending from the local exchange to the household served. Investment in rural plant is only undertaken because of public or regulatory pressure and, to a lesser degree, because of an accepted obligation to provide a minimal level of service.

Broadcasting

The commercial broadcasting industry has similar financial disincentives to upgrade rural service. Advertisers are interested in the high-density major markets, and broadcasters have little to gain by extending service through repeater stations serving low-density populations. Canada now has only 127 commercial TV repeater stations.

In contrast, the CBC's Accelerated Coverage Plan (ACP) had brought the number of TV repeaters operated by the English and French public networks to 352 by mid-summer 1978. But although economies of scale could be achieved by stacking up to six commercial and public TV channels at one repeater site, no ready mechanisms exist for doing this - aside from the odd instance of community pressure.

And with more than 350 licensees sharing the lucrative cable TV pie, the fragmented Canadian CATV industry cannot cross-subsidize rural subscribers as the telephone companies do.

Manufacturing

Canada's telecommunications hardware industry naturally concentrates on developing products to service urban subscribers and users - products that will yield higher returns than equipment designed for the much smaller rural market.

With the high costs of providing basic service, difficulties in financing it and the economics of rural telecommunications discouraging investment in R&D, rural services remain vastly inferior.

Will the future be any brighter?

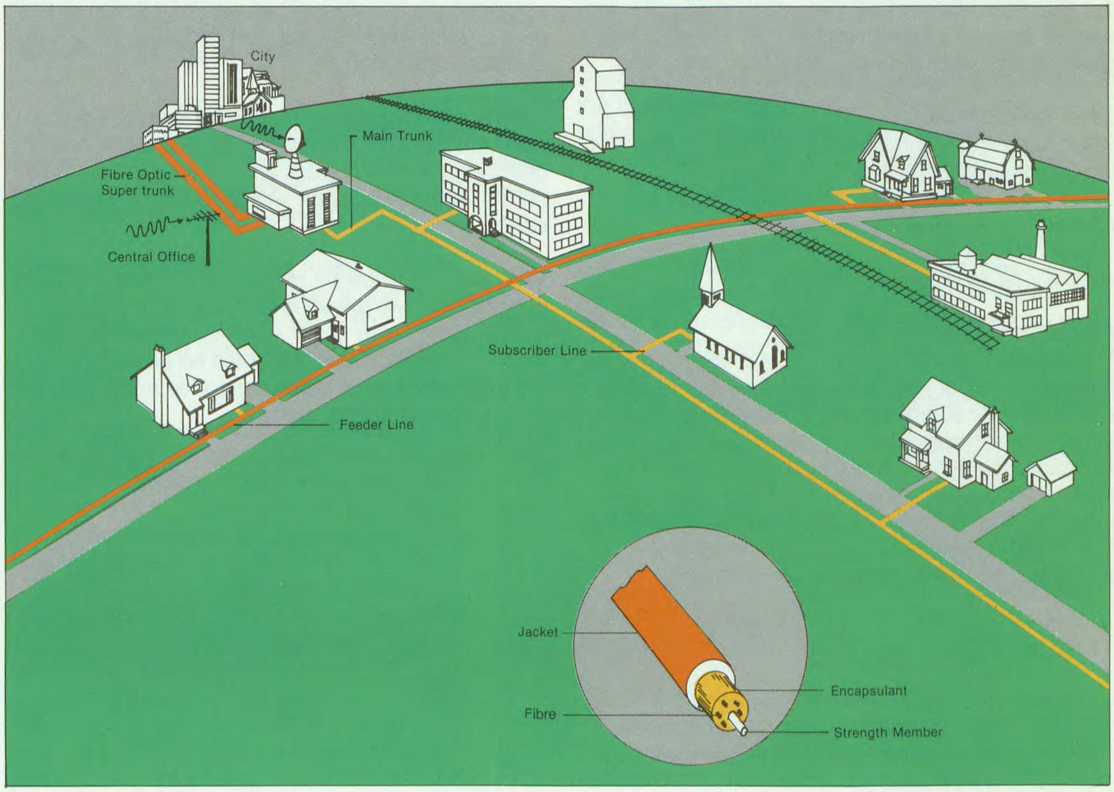
The coming of new technologies - such as fibre optics, satellite communications and LSI circuits - offers hope that reductions in the required investment, coupled with a broader revenue base, may bring about significant improvements for Canada's rural telecommunications users.

Similarly, new approaches to the use of existing technologies and plant will help. The operating industry has huge investments in as-yet-unamortized plant in rural areas. Until sound economics and market requirements permit its replacement, innovative ways of using conventional plant are required.

The department is studying how such techniques as subscriber carrier, subscriber radio, concentrators, low-capacity microwave radio-telephony, stacked transmitters, electronic telephones, satellites and fibre optics might be effectively applied under rural conditions.

The rural communications program

by J.R. Marchand
Director, Rural Communications Program



Elie, Manitoba field trial will determine if fibre optic technology is economically and technically suitable for improving rural communications.

The rural communications program is a $3 million activity started by DOC in mid-1976 to help close the urban-rural telecommunications gap. With about 60 per cent of its funds spent outside the department, the program includes consultations with industry, research and development contracts, field trials of new technology and examination of techniques to optimize the effectiveness of existing plant.

Major rural field trial of fibre optics

The technology of fibre optics is very new, but holds great promise for both rural and urban communications. Within a few years it will be possible to run a glass fibre to a telephone subscriber for the same cost as conventional copper pair. But the glass fibre can also deliver CATV and other information, education, and entertainment services. Quite apart from the social impact of such services, it may well be that the revenue per household derived from delivery of telecommunications by optical means could be doubled or tripled by the addition of CATV and new services fees. The economic viability of rural telecommunications services would improve significantly, while the need for cross-subsidies from urban subscribers would decline.

The department is co-sponsoring a $9.6 million, five-year field trial of a fibre-optics distribution system, to bring single-party telephone service, several TV channels, FM radio and interactive data signals from a central distribution point into 150 homes in Elie, Manitoba, 25 miles west of Winnipeg.

Proposed by the Manitoba Telephone System (MTS), the program is also being supported by the federal Department of Industry, Trade and Commerce.

DOC split the $200,000 cost of program definition studies for the Manitoba field trial with the Canadian Telecommunications Carriers' Association (CTCA). The studies were conducted by Bell-Northern Research and Canada Wire and Cable Ltd.

The Elie field trial will help determine the optimum uses of fibre-optic technology in rural Canada and stimulate Canadian industrial capability in the field.

Other technologies
Other promising technologies for the improvement of rural communications include:

- *Large scale integrated circuits*

LSI technology offers low cost, small size and high reliability as its chief advantages.

- *Satellite communications*

Among other things, satellite communications could improve the lot of rural television fans by ensuring easier delivery of high-quality TV signals to community antenna systems or head-ends. We may some day have operational direct-to-home broadcasting satellites. Government policy in aiding Canada's space communications industry has been framed to both improve service in non-urban areas and strengthen domestic industrial capabilities.

Industrial opportunities
The total value of all systems providing telephone service in rural Canada is between $3 and $4 billion. With conventional technology, it would take about that much again to upgrade existing service to single-party status for all customers.

Not until completion of the DOC rural communications program will it be possible to estimate properly the degree to which utilization of new techniques could reduce this cost. (Preliminary indications suggest a reduction of 50 per cent or more, if the right decisions are taken.)

The ultimate figure will depend on factors like the type and number of technologies used, the consequent effects on unit costs and the percentage of the under-served population willing to pay for upgraded service.

Whatever the solutions chosen, the potential market over the next two decades is at least $1.5 billion. The market looks even better when one considers the extent of new services that could be offered through the expanded transmission capacities made possible by satellites and fibre optics.

