THE DEPARTMENT OF COMMUNICATIONS RESEARCH PROGRAM

LE PROGRAMME DE RECHERCHE DU MINISTÈRE DES COMMUNICATIONS

COMMUNICATIONS TECHNOLOGIES RESEARCH

Communications Canada

The Communications Technologies Research Laboratories are located at the Communications Research Centre, five kilometres west of Ottawa, at Shirleys Bay
3701 Carling Avenue,
P.O. Box 11490,
Station H,
Ottawa, Ontario
K2H 8S2
Telephone: (613) 998-2261
Fax: (613) 990-7983.

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COMMUNICATIONS TECHNOLOGIES RESEARCH

The Communications Technologies Research (CTR) Branch performs generic research and development (R&D) to meet Canada's long-term needs in radio and satellite communications systems and services. It also promotes the application and introduction of these technologies. Through its research, CTR builds the technological base upon which future terrestrial and satellite radio systems can be developed and incorporated into Canada's communications and information networks.

CTR's activities complement the research and development performed in universities and industry, working closely with the private sector to ensure the effective transfer of these technologies. The Branch's clients include federal and provincial departments, radio and satellite communications (SATCOM) service providers, user groups, manufacturers, and R&D application centres.

Research activities are organized around three fields of endeavor:

- advanced communications satellite technologies, systems and applications;
- emerging terrestrial radio communications technologies and systems; and
- radio propagation.

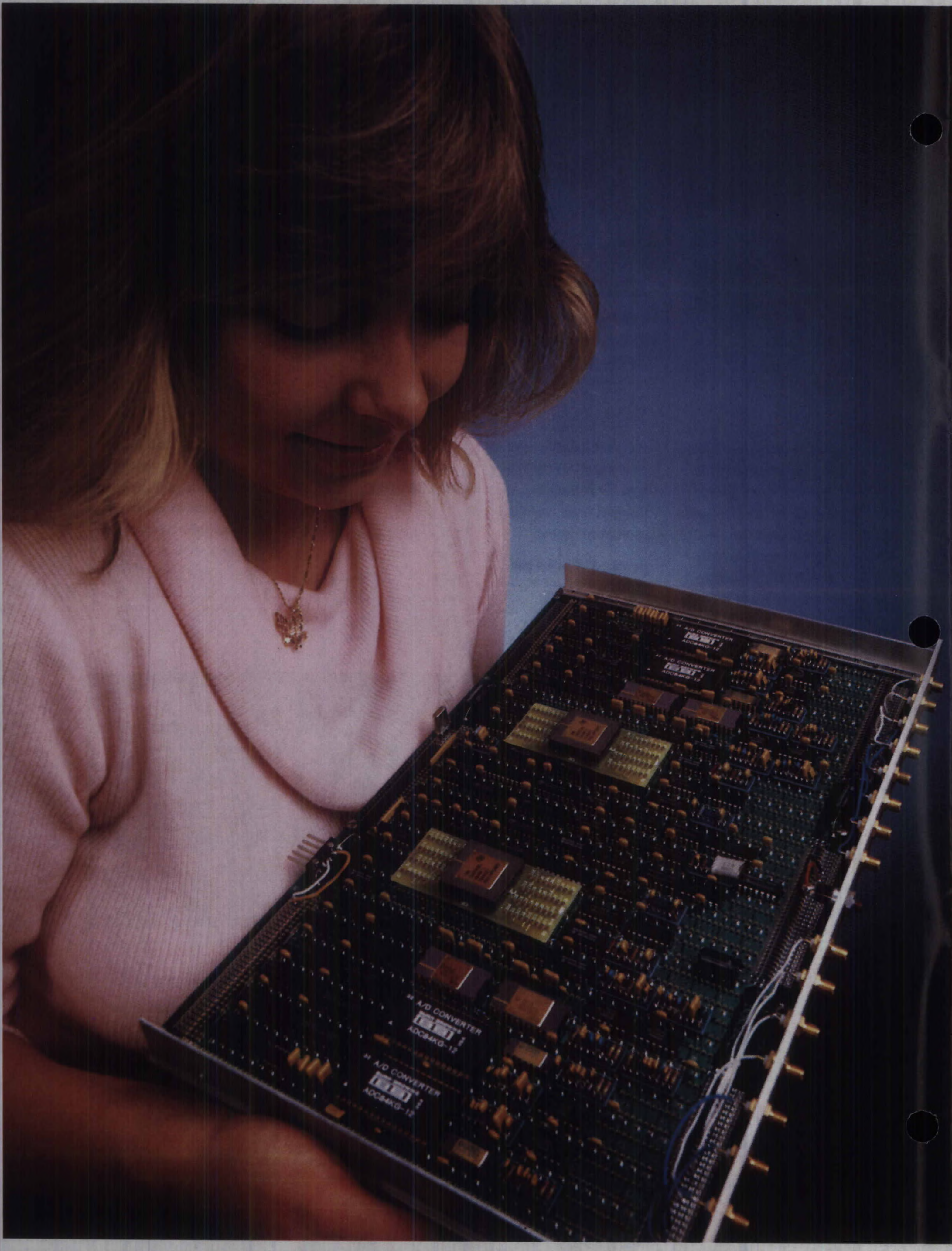
Two major projects are:

