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Review

CANADIAN SATELLITE COMMUNICATIONS PROGRAM

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ABSTRACT

In 1962, Canada became the third nation in the world, after Soviet Union and the United States, to pioneer satellite communication. Since then it has enjoyed a series of impressive firs: it was the first country to establish a commercial satellite communication system, the first to experiment with direct broadcast satellite systems and the first to conceive a mobile communications systems via satellite. In future application of highly sophisticated synthetic aperture radar satellite for remote sensing, surveying etc. are planned. In this paper an overview of Canadian Satellite Communication Program will be presented.

1. Introduction

Canada has a land area of almost 10 million square kilometers and a population of 24 million people. Although 75 % of its population live in urban areas that are within 350 kilometers of the Canadian-US border, these communities are spread out on an east-west direction by more than 4000 kilometers. In addition there are many small, relatively isolated communities located in the north. Providing a reliable communication and broadcasting services to such a widely dispersed population using conventional terrestrial systems could be a major technical and financial problem. As a result Canadian Government and industry were quick to appreciate the potential of satellite communication for domestic and international use and capitalize on it.

In the intemational sphere, in August 1964, Canada became one of the 11 founding members of the International Telecommunications Satellite (INTELSAT Consortium. Five years later, in September 1969, the Parliament of Canada implemented a legislation creating a domestic satellite communications carrier to provide telecommunication and broadcasting services 'to meet the unique needs dictated by the country's geography'.

Today, Canada excels in the development and manufacture of communications satellites and earth stations. Canada's space communication industry employed 3,200 people fulltime and enjoyed sales of $ 300 million in 1984. The Organization for Economic Cooperation and Development (OECD) has noted that 70 percent of these sales were exports, giving Canada's space industry by far the highest ratio of exports to sales among nations with space industry[1].

In Canada, applications of satellite communication have been diverse. Some examples of

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which are voice, data and video transmission, long distance health care, innovative broadcasting, distant education, weather briefing for pilots, winter road maintenance, remote sensing, satellite aided search and rescue etc.

There are a number of different organizations which have had a major role in the development and exploitation of satellite communication services in Canada. Their jurisdictions are as follows:

- experimental satellites are the purview of the Canadian government through its Department of Communications (DOC).
- domestic satellite communications come under the aegis of Telesat Canada and Telesat Mobile Inc.
- international satellite communications are the responsibility of Teleglobe Canada
- recently established Canadian Space Agency has the mandate to work with the space industry, universities and provincial governments to enhance application of satellite communication, space exploration and development in Canada.

Traditionally, the Government of Canada through Department of Communication has been involved, in varying degrees, in each area. For example, the government was responsible for the formation of 50:50 government/privately owned Telesat in 1969 but it does not control it. Telesat serves Canadian national political interests as well as have commercial objectives of its own. Similarly, Teleglobe Canada was formed in 1950 as Canadian Overseas Telecommunication Corporation, inaugurated by the Canadian Government as part of a 1948 agreement with British Commonwealth countries. Under the Commonwealth Telegraphs agreement, it was decided to put international communications into the hands of Commonwealth Governments rather than into those of private companies. However, at present Teleglobe Canada is a fully privatized company.

Telesat Mobile Inc. (TMI) began commercial operations on December 1988 with the signing of a shareholder agreement between Telesat Canada, Canadian Pacific Ltd. and the C. Itoh Group of Japan. TMI's mission is to construct and operate a commercil mobile satellite system in Canada.

In the following, the functions of these organizations in the context of satellite communication in Canada will be treated.

2. Department of Communication (DOC) and Canadian Space Agency

Acting on behalf of the Canadian Government, the DOC has been active in the forefront of satellite communications for almost 30 years. The interests of the DOC in the satellite communications were motivated by two factors:

- to improve the technology of communications such that communication satellite manufacturing capability develops within Canadian industry
- to provide communications and broadcast services to all Canadians including those living in remote, isolated localities.