Trail and remote camp radio

by Dr. J.S. Belrose
Director, Radio Communications Laboratory

Residents of Koartac, an Inuit community of 130 people, about 500 km north of Fort Chimo, Quebec, are now experimenting with a novel, hybrid HF-VHF trail and remote camp radio system developed by DOC.

The project which led to the prototype system was initiated after representatives of the Northern Quebec Inuit presented a brief outlining their communications needs to the federal government, late in 1974.

Canadian industry provided major elements of the system, which was turned over to the people of Koartac for user-testing in 1977, so native people themselves could make useful suggestions for its refinement.

More recently, a Northern communications workshop in Makkovik, Labrador, in February 1978 heard reports from people throughout the North which underlined the need for more work on the techniques and technologies needed to achieve more reliable and practical trail radio.

The requirement

The economic existence of many Northern people centres on traditional pursuits like hunting, fishing and berry-picking.

Such activities all require villagers to spend long periods away from home - either out on the trail, or in remote camps. There is an obvious need for communications between hunting parties and settlements. But trail-to-trail or camp-to-camp communications can be just as important - for instance, when one hunting party finds lots of game, while another just a few miles away might remain empty-handed.

The kind of co-operation a reliable and practical communications system would enhance could make an important contribution to the strength of this hunting and gathering economy.

A new approach

The principle of automation plays a fundamental role in the CRC system, which employs tone-signalling, operates without need of conventional radio operators and makes use of portable, lightweight and power-efficient new radios.

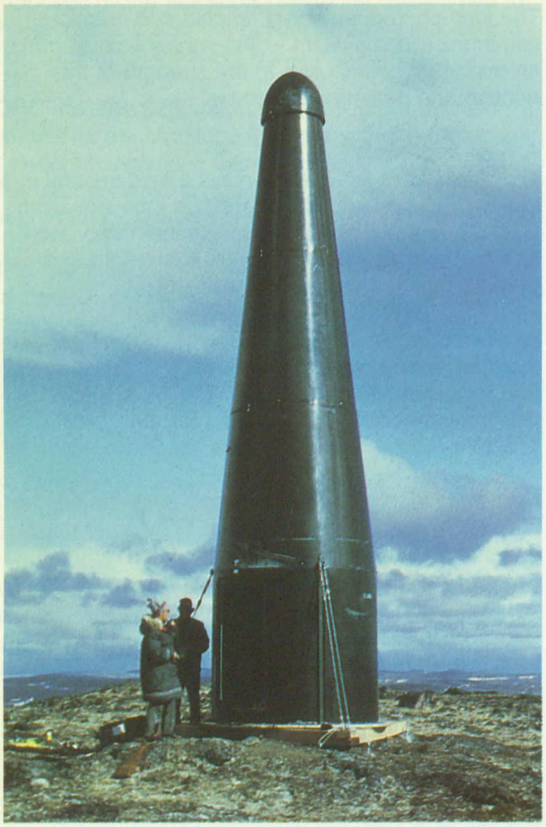
It draws from techniques and technologies familiar in the land mobile radio service, HF-SSB "bush radio" and radio amateur use of VHF-FM "autopatch" repeaters (shared hilltop facilities with automatic, mobile, tone-access to the switched telephone network).

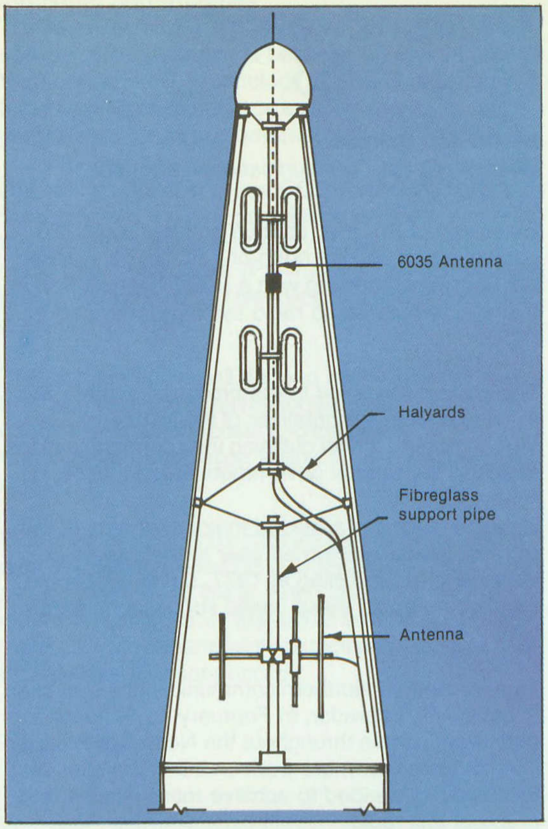
Conventional high frequency radio systems have a number of major disadvantages. They need large, bulky antennas, have built-in gaps in coverage (owing to the physics of propagation), require radio operators and are subject to unpredictable disturbances in ionospheric propagation. The DOC system employs HF radios only for longer-range coverage.

Hand-held VHF transceivers get the nod for trail communications to and from an area from 65 to 100 km surrounding a centrally-located community repeater station. Other VHF radios, about the size of a small cigar box, are scattered throughout the community - in the co-op store, in homes of selected individuals, and in the radio room used for inter-community communications, for example.

The VHF trail radios are equipped with efficient, end-fed, half-wave antennas (telescopic whips 1 m long). The community-based transceivers perform the same function as public telephones do in Southern Canada.

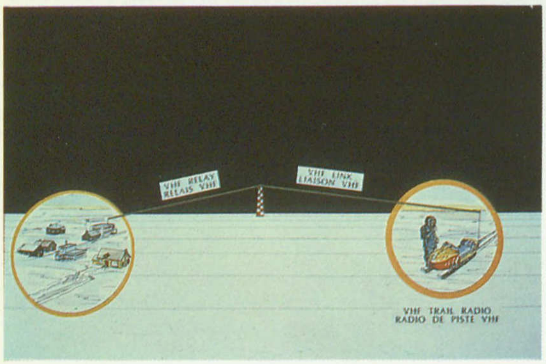
Hand-held VHF transceiver





This communications shelter (Comshel) houses the battery-operated VHF repeater.

Diagram of interior of the Comshel.



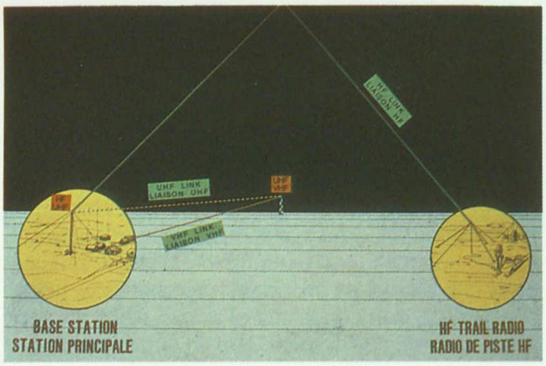


Diagram showing the VHF link

Diagram showing the HF link

The automatic, battery-operated VHF repeater rests on the highest point overlooking the village and its hunting area. At Koartac, the repeater is on Diana Island, 280 m above sea level and 20 km from the community. It is housed in a communication shelter, which was sent to Koartac by ship, assembled there, and flown to the island by helicopter. The equipment, antennas and batteries are all inside to protect them from the weather. The 32 salt-water batteries provide the power. The battery capacity allows the repeater to operate for more than 10 years if used 20 minutes a day. The equipment will operate at −50°C.

Adjacent to the village, but as far as possible from noise and interference caused by snowmobile traffic or diesel-generator power plants, is the AC-powered HF base station. A UHF link connects it with the VHF repeater.

The VHF repeater receiver easily picks up signals from both VHF trail transceivers and those in the community - retransmitting them at greater height and antenna gain on an adjacent frequency. The result is an enormous increase in the communications range for conversations between mobile units and the community, or between mobiles. Though most calls will originate in the field, members of the community will be able to contact hunters at the push of a microphone button.

