Communications Research Centre

ANIK-B
PROGRAM DELIVERY PILOT PROJECT
A 12 MONTH PERFORMANCE ASSESSMENT

by

I. BISCHOF, J.W.B. DAY, R.W. HUCK, W.T. KERR, N.G. DAVIES

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COMMUNICATIONS RESEARCH CENTRE

DEPARTMENT OF COMMUNICATIONS
CANADA

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ABSTRACT

This report provides an assessment of the Program Delivery Pilot Project (PDPP), one of the most significant projects of the ANIK-B Communications Program of the Department of Communications (DOC). This project is a field trial involving the reception of television signals at 12 GHz from the 20 watt rf channels of the ANIK-B using low cost TV receive-only earth terminals with antenna diameters of 1.2 and 1.8m. The PDPP has been in operation since late September 1979 with approximately 80 receive-only terminals located in the two geographically distinct regions of northwestern Ontario and British Columbia, the Yukon and Northwest Territories. The objectives of the project are to demonstrate, evaluate and gain field experience with direct-to-home and small community satellite broadcasting, to provide a testing ground and small initial market for terminals, to contribute to policy development and plans for future operational use of broadcasting satellites and to provide information to the various interested agencies. This report describes the pilot project, documents the technical results obtained, summarizes the reaction of the participants, including members of the general public, and draws conclusions regarding the implementation of future direct broadcasting satellite systems.

1. SUMMARY

The Program Delivery Pilot Project (PDPP) is one of the most significant field projects of the ANIK-B Communications Program, both in terms of public profile and utilization of DOC resources. This report documents the technical and non-technical results of the project, evaluates a technology which is unique in the world at this time and assesses its acceptability.

In addition to addressing the specific objectives of the PDPP, the general purpose of this performance assessment is to contribute to the planning and development of Direct Broadcasting Satellite (DBS) service in Canada.

The specific objectives of the 12-month performance assessment of the PDPP are:

(a) To document progress to 30 November 1980 in meeting the PDPP objectives.

(b) To document and assess performance of the system to date.

(c) To document and assess the operating history of the earth terminals used in the PDPP,

(d) To document the reaction of the user community to the PDPP and to assess the project in terms of potential implications for policy and planning.

The methodology, which includes use of questionnaires, analysis of records, direct observation, field and laboratory tests, interviews and other verbal information is discussed in each section of the report.

The PDPP is one of 17 communications pilot projects conducted using the experimental 14/12 GHz transponder on the ANIK-B satellite. The project is a trial of the reception of television signals at 12 GHz from the low power 20 watt travelling wave tube amplifiers (TWTAs) of ANIK-B using low-cost TV receive-only earth terminals (LCETs) with antenna diameters of 1.2m and 1.8m. Within the design coverage area, the effective isotropically radiated power (EIRP) ranges from 51 to 46 dBW.

The Department of Communications (DOC) (in co-operation with the Provincial and Territorial governments concerned) joined with the Ontario Educational Communications Authority (OECA) to carry out the PDPP in northwestern Ontario and with the Canadian Broadcasting Corporation (CBC) and B.C. Television Limited (BCTV) to carry it out in British Columbia, the Yukon and the Northwest Territories. Commencing in September 1979, over 40 terminals were installed in northwestern Ontario and over 30 terminals in the west. Approximately 12 months of operating experience is discussed in this report.

This report describes the organization of the project and the technical concept of the system design to permit reception of direct broadcast satellite signals at a power level much lower than generally considered to be necessary. In October-November 1980, after about a year of operations, detailed tests were made of 25 terminals in northwestern Ontario. Generally, the terminals were

found to function in accordance with the design concept and to provide signals that were as good as others available at the selected sites. While the prototype terminals had a number of faults, this was consistent with the early stage of their development, and no fundamental problems were found. Individuals were able to install and operate the terminals with little specialized training.

The users have generally judged the signals provided to be of good quality. While initially intended for individual reception, the demand for the alternative programs provided resulted in many of the terminals being installed at cable head ends and at rebroadcast transmitters. The experimental service would now be very difficult to discontinue.

The PDPP has shown that a direct broadcasting service is technically feasible and that there is a requirement for such a service. The results of the project will have a bearing on the Canadian position at the forthcoming Regional Administrative Radio Conference to be held in 1983 to plan the Broadcasting Satellite Service in Region 2 (The Americas), and in Canadian planning for a direct broadcast satellite which may include interim service on the 14/12 GHz ANIK-C satellites.

2. INTRODUCTION

The development of new communications services and associated delivery mechanisms is undertaken by the Department of Communications (DOC) in co-operation with user organizations as part of its responsibility to promote the establishment, development, and efficiency of communications systems and facilities in Canada.

The Canadian/United States satellite Hermes, known as the Communications Technology Satellite (CTS) when it was launched in 1976, was the world's first satellite which operated in the 14/12 GHz frequency band. In addition to technological objectives, the Hermes program incorporated the objective of conducting satellite communications experiments which used relatively small, transportable ground terminals. Of the many experiments and demonstrations conducted with Hermes during the period 1976-1979, two were significant precursors to the Program Delivery Pilot Project (PDPP). The first was a Direct Broadcasting Satellite (DBS) system trial in which the Canadian Broadcasting Corporation (CBC) Northern Service was transmitted to 3 isolated villages in Labrador and the programming of the Ontario Educational Communications Authority (OECA) was transmitted to 4 remote schools in northwestern Ontario during the period January to June 1979. The second trial was conducted during August 1979 and involved demonstrations of TV reception in over 50 sites in eastern Australia using reduced values of satellite transmitter power. In both of these trials, as well as in several other short experiments and demonstrations using Hermes, the feasibility was demonstrated of using small ground terminals with antennas of 1-2 metres in diameter for satellite-to-home TV broadcasting.

Although these activities demonstrated the technical feasibility of satellite direct-to-home TV broadcasting with a powerful 200 watt satellite transponder and the potential for use of lower powers with small terminals, the experimental nature of Hermes limited the extent to which economic viability and institutional considerations could be examined. As a result, DOC entered

into an agreement with Telesat Canada to incorporate and to lease to the DOC a transponder having up to four 14/12 GHz rf channels on Telesat's ANIK-B satellite which was launched in 1978.

Unlike the powerful Hermes satellite, ANIK-B has only a 20 watt TWTA for each of the four 14/12 GHz rf channels. These rf channels feed four spot beams which together provide Canada-wide downlink coverage. The hybrid satellite also has twelve 8 watt rf channels for commercial services at 6/4 GHz.

In 1978/79, DOC completed planning activities for a major direct-to-home program delivery project on ANIK-B. This project, involving about 100 low cost television receive-only terminals suitable for installation at individual homes, began operations in late September 1979. The basic data for this report were gathered in October and November 1980 to provide an assessment of performance over a 12 month period. The PDPP is one of several activities, including systems and economic studies, intended to lead to the definition of a possible operational Broadcasting Satellite Service (BSS) for Canada.

3. PROJECT DESCRIPTION

3.1 BACKGROUND

There is considerable discrepancy between the quantity and quality of television services available to urban and non-urban residents in Canada. On the average, urban dwellers have access to three times more television channels than rural residents who, in turn, are served better than communities in many of the more isolated parts of Canada, where the choice of television programs is none or only one or two channels, frequently of inferior quality. A total of some four to five million people reside in areas of the country which can be classified as under-served with respect to choice in TV broadcasting services.

The transmission of radio and television signals from a satellite-borne broadcasting transmitter direct to low-cost domestic and small community receivers has been the subject of much study and planning throughout the world. Direct Broadcasting Satellite (DBS) systems which will operate at 14/12 GHz differ from the systems using the ANIK-A communications satellite which are designed to operate at 6/4 GHz to provide long distance telecommunications and network TV delivery. They will operate at higher power and at a high frequency to permit the use of smaller and less expensive receiving terminals. One of the great advantages of DBS is that every part of a country, no matter how remote, can be reached with good quality signals.

One of the primary reasons for Canada's interest in a future DBS system stems from the harsh climate, rugged topography and low population density dispersed throughout major portions of the country. Television transmissions by satellites like ANIK-B to small low-cost terminals could make the reception of good quality signals possible for all Canadians regardless of where they live in the country.

In 1978, the DOC used Hermes to simulate the new ANIK-B satellite which uses 20 watt tubes producing an effective isotropically radiated power (EIRP)

of 50 dBW. This demonstrated the transmission of television signals through a medium-power satellite to earth terminals small enough to be located at individual homes and indicated that it was possible to provide a reasonable quality of service with the lower power of ANIK-B and still use terminals that could have antenna diameters as small as 1.2 meters. This was an important step forward since DBS cost-modelling studies carried out by DOC at the same time indicated significant savings in spacecraft costs if lower power systems could be proven operationally effective. In addition, this introduced the possibility of using one of the ANIK-C satellites, scheduled to be launched in 1982 or 1983, for an interim DBS service. This would mean that an interim DBS service could be provided using low power satellites that are now being procured for other services. Hence a DBS service could be initiated several years before it would be possible to build and launch an optimum DBS for Canada.

In March 1977, the Department of Communications signed a contract with Telesat to lease the experimental portion (up to 4 TWTAs) of the ANIK-B satellite for 2 years beginning early 1979, with an option for extension for a further three years. Phase I of the ANIK-B Communications Program, designed to build on the experience gained from a wide range of social and technical experiments conducted with Hermes [3.1] including the direct-to-home trials, consists of some 15 pilot projects sponsored by a variety of federal and provincial governments and public agencies throughout Canada. The pilot projects, which are social and technical in nature, have been selected and developed to examine the viability of new telecommunications services, further explore the potential of 14/12 GHz satellite technology and increase user awareness of the potential for delivery of services.

To test and prove the concept of direct-to-home program delivery through a less powerful satellite with small low-cost ground terminals and also address the economic and institutional concerns, it was decided to conduct an extensive pilot project on the ANIK-B 14/12 GHz system as part of the ANIK-B Communications Program.

3.2 PROJECT OVERVIEW

The ANIK-B transponder operates in the 14/12 GHz frequency bands. A block diagram of the transponder is shown in Figure 3.1. A 14 GHz signal received by the satellite is down-converted to 12 GHz and amplified by one of the four 20 watt TWTAs. The amplified signal is radiated in one of four beams which together cover all of Canada. The coverage of the four beams (designated west (W), centre west (CW), centre east (CE) and east (E)) is shown in Figure 3.2. The maximum radiated signal power along the axis of each beam is approximately 51 dBW. The inner contour corresponds to an EIRP of 49.5 dBW and the outer contour corresponds to an EIRP of 46.5 dBW. The radiation of signals into a given beam is determined by the frequency of the signal and positioning of switches in the satellite transponder. Figure 3.3 shows the frequency plan of the six channels into which the bandwidth of the transponder is divided.

Due to power supply constraints in the satellite, a maximum of three of the TWTAs can be in operation at present. Degradation of the solar arrays and the heat radiation properties of the satellite during its life will reduce the number of TWTAs that can be operated later in the mission to a minimum of two. Use of the TWTAs is shared both in time and power between the approved pilot projects.