- MSAT, a commercial mobile communications satellite to be launched in late 1993 or early 1994; and
- SHARP, the Stationary High Altitude Relay Platform, now in its early research stage.

ADVANCED SATELLITE COMMUNICATIONS

Satellite communications projects are long-term endeavors, typically ten years or more. The research is normally a mix of generic technology development (modulation and coding, for example), design and demonstration of new systems (like the Ontario Air Ambulance project), and technical support of very large projects to

Artist's impression of MSAT.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develop new satellite systems and services like MSAT. CTR is also responsible for long-term research into concepts and technologies suitable for future generations of communications satellites.

The Branch's support for major communications satellite projects includes consulting services, project management and hardware development. CTR develops payloads, performs mission analysis, plans satellite communications systems, provides launch support and evaluates proposals. In addition to MSAT the Branch supports Radarsat and other large projects, and is starting work on a new satellite for personal radio communications.

Mobile Satellite Technology. One of the main impediments to new applications of satellite technology is the scarcity of available radio spectrum. To improve spectrum utilization, CTR conducts research and development on modulation and coding concepts for specific propagation environments. These concepts are tested using prototype earth terminals and existing satellites. The goal is to develop commercial terminals that are as economical and as efficient as possible in terms of frequency and power consumption.

Good-quality voice service is possible with radio frequency bandwidths as small as 2.5 kHz. The Branch is therefore pursuing the development of very narrow band modulation concepts to use where the spectrum is severely limited. This research has already produced the modulation concepts required for MSAT (ACSSB and Trellis Coded Modems, for example) and concepts for future personal communications. CTR cooperates with industry to transfer this technology to the private sector and to help implement new satellite communications services.

Aeronautical Satellite Services. The Branch is working with INMARSAT to develop and implement an international satellite voice and data service for commercial aircraft. The generic technology being developed for this project is not limited to commercial aircraft; it can also be used in general aviation, both domestic and international. The satellite voice communications service used by the Ontario Air Ambulance system is an excellent example of the application of this type of research.

Ontario air ambulance used for aeronautical satellite communications experiments.

Personal Communications by Satellite could offer the individual user unrestricted access to state-of- the-art communications services anywhere in Canada via an integrated network that uses both terrestrial and satellite technologies. Preliminary R&D and program planning are under way.

Satellite On-Board Processing is increasingly important to future communications satellite systems. The Branch has been studying the basic group demodulation process, particularly the concept of an analog group demodulator using surface acoustic wave (SAW) technology. At the same time, CTR is investigating various concepts for a digital group demodulator.

EHF Satellite Communications Experiments have been planned, using a repeater on board the European Space Agency's Olympus satellite. The main experiment will demonstrate the SAW-based group demodulator in a double-hop mode, using a 4.2-metre hub station and two 1.8-metre remote terminals.

General purpose digital processing circuit board, developed by CRC.

MOBILE SATELLITE (MSAT)

MSAT mobile terminal with roof-mounted tracking antenna.

Novel L-Band antenna designed by CTR for MSAT mobiles.