As long as a hunting or fishing party remains within the VHF coverage area, it can respond on its portable VHF transceiver. Over longer distances, hunters must use an HF radio. The HF base station relays the trail signal over the UHF link to the VHF repeater transmitter which, in turn, will transmit the call to all VHF radios in the community. Thus, it will make no difference in the community whether a call originates with an HF or VHF portable out on the trail.

Because the system operates like a party-line, little chance exists that an emergency call will be missed. Anyone within hearing of a community radio is a potential emergency operator.

The use of VHF-FM and tone-calling for the HF part of the system bestows a very important advantage. It is possible to "squelch" community transceivers - that is, keep them wholly free of background noise and static - until a desired incoming signal appears. Without this advantage, noise, spurious signals or interference would constantly tempt villagers to turn their radios down - or off!

A mobile operator can also judge the availability and quality of a circuit before making his call, with the result that he does not waste time and battery-power on useless calls. This advantage arises from the fact the system has to be specifically accessed by the user in both the HF and VHF modes.

The operator of an HF portable must first push his microphone button, then a "call" button. A pair of audio tones are then transmitted. If the HF base station correctly receives and verifies these tones, the UHF link becomes operational and the HF base station transmitter sends back a one-second tone burst. If this occurs, the mobile operator will be assured that conditions are good enough for him to get his message through. If not, he won't waste time and battery power on a useless call. Instead, he will try again later when propagation conditions improve.

A basic project objective was to develop and demonstrate a practical working system using available technology. If such a system was to become operational and be distributed to users, its components (equipment, modules and interface elements) had to be commercially available. For this reason, DOC has from the outset collaborated closely with Canadian industry.

Seven Canadian firms supplied equipment or developed new elements for the prototype system:

1 Spilsbury Communications, of Vancouver, manufactured the portable HF-SSB transceivers (their Model SBX-11) and have now contracted to develop an improved trail and remote camp radio.

2 Challenger Electronics, also of Vancouver, developed an anti-falsing SSB tone decoder for the HF base station.

3 RF Electronics, another Vancouver firm specializing in custom-system, mountain-top repeaters, supplied the VHF repeater and UHF links. The same firm developed several interface modules for the system, under contract to CRC.

4 Sinclair Radio Laboratories, of Toronto and Vancouver, provided duplexers, antennas, and a "Comshel" (communications shelter) for the VHF repeater.

5 Cipel et Le Carbone Ltée, of Valleyfield, Quebec, manufactured the caustic potash sub-zero batteries used to power the unattended VHF repeater.

6 The Canadian Marconi Company, Monteal, supplied the HF-SSB base station radio.

7 Canadian Larsen Electronics, Ltd., of Vancouver, manufactured the base loading coils used in the laboratory-built VHF walkie-talkie antennas.

In some cases, it was necessary to go outside the country. For example, only in Japan could the department find inexpensive VHF radios which would work well at −30°C. The community transceiver is the Tempo model CL-146A, while the hand-held trail radio is the Wilson Model T-1405SM. The microphone encoder used with these transceivers is a crystal-reference touch-tone encoder (Drake Model 1525EM).

At the present time, industrially unavailable system components include tone encoders for the HF transceivers, the transportable HF antenna and a method of assuring compatibility between the Wilson radio and a "battery belt" to keep batteries warm in severe Arctic temperatures. Ni-Cad batteries lose, at - 30°C, half the capacity they possess at +20°C.

Light, transportable power sources are another area for future development. Though a 300-watt Honda motor generator can provide more than enough power for a 100-watt radio located in a remote camp, a generator of lighter weight would constitute a more realistic response to this need. In fact, natural power sources - such as the sun, wind or even human muscle, might afford the best means of charging the Ni-Cad batteries used in these systems.

Experiments with solar cells have proven their efficiency. But the sun does not always shine in the North! And hand-crank generators are good only to about 50 watts.

Wind power seems the only alternative. The wind is always blowing in the North. Small, portable wind generators have only recently become available, thanks to development work by a Kenora, Ontario, firm.

The future
Future advances in communications technology and techniques can easily be incorporated into the present DOC prototype trail radio system. For example, Challenger Electronics has developed for DOC the components of a system which would permit mobile users in the North automatic access to the public telephone system. Each mobile unit would employ a special SSB encoder for tone signalling.

The base station would receive and verify these tones, then generate touch-tones compatible with the telephone system. No one, however, has tested this HF autopatch system in the field.

Ultimately, DOC plans to bring these trail and remote camp radios into interface with a much more sophisticated and integrated HF communication system now under develoment in the department.

New services for homes and businesses

by Dr. C.D. Shepard
Director, Research Policy Development

Introduction

Futurists and science fiction writers before them have long been speculating about the shape and scope of new telecommunications services for the home.

But it is only in the comparatively recent past that consumer and industry interest have been heightened by such factors as advances in transmission technology, the growing penetration of CATV systems in urban areas and new widespread availability of cablevision converters, low-cost home computers, TV games and similar appliances.

Pay TV is now a familiar subject in Canada. New videotape offerings, alphanumeric services like the European Viewdata and teletext systems, word processors, facsimile transmission of mail and other innovations are all proliferating in the business environment, while homeowners toy with video games or scan news delivered electronically via cable.

New hardware and field trials are now mushrooming everywhere. And not surprisingly.

The new market developing is huge by any measure: for example, if only half of Canada's seven million households invested $500 each in new hardware during the next five years, the sum would be nearly $2 billion.

The new hardware carries price tags ranging from $10,000 for an on-line word processor, to less than a thousand for a simple home computer.

New services will need new modes of switched, integrated wide- and narrow-band delivery – many of them involving combinations of present-day telephone, broadcast and cable distribution. This evolution could force a painful restructuring of these traditional delivery systems – and will involve keen competition for the lucrative markets involved.

With the home subscriber able to interact with information sources and radically re-allocate such activities as his TV viewing time, there could be major impacts on culture, the broadcasting and cable industries and the identities and revenues of many established businesses.

Field trials under way

A variety of new or experimental telecommunications services are available to a limited number of homes today – but hold potential interest for a large percentage of Canadians.

Services introduced, tried, or still being evaluated include films-on-demand, interactive alphanumeric information retrieval, monitoring of homes for fire, burglary, energy consumption or similar purposes, pay television, tele-education and teleshopping. Specifically:

- Télécable Vidéotron, the Government of Quebec and the National Film Board have been looking at a film-on-demand service in St-Hubert, Quebec.

- The Department of Communications and Carleton University in Ottawa jointly evaluated an interactive alphanumeric information retrieval service, in which cablevision subscribers could order by telephone information to be displayed on their TV screens.

- In Edmonton, Alberta, and North York, Ontario, hydro utilities have been co-operating with the telephone systems in a trial of remote meter-reading.

- One of Canada's largest retailers, Simpsons-Sears Ltd., experimented with a telephone-talkback catalogue order-taking system in Toronto.

However, a number of initiatives that might have increased the level of change-directed activity in Canada failed to come to fruition, for a variety of reasons including the scale of investment required, risks involved and competitive pressures.

The role of the Department of Communications

While the technology and hardware scene evolves at a dizzying pace, the exact pattern of future services themselves is extremely hard to predict.

And, with a few limited (although notable) exceptions, there has until now been little significant domestic industrial involvement in researching, engineering and developing hardware for the new home services of tomorrow.

But the Department of Communications - in common with its counterpart agencies and ministries in most other countries - is assessing economic, regulatory, institutional, industrial, business and social implications of this seemingly inevitable revolution in communications.