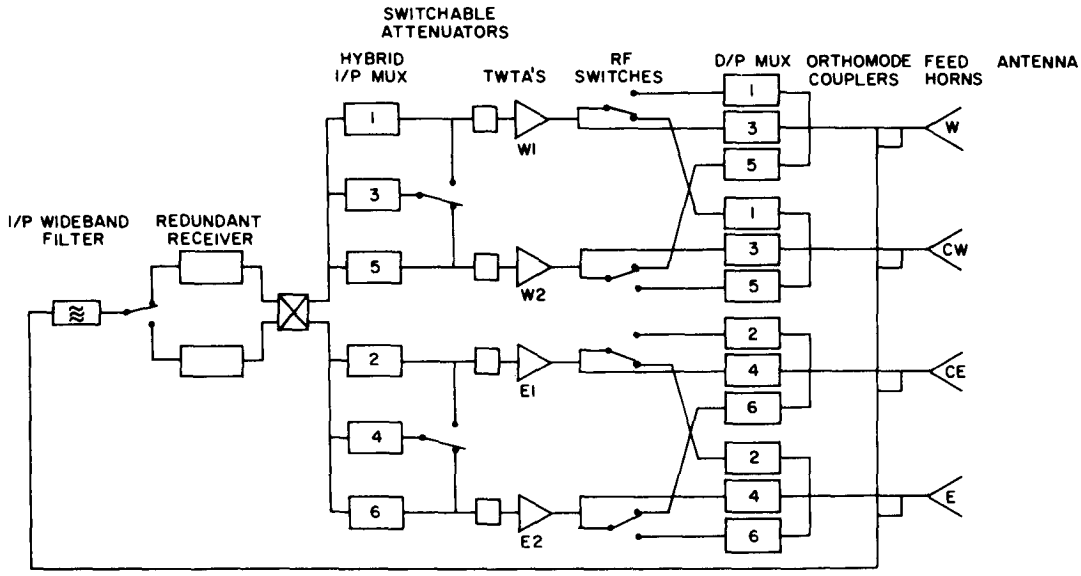


Figure 3.1. ANIK-B Block Diagram, 14/12 GHz Transponders

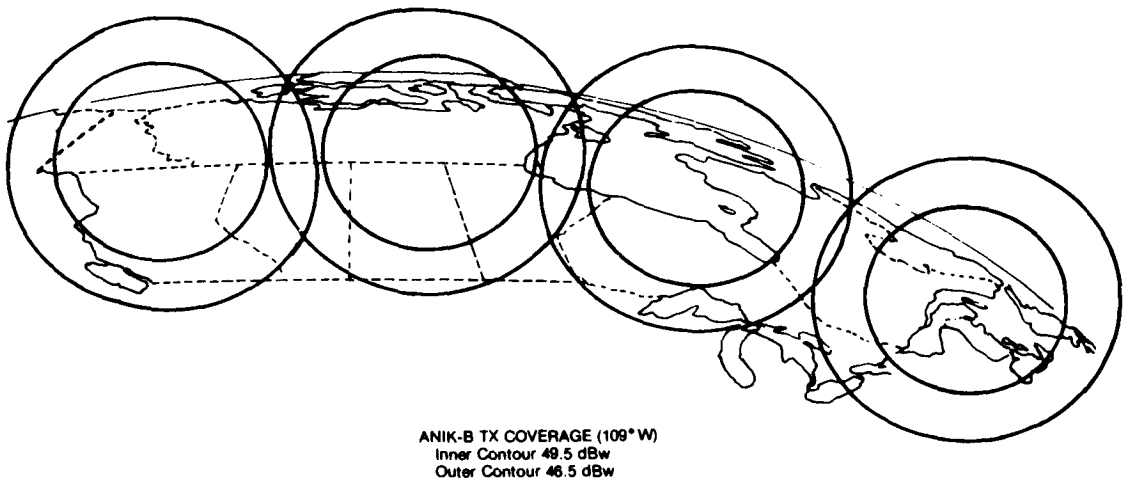


Figure 3.2. ANIK-B Transmit Antenna Contours

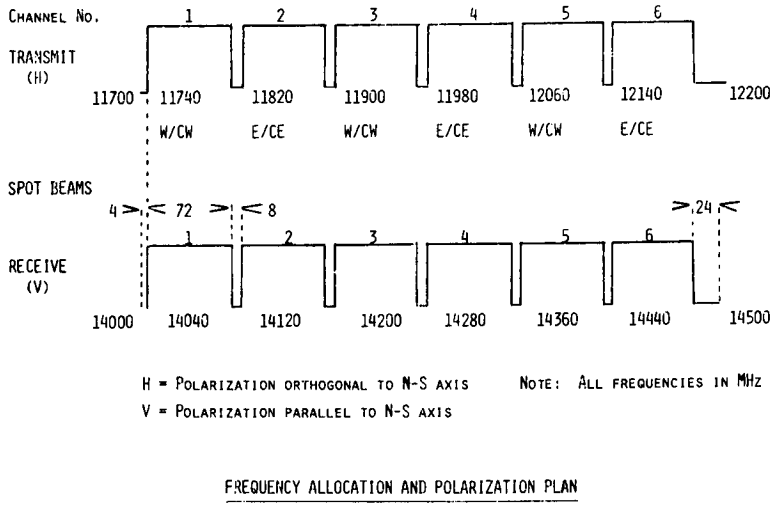


Figure 3.3. ANIK-B 14/12 GHz Channel Plan

Technical studies confirmed that it would be feasible to receive TV signals transmitted by ANIK-B with low-cost TV receive-only (TVRO) terminals of a type similar to experimental models developed by the Communications Research Centre (CRC). A contract was placed with SED Systems, with a sub-contract to Electrohome, to produce 100 low-cost earth terminals (LCETs) at a cost of approximately $3600 each. The terminals are described briefly in Appendix A.

Fifty of the terminals were supplied with 1.2m antennnas and 50 with 1.8m antennas. As described in considerable detail in Section 4, the system was designed for good quality signal reception with 1.2m antennas within the inner contours of the ANIK-B coverage patterns and 1.8m antennas in the outer ring.

As a result of many exploratory discussions, the DOC joined with the OECA and the Government of Ontario to carry out the PDPP in the CE beam of ANIK-B (principally northwestern Ontario) using the full power of one TWTA for a TV signal in accordance with the original design. In western Canada, the need to accommodate the programs of the Canadian Broadcasting Corporation (CBC) and the British Columbia Television Ltd. (BCTV) led to a compromise to transmit two video signals with one TWTA and to compensate for the reduced power by using only 1.8m antennas in the inner region of the west beam of ANIK-B. The Government of B.C. joined in this project.

In September 1980, a change was made in the transponder configuration of ANIK-B, in accordance with earlier program plans to accommodate planned pilot projects in the east, leaving only one TWTA for all projects in the west. To accommodate an educational pilot project of the B.C. Department of Education and a project of the Inuit Tapirisat of Canada in addition to the PDPP, it was necessary to introduce a third video signal in the single TWTA and to accept the consequent degradation. This move compromised the applicability of the results of the PDPP in the west, but was unavoidable.

3.2.1 Objectives of the PDPP

Since some four to five million Canadians live in areas with limited off-air television service and little or no cable television service, the PDPP is aimed at some of those areas to help determine whether satellite delivered direct-to-home television can provide a satisfactory improvement in service.

The primary objective of the PDPP is to test direct-to-home service, but some terminals are allocated for reception in small communities and for distribution via cable or off-air rebroadcast transmitters.

The specific objectives of the PDPP to be addressed in this 12-month performance assessment are:

(a) To demonstrate, evaluate and gain field experience with a direct-to-home and small community program delivery service using the ANIK-B satellite 14/12 GHz transponder.

(b) To provide a prototype testing ground and a small initial market to help stimulate the industrial sector to develop a line of internationally competitive products for this service.

(c) To provide information to the Government which will contribute to policy development and plans respecting the future operational use of broadcasting satellites.

(d) To provide information to the various agencies, institutions and corporations interested in satellite broadcasting to help them to formulate plans for future activities in this field.

3.2.2 Implementation

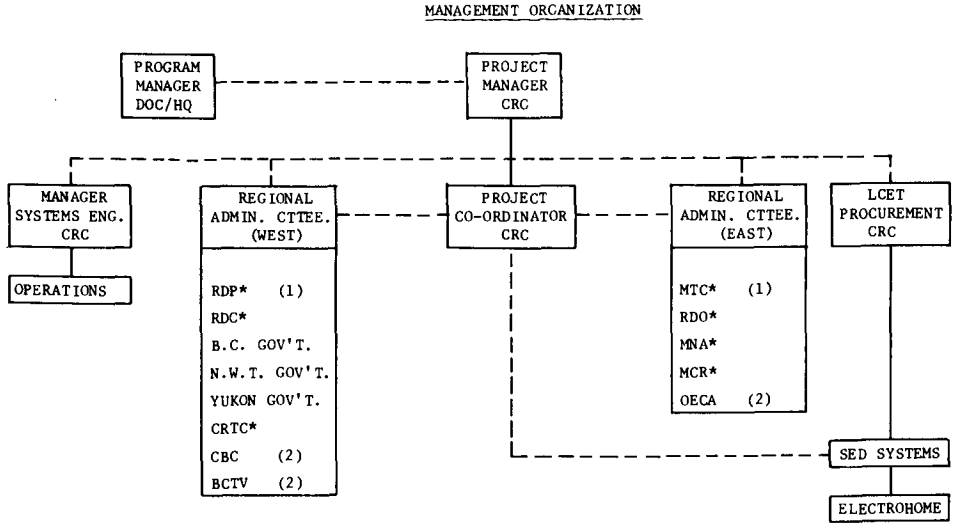
3.2.2.1 Management and Organization

The organization structure assembled to manage the PDPP was unique among the pilot projects in the ANIK-B Communications Program. Geography demanded decentralization, to permit day-to-day management of each of the western and eastern components to be effective. The large number of LCETs and their wide dispersion demanded technical effort far in excess of that available at CRC for their installation, maintenance and repair. Help had to be obtained for efficient system implementation and operation. Each of the major participants in the project brought to it significant organizational commitment. The functional structure that evolved is shown in Figure 3.4.

3.2.2.2 Terminal Distribution

The DOC agreed to provide some 100 terminals for the PDPP and to install them in suitable locations which would be selected to maximize the variety of users and environments in the east and in the west. In both areas, the site selection was undertaken by a Regional Administrative Committee which consists of representatives from all interested parties of the pilot project: Provincial

ministries responsible for Communications, Territorial Governments, Provincial educational authorities, broadcasters, and the Department of Communications, as depicted in Figure 3.4.



* CRTC - Canadian Radio TV and Telecommunications Commission (Vancouver)
MCR - Ontario Ministry of Culture and Recreation
MNA - Ontario Ministry of Northern Affairs
MTC - Ontario Ministry of Transportation and Communications
RDC - DOC Central Regional Office (Winnipeg)
RDO - DOC Ontario Regional Office (Toronto)
RDP - DOC Pacific Regional Office (Vancouver)

Notes: (1) Regional Administrative Committee Chairman
(2) Regional Program Provider

Figure 3.4. Functional Structure of the Organization of the PDPP

Installation of PDPP terminals in the east began in September and in the west in December 1979, with the assistance of DOC Regional and District Offices whose personnel had completed a short training period at the Communications Research Centre (CRC) in Ottawa. Equipment delivered to the District Offices in Ontario and to the Pacific Regional Office in Vancouver was subsequently taken to the pre-selected sites and assembled, aimed at ANIK-B and placed into service by a knowledgeable DOC technician.

Installations were paced by the delivery of terminals from the manufacturer until approximately forty units were in service in each area. A list of these sites, detailing installation dates, types of terminals and other data, is attached as Appendix B. Figures 3.5 and 3.6 show the terminal locations in the centre east and western beams respectively.

It will become apparent from a perusal of the installation dates that a great many of these occurred during the winter period. Outdoor work in temperatures as low as -40°C and high winds somewhat hampered the assembly of antennas and mounts. Nevertheless, the number of active sites grew gradually during the installation period and the majority of terminals were installed in the east by May 1980 and in the west by July 1980. The length of the installation period was primarily due to manufacturing delays, damages in shipping with consequent delays for repairs, and quality assurance which may not have been as rigorous as it would be in a production line operation (since these terminals were prototypes).