In 1962, Canada became the third country in the world to pioneer satellite communications through Alouette 1, an upper atmospheric research satellite. The satellite was built by Canada and launched by the U.S. National Aeronautics and Space Administration (NASA) in a co-operative Canada-United States programme. This was followed by many more successful made in Canada satellites, Alouette II, Isis I and II into the space history. Much of the scientific data and industrial and operational competence developed in these programmes were put to practical commercial use

when Telesat was created few years later.[2]

Since 1972 the Ministry of National Defence has been in charge of managing the COSPAS-SARSAT program in Canada. The program is for search and rescue of survivors involved in air or maritime disasters. The program is a joint collaboration between U.S.A, France, U.S.S.R and Canada. DOC provided technical assistance to the fabricadon of repeaters, ground stations, mission control centre for SARSAT in Canada during its R&D phase. The engineers of DOC also led to a good end of technical trials and complex simulation exercise of SARSAT.

In 1976, DOC teamed up with the NASA and European Space Agency (ESA) to develop and launch Canada's eighth satellite the Communications Technology Satellite (CTS). Once launched, CTS was re-christened 'HERMES', and began its intended two year mission. The HERMES contributed a number of space 'first' to Canada, including[3]:

- the first 14/12 GHz transponder in space
- the highest-power communication satellite in orbit, both in array output and transmission EIRP terms
- the first flexible blanket solar array on geostationary orbit.

Its performance and usefulness in orbit was so successful that funding was granted by the Canadian government to extend its mission life several times. The technological expertise obtained from the HERMES program was extensively used in designing the 14/12 GHz payload of Canadian second generation domestic satellites ANIK-B and C. Also, the experience gained by Canadian industry on the program was instrumental in allowing it to become a major competitor in this field. The testimony to which is Spar Aerospace getting prime contracts for ANIK-D and other satellites.[3]

Again, in early 1980, the DOC in co-operation with NASA directed its efforts to conduct preliminary studies on the use of satellite technology for public mobile communication services (MSAT) in Canada and the U.S. These studies explored system concepts and gave strong indications that market demand would be sufficient to ensure the future viability of mobile satellite systems. Consequently, the DOC defined and carried out a complete plan for the implementation of Mobile Satellite Services (MSS). Based on an extensive dialogue between government, industry and users and encompassing all technical, economic regulatory and institutional aspects, this plan resulted in the completion by 1986 of a comprehensive business plan and a decision for commercial MSS delivery. The Canadian lead for a commercial system was quickly followed by others, and in particular the U.S., giving rise to the concept of North American MSS[4].

Effective April 1986, the Canadian MSAT Program has been turned over to the private sector with DOC maintaining a support and oversight role. Now, Telesat Mobile Inc. (TMI) has been authorized to provide MSS in Canada. TMI along with their counterpart, the American Mobile Satellite Corporation (AMSC) of U.S.A have started to develop compatible satellite and ground segment towards an operational North American MSAT system by late 1993.

In March, 1989 the Government of Canada announced the establishment of a new Canadian Space Agency(CSA) to coordinate Canada's civilian space program, which has an anticipated budget of almost $3 billion to the end of the century. The Agency will be involved in directly managing or coordinating the majority of present and future canadian space program and space communication related activities.

Presently, DOC along with CSA, is involved in Olympus program. The program is a joint venture in space with the European Space Agency (ESA) providing overall management. Canada has participated in the program since its inception in 1980 and is the third largest contributor.

There is also a significant participation by Canadian industries e.g. Spar Aerospace, Canadian Astronautics etc.

The Olympus-1 satellite was launched in July 1989. DOC is performing experiments with one of its payload by means of the Olympus-1 steerable beam antenna[5].

The CSA is involved in the management of a highly advanced remote sensing satellite project called RADARSAT. The program is the result of close collaboration between federal and provincial governments, Canadian industry and other potential users of the data. NASA will provide the RADARSAT launch in exchange for data to support its research program. The launch is scheduled in 1994.

RADARSAT will carry a synthetic aperture radar(SAR) that sends signals to earth and record their reflections to form its highly detailed images or 'pictures'. This distinguishes it from existing satellite technologies for earth observation, which cannot see through cloud or in darkness. RADARSAT data will be used for agricultural management, forest mangement, topography map production, environmental management, natural disasters and emergency monitoring etc. through out the world[6].

The 3200 Kg. RADARSAT comprises two parts, almost equal in weight, the platform and the payload module. The platform provides the power from solar panels, the thrusters and attitude control and communication link for spacecraft control. The payload module consists of the SAR with its antenna which will be 15 meters long and 1.5 meters wide when unfolded in space. The antenna will be able to point its beam anywhere within a swath of 500 Km between 20 and 50 degrees off the side of the satellite. This means the whole Canada can be covered once every 72 hours and the Arctic every day[6]. In Fig. 1 and Table 1 SAR operating modes and characteristics of the SAR beams are presented.