Activities in 1977/78 included a joint review with Bell Canada of interactive visual communications projects (which includes any new service not purely audio), contracts to the University of Western Ontario and Ecole Polytechnique (the latter half-funded by the Province of Quebec) to investigate the possibilities of new service offerings and identify those most likely to grow, analysis of the potential impact of different forms of pay TV on the systems needed to deliver them, preliminary analysis of the impact of fibre optics on existing plant and of the economic feasibility of upgrading cable TV plant to provide a broader range of services, and investigations of the design of modular home terminals for possible new services.

Plans for 1978/79 include monitoring the continuing activity of other organizations trying new services, conducting systems analysis of ways of combining services for efficient and effective delivery, studying the implications of this analysis for the delivery system, examining the adequacy of the present quality of home video signals for alphanumeric information, and more detailed exploration of the possibilities for modular home terminals in the future.

It can be expected these exploratory activities will lead to both large-scale experimental undertakings and formulation of new policies. But it would be difficult, and perhaps even foolhardy, to forecast the course of events for even as few as two or three years hence.

Research and Space Sector Activities

The following pages comprise a comprehensive, alphabetical listing of major research and development-related activities of the federal Department of Communications.

You are invited to write or telephone the research managers, project leaders and other officials named for more details. Telephone numbers (Area Code 613) are included for those associated with each project or activity listed.

The department's general mailing address is:

Department of Communications
300 Slater Street
Ottawa, Ontario
K1A 0C8

Advanced Electronic Components
Dr. A.R. Molozzi, 996-9403
Dr. M. Palfreyman, 596-9410

Evaluates feasibility of applying such advanced devices as surface acoustic wave (SAW) configurations or charge-coupled devices (CCD) in selected circuitry components (band-pass, programmable and coded filters; discriminators; demodulators and stable oscillators). Reliability of experimental and commercial devices is also investigated.

Aerosat
Dr. R.W. Breithaupt, 995-7783

Co-operative venture proposing a communications satellite system to control trans-Atlantic airline traffic. Program, including Canadian participation, delayed pending further studies. Details of future plans on request.

Anik B Communications Program
Dr. R.W. Breithaupt, 995-7783
Mr. N.G. Davies, 596-9215

Program to use Canada's new dual-band satellite due for launch in December 1978. Spacecraft will provide Telesat Canada with 6/4 GHz replacement capacity and four 14/12 GHz channels, which will be leased to DOC for at least two years. Program will continue exploratory work begun with Hermes to determine viability, on a pre-operational basis, of advanced satellite telecommunications services at 14/12 GHz. Includes pilot projects in telehealth, TV production and delivery, tele-education, public telecommunications applications, communications in remote areas and advanced-technology experiments.

Antenna Control and Pointing
(See *Satellite and Antenna Control and Pointing*.)

Attitude Determination
(See *Orbit Attitude Determination*.)

Behavioral Research
Mr. H.G. Bown, 596-9436
Dr. D.A. Phillips, 996-8872

This project is concerned with the effect on human communication of various channel characteristics, such as echo-delay in a satellite circuit. It aims to determine these effects in order to recommend ways of improving interpersonal telecommunication between two or more persons or groups and, in the longer run, to understand more fully the impact of new systems and devices on their users. Specific activities under way include evaluation of an improved voice-processing system for HF/SSB radio (SYNCOMPEX), studies of effects of satellite transmission delays on interpersonal exchange and supervision of contract work on how technology affects person-to-person communication. (See also *New Home Service Terminals - Human Factors.*)

Broadband Rural Services
Mr. J.R. Marchand, 593-6072
Mr. A. Lillemark, 593-6460

Component of DOC's Rural Communications Program, intended to establish an engineering framework for development of federal policies to improve broadband telecommunications in rural areas. A secondary objective is the stimulation of Canadian product design. Technologies being studied include stacked terrestrial rebroadcasting systems, direct satellite broadcast configurations, fibre-optics systems, radiating cables, SHF terrestrial radio distribution and terminal equipment requirements.

Computer Communications Network Research
Mr. H.G. Bown, 596-9436
Dr. Y.F. Lum, 996-8871

Aims at increasing expertise in computer communications networks, in support of policy-making; developing techniques and tools for evaluation of interconnection protocols; promoting compatibility between private and public networks; and making a contribution in such promising new areas of computer communications as packet radio and distributed processing. Much of the work carried out by university contracts. (See also *Data Communications Internetworking*.)

Computerized Business Systems
Mr. H.G. Bown, 596-9436
Mr. G.S. Collins, 996-4243

Studies computerized business communication systems, mail alternatives, and other new areas receiving attention from computer manufacturers. DOC aided development of intelligent terminals for the *Tradex* network and is also monitoring other large, closed user systems.

CTS/Hermes Technology Experiments
Dr. R.W. Breithaupt, 995-7783
Dr. M. Palfreyman, 596-9410

Continuing project to flight-test new stabilization system for a spacecraft (Hermes) with flexible appendages and unfurlable, 1 kW solar power arrays. Co-operating experimenters include Spar Aerospace Products Ltd., Telesat Canada and NASA. Data being made available to European Space Agency.

Data Communications Internetworking
Mr. H.G. Bown, 596-9436
Dr. Y.F. Lum, 996-8871

Activity to provide technical assistance and recommendations for formulation of public policies respecting compatibility and internetworking of networks provided by CNCP, TCTS and Teleglobe Canada.

Data Network Standards
Mr. H.G. Bown, 596-9436
Dr. Y.F. Lum, 996-8871

Activity to develop international data network standards is growing fast. Canada, with two sophisticated national data networks, is in the forefront of this work. Of particular interest in the Canadian environment are standards for packet- and circuit-switching interfaces and network interconnection.

Data Retransmission Platform Studies
Dr. R.W. Breithaupt, 995-7783
Dr. M. Palfreyman, 596-9410

Assess technical and economic feasibility of unattended data retransmission platforms (DRPs) to transmit sensor-collected data up to a satellite, for relay to a central ground facility. DOC loans equipment and evaluates data for a joint Telesat Canada/COMSAT experiment utilizing 6 GHz DRP. A key objective is to assure Canadian industry can meet future domestic DRP requirements, particularly at UHF (see also MUSAT.)

David Florida Laboratory
Dr. A.R. Molozzi, 996-9403
Mr. W.F. Croskery, 596-9593

A national facility at the Communications Research Centre, for environmental testing and integration of satellite and space hardware. Equipped with thermal/vacuum chambers up to 3 by 9 metres. Chambers can be temperature-cycled between $-195°$ and $+150°C$ and have a vacuum capability of at least 10^{-7} torr. Instrumentation available for vacuum and temperature measuring, outgassing analysis and digital storage of temperature data. Systems for vibration testing also available. Shielded enclosure equipped for radio frequency interference or electromagnetic (frequency up to 20 GHz) studies and system assessment. Plans being formulated with industry for upgrading this facility. Inquiries invited.

Demand for Rural Communications Services
Mr. J.R. Marchand, 593-6072

Project aimed at defining needs for policies and programs in support of improved rural telecommunications services. Assesses current and future service demands of both domestic and business subscribers in rural Canada. Hopes to quantify subscriber satisfaction and report on consumer demand for improved services, willingness to pay for such services and demand/revenue implications of upgrading. Study of demographic, economic and other factors expected to lead to penetration predictions for both new and existing services.

Digital Communications Space Components
Dr. A.R. Molozzi, 996-9403
Dr. M. Palfreyman, 596-9410

Project to define device and component requirements for future high-speed digital space/communications capabilities for Canada. Such capabilities will be essential for new satellite systems involving data retransmission terminals (see *Data Retransmission Platform Studies)*, on-board signal-switching, SARSAT (see SARSAT), and high-speed Anik B modems. Develops appropriate new micro-electronic approaches.