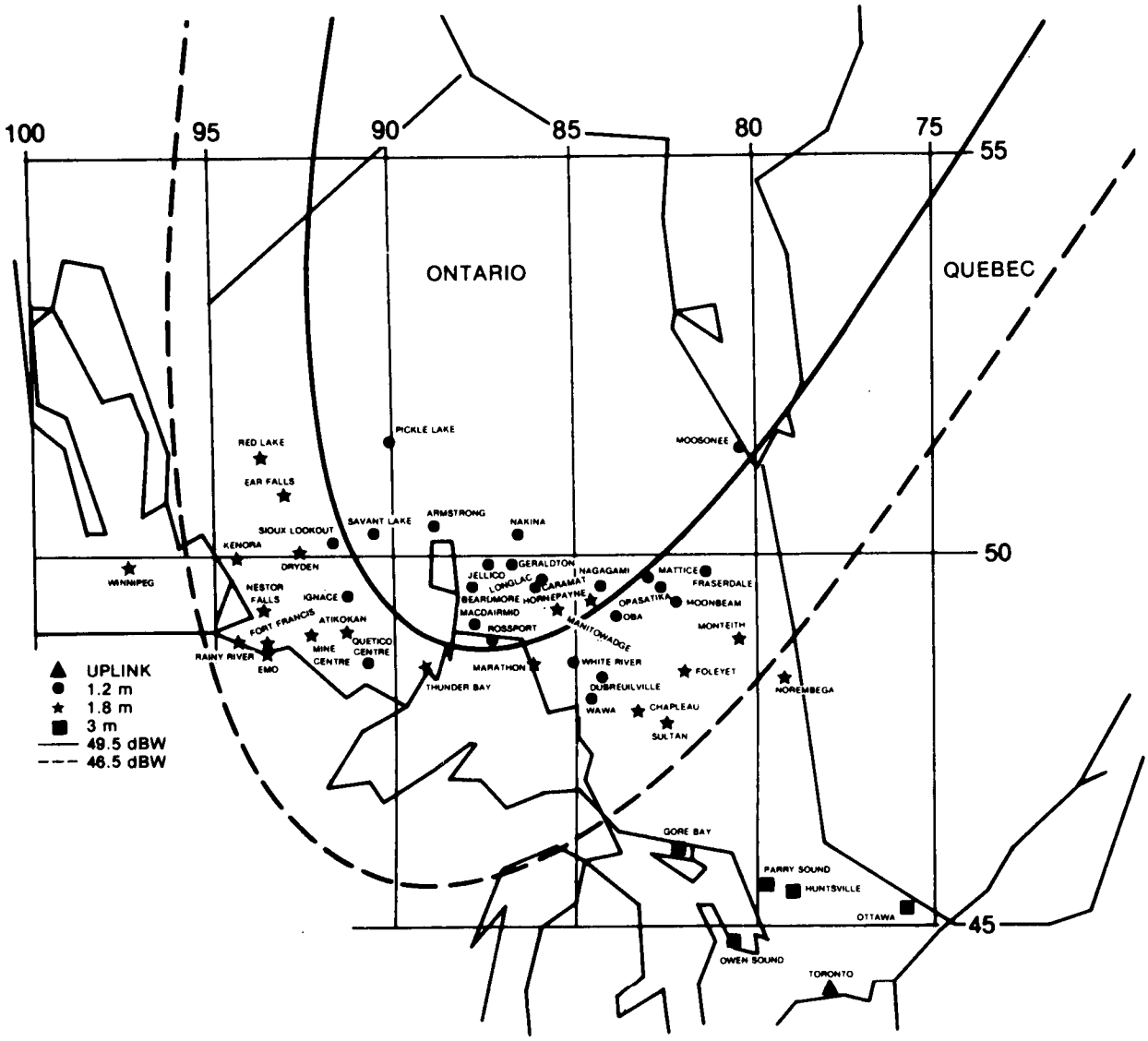


Figure 3.5. ANIK-B Program Delivery Project in Eastern Canada 1980

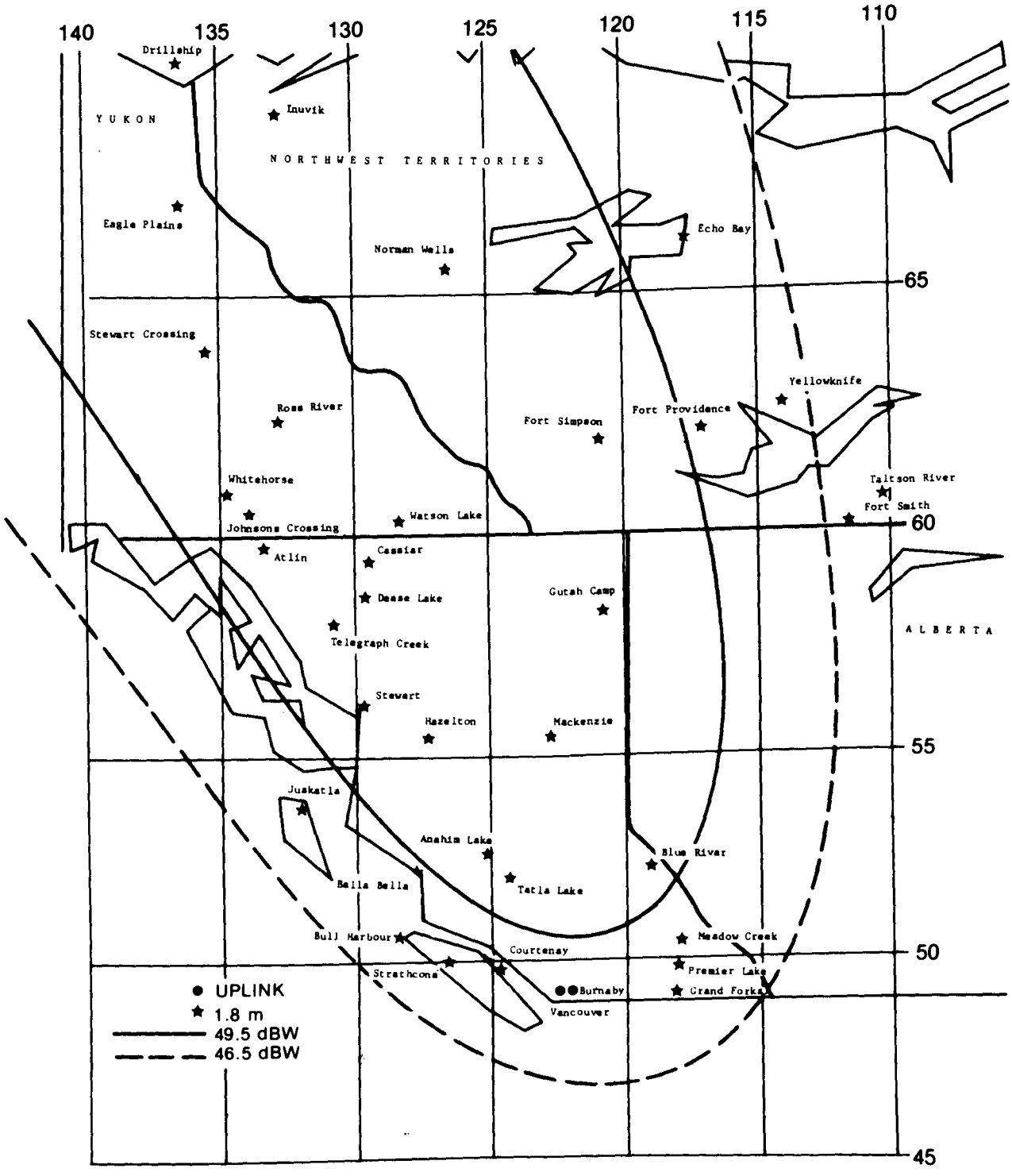


Figure 3.6. ANIK-B Program Delivery Project in Western Canada (1980)

During the performance assessment period some 48 terminals had been operating in the eastern part of the PDPP. In Ontario and Manitoba the deployment of terminals was as follows:

Ontario

24	–	1.2 meters
19	–	1.8 meters
4	–	3 meters

Manitoba

1	–	1.8 meters

The utilization of these terminals can be categorized as follows:

Homes	19
Cable Systems	21
Low Power Repeater	1
Public Institutions (e.g., community recreation centres)	6
Spare	1
	48

In the western portion of the PDPP 34 terminals are distributed as follows (with an additional 4 spares):

British Columbia	19 – 1.8 meters
Yukon Territory	7 – 1.8 meters
Northwest Territories	8 – 1.8 meters

Users in the west consist of:

Homes	14
Cable Systems	7
Rebroadcast transmitter and repeaters	3
Institutions (including community centres, railroad camps)	10
	34

The maps of Figures 3.5 and 3.6 identify the ANIK-B satellite footprints, EIRP contours and locations and sizes of the terminals in both the east and west components of the PDPP.

3.2.2.3 Transportation and Installation

During the installation phase of the PDPP, the vast majority of terminal units were shipped in bulk from the supplier to several central points in both the east and the west. Since bulk shipments required large vehicles, little or no difficulties were experienced during this stage.

However, in a few cases where single units were required and/or some urgency was attached to a particular installation, transportation of the 1.8 metre antenna proved to be difficult. The shipping container for this size

antenna is slightly larger than 1.8m x 1.8m x 0.3m. A container of this size will not fit into small aircraft and also is too large for the cargo bays of standard aircraft such as the Boeing 737, which are used by many of the smaller airlines to service the remote regions in Canada. Only some of these aircraft, specifically fitted for freighter service, can accommodate the 1.8 metre container. This problem was overcome for some installations by removing the dish from the container. However, this exposed the dish to possible handling damage - the surface of the dish must have an accuracy better than two millimeters for adequate performance at 14/12 GHz, and even small surface distortions cannot be tolerated. Extra expenses were frequently incurred to secure a vehicle large enough to carry the antenna safely.

The antenna mounts provided were of steel angle iron construction, which, while relatively inexpensive, significantly contributed to the shipping weight and shipping costs. It is evident, therefore, that antennas of diameter larger than 1.8 metres, and with proportionally larger mounts, would increase transportation difficulties.

Prior to installation of the first LCET in September 1979, the persons to be involved in the process participated in a brief training session at CRC in Ottawa. They were instructed on the assembly of the antenna and mount, the aiming of the dish at the satellite and the operation of the equipment. The necessary skill and knowledge required to assemble the unit was easily and rapidly acquired. The average "home-handyman" would be able to assemble a unit in several hours by following the manufacturer's instructions.

Aiming the dish to find the satellite is a more difficult task, requiring setting the antenna elevation angle referenced to the horizontal and setting the azimuth angle referenced to true North. Both of these angles must be set very accurately to within a fraction of a degree. The angles vary from location to location across Canada, and it is not always easy to measure them to the accuracy required. Those involved in the installation of the PDPP LCETs were provided with the pointing and polarization angles for each location. However, accurate knowledge of true north for a given location and the means to measure a directional bearing accurately is not usually available to the layman who may wish to set-up his own terminal. Use of the sun to provide an azimuth reference proved to be a very effective technique when other references were not available but this requires knowledge of the use of navigation tables.

When the equipment is properly installed, the received picture quality is directly dependent upon the condition of the recipient's television set. During the PDPP installations, it was found that this very often resulted in a poorer picture than should have been expected. Also, it was found that picture degradation was sometimes due to the local distribution system (e.g., a poorly designed and/or poorly maintained cable system).

3.2.2.4 Content Description

In the east, the program source is the OECA which produces educational programming designed for use in the province of Ontario. This signal, originally picked-up off-air at CRC near Ottawa, and transmitted to the satellite by an uplink at this same location, is now being relayed by a direct program feed to the satellite from an uplink at the OECA studio in Toronto. Transmission

begins at 1300 hours Monday to Friday and at "sign-on" at 0900 hours on Saturday and Sunday. Transmission ends at "sign-off" when the OECA network closes down at approximately 0100 hours.

In the west, the program sources are the Canadian Broadcasting Corporation (CBC) and British Columbia Television Limited (BCTV) which provide network entertainment programming. There are two separate uplinks, one located at each studio in Vancouver. In both these instances, the normal programming of the respective Vancouver station is carried in its entirety for 24 hours/day.

4. SYSTEM CONCEPT OF THE PROGRAM DELIVERY PILOT PROJECT

4.1 INTRODUCTION

The objectives of the PDPP and the deployment of some 100 terminals in the field have been discussed earlier in this report. It is the purpose of this Section to address the technical concepts, system design, expected performance for the PDPP, and the ground terminal specifications and performance. Actual performance realized is discussed in the next Section.

4.2 TECHNICAL CONCEPT OF THE PROGRAM DELIVERY PILOT PROJECT

Many studies of direct broadcasting satellites have been carried out in the past, and these have generally concluded that a satellite EIRP in excess of 60 dBW is required for direct broadcast applications. Careful examination of the assumptions for such studies led to consideration of the practicality of using ANIK-B, which has an EIRP about 10 dB less than this, with antennas that have diameters not too much larger than the typical one metre size often postulated as a model for direct broadcasting. With the low EIRP of ANIK-B, a design based on the usual assumptions for direct broadcasting would have resulted in antenna sizes inconsistent with low-cost receivers intended for the Broadcasting Satellite Service.

The concepts on which the ANIK-B PDPP is based are:

(a) *Large margins (particularly associated with propagation effects) are not necessary to achieve user-acceptable picture quality.* Margins that may enter into a 12 GHz link calculation include:

- (i) clear weather atmospheric attenuation, increased for low elevation angles;
- (ii) rainfall attenuation;
- (iii) increased noise temperature with increased atmospheric attenuation;
- (iv) antenna pointing loss;
- (v) reduced terminal gain-to-noise temperature ratio (G/T) with ageing;
- (vi) increased antenna temperature at low elevation angles;
- (vii) increased free space loss at low elevation angles;
- (viii) reduced satellite EIRP at edge of beam;
- (ix) reduced edge EIRP due to spacecraft antenna mispointing.

The assumption of worst-case values and the use of linear addition of these values in dB can result in a significant excess margin under normal operation conditions. The values

that should be used and how they should be added are still questions on which it is difficult to obtain agreement.

(b) *Non-faded operation near FM threshold gives acceptable performance.* Given a system design for adequate signal-to-noise ratio (SNR) and provided normal operation is above threshold, the viewer will not find the noise objectionable.

(c) *Fades below threshold result in a noisy picture but this is acceptable if they are infrequent and of short duration.* Because of the factors mentioned previously, it was decided to design for clear weather operation above FM threshold. Therefore, propagation fades could result in operation below threshold.

System designers do not generally consider operation below FM threshold. Below threshold (which occurs typically at a carrier-to-noise ratio of 9.5 dB), the noise effects on a picture are characterized by random black and white streaks, the equivalent of noise clicks in audio FM demodulators. This noise is generally more objectionable to a viewer than that observed above threshold. However, the picture is still recognizable well below threshold and this degradation can be acceptable for short periods such as occur during intense rain events. A subjective assessment of picture quality near threshold is given in Table 4.1. System design should be such as to maintain acceptable audio during fades.

(d) *Deep fades causing picture loss are rare, but inevitable.* In many climates, including parts of Canada, it will not be feasible in any case to preclude operation below threshold at all times. It is a question of choice of the percent of time that this occurs.

TABLE 4.1

Subjective Assessment of Picture Quality near Static Threshold

Carrier Power (dB Relative to Static Threshold	Picture Quality
+4	No threshold noise.
+2	Threshold noise just starts to appear on color bars; not generally noticeable on pictures except those having wide deviation components
+1.5	Dynamic threshold; threshold noise just starts to appear on pictures.
0	Significant threshold noise on color bars; significant on pictures.
-2	Large amount of threshold noise on color bars; significant on pictures.
-4	Large amount of noise on all pictures; at some point below this the picture will be lost.

(e) Over-deviation is useful to add threshold margin. This is discussed below.

4.3 SYSTEM DESIGN

4.3.1 Trade-Offs

The starting point in examining the link parameter trade-offs is the required video SNR deemed acceptable to the viewer. To some extent, the choice is a matter of judgement and is usually based on subjective tests involving a number of viewers. The goal for the ANIK-B link was chosen to be 42 dB weighted (old CCIR weighting curve for System M [4.1]) which is consistent with values assumed in many studies for satellite broadcasting. It is about the same as a TASO rating of "excellent" for 50% of the viewers and the CCIR quoted value of 43 dB for System M [4.2] when the new CCIR unified weighting curve [4.3] is used.

Demodulator performance above FM threshold is given by the simple expression

$$\begin{aligned} SNR_v = {} & 10 \log 3/2 + 20 \log \left[(2\sqrt{2})\, \frac{100}{140}\right] \\ & + WP - IM + 20 \log \frac{\Delta f_v}{f_v} \\ & - 10 \log f_v + C/N_o \end{aligned} \tag{4.1}$$

where

SNR_v - video signal-to-noise ratio

$[(2\sqrt{2})\ 100/140]$ - converts from rms SNR to the CCIR definition of peak-to-peak video (excluding synchronization tip) to rms weighted noise

WP - improvement due to low-pass filtering, noise weighting and de-emphasis, theoretically equal to 13.3 dB (old CCIR weighting curve) at values of C/N_o above threshold

IM - implementation margin to reflect non-ideal performance of filters and demodulators; the net value of (WP-IM) is taken as 11.8 dB here

Δf_v - peak video deviation

f_v - video baseband, normally 4.2 MHz

C/N_o - carrier-to-noise density ratio.

Equation (4.1) illustrates the point that, above threshold, there is a trade-off between video deviation and C/N_o for a given SNR_v and that SNR_v depends only on the noise power density.

For the chosen value of 42 dB SNR_v, Equation (4.1) becomes

$$C/N_o = 221.0 - 20 \log \Delta f_v \tag{4.2}$$

Using the additional expressions

$$B_c = 2(\Delta f_v + f_v) \tag{4.3}$$

and

$$C/N = C/N_o + 10 \log B_c \tag{4.4}$$

where

B_c - Carson Rule bandwidth

C/N - carrier-to-noise ratio,

Table 4.2 can be constructed. At this point, the impact of sound subcarriers is neglected and Carson's Rule is used for the required bandwidth.

TABLE 4.2

Peak Video Deviation to Achieve $SNR_v = 42$ dB

C/N_o (dB-Hz)	Δf_v (MHz)	B_c (MHz)	C/N (dB)
91.5	3	14.4	19.9
85.5	6	20.4	12.4
81.0	9	26.4	7.7
79.4	12	32.4	4.3

A number of points can be drawn by examination of the table:

(a) For the given required SNR_v, a minimum C/N_o (and hence, satellite EIRP and/or ground station G/T) is achieved with operation near threshold.