3. Canadian Domestic Communication Satellite Systems

3.1 Fixed Satellite Systems

The Canadian domestic fixed satellite system is the responsibility of Telesat Canada. It has a

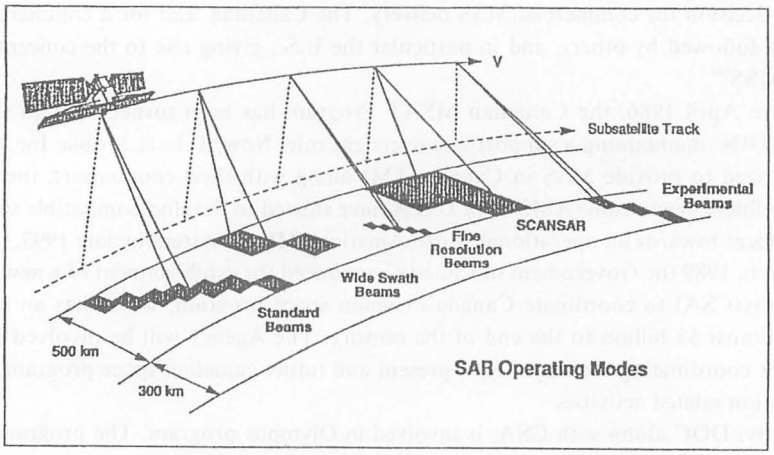

Fig. 1 SAR operating modes.

Table 1 Characteristics of RADARSAT SAR beams

	Standard Beams	Wide Swath Beams	Fine Res. Beams	SCAN SAR Beams	Expt. Beams
Incidence Angle	20-49 degs	20-40 degs	37-49 degs	20-49 degs	49-59 degs
Swath Width	100 Km	150 Km	45 Km	300 or 500 Km	75 Km
Res.	28x25 m 4 looks	28x35 m 4 looks	10x10 m 1 look	100x50 m, 8 looks	28x30 m

mandate to provide, on a commercial basis, satellite telecommunications system between locations in Canada and, subject to appropriate inter-governmental arrangements, service to and between other locations.

With the formation of Telesat in 1969, an initial budget of $ 90 million was set to procure space and ground segments for the first domestic satellite project of Canada. In August 1970, Telesat contracted Hughes Aircraft Company (HAC) for the provision of three satellites. The satellites were christened 'ANIK', the eskimo word for brother. Telesat also contracted NASA for the launch of satellites. ANIK-I (later known as ANIK-Al) was launched in November 1972 and was placed in the geostationary orbital position of 104 West. ANIK-I was put into commercial services in January 1973, making Canada the first country in the world with its own geostationary domestic communication satellite.

The ANIK-A2 and A3 was launched in April 1973 and May 1975 respectively. By the end of 1977, the Telesat had three ANIK-A satellites each having 12 transponders, and some 90 earth terminals. These interconnected all the major cities of Canada, and many small communities, into a network that provided TV distribution, radio, telex, data transmission and facsimile services. Isolated northern communities were able to eliminate their previous reliance on HF radio, and obtain reliable, year-round radio contact with the rest of Canada. more than 40 small (less than 12000 population) communities were able to receive highquality network TV.

In December 1975, Telesat signed a contract with RCA to provide next generation satellite called ANIK-B. This satellite was an advanced dual-band satellite designed to provide telecommunications services in both the conventional 6/4 GHz and 14/12 GHz band. To promote the use of 14/12 GHz band DOC leased the channels of this band from Telesat , purchased some 100 terminals with 1.2 or 1.8 m antennas and paid to have them installed at the homes of selected families throughout Canada. On September 1979, Canada became the first country to begin broadcasting television by satellite direct to the home in 14/12 GHz.

In 1977 anticipating higher growth in the demand for telecommunication, Telesat initiated a procurement action for new satellite series called ANIK-C. Three satellites of this series ANIK-C3, C2 and Cl were launched in November 1982, June 1983 and April 1985 respectively. ANIK-C satellites have 16 transponders each capable of carrying two FM TV signals or equivalent data rate of 91 Mbps in the 14/12 GHZ band. These satellites provide coverage of virtually all of populated Canada by means of four spot beams focussed on the western, western-central, eastern-

central, and eastern regions of the country. Depending on needs and budgets, Telesat customers can choose quarter country, half-country, or whole country coverage.