Digital Communications Systems
Dr. A.R. Molozzi, 996-9403
Mr. L.A. Maynard, 596-9348

Includes existing projects to develop both high- and low-rate digital communications systems for advanced satellite applications. High-rate systems concerned are primarily for trunk traffic. Investigates applications of wide band digital systems and subsystems. Low-rate systems work aimed at application of digital modulation techniques for voice and data transmission from small earth terminals. Large numbers of efficient, low-cost terminals will be needed. Systems resulting from this project will be of use in UHF (MUSAT), Anik, and advanced military satellite systems.

Earth-Space Radio Propagation
Dr. R.E. Barrington, 596-9311
Dr. K.S. McCormick, 596-9395

Research project concerned with propagation information for planning and designing earth-space (satellite) communications systems and spectrum management. Includes work on low-angle fading in systems accessing geostationary satellites from high latitudes. Analyses broadband signals from satellites to assess effects of ionospheric perturbations on synthetic aperture radars working at L and C bands. Studies rain attenuation, polarization discrimination, fading and consequent benefits of site diversity under contract for Teleglobe Canada. Another investigation jointly funded with Bell-Northern Research. Researchers also conduct measurements of rain attenuation and depolarization at 18 and 28 GHz, using COMSTAR satellite beacons to help plan future use of these bands.

Earth Terminal Technology Development
Dr. A.R. Molozzi, 996-9403
Dr. M. Palfreyman, 596-9410

Aims at staying on top of future technological requirements for the earth segment of SHF satellite systems, advancing the technology and optimizing domestic industrial participation in supply of components. Work to date concentrated on development and demonstration of a low-cost, receive-only earth terminal (LCET). Plans afoot for industry contruction of multi-channel LCETs for Hermes and other high power satellites, and studies of an improved 14 GHz mixer and low-cost cavity temperature stabilization. Possible RF components for a portable, 1-watt, single-channel (voice) terminal for such applications as surveying, remote nursing and pipeline construction also under study. Over-riding aim is to have Canadian industry selling as many of these and other components as possible. Close liaison with industry will continue.

Effects of the Radio Environment
Dr. J.S. Belrose, 596-9362
Dr. T.N.R. Coyne, 596-9288

Project to investigate effects of the radio environment on radio communications and consumer electronics equipment and to foster development (particularly in Canadian industry) of radio communications technology. Immediate objectives include investigation of error rate performance of digital communications systems in presence of man-made radio noise and interference, and quantitative assessment of power line and ignition noise effects of TV reception. A broad aim is to develop a test and simulation capability, and to plan research into electromagnetic susceptibility and compatibility of electronic equipment. Other work involves system design by DOC for extending and optimizing terrestrial radio coverage for remote communities. Prototype system enabling trail parties to keep in touch with their base communities installed at Koartac, Northern Quebec, for extended field testing. An MF/HF SSB transceiver, more suited to this type of work, is now under development for the department and will be tested. Means of interfacing this system with other telecommunications networks will also be evaluated.

Electronic Payment Systems
Mr. H.G. Bown, 596-9436
Mr. G.S. Collins, 996-4243

Policy-oriented activity, gathering information, analysing it and advising senior management on such questions as internetworking, security, integrity and reliability.

Fibre-Optic Rural Pilot Project
Dr. M. Fournier, 596-9387
Dr. K.O. Hill, 596-9615

DOC is co-sponsoring a five-year field trial of an operating fibre-optic distribution system for delivery of TV, FM, single-party telephone and data signals in the town of Elie, Manitoba. The Elie trial, in co-operation with the Manitoba Telephone System, the Canadian Telecommunications Carriers' Association (CTCA) and the Department of Industry, Trade and Commerce, will evaluate the technology under real market and operating conditions, assess implications of integration of telephone and broadcasting type services and further the objective of keeping Canadian industry in the forefront of potentially huge fibre-optics sales. Program definition stage, for completion in late 1978, is jointly sponsored by DOC and CTCA, with Bell-Northern Research and Canstar (Canada Wire and Cable) carrying out contract work. CRC is also designing and building a 2 km single-fibre subscriber loop for integrated delivery, in order to both gain experience and test a new technique for making optical taps.

GPS/Global Positioning System
(See NAVSTAR/GPS.)

Hermes Communications Experiments
Dr. R.W. Breithaupt, 995-7783
Mr. N.G. Davies, 596-9215

A wide range of experiments to demonstrate applicability of the advanced high power 14/12 GHz transponder on Hermes to unique Canadian needs is continuing. Optimum use of frequency and power enables low-cost, small earth terminals to provide two-way video services previously technically or economically unfeasible. Experiments cover fields including telehealth, tele-education, community interaction, and teleconferencing.

Hermes Operations
Dr. R.W. Breithaupt, 995-7783
Mr. N.G. Davies, 596-9215

Began with the 1976 launch of Canada's Hermes satellite, in a co-operative DOC/NASA venture. Besides enhancing and maintaining Canadian capability in space systems for domestic use, Hermes explores use of high power communications satellites with low-cost ground stations in the 14/12 GHz band. Another objective is to investigate social and other aspects of potential satellite services. High power active devices, extendible solar cell arrays and accurate three-axis stabilization system have all been flight-tested. Round-the-clock operations maintain the spacecraft in a satisfactory condition, available for U.S. and Canadian experimentation. This program schedules all functions involving the spacecraft and co-ordinates Canadian communications experiments, as well as deployment and maintenance of ground terminals.

High Frequency Direction Finding
Dr. J.S. Belrose, 596-9362
Dr. G. Atkinson, 596-9470

Investigates ionospheric irregularities and other propagation factors limiting accuracy of HFDF measurements, as well as techniques for reducing associated errors.

High-Reliability Laboratory
Dr. A.R. Molozzi, 996-9403
Dr. M. Palfreyman, 596-9410

A unique national centre of expertise, situated at the Communications Research Centre, west of Ottawa. The hostile outer space environment and impossibility of repairing conventionally-launched satellites impose rigorous quality and reliability demands on electronic designs. Quality and cost considerations compete – in ground segment procurement as well. New devices significant for spacecraft design continue to be introduced. Thus, the major objective of the project is to develop and apply techniques necessary for reliability assessment of electronic subsystems and to support high priority projects in DOC, other government departments and agencies, and Canadian industry.

Image Communications Trials
Mr. H.G. Bown, 596-9436
Dr. W. Sawchuk, 596-9221

Field trials of existing systems with outside agencies (Royal Military College, University of Manitoba, Manitoba Telephone System, and the Defence Research Establishment, Ottawa), to obtain evaluation data in the field of education and training. Project also assesses multi-mode visual communications networks using packet-switching, and investigates mixed-mode presentation (graphics and video) over networks, techniques of sharing a common data base, and attributes of a document-editing system employing such a network.

Image Recognition/Data Compression Research
Mr. H.G. Bown, 596-9436
Dr. W. Sawchuk, 596-9221

Research performed by CRC's image communications group has led to development of computer graphics hardware and software systems for facilitating transmission of graphical images over a computer graphics network and supporting the concept of a common visual space (interactive visual communications). Objective is to obtain bandwidth compression when transmitting images, by devising efficient techniques for reading them from various sources (fascimile, TV camera, video digitizer), as well as digitizing and compressing them.

Information Economy Identification
Dr. M. Fournier, 596-9387
Dr. G.W. Jull, 596-9217

Activity to gauge the extent, identify component sectors and predict growth of the information economy (information sector of the Canadian economy). Co-ordinated with OECD efforts and other foreign developments.

Integrated Remote Communications
Dr. M. Fournier, 596-9387
Mr. G.W. Irvine, 596-9357

Departmental activity to develop a system for integrating conventional automatic telephone exchanges in small, remote communities with both HF radiotelephone and satellite communications systems. A reliable, automated system with provision for HF/VHF trail radio (see page 29) interface being defined and developed through Canadian industry. System will employ automatic real-time channel evaluation techniques to select optimum HF frequencies from a variety of available channels, chosen to accommodate most propagation conditions. SYNCOMPEX – a new voice-processing system that greatly improves HF/SSB intelligibility against radio noise or interference background – is also included. System design and development management by CRC; development by contract with industry. Timetable calls for completion of trial hardware late in 1978; system integration in 1979.