(b) For operation at a given margin above threshold at a prescribed SNR_V, there is a specific video deviation and C/N_o that will allow an optimum trade-off between EIRP and G/T.

The 6 MHz deviation is "better" than 3 MHz since the C/N_o is less and operation is closer to threshold. For deviations of 9 MHz and above, the C/N is below threshold and the simple equation does not apply. As described in Reference [4.4], a more complex expression for SNR_V is required. The net result is that for SNR_V values in the low 40's, deviations around 6 MHz appear "optimum". For higher SNR_V values (for community or network applications), wider deviations could be appropriate. A combined service would require a compromise.

Reference [4.4] also discusses pre-detection bandwidth restrictions. Carson's Rule is not an analytical expression and the use of narrow pre-detection bandwidths can give improved performance at threshold for a given C/N_o. A balance must be realized between truncation noise introduced by a restricted bandwidth, the onset of threshold noise, and nonlinear distortion. Laboratory measurements indicated that a bandwidth of 18 MHz could be used with a deviation of 6 MHz. This gives a C/N of 12.9 dB at a C/N_o of 85.5 dB-Hz, with a margin of 3.4 dB above a typical measured threshold C/N of 9.5 dB for low-cost demodulators. This margin of 3.4 dB is available for allocation amongst the factors listed in Section 5.2.1.

4.3.2 Ground Station Requirements

It was shown in the previous Section that a C/N_o of 85.5 dB-Hz coupled with a video deviation of 6 MHz would satisfy the basic requirements of the conceptual ANIK-B link, viz.:

(a) a SNR_V of 42 dB;

(b) clear weather operation above FM threshold;

(c) a modest margin (3.4 dB) above threshold;

(d) a reasonable margin (7.4 dB) to picture loss (see Table 4.1).

Given freedom to design the satellite/ground terminal link, it would be possible to trade-off satellite EIRP and ground station G/T given the desired C/N_o. However, the characteristics of the ANIK-B transponder are, of course, fixed. Based on pre-launch data, Figure 2.2 shows the nominal EIRP contours for the four spot-beams of ANIK-B. Actual values may vary slightly dependent on channel/TWTA/beam combinations. Likewise, the uplink parameters are dependent on configuration, but nominal values in the low gain mode can be taken as -81 dBW/m^2 for the uplink saturating flux density (SFD) and 0 dB/K for receive G/T.

The uplink C/N_o is given by

SFD (dBW/m^2)	-81.0	
Spacecraft G/T (dB/K)	0.0	
$10 \log[\lambda^2/4\pi]$ (dB)	-44.54	
k (dBW/Hz/K)	+288.6	(Boltzmann's Constant)
Uplink C/N_o (dB-Hz)	103.1.	

For a total C/N_o of 85.5 dB-Hz, the downlink C/N_o is then calculated to be 85.6 dB-Hz.

Finally, the required ground station G/T can be determined from the downlink equation

$$EIRP - Lp + G/T - k = C/N_o \tag{4.5}$$

where

EIRP - satellite effective isotropically radiated power

Lp - total path loss including free space loss, plus allowances for all other losses such as are outlined in Section 5.2.1

G/T - ground station antenna gain-to-system noise temperature ratio

k - Boltzmann's Constant

C/N_o - downlink carrier-to-noise density ratio.

If we now consider the inner contour of the centre-east beam, in Figure 2.2, the nominal EIRP is 49.5 dBW, the free space loss at 50° latitude and the eastern contour is -205.79 dB with a clear-weather atmospheric attenuation of 0.12 dB. Only the G/T is unknown and this can be determined from Equation 4.5 to be 13.3 dB/K. This yields a C/N in a nominal 18 MHz bandwidth of 12.9 dB.

At the time ground station procurement action was initiated for the PDPP, a noise figure of 4.5 dB appeared to be a reasonable goal for the then current state-of-the-art technology for low-cost 12 GHz low noise amplifiers (LNAs). With an allowance of 50K for antenna noise and miscellaneous losses, it follows that a 1.2m (4 foot) diameter antenna with a nominal aperture efficiency of 55% is reasonable to meet the above required G/T of about 13 dB/K.

4.3.3 PDPP East

A system with a single, saturating carrier was planned for the PDP in the centre-east beam of ANIK-B. Based on the analysis described in the previous Sections, the following guidelines were developed:

(a) 1.2m LCETs would give adequate performance within the inner contour as given in Figure 3.2 (i.e., a SNR_V of 42 dB at a C/N of 13 dB under clear weather and ideal conditions);

(b) 1.8m LCETs would give adequate performance between the outer and inner contours as shown in Figure 3.2. The increased G/T (about 3.5 dB) provided by the larger antenna offsets the 3 dB loss in satellite EIRP.

In fact, as seen in Figure 3.5, these guidelines were not always strictly adhered to and some 1.2m terminals were installed outside the inner contour. Conversely, larger 1.8m antennas were located at some sites within the inner contour to give improved performance at cable head-ends.

The uplink signal for OECA was transmitted from the Ottawa 9m station, starting in September 1979, using an off-air pick-up of the TV signal from a local OECA UHF transmitter. In September 1980, uplink transmissions were transferred to a user-operated DOC terminal located on the roof of the OECA building in downtown Toronto. The terminal includes a 4.5m antenna and a 250W TWTA HPA.

4.3.4 PDPP West

It was decided that two channels would be transmitted for the west beam of ANIK-B recognizing that this would require use of 1.8m antennas within the inner contour. This necessitated consideration of a mode with two video carriers transmitted in one transponder channel. Such operation introduces a number of factors in addition to those already discussed. These include:

(a) a reduction in the EIRP per carrier of more than one-half due to the additional effects of intermodulation product generation and multi-carrier back-off;

(b) possible modulation interference effects between the video carriers due to the non-linear transponder operated near saturation;

(c) increased uplink noise contribution with required input back-off;

(d) possible adjacent channel interference because of intermodulation products and finite filter response;

(e) differential power balance problems in the non-linear transponder with two uplink signals from different sites'

(f) a reduced margin for uplink fading since the input carriers are backed off from saturation.

For the ANIK-B application, it was possible to choose the operating point primarily on the basis of maximizing the EIRP per carrier. For operational systems, other factors listed above may be more significant and more back-off may be required.

It was possible to calculate the per carrier output back-off (OBO) relative to the per carrier input back-off (IBO). The results are given in Table 4.3

TABLE 4.3

Transponder Output Versus Input Back-Off

IBO (dB)	OBO (dB)
2	4.6
3	4.4
4	4.4
6	4.7
8	5.2

An operating IBO of 4 dB for each carrier was chosen.

The predicted uplink performance for the west beam then becomes

saturated uplink C/N_o (dB-Hz)	103.1
IBO (dB)	-4.0
uplink C/N_o (dB-Hz)	99.1

If we consider the inner west contour on Figure 3.2 at 60° latitude (elevation angle to ANIK-B is 18°), the downlink calculation is

EIRP (dBW)	49.5
OBO (dB)	-4.4
free space loss (dB)	-206.01
atmospheric attenuation (dB)	-0.185
1.8m G/T (dB/K)	+16.5
k (dBW/Hz/K)	+228.6
downlink C/N_o (dB-Hz	84.0

Therefore, the total C/N_o is equal to 83.9 dB-Hz.

This value, using 1.8m antennas at the inner contour, is 1.6 dB less than the design value for the inner contour in the centre-east beam with a 1.2m terminal and full power. The expected margin above threshold is now only 1.8 dB. It was with some concern that it was agreed to proceed with the two carrier operation, because it was generally considered that margins had already been trimmed as much as was practical. The recommended guideline was a 1.8m terminal within the inner contour. However, as can be seen from Figure 3.6, the guideline was ignored and terminals were installed well outside this contour. In fact, quite usable reception was reported from sites where threshold margin must have been non-existent.

4.3.5 Three Video Carriers in one TWTA

Although the ANIK-B 14/12 GHz transponder system has four TWTAs, prime power and thermal limitations on the spacecraft may limit the number that can be operated to two, dependent on loading of the operational 6/4 GHz system also on board. During the summer of 1980, one western transponder was carrying the two-carrier PDPP described in Section 4.3.4, and a second was carrying an educational video channel. It was determined that one of these TWTAs would have to be turned off in September 1980 in order that an additional TWTA could be turned on in the East. A mode of operation with three simultaneous video carriers in one TWTA was examined, even though such operation was well outside system design concepts for ANIK-B projects.

This mode is only possible because the configuration of ANIK-B allows switching of two 72 MHz wide RF channels into one TWTA. The two PDPP carriers were located on Channel 3, and the third signal was placed in the bottom half of Channel 1, together with a number of low-level single-channel-per-carrier telephony carriers in the top half of Channel 1 (see Figures 3.1 and 3.3). A test was carried out, and even though the results, predictably, gave marginal picture quality, a trial period with 3-carrier transmission was started in September 1980. This mode of operation has continued. The programmers preferred acceptance of reduced quality to the option of withdrawal from the project.

The problems stated above with respect to two-carrier operation are only compounded with three. In particular, the difficulty of power balancing three carriers separated by up to 195 MHz in a non-linear amplifier near saturation, with three separate uplink terminals is formidable. Any change in one, of course, impacts on the others. At least two of the users have complained at various times that their signal was the poorest of the three.

An estimate of the C/N for a 1.8m LCET at the inner EIRP contour was given in Section 4.3.4 for two-carrier operation. With three carriers, the IBO was set to 5 dB, which gives an OBO of 6.3 dB. The predicted C/N at the inner contour is then 9.4 dB, or about at FM threshold. Of course, those terminals located well outside our guideline of the inner contour for two carriers would be expected to have difficulty. In general, comments on the quality have ranged from "poor" to "good".

The need for *some* margin has been amply demonstrated. Factors that should not normally enter into the determination of quality now must be considered, including:

(a) variation in performance to be expected statistically from unit-to-unit for the LCETs;

(b) variation in performance of the LCET across the frequency band (the two extreme carriers are separated by 195 MHz);

(c) a need for highly accurate uplink power balancing;

(d) a need for extreme care in terminal alignment; and

(e) the fact that with a poor satellite link SNR_V, the use of video source material also having a poor SNR further degrades the resultant received quality;

Nevertheless, people have preferred to receive the programming at reduced quality rather than not at all.

4.4 EXPECTED PERFORMANCE

Since the system concept for the ANIK-B PDPP was to operate close to FM threshold, an attempt was made to evaluate the subjective performance to be expected with fades to and below threshold. Two tests were carried out.

The first involved still picture and colour bar signals transmitted through an LCET, using a laboratory simulator, at various values of C/N. Photographs of the results are shown in Figures 4.1 through 4.5. The LCET used had a static threshold C/N of 9.2 dB. Of course much of the colour quality and definition of the picture as seen on the video monitor are lost in the photographic and reproduction processes. However, the figures serve to illustrate the character of threshold 'click' noise and, in fact, the visual appearance of this noise on the monitor is quite well reproduced in the Figures.

The source of the still picture signal was a Hitachi type FP-1010U colour camera focussed on a test photograph. Evaluations were also carried out with colour bars and Table 4.4 is based on conclusions from these tests.

A second evaluation using video tape material was carried out by a consultant in co-operating with OECA [4.5]. OECA provided a test tape consisting of a variety of different scenes. The tape signal was used to modulate a carrier passed through an LCET in the DOC laboratory simulator. A new tape was made with signals at various C/N ratios above and below threshold, and a group of 28 urban viewers (Toronto) and 27 rural viewers (Northern Ontario) were asked to rate the various clips on a five point scale. Table 4.4 also lists an estimate of performance to be expected using a typical PDPP LCET in the field under fading conditions.

In the table:

(a) Column 1 gives the LCET C/N in dB. In Section 4.3 a design C/N for a 1.2m LCET at the edge of the ANIK-B inner EIRP contour was given as 12.9 dB. With an allowance of 0.7 dB for antenna mispointing, a non-faded C/N of 12.2 dB is expected as listed at the top of the first column;

(b) Column 2 is the margin relative to the 9.2 dB C/N threshold for the LCETs used in the laboratory tests;

(c) Column 3 refers to the still picture in Figures 4.1 - 4.5 that most closely matches the given conditions;