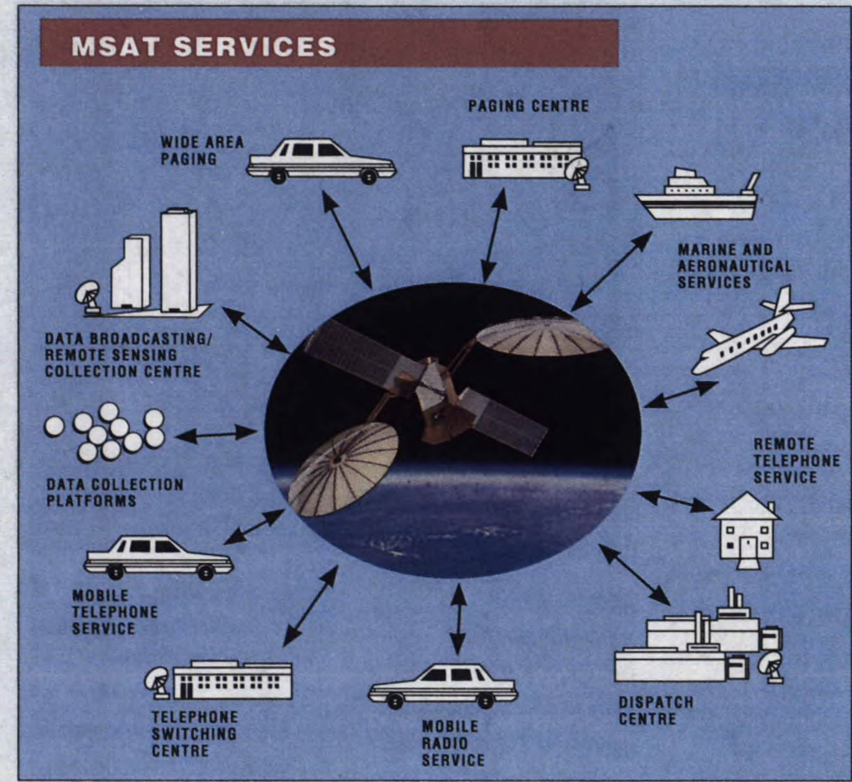
The Communications Technologies Research Branch spearheaded much of the early research and program development activities in the new, commercial, mobile satellite communications system and service known as MSAT. The system will provide a direct link for Canadians in rural and remote areas to public and private mobile radio systems, and with the public telephone systems. It will also provide two-way voice and data services to vehicles, ships and aircraft, and to portable stations that will need to venture beyond the range of land-based networks. When launched in late 1993 or early 1994, the MSAT satellite will be owned and operated by Telesat Mobile Incorporated (TMI).

The System

One Canadian satellite will serve Canada and a similar American satellite will serve the United States. Each satellite system will back up the other. On the ground, a Central Control Station will control the satellite and manage the flow of communications. An intricate network of privately-owned base stations and gateway earth stations interconnected with the public telephone network will ensure module terminal accessibility – of which there may be more than 150,000 – to any fixed location in North America. Most mobile terminals will be about the same size as present mobile units, working in conjunction with small roof-mounted antennas. Terminals small enough and light enough for a person to carry will also be available.

The Service

MSAT will provide a range of public and private voice and data services. Data communications includes such services as two-way messaging, position reporting and text transfer. It will also be able to collect data transmitted from remote



MSAT services.

monitoring and alarm installations, and to send commands to automated control stations. Nationwide paging, broadcast weather forecasts and agricultural information will also be possible. Truck operators will be able to monitor their fleet from their dispatch centre. In some cases, voice radio may be used with data transmission to offer enhanced services.

Business Opportunities

***M**SAT offers many unique new opportunities, both in manufacturing and in services. Canadian manufacturers can build: mobile radio, telephone and data terminals; spacecraft and allied sub-systems; and gateway and base stations for sale domestically and abroad. Telephone companies, radio common carriers and equipment suppliers will be able to extend their services or develop and market new services.*

CTR Support Activities

***C**ommunications Technologies Research is helping to develop a portfolio of new services for MSAT's subscribers and to define an industrial strategy for developing ground terminals and spacecraft subsystems in Canada. The Branch is carrying out developmental work on antennas, modulation and voice-coding techniques and drawing up standards for equipment and licensing. In addition, the Branch is heavily involved in spectrum allocation and international frequency coordination issues critical to the effective implementation of the MSAT system and service. Beginning in 1990, the Branch will carry out pre-launch demonstrations of the voice and data capabilities. Trials and demonstrations will continue once MSAT is in orbit, while government users will benefit from commercial MSAT services through a $126.5 M service lease agreement negotiated between the Branch and TMI.*

Search and Rescue Development support is provided to the National Search and Rescue Secretariat (NSS) under a memorandum of understanding. CTR is developing equipment and techniques to add position-locating information to distress beacons. The Branch is also investigating the use of various geostationary and low earth-orbiting satellites for search and rescue.