ANIK-C3 was Canada's first dedicated telecommunications spacecraft to offer point-to-point commercial services using 14/12 GHz band of frequency. It offers time division multiple access (TDMA) transmission for the Trans-Canada Telephone Systems (TCTS) and Integrated Satellite Business Network (ISBN). For video transmission, numerous Canadian pay TV, educational TV, news service of Canadian Broadcasting Corporation (CBC) and many other networks use its service. Some of the transmission are whole Canada wide others are carried on only to a part of the country[7][8].

Anik-C2 was initially deployed at a orbit of 105 West to provide a quasi-DBS service to 26 states in the northeastern portion of the United States on behalf of United Satellite Communications Incorporated (USCI) of U.S.. Telesat leased five of ANIK-C2 satellite transponders to USCI through GTE Spacenet of U.S.. However, after USCI discontinued its service, Telesat relocated the spacecraft to 112.5 West in 1985. Using ANIK-C2, Telesat now offers a number of innovative voice, data and image services to satisfy the communication need of Canadian businesses and governmental organizations[7].

When the ANIK-C satellite program was planned in 1976-1977, the forecasts for Canadian satellite utilization in the 1980s for long distance telephone, business telecommunication services and television distribution were extremely bright. However, as a result of economic recession, emergence of alternate technologies etc. demand for satellite use was much lower than expected. This prompted Telesat to offer their ANIK-Cl for sale to reduce investment in plant and develop new satellite optimized for the future business. However, it was never realized. Now with their spare capacity Telesat provides back-up satellite services for customers like British Satellite Broadcasting Limited (BSB), Telecom Canada etc.[9]-[11]

ANIK-D satellites were designed to replace the aging ANIK-A and B satellites. The satellites of this series operate in 6/4 GHz band and have 24 transponders, each of which capable of carrying 1 color TV signal or an equivalent of 900 one way voice channels. The satellites were built by Spar Aerospace Ltd. of Canada.

The first satellite of this series ANIK-Dl was launched in August 1982 and currently carries telecommunications on behalf of the CBC, Global TV Networks, Canadian TV services, Canadian Radio Broadcast Services, private business Networks for VSAT and other services and Government of Canada for Canadian Hydrographic services[7].

ANIK-D2 was launched in November 1984 and was placed into a storage orbit as Telesat did not require its capacity initially. In November 1985, it was placed at the orbital slot of 111.5 west and the traffic from ANIK-B was gradually switched over. Since, the capacity of ANIK-D2 is two times that of ANIK-B, new channels have been allocated for several other Television companies, and for low cost private line voice/data communication between customer offices in North America.

In October 1986, Telesat and Spar Aerospace made a contract for Canada's next generation of telecommunications satellites: ANIK-El and ANIK-E2. The satellites are scheduled for launch in 1991. Each of the satellites will operate in both 6/4 and 14/12 GHz bands and will carry an equivalent capacity of 56 TV channels, or approximately the combined capacity of one ANIK-C and one ANIK-D satellite. ANIK E's 6/4 GHz band footprint will be equivalent to the existing footprint of the ANIK Dl and D2 satellites. In 14/12 GHz band one of the satellite antennas will be able to generate either half- or full-Canadian coverage beams, while the other will provide extended cross border coverage (ECBC) of the contiguous U.S. With the launch of ANIK El, for

the first time Telesat will be able to provide national coverage via a single Ku-band transponder. In Fig. 2 the antenna coverage of both bands are illustrated[3].

Both ANIK-E satellites have been designed to meet Telesat's communications requirements until at least the year 2000. After launch, ANIK-El satellite will take over the TV and radio broadcast traffic now carried by ANIK-Dl and ANIK-C3 which will reach the end of their mission lifetimes in the early 1990s. ANIK-E2 initially will be placed into a storage orbit and in 1992 it will take over the traffic now carried by ANIK-D2 and ANIKC2.

In Table 2 a short specification of all ANIK satellites are given for comparison[3][7].

3.2 Mobile Satellite Systems

Besides, fixed satellite systems, in the field of domestic Mobile Satellite Communication (MSAT) Canada is rapidly moving forward. TMI of Canada which was formed in December 1988 under joint agreement between Telesat, Canadian Pacific Ltd. and the C. Itoh Group of Japan, has been authorized to provide mobile satellite services (MSS) in Canada. TMI is collaborating with the AMSC, the licensed operator in the U.S., to develop a compatible operational system by late 1993.