Figure 4.1. Video Reception with C/N 4 dB above Threshold

Figure 4.2. Video Reception with C/N 2 dB above Threshold

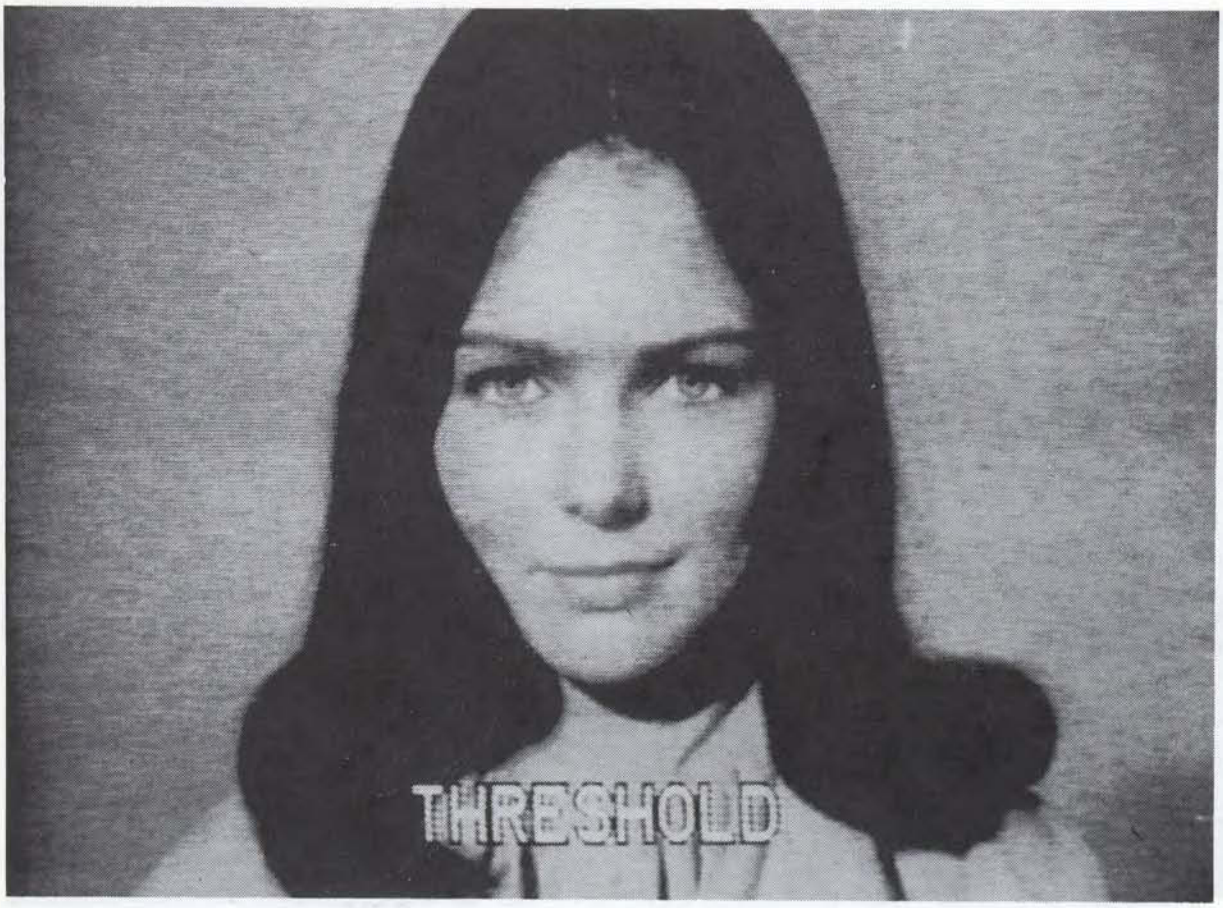


Figure 4.3. Video Reception with C/N at Threshold

Figure 4.4. Video Reception with C/N 2 dB below Threshold

Figure 4.5. Video Reception with C/N 4 dB below Threshold

TABLE 4.4

Expected Performance of an LCET

LCET C/N (dB)	Threshold Margin (dB)	Still Picture No.	MEAN VIEWER RATING		Rating Scale	PROPAGATION ATTENUATION		
			Rural	Urban		Fade (dB)	Total Time Per Year Attenuation Exceeded	Longest Single Event
					5 excellent			
12.2	+3	4.1	4.6	4.3		0	–	–
11.2	+2	4.2	4.4	4.2		1	30-50 hrs.	–
					4 good			
9.2	0	4.3	3.8	3.2		3	5-7½ hrs.	30 mins.
					3 fair			
7.2	-2	4.4	2.5	2.0		5	1½-2½ hrs.	20 mins.
					2 poor			
5.2	-4	4.5	<1.4	<1.1		7	½-1 hr.	15 mins.
					1 bad			

(d) Columns 4 and 5 give the mean viewer rating, obtained from the video tape test, on the five point scale provided in Column 6;

(e) Columns 7 to 9 present propagation data based on results from a CRC experimental study [4.6]. A 13 GHz radiometer was located at each of two sites in southern Ontario and propagation attenuation statistics developed from the recorded data. The estimated fading durations given in the Table were developed from data obtained during this experiment over a one year period (1976).

It then follows from Table 4.4 that the LCET in southern Ontario would operate at or below threshold (>3 dB fade) for a total of about 5 to 7-1/2 hours per year. The duration of the longest single event, at the two sites in one particular year, was 30 minutes. The signal would be unuseable (7 dB fade) for a total of about 1/2 to 1 hour per year, with a longest single event duration of 15 minutes. Because of the statistical accuracy expected from propagation data, the total C/N has been simply reduced by the amounts of the fade, and second order effects such as uplink contribution and increased antenna temperature have been neglected.

Two questions that were asked during the subjective viewer tests were:

(a) What is the worst level that you would find acceptable for home viewing on a regular basis?

(b) If you were watching an interesting picture and it began to degrade, what is the worst level at which you would still watch the program?

The mean rural and urban viewer responses to the questions were, respectively 3.6 and 3.9 and 2.2 and 2.3 on the five point quality scale. This, not surprisingly, substantiates the premises stated earlier in Section 4.2, namely, that long term objectives should be for operation above threshold, but that short fades below threshold are tolerable.

5. TECHNICAL ASPECTS OF THE LOW COST EARTH TERMINALS

5.1 LCET SPECIFICATIONS AND TEST DATA

On 28 March 1979, a contract was issued to SED systems Inc. for 100 LCETs to be used in the PDPP. The specifications for these terminals were based on experience gained during the Hermes experimental satellite program and through in-house development at CRC on a prototype LCET. A list of the design goal specifications is given in Appendix C.

The LCETs can be broken down into 3 principal components: the antenna and its mount, the outdoor unit (ODU) consisting of the antenna feed, low noise front end, mixer and local ascillator, and the indoor unit (IDU) consisting of tuning and further demodulation circuitry.

5.2 MANUFACTURER'S TEST DATA

As part of the contract, SED Systems was required to measure and to document certain key parameters for each of the 100 terminals. This Section summarizes results on some of the more important items.

(a) *ODU Noise Figure.* The noise figure of the ODU was measured using a Micronetics NS1 10/2 noise source and an Ailtech 75 Noise Figure Indicator. Only the ODU contribution is included in the results given here. Figure 5.1 shows the percentage of units with noise figure equal to or less than the ordinate values. The data show 50% of the units had noise figures less than 4.3 dB across the band and 95% less than 4.8 dB.

(b) *IDU Parameters.* Measurement results are given in Table 5.1.

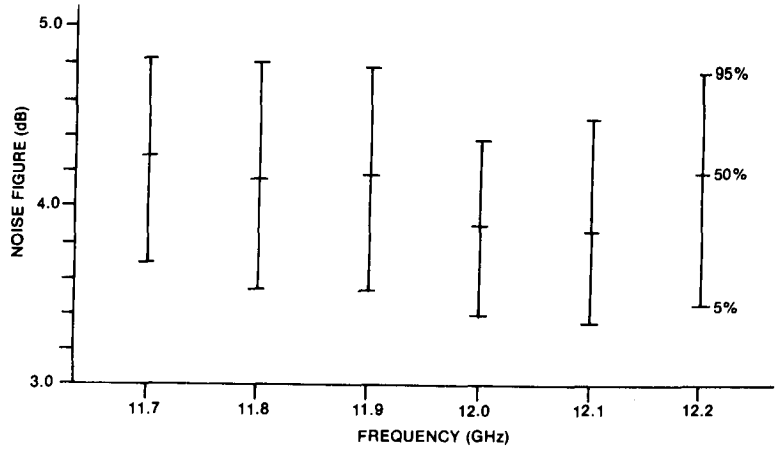


Figure 5.1. Distribution of ODU Noise Figure

TABLE 5.1

IDU Parameters

Value	Spec. Value	% of Units Equal to or Better than Spec.	95% Value	5% Value
IDU Noise Figure (dB)	12.0	89	13.2	9.2
Low Band Image (dB)	15.0**	44	12.7	18.2
High Band Image (dB)	10.0**	18	9.9	15.0
Diff. Phase (deg.)	8.0	99	–	0.7
Diff. Gain (%)	16.0	96	–	–
Video SNR* (dB)	>40.0	96	–	42.0
Audio SNR* (dB)	>44.0	99	–	49.0
Threshold C/N (dB)	9.5	96	–	9.0

* *At a C/N_0 of 85.1 dB-Hz.*

** *Note that only the image rejection of the IDU tuner fell considerably short of the design objective.*

5.3 POST FIELD TRIAL EVALUATION

Approximately 25 each of the IDU and ODU electronics units were identified as special evaluation units. These were subjected to a careful measurement program at SED Systems prior to shipment. The intent is to send them back for re-evaluation at SED Systems after a period of a year or more of field operation. Hopefully, information on the subject of ageing will be obtained. At the time of preparation of this report, the return of the units to SED Systems has just started and no results are yet available.

6. EVALUATION OF SIGNAL RECEPTION AND THE PERFORMANCE OF LOW COST EARTH TERMINALS IN NORTHWESTERN ONTARIO

6.1 INTRODUCTION

The ANIK-B program delivery pilot project afforded an ideal opportunity to evaluate the technical and operational performance of the LCET designed for reception of satellite broadcasting signals. Since the beginning of the project in September 1979, 43 LCETs were installed in northwestern Ontario while 34 terminals were installed in British Columbia, the Yukon and N.W.T. Some of the terminals had been operating for more than 1 year at the time of evaluation.

A test program was established to evaluate the technical performance of 25 terminals in Ontario. In October 1980, a vehicle equipped with specialized test equipment was taken to each of the 25 sites where detailed performance measurements were made using both satellite signals and test signals. Reference [6.1] contains complete details of the test program.

The sites illustrated on the map shown in Figure 6.1 were selected to ensure that:

(a) both 1.2m and 1.8m diameter terminals were evaluated inside the 49.5 dBW EIRP contour and between the 46.5 and 49.5 dBW EIRP contour;

(b) terminal measurements were made to obtain a sampling of performance across the spacecraft east-central beam pattern;

(c) a variety of users were sampled, including private homes, cable head-ends, Master Antenna TV (MATV) distribution schemes, users with reasonable alternate service, people with no or very limited alternate service; and,

(d) the terminals were readily accessible by road.

6.2 THE TEST PROGRAM

A detailed test plan was prepared and used for all the measurements to ensure uniformity of measurement procedures. The tests were comprehensive and were divided into two sections; (a) satellite tests, and (b) bench tests.

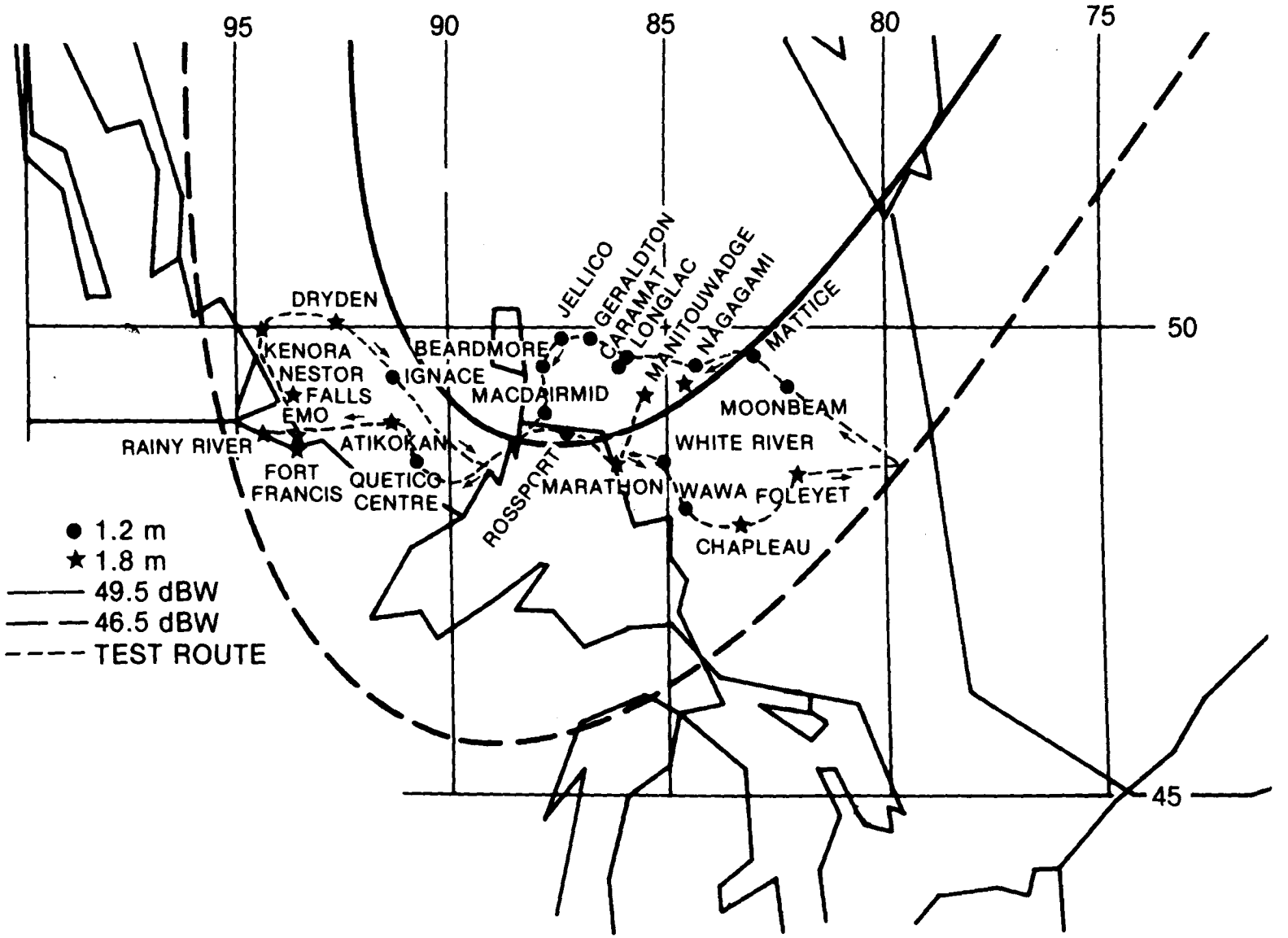


Figure 6.1. LCET Test Sites and Test Route

The satellite tests were used to check antenna alignment, received carrier-to-noise ratio (CNR) with a saturated carrier, received CNR and baseband signal-to-noise ratio (SNR) for the OECA signal, and baseband distortion parameters for the OECA signal. Bench tests were then conducted to determine the system noise temperature, the SNR for video and audio as a function of CNR, pre-detection filter response, AFC lock-up performance, baseband distortion to TV test signals, and the VHF remodulator spectrum.