Military Satellite Communications support to the Department of National Defence in developing a prototype satellite system capable of reliable operations in hostile environments is another CTR project. The Branch helps with the industrial contracting and is designing a simulator for the satellite payload. In addition, the Branch is conducting longer-term research into spacecraft-based signal processing techniques, both in its own laboratories and through contracts with universities. CTR is also looking into laser communications systems to link satellites to each other.

RADIO COMMUNICATIONS TECHNOLOGIES

Most of the research and development in terrestrial radio communications that CTR carries out for the Department of National Defence involves state-of-the-art communications technologies.

Voice Coding. Voice communication is essential to military command and control, and in many cases it is important to be able to recognize the speaker's voice. Digital speech processing makes encryption easier and permits voice messages to be transmitted along with data. Bandwidths, however, must be smaller than those used in ordinary digitized telephone transmission. CTR has therefore developed narrow-band voice coders that yield good voice quality and resist background noise and interference. Some of these applications have been licensed to Canadian industry for civilian products.

A 4.2 metre Ka Band Earth Station, used with Olympus trials.

Multi-Media Communications. Operating efficiency, economy and functionality all demand that military communications evolve into integrated networks. It will be necessary to integrate several different media such as HF, VHF, UHF, SAT-COM, and optical fibre into a single multi-media communications system. CTR has developed a packet-switched HF network that is expected to improve HF communications in locations like the Arctic (where the ionosphere causes problems) and Europe (where radio noise is high because the spectrum is heavily used). A sophisticated network simulator for evaluating networking architectures is under development, and the Branch is also investigating optical LANs and developing expert systems for network management.

Electronic Counter-Counter Measures. In military operations, it is important to protect communications against interference – accidental or deliberate. Electronic counter-counter measures are the means used to achieve this. These techniques normally involve sophisticated modulation and demodulation techniques or tactics such as self-adapting antenna arrays that can point "nulls" in the direction of interfering transmitters.

Trail Radio, designed by researchers at CTR, enables people in remote areas to contact home and to report their position without relying on an operator at a base station. With Trail Radio a user can dial anyone in the telephone system, or be selectively reached via a direct dial-access base station. This offers significant improvements over ordinary portable radio.

Modular in design, implementation and operation, the trail radio system is flexible. The concept allows high frequency (HF) and very high frequency (VHF) systems to be interconnected, thereby providing better, more reliable and improved radio communications.

Other Projects Under Development include:

- developing high-speed, limited-distance, transportable, wireless data and voice LANs that can be deployed rapidly;
- using thin-route UHF relay as a backup for the primary communications systems of the North Warning System;
- exploring the use of SHARP to provide a variety of communications services.

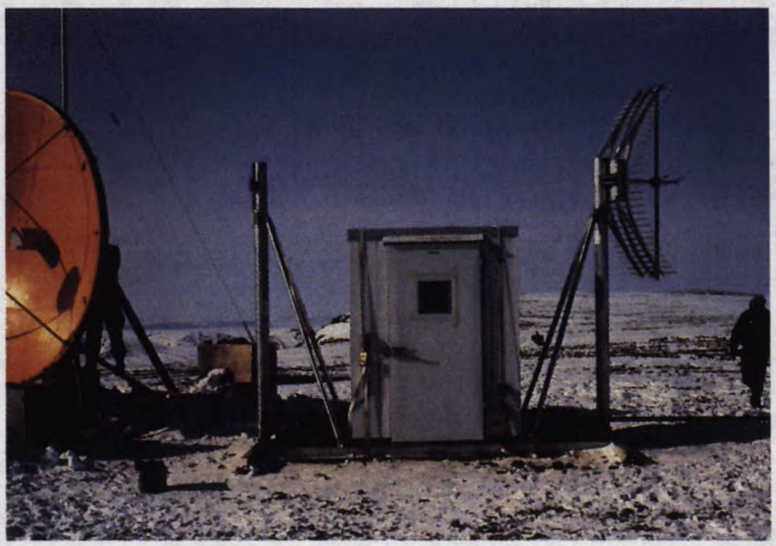
RADIO PROPAGATION

Most of the basic research into radio-wave propagation conducted in Canada is carried out by CTR. The Branch studies the interaction of radio waves with various media and environments, primarily to lay the technical basis for Canada's participation in making spectrum allocations at the national and the international levels. Three aspects of propagation are of particular interest:

- determining the characteristics of those parts of the radio spectrum not currently in use;
- investigating how radio systems perform in changing environments; and
- increasing the information-carrying capacity of those parts of the spectrum in greatest demand.