TMI has planned to introduce MSS in two phases. In phase 1, Mobile Data Service (MDS) was to be introduced starting June 1990. MDS provides full two-way digital messaging, automatic vehicle location and fleet management services using space segment capacity leased from Intemational Maritime Satellite Organization (INMARSAT). For this purpose an INMARSAT satellite has been repositioned to 106 West to provide coverage of Canada and U.S.. Using this satellite a 'Stop and Talk' voice service will also start from June 1991[12].

In second phase, MSAT will be constructed, launched and made operational. Phase 2 services will commence when MSAT is commissioned in late 1993 and consist of a full range of

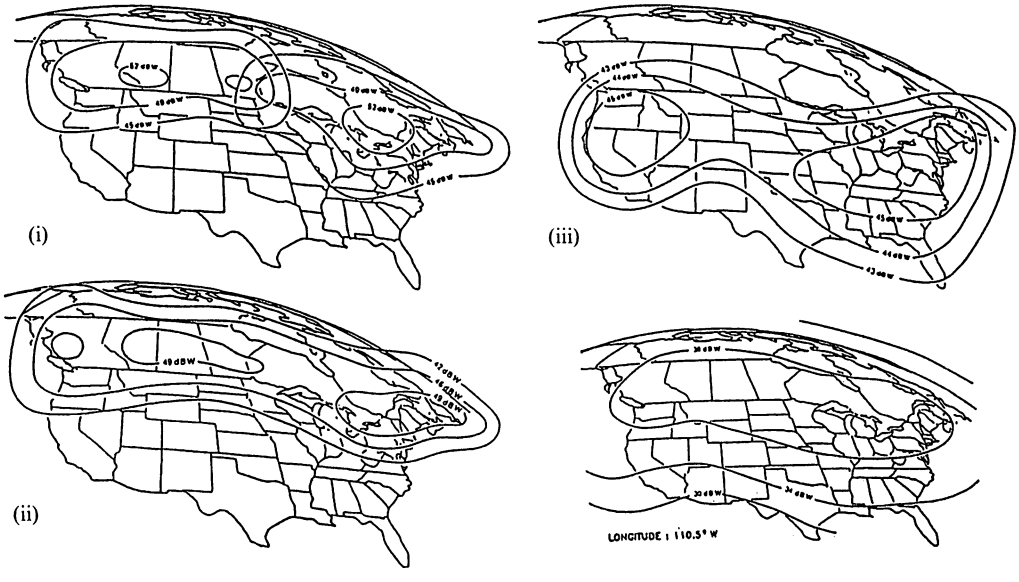

Fig. 2 a) ANIK-E Ku-band EIRP coverage i) half Canada, ii) national beam, iii) ECBC. b) ANIK-E C-band EIRP coverage.

Table 2 Short technical specification of ANIK series of satellites

Paramaters	ANIK-A	ANIK-B	ANIK-C	ANIK-D	ANIK-E
Launch dates	A1: Nov 1972 A2: April 1973 A3: May 1975	Dec 1978	C3: Nov. 1982 C2: June 1983 C1: April 1985	D1: Aug. 1982 D2: Nov. 1984	E1: 1991 E2: 1991
Orbital Assignment	A1: 104 West A2: 109 West A3: 114 West	109 West 107.5 West	C3: 117.5 West C2: 110 West C1: 107.3 West	D1: 104.5 West D2: 110.5 West	E1: 110.5 West E2: 107.5 West
Frequency band	6/4 GHz	6/4 GHz 14/12 GHz	14/12 GHz	6/4 GHz	6/4 GHz 14/12 GHz
No. of transponders	12, each can carry 1 FM TV signal or an equivalent of 900 voice channels	12 in 6/4 GHz, each having equal capacity as in ANIK-A's, 6 in 14/12 GHz.	16, each can carry 2 FM TV signal or an equivalent data rate of 91 Mbps	24, each having equal capacity as in ANIK-A's.	40 in total
RF power [Watts]	5	10 for 6/4 GHz 20 for 14/12 GHz	15	11.5	11 for 6/4 GHz (SSPA) 50 for 14/12 GHz
Designed lifetime (years)	6-7	7	10	10 years	12 years
Manufacturer	Hughes Aircraft Co.	RCA	Hughes Aircraft Co.	Spar Aerospace Co. Hughes Aircraft Co.	Spar Aerospace Co. GE Astro-Electronincs
Launch Vehicle	Delta 1914/2914	Delta 3914	NASA Space Shuttle	D1: Delta 3920 D2: Space shuttle	Ariane-4.

integrated voice and data services under the portfolio name 'mobile ISDN'[12].