Integration of Telecommunications Services in Rural Areas
Mr. J.R. Marchand, 593-6072
Mr. A. Lillemark, 593-6460

Because of high costs of individual subscriber loops in low-density rural areas, telecommunications services such as private-line telephone and cable TV can often only be provided at unacceptably high prices. Utilization of new technologies such as fibre optics, however, could enable a single loop to offer a variety of services, thereby generating sufficient revenue to make extension of services in sparsely-settled regions more viable. DOC has a number of technical studies under way, supported by field trials and other activities, to investigate and verify the practicability of such approaches.

Interdepartmental Committee on Space (ICS)
Dr. R.C. Langille, 593-5590

Reporting to the Minister of Communications, the committee promotes liaison and co-ordination between government departments and agencies involved in space-related activities; helps plan future programs and activities; works to ensure orderly growth of a healthy Canadian space industry; liaises with foreign space agencies; co-ordinates studies; and publishes reports. ICS secretariat established and maintained by DOC.

International Commitments
Dr. R.E. Barrington, 596-9311
Mr. D.B. Muldrew, 596-9101

DOC participates in international scientific and technical programs including ITU study groups, International Satellites for Ionospheric Studies (ISIS) experimenters' groups, planning of future satellite missions and facilities and Canadian preparations for world radio conferences in 1979 and 1982.

International Maritime Satellite Communications (INMARSAT)
Dr. R.W. Breithaupt, 995-7783
Mr. L.A. Maynard, 596-9348

Project covering DOC technical and management support for Department of Transport-led Canadian participation in the INMARSAT program. DOC activities include experimental assessment of small shipboard terminal performance, studies of propagation margins and evaluation of multipath effects and requirements for transmission and reception of voice, data and ranging information.

Low Rate Digital Systems
(*See Digital Communications Systems*.)

Maritime and Aeronautical Satellite Communications
Dr. R.W. Breithaupt, 995-7783
Mr. L.A. Maynard, 596-9348

Involves technical studies of satellite communications to ships and aircraft, in support of potential Canadian participation in INMARSAT, AEROSAT, and GPS/NAVSTAR. (See these headings for more detail.)

Microwave Radio Relay Propagation
Dr. R.E. Barrington, 596-9311
Dr. K.S. McCormick, 596-9395

Research activity to obtain propagation data needed to plan and manage terrestrial radio relay systems. Work includes studies of limitations imposed on dual-polarized 7 GHz digital systems by rain and multipath effects and examination of hop-length limitations on 12 and 18 GHz systems brought about by rain attenuation. Of particular relevance to management of 12, 14 and 18 GHz bands are studies of how rain limits the potential effectiveness of dual polarization as a means of encouraging spectrum conservation and frequency re-use. DOC policy-making on 15-GHz CATV relay systems is being aided by year-long monitoring and analysis of TV transmissions over a 33-km path. The department is supporting university research into the potential of millimetric waves (at 37 and 70 GHz) for wideband, short-haul systems (of up to 5 km).

Microwave Remote Sensing
Dr. D.F. Page, 596-9412
Dr. A.W.R. Gilchrist, 596-9426

Canadian government expertise in microwave remote sensing largely resides in the research sector of the Department of Communications. Work here includes studies in support of the proposed surveillance satellite program, including evaluation of how the disturbed northern latitude ionosphere might affect satellite-borne synthetic aperture radar, and how ocean waves affect the ability of radar to detect movement of small targets like fishing boats.

Military Communications Technology – Non-Satellite
Mr. G.W. Irvine, 596-9357
Mr. J.L. Lyrette, 996-0727
Dr. R. W. Jenkins, 596-9070

The Canadian Armed Forces gets direct help from DOC experts in solving problems in terrestrial communications technology. The fields of propagation, display, and antennas are all included. Major new effort will be devoted to improved communications systems for ships.

Military Satellite Communications Technology
Dr. A.R. Molozzi, 996-9403
Mr. L.A. Maynard, 596-9348

Program to provide technical support, practical assistance and advice to the defence department on advanced satellite communications. Includes feasibility studies for future facilities, help in specifying and developing ground stations, systems studies for patrol frigate communications, development work on a small transportable terminal for use with a NATO satellite and a project involving satellite communications for Canada's new fighter aircraft.

Mobile Radio Data Systems
Dr. M. Fournier, 596-9387
Mr. R.L. Hutchison, 596-9666

Project to foster development of mobile radio data systems built by Canadian suppliers to meet Canadian needs. Data generated helpful for both standards development and spectrum management purposes. Now being demonstrated with Vancouver City Police is a pilot system, enabling mobile terminal status reporting, giving access to data bases and capable of incorporation into computer-aided dispatch (CAD) systems or local records subsystem. Development of communication controller and other specialized subsystem hardware under way.

Multiple Purpose UHF Satellite (MUSAT)
Dr. R.W. Breithaupt, 995-7783
Dr. M. Palfreyman, 596-9410

A proposed domestic UHF satellite communications system intended to meet mobile and data-readout needs of government users. System is in project planning stage. It would serve ships, aircraft, environmental monitoring platforms, field parties and other users requiring a satellite, with a number of transponders operating in frequency bands appropriate to each application. Present activities include planning, interpretation of user needs, preparation of communication system specifications, and definition of the communications control station for the system. Transponder studies and demonstrations under way will ensure viability of critical satellite subsystem components, within stringent passive intermodulation restraints. Development and production of a highly portable, low-cost earth terminal essential to the MUSAT system is also being planned.

NAVSTAR/Global Positioning System (GPS) Studies
Dr. A.R. Molozzi, 996-9403
Mr. L.A. Maynard, 596-9348

Research and technical support for the Department of National Defence to improve effectiveness of Canadian participation in the USAF/SAMSO Global Positioning System (GPS/NAVSTAR). DOC participation involves: consultation with DND in industrial development of user equipment; research to determine possible errors due to propagation effects, especially at high geomagnetic latitudes; research to improve performance of aircraft antennas and develop an antenna to meet Canadian requirements; and simulation and development of an inertial strapdown system integrated with the GPS receiver.

New Home Services – Field Trial Planning
Mr. H.G. Bown, 596-9436
Mr. G.S. Collins, 996-4243

Activity closely related to systems studies in the same area. Aims at helping determine what new home services Canadians are willing to pay for; encouraging domestic industry to develop new information and entertainment services; and providing input to related social and regulatory policy planning. Possibilities for Canadian field trials and industry proposals for new ones are evaluated and results of those in other countries closely monitored. The work is basic to determination of what role, if any, government should play in such trials. It is expected the Elie, Manitoba, fibre-optics experiment will provide opportunity for relevant interactive trials.

New Home Services – Systems
Mr. H.G. Bown, 596-9436
Mr. G.S. Collins, 996-4243

Study of various configurations and scenarios for modular home data terminals, communications networks and the services possible with them. Concerned with the question of what combinations of technology and user services consumers would be willing to pay for and what organizations and systems could provide them. Preliminary systems configurations are outlined, rough cost analysis performed and resultant ideas discussed with the private sector, in hope of stimulating joint activity or industry trials.

New Home Service Terminals - Human Factors
Mr. H.G. Bown, 596-9436
Dr. D.A. Phillips, 996-8872

Focusses on behavioral factors likely to play a major part in determining acceptability of proposed new home services. Transmission standards for commercial television may well be inadequate for displaying graphics, alphanumeric material or new entertainment offerings. Requirements for resolution and refresh rate may vary with content characteristics. Standards will eventually have to be suggested for both red-green-blue and composite video systems. Immediate objectives are to use behavioral responses as criteria to study these factors and determine characteristics of home terminal input devices appropriate to different services. The project involves considerable terminal hardware, software and device support.