Indoor Radio is one of the most difficult of the potentially significant areas under study. The increasing demands for personal wireless communications and for mobility and flexibility have led to the concept of using radio instead of wire inside buildings. However, the characteristics of the propagation channel and the compatibility between such systems operating in nearby or adjacent buildings affect the performance of indoor radio systems. Such effects as reflection from walls, from furniture and even from people are being studied, as well as propagation losses between offices and between buildings.

Land Mobile Propagation is a special problem because the mobile antenna is close to the ground and its environment changes constantly. The signal can be reflected from trees or buildings, and often its direct path is blocked. Thus, the signal level is highly variable and it also echoes from nearby objects, resulting in a spread of short signals that makes it difficult to transmit information at a high rate. Since the trend is towards digital communications at increasingly higher data rates, the characteristics of the channel are being measured to optimize circuit performance.



Connecting a satellite terminal to a radio-relay system in the Arctic.

Microwave Links, for the most part, operate on paths that are free of blockage. Nonetheless, the refractive properties of the atmosphere change and the effects increase as the transmission rate increases. Signals can arrive at a receiver by several paths and can interfere with each other. Microwave signals can also be attenuated by rain, melting snow, clouds, water vapour or oxygen (depending upon the frequency). Finally, the strength of the signal affects the reliability of the circuit. CTR investigates the characteristics of signal fading in order to design systems that operate with predetermined reliability.

VHF and UHF – the frequencies between 30 MHz and microwaves – are used in TV, FM radio and land-mobile communications. CTR has developed a computer program to predict propagation attenuation at these frequencies. An important component of the program is a database of terrain elevations and characteristics, which permits automatic calculations without consulting topographical maps.

The ionosphere reflects radio waves at frequencies up to approximately 30 MHz, depending on solar activity. As a result, these radio waves travel long distances. Geographically, Canada is located at a high latitude where the ionosphere is often disturbed by auroras and geomagnetic storms. Radio-wave propagation studies have been conducted at all frequencies below VHF. Because of a renewed interest in the HF band, CTR is carrying out some work in this area.

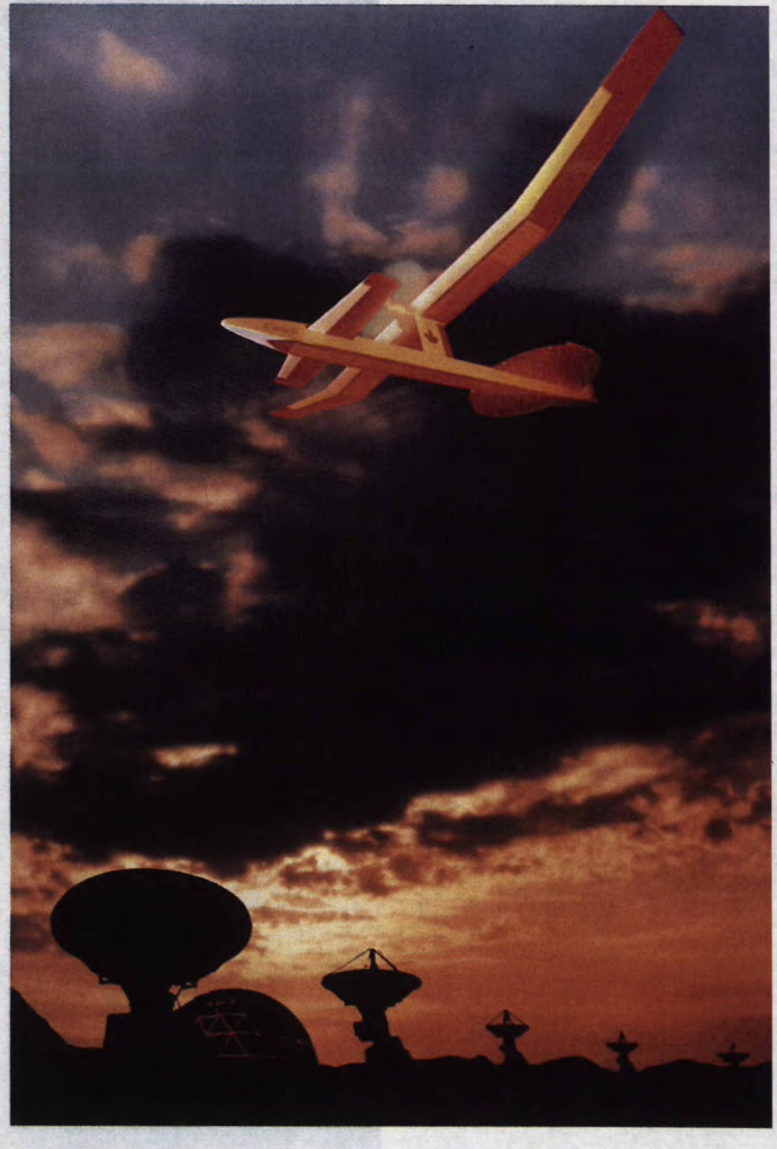
Propagation measurements for micro cellular radio (a proposed system that could involve repeaters at lamp post height).