The North American MSAT when completed will have a coverage of the whole North American land mass and coastal waters up to 300 km limit plus the islands of Hawaii and Puerto Rico. Optional coverage includes Mexico and the Caribbean, and the international flight information regions controlled by Canada and the U.S. The MSAT system will have multiple spot beams in order to increase the satellite EIRP and to allow for frequency reuse since the available spectrum is limited. In Fig. 3 L-band (1.6/1.5 GHz) beam coverage for the MSAT system and in

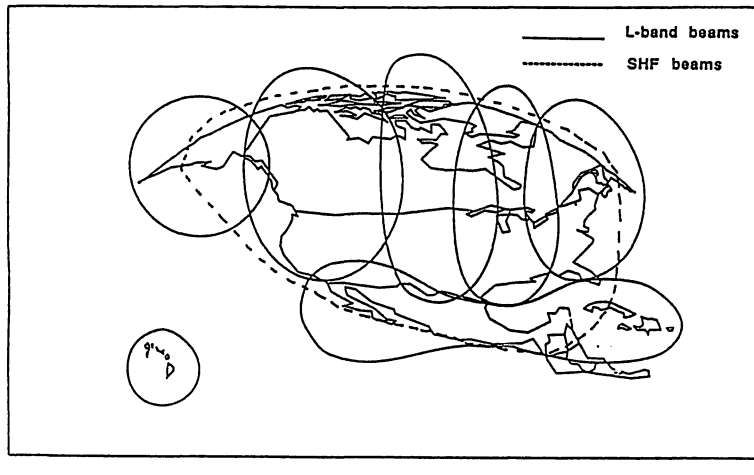

Fig. 3 MSAT L-band EIRP beam coverage.

Table 3 Short technical specification of MSAT

Launch date	1993
Orbit Assignment	106.5 W (Can), 62 W, 101 W, 134 W (US)
Frequency band	1.6/1.5 GHz
Transponder BW	29 MHz
No. of beams	5 at L-band (+ one for Mexico) 1 North America SHF
Antenna size	two 5m reflectors for L-band
Designed lifetime	10 years minimum

Table 3 a short technical specification of the MSAT is given[13].

TMI estimates the potential demand for MSS at 300,000 to 450,000 mobile terminals in Canada by the year 2000. Studies of the requirements for the mobile data services indicate that the requirements for mobile data terminals could reach 50% to 60% of the total demand. Assumptions regarding this market penetration rate indicate that TMI's system should support 75,000 to 130,000 mobile voice terminals by the year 2000[14]. Capacity of a first generation Canadian system has been planned to serve, during the peak traffic period, at least 60 thousand equivalent voice users.

4. International Satellite Communication Linking Canada

Canada's satellite links to the rest of the world are the fruits of Teleglobe Canada's cooperation with member countries of INTELSAT, INMARSAT and other organizations. One of the 11 founding members of INTELSAT, Teleglobe as early as 1966 provided a satellite link with European countries through its Mill Village earth station in Nova Scotia. In July 1984 investment share of Teleglobe in INTELSAT was sixth largest.

Teleglobe is also a signatory of INMARSAT. Its investment share in the organization at the time of its formation was eleventh largest.

Ever since its existence, Teleglobe Canada expanded its facility, undertook aggressive marketing policy and spent much effort in service development. Now, it is highly probable that a overseas call will be routed through one of the satellite gateways in Montreal, Toronto or Vancouver.

Teleglobe in co-operation with other telecommunicators provide direct customer dialling to most of the world, sophisticated overseas data networks, toll free overseas call service and many other services.

Teleglobe also provides satellite link to TV broadcast networks at home and abroad for video transmission.

5. Conclusion

In this paper an overview of Canadian Satellite Communication Program was presented. Canada has been in the forefront of satellite communication for almost thirty years. The efforts of the Canadian government and private industries over this period allowed Canadians to enjoy one of the most sophisticated communication services and satellite applications at a very convenient price. With expertience and expertise so far gathered, it is hoped that Canada will step in the 21st century bringing new milestones and successes.

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