During the conduct of the tests, several difficulties were encountered when repeatable measurements from site-to-site were attempted. These will be referred to in the measurement analysis section (Section 6.4). However, among the most common which limited the accuracy was the difficulty of accurately measuring CNR in the RF bandwidths of the Indoor Unit (IDU). A carrier-to-noise density measurement was not sufficient due to the different filter band-pass characteristics among the IDU's. Indeed, even in the same IDU, the amplitude response of the filter changed with tuning. Some attempts were made to correct for this in the measurement procedure.

A second difficulty encountered was the variation in the modulation level of the OECA test signal. By later analysis, it was possible to correct for this variation by normalizing to a reference of 6.0 MHz peak deviation.

A further problem which affected some of the OECA test signal measurements was the presence of digital Telidon data signals on lines in the vertical interval. These were shifted to different lines from time to time and there was not sufficient versatility in the test instruments to compensate. Consequently, some data were lost.

Equipping a motor-home van to visit the sites with a suitable array of test equipment and test jigs proved to be a very workable and consistent way of operating. A photograph of the van is shown in Figure 6.2. Figure 6.3 shows the equipment mounted inside.

Figure 6.2. LCET Test Van

Figure 6.3. Test Equipment Inside Test Van

It should be noted that all sites visited were accessible by road and, in fact, were sufficiently close together that a different site could be reached and tested each day. Figure 6.1 shows the route which was followed.

6.3 OPERATIONAL CONSIDERATIONS

Some of the most useful and instructive results from this test program were the general observations made at each individual site. To the extent possible, the type of data recorded included:

(a) the application of the LCET, i.e., home receiver, cable head-end, MATV, etc.:

(b) the general physical condition of the LCET;

(c) the general electrical performance of the LCET;

(d) the manner in which it was connected to user facilities, eg., TV set, distribution amplifier, etc.;

(e) the type and construction of the foundation and the location of the installation; and,

(f) a description by the user of any operating difficulties.

Foundations for the antennas varied from simple ground placement with sand or brick weighting, through mounts on platforms on the sides of huts, to special wooden bases. Figures 6.4 to 6.6 show installations at Mattice, a

cable head-end installation, at Atikokan, a cable company roof-top installation, and at Foleyet, a home installation. In only one known instance, at Manitouadge, had the antenna been overturned by winds, damaging the cable to the Outdoor Unit (ODU) and bending the struts holding the ODU.

Figure 6.4. Mattice — A Cable Head-End

Figure 6.5. Atikokan — A Cable Company Roof-Top Installation

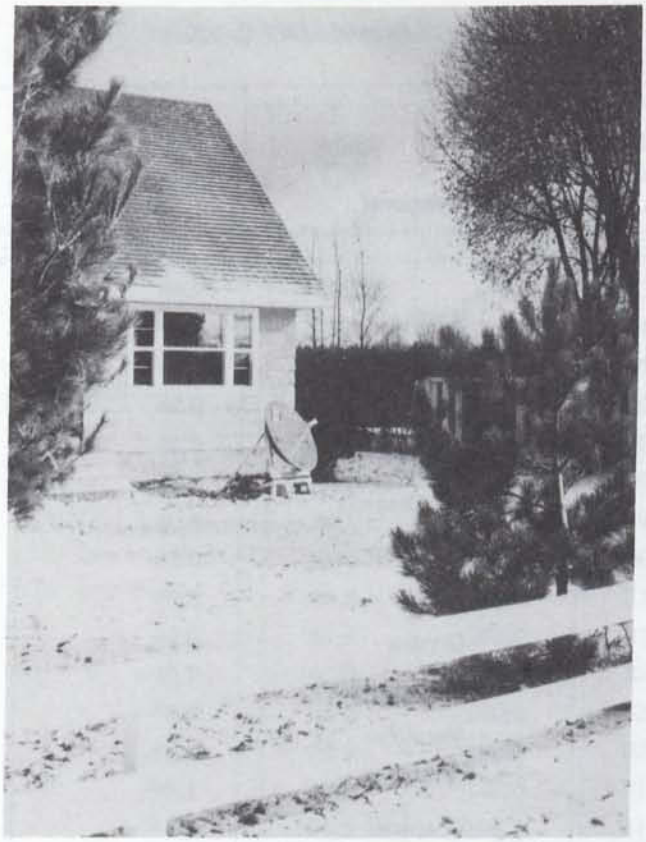


Figure 6.6. A Home Installation

Table 6.1 contains a summary of the operating condition of the 25 LCETs on arrival and after departure of the test van. Most of the terminals were working reasonably well.

Appendix D contains a description of general operating conditions and environment for each individual site.

6.4 SUMMARY AND ANALYSIS OF TEST RESULTS

It should be noted that considerable analysis was done on the raw data in order to attempt to remove erroneous measurements to the extent possible and to normalize the performance to a common reference, particularly for CNR and SNR, so that a reasonable evaluation of LCET performance could be made.

Although weather conditions at each site and at the uplink terminal were recorded, their effects are not factored into the analysis since they would have to be estimated. No significant storms occurred during the measurements in any case and the primary variation was the degree of cloud over.

TABLE 6.1

Summary of General LCET Condition

Not Functional or Problems on Arrival/Repaired/ Functional on Departure	Functional	Not Functional	Functional With Problems
Moonbeam	Mattice	Caramat	Jellico
Quetico Centre	Nagagami		Manitouwadge
Nestor Falls	Geraldton		Wawa
Ignace	Longlac		
Foleyet	MacDiarmid		
Rainy River	Atikokan		
	Kenora		
	Dryden		
	Beardmore		
	Marathon		
	White River		
	Chapleau		
	Fort Frances		
	Emo		
	Rossport		

This Section presents results for the following:

(a) polarization angle error

(b) pointing errors (antenna alignment)

(c) noise figures

(d) CNR and SNR values for video and audio signals for both satellite tests and bench tests

(e) baseband distortions

(f) remodulator response

A list of sites with location information is given in Table 6.2.

TABLE 6.2

ANIK-B Site Information (Ontario)

Location	Lat. (°N)	Long. (°W)	AZ (Degrees)	EL (Degrees)	Polarization Angle* (Degrees)
1. Moonbeam	49.25	82.15	213.7	27.9	21.2
2. Mattice	49.6	83.2	212.4	28.0	20.3
3. Nagagami	49.9	84.7	210.5	28.3	19.1
4. Jellico	49.8	87.5	207.3	29.3	17.2
5. Geraldton	49.8	86.9	207.9	29.1	17.6
6. Longlac	49.8	86.5	208.5	29.0	17.9
7. Caramat	49.6	86.1	209.0	29.1	18.7
8. Macdiarmid	49.0	88.0	206.9	30.2	17.3
9. Quetico	48.5	91.0	203.4	31.7	15.3
10. Atikokan	48.8	91.6	202.6	31.5	14.6
11. Fort Frances	48.7	93.8	199.9	32.2	12.9
12. Emo	48.6	93.8	200.0	32.3	13.0
13. Rainy River	48.7	94.6	198.9	32.4	12.3
14. Nestor Falls	49.1	93.9	199.6	31.8	12.7
15. Kenora	49.2	94.5	198.7	31.2	11.9
16. Dryden	49.9	92.9	200.7	31.1	13.2
17. Ignace	49.4	91.5	202.5	30.9	14.4
18. Beardmore	49.5	88.0	210.0	29.0	18.9
19. Rossport	48.8	87.5	207.6	30.3	17.8
20. Manitouwadge	49.1	85.7	209.6	29.4	18.9
21. Marathon	48.8	86.4	208.9	29.1	18.6
22. White River	48.5	85.3	210.3	29.8	19.6
23. Wawa	48.0	84.8	211.0	30.1	20.0
24. Chapleau	51.6	83.6	211.2	26.3	18.8
25. Foleyet	48.25	82.3	214.0	28.9	21.8

* *Referenced clockwise from vertical looking towards the satellite.*

6.4.1 Polarization Angle Error

Since ANIK-B transmits a linearly polarized signal, the LCET feeds required alignment for polarization. The actual polarization angles were checked against computed values for each site and adjusted as required. Most of the installations were done by DOC Regional or District Office staff after a brief training period at CRC. Since polarization angles are not a critical

factor until gross maladjustments occur, the accuracy of initial installation was not stressed. The received signal power for a linearly polarized signal is proportional to the cosine squared of the angle between the incident signal and receiver feed orientation. For example, an error offset of 15° would reduce the signal power by:

$$20 \log \left(\frac{1}{\text{Cos } 15°}\right) = -0.30 \text{ dB.}$$

Polarization errors have significant impact when frequency re-use is used in the same or adjacent coverage areas and polarization discrimination is used as the mechanism to provide isolation. For example, for two equal level signals transmitted on orthogonal polarizations, a misalignment of the receiver polarizer of 15° would mean that the unwanted signal would be approximately only 12 dB below the desired signal; an unacceptable interference for co-channel operation. ANIK-B does not use frequency re-use and thus polarization errors are not significant. However, with a satellite like ANIK-C, where frequency re-use will be employed, considerable care will be required to set the polarization angles correctly in the parts of the country where antenna footprints overlap.

Table 6.3 shows the errors determined at the 25 test sites. The mean error was 7.1° with a standard deviation of 5.5°. However, since these errors are set-up errors where little attempt was made to set them accurately, they should not be considered representative of errors which would occur if accurate alignment were attempted.

6.4.2 Antenna Pointing Errors

The antenna pointing error for each site was measured, with either a saturated unmodulated carrier or an OECA signal from the satellite, by moving the antenna to peak the detected signal level. Table 6.4 gives the measurement results for all sites. It should be noted that two antenna sizes are involved, 1.8m and 1.2m with 3 dB beamwidths of 0.9° and 1.4° respectively. For reference, Figure 6.7 shows theoretical antenna patterns for the two sizes of reflectors.

Ten terminals were operating with pointing errors equal to or greater than 1.0 dB. Of these 10, only 2 terminals, at Moonbeam and Wawa, did not have significant margin and indeed, were likely operating near their thresholds. Note that both sites were installed for private home use. On the remaining terminals, the pointing error losses could probably not be detected subjectively in isolation without some reference for comparison. Hence it is unlikely users felt a need to improve pointing. Two terminals that had pointing losses equal to or greater than 2 dB were both used for cable systems.

Average pointing errors are given in Table 6.5.

In Table 6.5 several ways of examining the data are provided. Although the number of terminals involved may not be statistically significant, some relative indications can perhaps be extracted. For example, it appears that losses associated with the 1.8m terminals were higher on the average, as one

TABLE 6.3

Polarization Angle Errors

Location	Calculated Polarization Angle* (Degrees)	Actual Polarization Angle* (Degrees)	Error (Degrees)	Signal Loss (dB)
1. Moonbeam	20	8	12	0.19
2. Mattice	20.3	21	-0.7	0.00
3. Nagagami	19.5	8	11.5	0.18
4. Jellico	17.2	8	9.2	0.12
5. Geraldton	17.6	12	5.6	0.04
6. Longlac	18.7	10	8.7	0.10
7. Caramat	18.7	–	–	–
8. Macdiarmid	17.3	18	-0.7	0.00
9. Quetico Centre	15.3	20	-4.7	0.02
10. Atikokan	14.6	11.0	3.6	0.02
11. Fort Frances	12.9	13	-0.1	0.00
12. Emo	13	11	2.0	0.00
13. Rainy River	12.3	–	–	–
14. Nestor Falls	12.7	5.5	7.2	0.06
15. Kenora	11.9	27.5	-15.6	0.32
16. Dryden	13.2	9.2	4.0	0.02
17. Ignace	14.4	-1.0	15.4	0.32
18. Beardmore	18.9	20	-1.1	0.00
19. Rossport	17.8	14	3.8	0.02
20. Manitouwadge	18.9	26	-7.1	0.07
21. Marathon	18.6	19	-0.4	0.00
22. White River	19.6	36	-16.4	0.36
23. Wawa	20.3	3	17.3	0.40
24. Chapleau	18.8	28	-9.2	0.11
25. Foleyet	21.8	14	7.8	0.08

* *Referenced clockwise from vertical looking towards satellite.*

would expect, due to their narrower beamwidth. There appears to be a significantly greater pointing error outside the 49.5 dBW EIRP contour than inside. However, this is consistent with the fact that all but one of the 1.8m terminals were located outside the 49.5 dBW EIRP contour. It is also interesting to note that terminals employed for private home use were, on the average, better aligned than cable head-end and MATV terminals.

A further column in Table 6.4 shows the pointing error as a function of degrees rather than dB loss. The mean and standard deviation for the pointing errors expressed in degrees are given in Table 6.6.

The averages indicate that 1.8m terminals were not only pointed more accurately, but that the pointing was more consistent. However, when these figures are compared to those in the previous Table, it is noted that the increased accuracy is not sufficient to overcome the increased loss due to a narrower beam.