Earth-Space Propagation. Using higher frequencies for satellite communications relieves congestion in the crowded parts of the spectrum and permits the use of smaller antennas. On the other hand, attenuation from rain, melting snow and clouds can be more severe at these frequencies. The Branch is measuring beacon signals from the Olympus satellite to assess these effects. Also, in co-operation with the Association of South-East Asian Nations, CTR is studying the effect of tropical rain on earth-space attenuation statistics.

Antenna Effects. Electromagnetic antennas interact with the ground and with objects nearby to produce unwanted effects. This is particularly critical with large antenna systems. The demands for improved efficiency and bandwidth call for new antenna design concepts. CTR uses scale models and sophisticated mathematical methods to find ways to reduce unwanted electromagnetic effects and to improve antenna design.

A UHF repeater site. Equipment similar to this is being developed to provide back up communications for the radars in the North Warning System.

SHARP



Artist's impression of SHARP in flight.

Researchers at the Communications Technologies Research Branch are exploring the use of a microwave-powered, high-altitude, pilotless platform to serve a variety of communications requirements and services. SHARP, the Stationary High Altitude Relay Platform, would circle above the surface of the earth at an operating altitude of 21 km, relaying signals on the ground over a fixed circle of approximately 600 km in diameter. A novel feature of SHARP is its source of power. Microwaves beamed from the ground would permit the platform to remain aloft for six months to a year, landing only for maintenance.

The feasibility of this concept was demonstrated in 1987 with the successful flight of a 1:8 scale prototype – the first aircraft in the world powered by an energy beam.

Developed further, SHARP could deliver specialized services such as mobile communications, radar surveillance, direct-to-home broadcasting, remote sensing and environmental monitoring. SHARP could prove to be an effective means of providing wide-area surveillance such as monitoring fishing vessels in coastal waters, continuous ice reconnaissance for the Canadian Coast Guard, early warning of approaching aircraft, and long-term monitoring of atmospheric pollutants.

Research performed at CTR resulted in the development of efficient, dual-polarized, printed antennas – one of the technologies required for high-altitude microwave-powered platforms. These antennas receive and convert the microwave energy to direct current power. In addition, research carried out under contract to CTR has led to the design of cost-effective microwave power transmission systems and the development of a unique platform ideally suited to beam powering.

Collaboration with industry, universities, provincial and federal departments and agencies will further refine the market opportunities for SHARP-based systems, and will help to determine research and development activities for commercialization by the mid-1990s.

A digital telephone developed at CRC, that transmits high quality voice at 4800 bits per second.

TECHNOLOGY TRANSFER AND COLLABORATION

CTR supports long-range technological development. Many of the new technologies and systems it develops directly benefit Canadian industry, opening up new services and markets.

Technology and knowledge is transferred to industry in various ways, depending on industry's interests and needs. Support programs, such as the Industrial Research Assistance Program (IRAP), help industry to take laboratory innovations and develop them into new products. Arrangements under IRAP often include access to the laboratories and technical experts at the Communications Research Centre.

CTR frequently contracts directly with industry and universities to carry out research and development. It also undertakes joint projects with industry and research organizations, both national and international. In these cases, CTR draws up memoranda of understanding with these organizations that describe areas of mutual interest and protect intellectual property.

From time to time, research fellows, exchange scientists, professors on sabbatical leave and students work in CTR's laboratories, as do scientists from industry. This promotes direct contact among researchers and expands Canadian expertise.

Canada is a very large, thinly populated country and communications are its lifeblood. For Canada to remain in the forefront of communications technology, applied research is fundamental. Communications Technologies Research works closely with industry and academia in the field of radio communications to guarantee that Canada maintains and enhances the needed expertise.

Downed aircraft located using CRC-developed Position Determination System.

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