New Home Services - Terminal Technology
Mr. H.G. Bown, 596-9436
Dr. W. Sawchuk, 596-9221

Involves research on technical aspects of terminal devices to provide insight into technological trends for equipment suitable for displaying future home and office services. CRC work on low-speed image communication devices has led to substantial transfer of technology to a Canadian company (Norpak Limited) now manufacturing color-graphics display terminals and video input devices. Present research on display technologies focusses upon such matters as cellular and random display techniques, memory structures for providing a variety of image resolutions, input/output interface devices, and efficient coding of graphical information for transmission and viewing on home or office terminals. The intent is to provide a basis for policy and regulation decisions and technology transfer to industry for creation of innovative products.

Optical Communications Applied Research
Dr. M. Fournier, 596-9387
Dr. K.O. Hill, 596-9615

A response to the rapid development of optical-fibre communications technology. Installation of optical systems by telecommunications companies will likely start in the early 1980s. The research aims at fostering the technology, development and use of these systems in Canada. It also provides DOC with technological information for its own strategic planning. Work includes such activities as seeking better ways for coupling light into and out of fibres, splicing, modulation of lightwave sources, investigations of the information-carrying limits of systems, assessments of available components and studies on experimental optical-fibre links. The research group also monitors a number of related external contracts and studies.

Orbit/Attitude Determination Techniques
Dr. A.R. Molozzi, 996-9403
Mr. S.P. Altman, 596-9281

CRC is developing a sophisticated computer capability, to enable faster, much more accurate determination and prediction of satellite orbits than is possible with current methods. Algorithms are being verified and extended through use of Hermes satellite flight data. Both university and industry participants share in the work.

Propagation Studies for Broadcasting and Mobile Services
Dr. R.E. Barrington, 596-9311
Dr. F.H. Palmer, 596-9462

Entails development of propagation models to enable more accurate prediction of potential coverage and mutual interference in the VHF and UHF broadcasting and land mobile bands. Includes work with the FCC to co-operatively measure and assess anomalous long-range propagation in these bands in the Great Lakes region, West Coast border areas and elsewhere. Results should enable more effective channel assignments in these areas. Another important measurement program covers accumulation of radio wave amplitude data in urban areas, to improve and extend models currently in use for computerized propagation prediction. CRC now has both HF and VHF prediction programs and provides assistance and advice to the defence department and other clients. Requests for improved predictions for the standard broadcast band, which has been experiencing growing interference problems, are being assessed.

Radar Research
Dr. A.W.R. Gilchrist, 596-9426
Dr. F.H. Palmer, 596-9462

The radar field is advancing rapidly towards multipurpose, electronically scanned systems with easy adaptability to meet differing target and background conditions. DOC houses the principal public sector expertise in the field in Canada, carrying out both specific R & D projects for the defence department and background research. An experimental adaptive radar system involving a phased array and electronic scanning, as well as sophisticated digital data and signal processing techniques, is being developed at CRC as a test-bed for experimental and theoretical studies.

Radar Technology
Dr. A.W.R. Gilchrist, 596-9426
Mr. J.L. Lyrette, 996-0727

Continuing program of radar research and exploratory work to develop competence in advanced radar techniques, to further technology in areas of interest to Department of National Defence and to provide a basis for advice and assistance. Work focusses upon airborne, shipborne and ground radar; and signal processing. Staff are involved in radar aspects of new DND aircraft, ship and surveillance program developments.

Radio Noise Studies
Dr. J.S. Belrose, 596-9362
Dr. F.D. Green, 596-9359

Objective of this work is to develop technology for measurement of meaningful noise parameters, to help predict performance of sophisticated communications systems in the 3 MHz to 1 GHz (and above) region. Growing levels of man-made radio noise degrade system performance and limit efficient spectrum usage. Up until now, there have not generally been measurement techniques suitable for system performance prediction. Results of CRC work could help set noise radiation limits, develop better design and performance specifications and aid in surveys of potential radio sites. Important advances in development of instrumentation technology, power line corona noise modelling and measurement and characterization of sources and sites have been made. Work has also been carried out on high voltage DC transmission line noise and noise affecting landing and other aeronautical communications.

Re- radiation Problems in AM Broadcasting
Dr. J.S. Belrose, 596-9362

Research into effects of, and cures for, re-radiation from high-rise buildings, power lines and other structures in the vicinity of AM broadcasting stations' directional antenna arrays. While theoretical studies proceed, simulations of possible situations are being conducted on an antenna model range, with a view to developing a capability to predict pattern distortion effects. The next phase of the work will involve practical ways of reducing or eliminating re-radiation. The project is in response to representations from a working group of the Canadian Association of Broadcasters, CBC, DOC, CRTC and the Ministry of State for Urban Affairs.

Rural Telephone Systems
Mr. J.R. Marchand, 593-6072
Mr. A.T. Schindler, 993-6460

Part of DOC's rural communications program, seeking to establish an engineering framework for federal policies on telephone network development in rural areas. With the co-operation of telephone companies, investigations are expected to help plan a coherent domestic market for equipment and systems and stimulate new Canadian product design. Technology studies cover pole-line microwave, digital cable carrier systems, evaluation of high-sensitivity telephone sets and rural interface devices and concepts for radiotelephone systems and networks. Industry support will be solicited in organization of demonstrations and adoption of solutions developed under the program.

SARSAT
Dr. A.R. Molozzi, 996-9403
Mr. L.A. Maynard, 596-9348

A Canada-U.S.-France program to demonstrate an experimental search and rescue satellite system by 1981, using transponder packages designed, developed and built in Canada aboard polar-orbiting U.S. weather satellites. A relatively simple satellite system could provide search and rescue authorities with quick alarm alerts and position fixes when aircraft or other emergency locator transmitters (ELTs) go off. Such a system would greatly reduce the time needed to locate and rescue survivors of air crashes and other disasters. DOC is providing technical management of the project and other major support to the defence department, which is responsible for aerial search and rescue in Canada. This country will also develop and specify a SARSAT ground station and participate in evaluation of the total system.

Satellite and Antenna Control and Pointing
Dr. A.R. Molozzi, 996-9403
Mr. S.P. Altman, 596-9281

Work on control system technology required for the commercial communications satellites of the 1980s, for MUSAT (see MUSAT) and for other future Canadian spacecraft. Objectives include establishment of a viable Canadian supplier of such systems for both domestic and export markets. Underlying the work is rapidly evolving "strapdown" technology for guidance and control. Basic sensors are rigidly attached to vehicle mainframes and sophisticated on-board systems compute functions performed electro-mechanically in gimballed systems.

Satellite and Antenna Structures Development
Dr. A.R. Molozzi, 996-9403
Mr. S.P. Altman, 596-9281

Project seeking to maintain in Canada a familiarity with and industrial capability for, design and supply of critical mechanical systems and structures for future communications spacecraft. Such satellites will have large, deployable antennas and solar arrays and varying thermal dissipation requirements. Industry and university activity in materials and structures is sponsored. Designs, analytical models, technologies and models developed are checked out in CRC facilities and used by industry.

Satellite Control Operations
Dr. R.W. Breithaupt, 995-7783
Mr. N.G. Davies, 596-9215

Ongoing condition-monitoring, control and maintenance of orbiting Canadian government satellites. This task includes maintenance of spacecraft health, scheduling of operations, and reduction and provision of data for users. Spacecraft under control are Hermes, and those of the ISIS (International Satellites for Ionospheric Studies) program. (See also *Hermes Operations*.)

SHF Space Technology Development
Dr. A.R. Molozzi, 996-9403
Dr. M. Palfreyman, 596-9410

Includes development of microwave circuits, components, techniques and solid state devices for SHF satellite subsystems. A key objective is support and stimulation of Canadian industry in the field, through consultation and technology transfer. The present favorable competitive position of Canadian firms in 14/12 GHz satellite communications equipment is a result of this project. Future developments at higher frequencies (up to 40 GHz) are planned.