TABLE 6.4

Antenna Pointing Errors

Site	Change in Peak Signal (dB)	Antenna Diameter (M)	Beamwidth (Degrees)	Error (Degrees)
1. Moonbeam	1.8	1.2	1.4	0.54
2. Mattice	0.5	1.2	1.4	0.29
3. Nagagami	0.2	1.2	1.4	0.18
4. Jellico	1.2	1.2	1.4	0.44
5. Geraldton	2.0	1.2	1.4	0.57
6. Longlac	0.25	1.2	1.4	0.20
7. Caramet	–	1.2	1.4	–
8. Macdiarmid	-0.25	1.2	1.4	-0.20
9. Quetico Centre	0.25	1.2	1.4	0.20
10. Atikokan	2.0	1.8	0.9	0.39
11. Fort Frances	0	1.8	0.9	0.00
12. Emo	1.0	1.8	0.9	0.27
13. Rainy River	1.0	1.8	0.9	0.27
14. Nestor Falls	1.15	1.8	0.9	0.29
15. Kenora	1.0	1.8	0.9	0.27
16. Dryden	0.15	1.8	0.9	0.10
17. Ignace	0.85	1.2	1.4	0.37
18. Beardmore	0.3	1.2	1.4	0.22
19. Rossport	-0.2	1.2	1.4	-0.18
20. Manitouwadge	0.1	1.8	0.9	0.08
21. Marathon	0.1	1.8	0.9	0.08
22. White River	0.9	1.2	1.4	0.38
23. Wawa	1.15	1.2	1.4	0.43
24. Chapleau	1.65	1.8	0.9	0.34
25. Foleyet	0.25	1.2	1.4	0.20

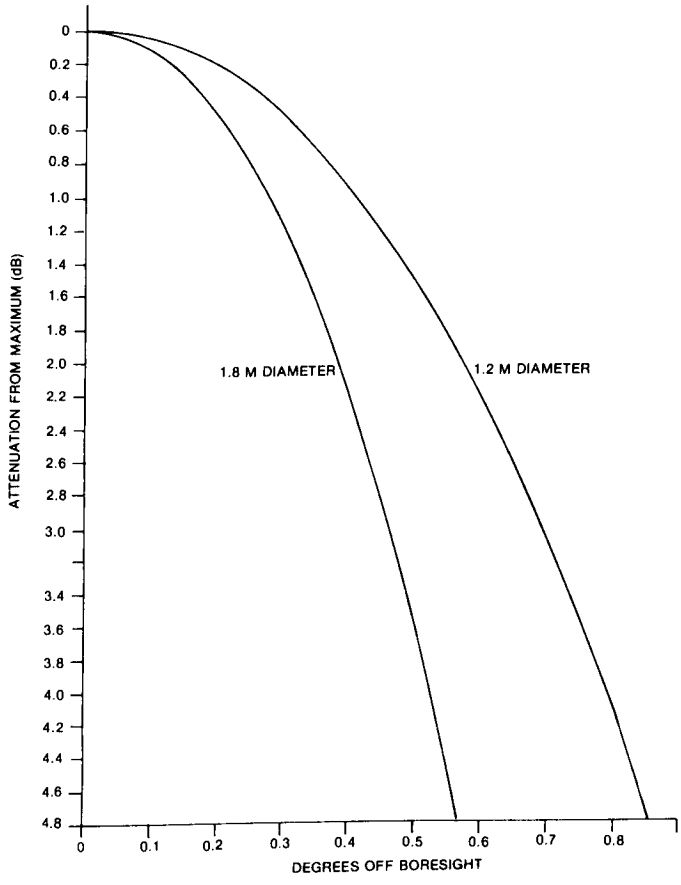


Figure 6.7. Theoretical Antenna Patterns for LCET Reflectors

TABLE 6.5

Average Signal Loss Due to Pointing Errors

	Mean (dB)	Standard Deviation (dB)
All Terminals Combined	0.78	0.20
All 1.2m Terminals	0.71	0.20
All 1.8m Terminals	0.88	0.21
All Terminals within 49.5 dBW EIRP Contour	0.51	0.22
All Terminals between 49.5 and 46.5 dBW EIRP	0.91	0.18
All Terminals Used by Homes	0.78	0.18
All Terminals Used for MATV Systems or Cable Head-Ends	0.83	0.22

(Note that except for Manitouwadge, all 1.8m terminals were outside the 49.5 dBW EIRP contour.)

TABLE 6.6

Average Pointing Errors

	Mean (deg.)	Standard Deviation (deg.)
All Terminals Combined	0.24	0.20
All 1.2m Terminals	0.26	0.23
All 1.8m Terminals	0.21	0.13

6.4.3 Noise Figures

Table 6.7 summarizes the measurement of noise figure (NF) in Channel 2, the frequency at which the OECA signal was transmitted by the spacecraft. For comparison, the factory test results are included. It should be noted, however, that the factory test results measured the noise figure for the ODU only, while the field tests measured the noise figure including all contributions to a 5 MHz frequency slot at the 70 MHz IF. Empirically, the ODU should predominate with little addition from the IDU. Also, it is expected that the factory measurements are somewhat more accurate (eg., factory tests accurate to approximately 0.1 dB, while field tests accurate to approximately 0.25 dB). However the use of different reference noise sources for the measurement, which cannot be avoided, can introduce errors of ±0.5 dB.

The results tabulated in Table 6.7 can be summarized as follows:

(a) If one assumes the NF measurements in the field are accurate to better than 0.25 dB, and that the factory test measurements are of equal or better accuracy, it appears that several of the terminals have degraded somewhat in performance. However, significant degradation greater than 1 dB, has occurred in only 3 of the 25 terminals. Since the field measurements include the IDU noise figure, it is uncertain whether the degradation was caused by the ODU or the IDU.

(b) Eleven of the 25 terminals were within estimated measurement accuracy (0.25 dB) of the factory measurements.

(c) One parameter of interest is the amount the NF appears to have changed. Table 6.8 tabulates the differences between tests and factory tests.

6.4.4 Carrier-to-Noise Ratio and Signal-to-Noise Ratio

A detailed analysis was conducted on the data collected from several tests to attempt to determine the CNR and SNR performance of each terminal.

Table 6.9 summarizes the results of this data analysis. Reference [6.1] describes how the analysis was done. In order to obtain a measure of

TABLE 6.7

Noise Figure Measurements at Approximately 11.82 GHz

Site	Field Tests		Factory Tests		Difference (Field-Factory) With Adjustment* For IDU	
	NF (dB)	System Temperature (K)	NF (dB)	System Temperature (K)	NF	System Temperature*
1. Moonbeam	5.10	648	4.45	518	0.51	100
2. Mattice	4.12	459	3.65	382	0.29	47
3. Nagagami	4.60	546	4.00	458	0.44	58
4. Jellico	3.80	406	3.55	367	0.06	9
5. Geraldton	4.00	458	4.20	473	-0.26	-45
6. Longlac	4.00	458	3.50	359	0.44	69
7. Caramat	4.30	481	4.20	473	-0.07	-12
8. Macdiarmid	5.90	838	4.70	566	1.08	242
9. Quetico Centre	5.00	627	4.25	482	0.61	115
10. Atikokan	4.49	525	4.4	509	-0.08	-14
11. Fort Frances	4.38	505	4.15	464	0.06	11
12. Emo	3.96	432	3.30	330	0.48	72
13. Rainy River	4.87	600	4.05	447	0.67	123
14. Nestor Falls	4.06	449	3.85	414	0.03	5
15. Kenora	4.76	578	4.80	486	-0.19	-36
16. Dryden	4.60	546	3.80	406	0.64	110
17. Ignace	3.96	432	3.85	414	-0.07	-12
18. Beardmore	5.69	785	4.60	546	0.97	209
19. Rossport	5.36	706	4.40	509	0.83	167
20. Manitouwadge	5.09	646	3.90	422	1.05	194
21. Marathon	4.60	546	3.70	390	0.74	126
22. White River	5.03	633	4.85	596	0.03	7
23. Wawa	4.55	537	4.40	509	-0.01	-2
24. Chapleau	4.40	509	4.30	491	-0.06	-12
25. Foleyet	4.40	509	3.85	414	0.39	15

**30° Kelvin, assumed for IDU, removed for comparison to factory tests.*

TABLE 6.8

Difference Between Field and Factory Measurements of Noise Figure

	Mean	Standard Deviation
Noise Figure as Measured (dB)	0.49	0.40
Noise Temperature as Measured	92	81
Noise Figure (adjusted for IDU contributions) dB	0.34	0.41
Noise Temperature (adjusted for IDU contributions) (K)	62	81

performance relative to a standard set of conditions, several factors had to be considered:

(a) A theoretical calculation of received CNR and video SNR (S/N_V) was done for each terminal for a saturated carrier signal transmitted by the satellite. EIRPs for the satellite for each terminal location were obtained from estimated beam patterns. The measured system noise temperature was used in the calculation. The following link parameters were assumed:

Deviation sensitivity	=	6.0 MHz peak
Implementation margin	=	1.0 dB
Atmospheric attenuation	=	0.26 dB
Antenna efficiency	=	65%
System temperature	=	measured value plus 50K for antenna noise
Pointing loss	=	0 dB (measurement made after repeaking)
Receiver pre-detection noise bandwidth	=	19 MHz

This value of pre-detection noise bandwidth is taken as representative of that provided by the manufacturers rather than that specified.

(b) It was fairly difficult to achieve any degree of accuracy in the measurement of CNR on a satellite signal due to non-linearities in the LCET, inherent in the low cost design. Hence, the true RMS voltmeter readings of S/N_V were, in most instances, considered more accurate. The implied CNR (CNR^1) in the table is based upon a calculation of the CNR to produce the measured S/N_V.

(c) The signal transmitted by OECA was not of constant deviation from day-to-day and, in fact, the transmitter deviation was adjusted at least on one occasion during the tests at the request of the Communications Control Terminal in Ottawa. The deviation variations had to be normalized.

Hence, in summary, all the S/N_V given in Table 6.9 are corrected to give the measured and theoretical performance for a 6.0 MHz peak signal deviation for a 1 volt (140 IRE units) peak-to-peak input signal.

Examining Table 6.9 indicates that after normalizing the data, considerable variation still exists in the terminal performance. However, there appear to be approximately equal numbers which have CNRs greater than and less than theoretical. Only a few terminals exhibited consistent performance for all the different measurements taken. The data serve to illustrate that the measured results vary over a range of approximately 5.2 dB relative to those predicted; (+2.0 to -3.2 dB, where difference is theoretical - measured).

Some attempt was made to determine the source of these variations. Some of the possibilities include:

(a) the spacecraft antenna patterns may be shifted from nominal position,

(b) The RF pre-detection filters may be significantly different from the assumed 19 MHz noise bandwidth,

(c) The non-linearities in the LCETs introduced measurement difficulties in measuring CNR and accuracies were reduced. For example, in some cases, CNR varied with AGC level setting.

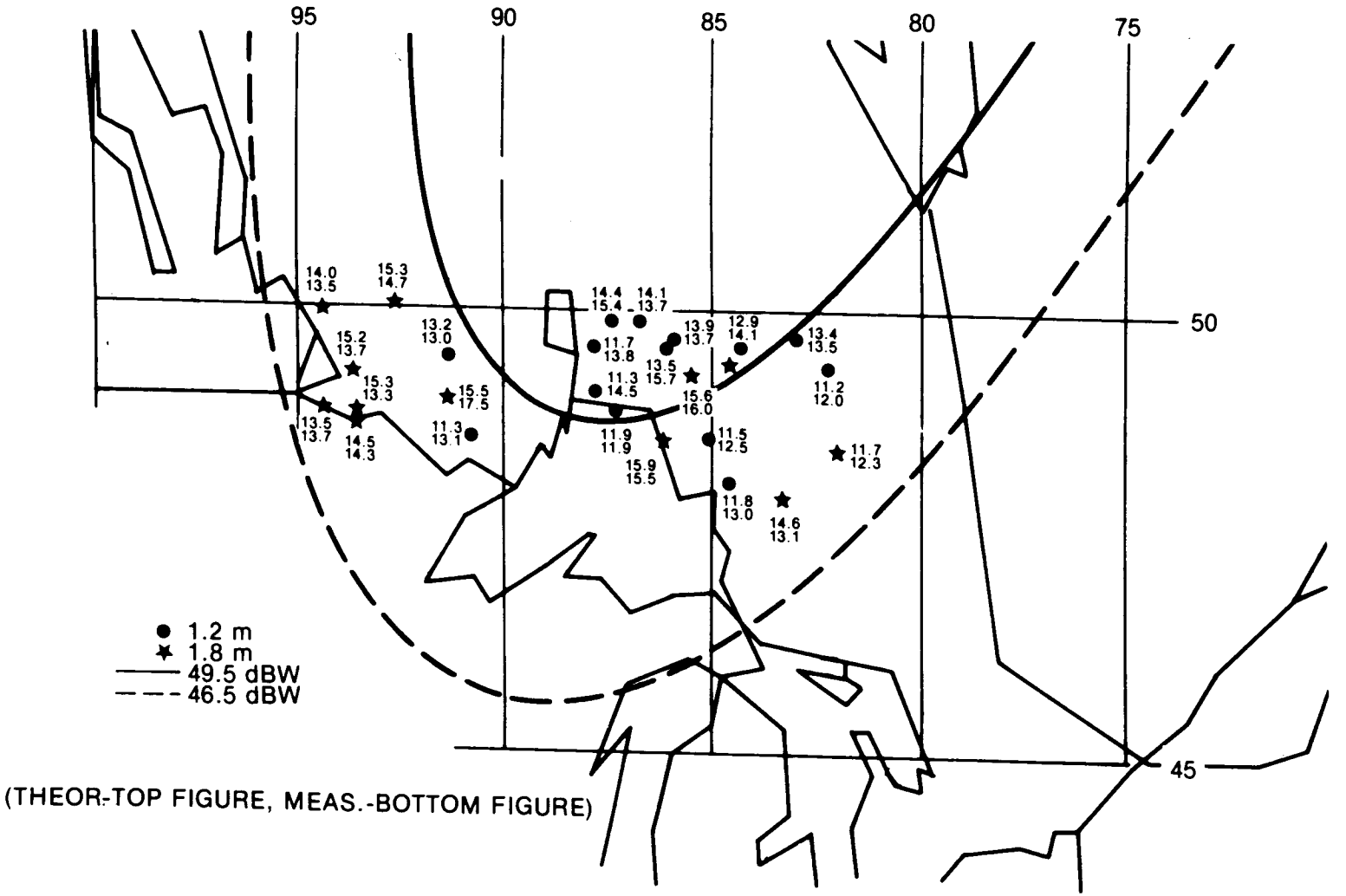
The measurement procedures were not sufficiently detailed to identify the latter two possibilities. The first possibility was examined in more detail. Figures 6.8 and 6.9 shows maps of the region of interest with 49.5 dBW and 46.5 dBW EIRP contours indicated. In Figure 6.8, each site is given the theoretical and measured CNR. Figure 6.9 shows the difference, i.e., the theoretical-measured. It is difficult to conclude from this data that the beam patterns are all different from those expected.