Shuttle Remote Manipulator System (SRMS)
Dr. A.R. Molozzi, 996-9403
Mr. S.P. Altman, 596-9281

Under an agreement between the National Research Council and the U.S. National Aeronautics and Space Administration (NASA), a Canadian industrial team is developing the shuttle remote manipulator system (SRMS) for the NASA space transportation system (space shuttle) which is about to revolutionize the launching of satellites and enable their in-orbit retrieval and repair. DOC is supporting this vital project through provision of technical assistance and by making available its David Florida Laboratory, where environmental testing of components and assemblies takes place.

Signal Environment Studies
Dr. J.S. Belrose, 596-9362
Dr. T.N.R. Coyne, 596-9288

Work complementary to radio noise studies, concentrating on emission arising from deliberate, intelligent transmissions – as opposed to "noise" from man-made devices (power line, auto ignition, etc.) and natural phenomena (lightning, galactic noise). Ability to measure quantitatively both noise and signal environment will provide DOC with data to resolve electromagnetic interference problems, better manage the radio spectrum and test consumer electronics for electromagnetic immunity. CRC has been developing an automatic, 3 MHz to 1,000 MHz system for measuring pertinent features of the radio signal environment (field strength, frequency, modulation, time domain characteristics, etc.). A comprehensive program of measurements will begin when development is complete. Needs for monitoring capabilities above 1 GHz will be identified and these capabilities developed.

Space Industrial Contracts Program
Dr. A.R. Molozzi, 996-9403

Involves an industrial contract fund intended to foster a strong independent Canadian capability in design, development and construction of future Canadian satellites, earth stations and components. Such a capability is needed to supply domestic and export markets. The program concentrates on development in industry of systems, subsystems and components. Close liaison with the Interdepartmental Committee on Space (ICS), Industry, Trade and Commerce and other departments is maintained.

Spacecraft Charging Studies
Dr. A.R. Molozzi, 996-9403
Dr. M. Palfreyman, 596-9410

This project aims at developing an understanding of the physical phenomena involved in potentially catastrophic failures of orbiting communications satellites, caused by spacecraft charging with high negative voltages. The charging, influenced by geomagnetic substorm activity and ultra-violet radiation, occurs at particular times and is blamed for actual reported failures. Work covers studies of charging effects on components and communications performance through monitoring, analysis and experiments. The practical objective in mind is to develop engineering guidelines and spacecraft test specifications to minimize the hazards to be faced by new satellites.

Spacecraft Power Sources
Dr. A.R. Molozzi, 996-9403
Dr. M. Palfreyman, 596-9410

Battery performance, the weakest element in present communications satellite design, is crucial in determining spacecraft reliability and longevity. It is vital that battery cells and the efficiency of their management be improved for future satellites. This CRC project will employ studies in Canadian industry to develop new electronic battery management systems. Researchers are also assessing the performance and reliability of existing and new cell types and developing test procedures and specifications.

Spectrum Systems Research
Mr. W.L. Hatton, 596-9341
Mr. E.A. Walker, 596-9526

Involves systems analysis of management options for the radio spectrum as a basis for DOC policy formulation. This new research activity is focussing first on developing necessary research expertise in demand analysis, technology forecasting, engineering, economic and social value analysis.

Strapdown (See *Satellite and Antenna Control and Pointing*.)

Structures
(See *Satellite and Antenna Structures*.)

Support for Spectrum Management
Dr. J.S. Belrose, 596-9362
Mr. M.J. Burke, 596-9288

The Department of Communications is developing a sophisticated, computerized spectrum management system (SMS), to assure more effective user-sharing of increasingly scarce channels and cope with the heavy engineering and other workload resulting from band congestion in urban areas. CRC support for the project includes development of a usage monitoring capability for the crowded land mobile bands, with quantitative definitions of channel performance and capacity. Monitoring plans and analysis procedures are being designed for several major urban areas, in order to provide for input to the SMS data base sufficient for more efficient management of the land mobile bands. Work is also proceeding on investigation of suitable parameters for quantitative description of channel usage, capacity and quality of service, and development of related algorithms. DOC spectrum managers will have CRC help in determining equipment requirements for an effective nation-wide monitoring capability.

SURSAT Experiments
Dr. A.R. Molozzi, 996-9403
Mr. L.A. Maynard, 596-9348

A surveillance satellite experiments project is being planned, to carry out a variety of environmental, surface detection, scientific research and territorial surveillance experiments in areas for which the Canada Centre for Remote Sensing (CCRS) has overall responsibility. A DOC scientist is attached to CCRS as a project leader. The department is also participating in a working group on related international co-operation. (See also Microwave Remote Sensing.)

Symphonie Communications Experiments
Dr. R.W. Breithaupt, 995-7783
Mr. L.A. Maynard, 596-9348

A program of experimental, cultural and technical exchanges between Canadian experimenters and similar groups in France and Germany, using Symphonie, an experimental Franco-German satellite, to promote Canada-Europe co-operation in science and technology. Proposed experiments are evaluated and recommended by a joint DOC, External Affairs and Teleglobe Canada working group. DOC and Teleglobe maintain earth terminals, co-ordinate use and advise users on interface problems.

University Research Program
Mr. J.L. Lyrette, 996-0727
Mr. J.R. Aubin, 996-0727

DOC's policy, research, space and operating sectors all utilize contracts with universities to carry out a variety of studies and investigations required to both meet departmental responsibilities and maintain communications expertise on Canadian campuses. The department tries to improve the effectiveness of the program by seeking provincial and industrial co-operation in areas of common interest and by encouraging sharing of significant results and solutions and through the transfer of technology .

Urban Network Studies
Dr. M. Fournier, 596-9387
Dr. G.W. Jull, 596-9217

Studies concerned with technical and economic factors impacting on integrated or separate development of cable television and telephone plant for distribution of both traditional and new telecommunications services to homes. The national approach towards expected heavy new demands for urban services seems to be leaning towards at least some integration.

Visual Ear
Mr. H.G. Bown, 596-9436
Mr. G.S. Collins, 996-4243

DOC is helping orchestrate development of a lightweight, hand-held terminal for the deaf to use for communicating via the telephone network. Being developed under contract, the device is intended for manufacture in Canada with efficient distribution to users. It features our alphanumeric keyboard and display capability.

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Research and Space Sector Budgets 1977-78

Total departmental budget	$84,133,000
Space sector budget % of total budget	$21,670,000 26%
Research sector budget % of total budget	$ 8,038,000 10%
Total research and space sectors % of departmental budget	$29,708,000 * 36%
Contracts	
Space sector contracts % Contracted	$12,933,000 60%
Research sector contracts % Contracted	$ 2,933,000 36%
Total research and space contracts % of research & space budgets contracted	$15,871,000 53%

* Includes $1,189,000 paid by Department of National Defence (DND). DND also provided $1,780,000, for contract and other support of these R&D projects, which does not appear in the DOC budget.

Proposed Research and Space Sector Budgets 1978-79

Proposed total departmental budget	$101,656,000
Proposed space sector budget % of total budget	$ 38,857,000 38%
Proposed research sector budget % of total budget	$ 8,663,000 8%
Total space and research sectors % of total budget	$ 47,490,000 * 47%
Contracts	
Estimated space sector contracts % Contracted	$ 32,640,000 84%
Estimated research sector contracts % Contracted	$ 3,464,000 40%
Total estimated space and research contracts % of research & space budgets contracted	$ 36,104,000 76%

* Includes an estimated $1,270,000 to be paid by DND for effort on DND projects. DND is also planning to lend man-years to DOC for additional R&D support, and to provide significantly increased funding for contract R&D effort in connection with new defence programs.