Table 6.10 provides a summary of measurements of the audio channel performance. Provided for each site is the theoretical CNR, the best estimate for measured CNR, the theoretical audio SNR (S/N_A) and the measured S/N_A. At the start of the program, the audio subcarrier deviations on the uplink were set considerably higher than required. In 14 out of 25 cases, the measured values exceeded the theoretical predictions, where the theory was based upon specific assumptions for modulation indices. It should also be noted that the S/N_A was measured using program weighting. The theoretical calculation assumes the noise at the discriminator output to be triangular, and that a de-emphasis circuit of 75 μsec is used. Laboratory measurements done on other IDUs indicate that, in fact, the noise is not triangular.

TABLE 6.9

Data Analysis Results for CNR and S/N_V

Site	Saturated Theoretical			Saturated Measurement		Implied CNR (dB)	OECA Measurement		Implied CNR (dB)
	EIRP (dB)	CNR (dB)	S/N_V (dB)	CNR (dB)	S/N (dB)		CNR (dB)	S/N_V (dB)	
1. Moonbeam	48.6	11.2	40.5	12.0	42.3	13.0	13.5	43.7	14.4
2. Mattice	49.5	13.4	42.8	13.5	43.0	13.7	11.8	42.3	13.0
3. Nagagami	49.6	12.9	42.2	14.1	43.2	13.9	14.0	44.5	15.2
4. Jellico	50.0	14.4	43.7	–	–	–	17.1	44.7	15.4
5. Geraldton	50.0	14.1	43.4	15.8	43.0	13.7	14.6	45.8	16.5
6. Longlac	49.8	13.9	43.2	13.7	41.7	12.4	12.5	42.6	13.3
7. Caramat	49.8	13.5	42.8	15.7	–	–	–	–	–
8. Macdiarmid	49.7	11.3	40.6	14.5	43.8	14.5	12.7	44.7	15.4
9. Quetico Centre	48.6	11.3	40.7	13.1	40.9	11.6	13.5	41.0	11.7
10. Atikokan	48.6	15.5	44.8	17.5	44.2	14.9	17.2	47.1	17.8
11. Fort Frances	47.5	14.5	43.9	–	–	–	14.3	43.9	14.6
12. Emo	47.6	15.3	44.6	13.3	42.8	13.5	12.2	43.2	13.9
13. Rainy River	47.1	13.5	42.8	13.7	41.1	11.8	13.1	41.4	12.1
14. Nestor Falls	47.7	15.2	44.5	13.7	42.5	13.2	13.8	43.9	14.6
15. Kenora	47.5	14.0	43.4	13.5	41.6	12.0	13.7	42.9	13.6
16. Dryden	48.6	15.3	44.7	14.7	43.7	14.4	14.3	44.2	14.9
17. Ignace	49.0	13.2	42.5	–	–	–	13.0	41.6	12.3
18. Beardmore	49.9	11.7	41.1	–	–	–	13.8	44.0	14.7
19. Rossport	49.6	11.9	41.2	–	–	–	11.9	41.9	12.6
20. Manitouwadge	49.6	15.6	45.0	16.0	–	–	12.1	–	–
21. Marathon	49.2	15.9	45.7	15.5	44.5	14.9	14.3	47.6	18.3
22. White River	49.0	11.5	41.0	–	–	–	12.5	42.3	13.0
23. Wawa	48.4	11.8	41.1	13.0	41.5	11.9	12.1	42.6	13.3
24. Chapleau	47.6	14.6	44.0	13.1	42.4	12.8	13.1	44.3	15.0
25. Foleyet	47.6	11.7	40.5	12.3	42.2	12.9	12.3	42.7	13.4



(THEOR.-TOP FIGURE, MEAS.-BOTTOM FIGURE)

Figure 6.8. Theoretical and Measured CNR at LCET Sites.

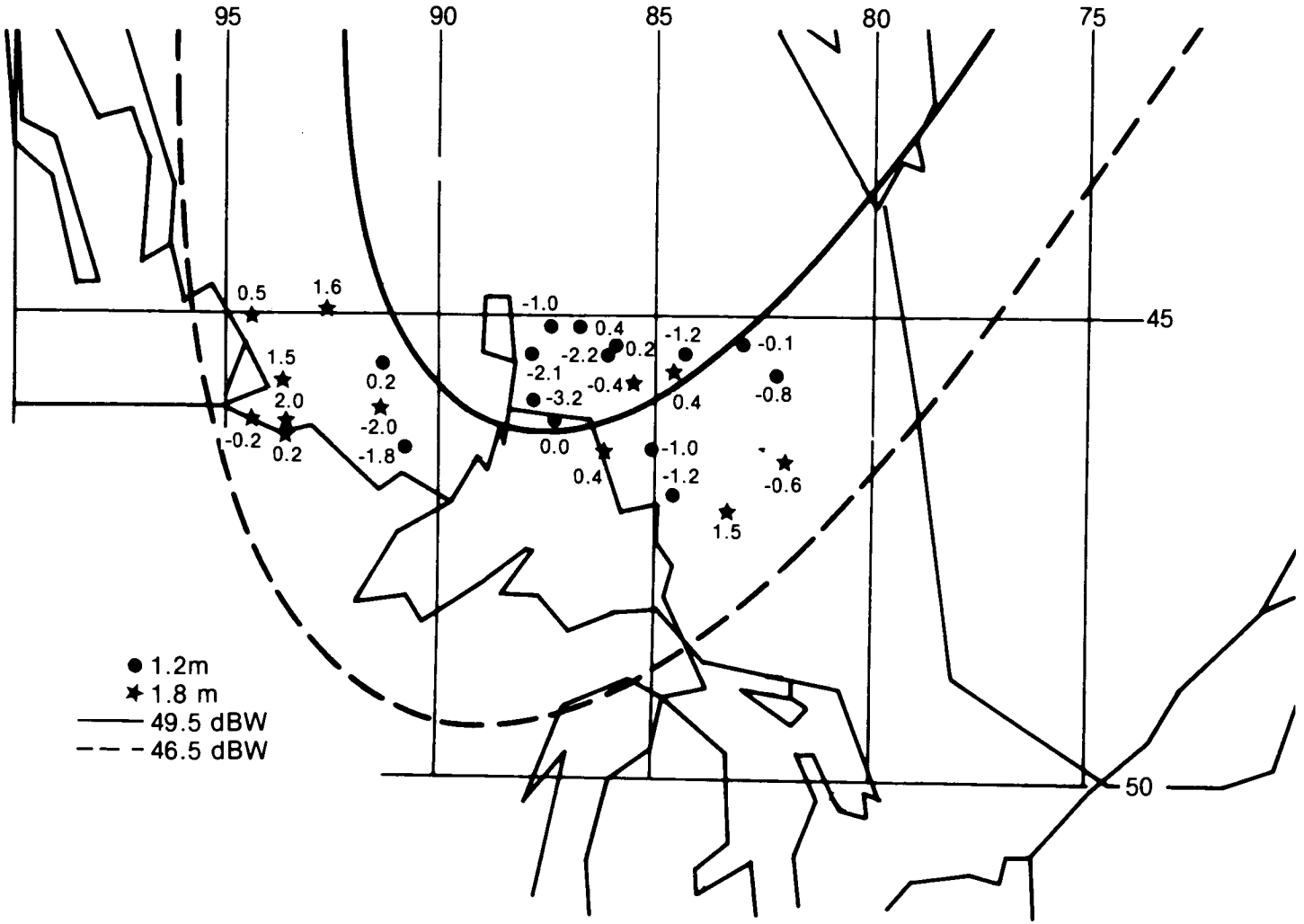


Figure 6.9. CNR Differences (Theoretical-Measured).

TABLE 6.10

Audio Performance

Site	CNR Theoretical	CNR Measurement (Best Available)	S/N_A Theoretical	S/N_A Measurement
1. Moonbeam	11.2	12.0	44.9	47.2
2. Mattice	13.4	13.5	47.1	48.2
3. Nagagami	12.9	14.1	46.6	50.5
4. Jellico	14.4	15.4*	46.6	–
5. Geraldton	14.1	13.7	47.8	–
6. Longlac	13.9	13.7	47.6	49.1
7. Caramat	13.5	15.7	47.2	51.6
8. Macdiarmid	11.3	14.5	45.0	46.3
9. Quetico Centre	11.3	13.1	45.0	53.2
10. Atikokan	15.5	17.5	49.2	51.7
11. Fort Frances	14.5	14.3*	48.2	–
12. Emo	15.3	13.3	49.0	44.3
13. Rainy River	13.5	13.7	47.2	49.5
14. Nestor Falls	15.2	13.7	48.9	48.8
15. Kenora	14.0	13.5	47.7	48.6
16. Dryden	15.3	14.7	49.0	51.8
17. Ignace	13.2	13.0*	46.9	–
18. Beardmore	11.7	13.8*	45.4	–
19. Rossport	11.9	11.9*	45.6	–
20. Manitouwadge	15.6	16.0	49.3	50.7
21. Marathon	15.9	15.5	49.6	46.1
22. White River	11.5	12.5*	45.2	–
23. Wawa	11.8	13.0	45.5	38.6
24. Chapleau	14.6	13.1	48.3	52.3
25. Foleyet	11.7	12.3	45.4	50.2

* *Measured on OECA Signal.*

6.4.5 Baseband Distortions

Table 6.11 contains the measurement results for differential phase and gain, the values measured at the factory, and another result of some interest, the amount of discontinuity in the vertical retrace interval. On some units, there existed a large D.C. shift during the vertical retrace interval, indicating one of several possibilities, including:

(a) the A.C. output coupling was insufficient or defective,

(b) the discriminator was defective,

(c) the clamper was defective.

TABLE 6.11

Baseband Distortions

Site	Differential Gain (%)	Differential Phase (degrees)	Differential Gain (%)	Differential Phase (degrees)	Discontinuity in the Vertical Interval (IRE Units)
1. Moonbeam	7	–	6	3.2	–
2. Mattice	7.7	2.9	4	5.2	7
3. Nagagami	4.6	2.2	14	2.7	7
4. Jellico	5.3	4.2	6	2.6	7.5
5. Geraldton	3	–	7	6.8	15
6. Longlac	3.5	2.9	14	2.7	6
7. Caramat	–	–	7	3.0	–
8. MacDiarmid	5.2	1.5	10	6.0	10
9. Quetico Centre	9.0	2.2	10	5.1	10
10. Atikokan	11.8	5.0	–	–	15
11. Fort Frances	10.6	6.8	13	5	10
12. Emo	6.4	2.0	1.5	1.1	8
13. Rainy River	6.8	5.2	15	7.2	10
14. Nestor Falls	12.1	4.1	8	3	10
15. Kenora	3.7	6.7	3	6	8
16. Dryden	6.6	4.3	6	3.2	5
17. Ignace	8.5	2.3	10	4.3	8
18. Beardmore	2.4	5.9	4	0.6	12
19. Rossport	10.1	2.5	14	5.7	5
20. Manitouwadge	–	3.2	5	2	22
21. Marathon	14.8	4.8	15	1.6	8
22. White River	3.7	4.9	9	3.7	8
23. Wawa	6.6	2.3	15	5.1	7
24. Chapleau	21.7	4.8	7	4.9	6
25. Foleyet	8.0	7.9	6	3.3	9

In any case, the net result was that those units which displayed fairly large discontinuities had large distortions in the vertical interval. The results were:

(a) the vertical sync was less precise, depending upon the amount of distortion,

(b) any signal transmitted during the vertical interval, such as video test signals or Telidon digital data signals were severely distorted.

It should be noted that one would expect these values to be less than 5 IRE units. Nine units displayed distortions of 10 or more IRE units.

In the data showing both field and factory tests, there is essentially no consistent agreement. This is not unexpected since large variations in differential gain and phase occur and are very much a function of the signal location in the RF passband. Any biases on the AFC manual control knob, tends to skew the signal to one side or the other, with considerable changes to differential gain and phase. Other measurements of baseband distortion were taken and the data on these measurements are summarized and reported in Reference [6.1].

6.4.6 Remodulator Response

Each of the IDUs was equipped with an AM remodulator to provide a signal compatible to the RF inputs of consumer TV sets. Although the required modulation was vestigial sideband amplitude modulation with an FM carrier for the audio, the sideband filtering was not provided, resulting in an amplitude modulated spectrum symmetrical about the carrier.

This scheme performed satisfactorily in all cases but one, where a remodulator unit was malfunctioning. Several users, however, indicated that they experienced interference when attempting to combine the remodulated signal with antenna feeds. This interference would have been eliminated, of course, had a channel filter been used to pass only the signal of interest (Channel 3 or 4) and reject all spurious and harmonics.

6.5 CONCLUSIONS

The design details for the PDPP were discussed in Section 4 and the results of field measurements are given here in Section 6. In Section 4.3.1, a design CNR of 12.9 dB was developed for a 1.2m LCET at the inner EIRP contour. This is within quite acceptable agreement with the values shown on Figure 6.8 for calculated CNR (based on 19 MHz bandwidths and measured noise figures) and measured results, taking into account accuracy expected in the field. Six 1.2m LCETs were located outside the inner contour guideline for the centre-east beam. These all received acceptable signals. In fact, in an environment where non-technical users make decisions about terminal placement, it is quickly discovered that engineering guidelines are just that, guidelines. In the 3-carrier mode in the west, watchable pictures were received on a 1.8m LCET with a EIRP of about 43 dBW. Some EIRP values in the 1977 WARC broadcasting plan exceed 68 dBW suggesting that, with this power, people having 1m terminals could receive signals 20 dB off the main boresight.

Section 6.4.2 discusses antenna point loss. Antenna alignment does not appear to have been a significant problem. In some cases, users had moved the terminal and in others they repointed the antenna. Most reported little difficulty in doing this.

Examination of the data in Tables 6.4 and 6.9 indicates that the CNR at 24 sites (measurements were not made at one site) was above 11 dB and at 20 sites was 12 dB or more *before* the antennas were realigned. Of the four sites with CNR below 12 dB, three were 1.2m antennas which were outside the inner contour guideline. This would indicate that the signal was sufficiently good that the users were not aware of the small pointing loss. Seventeen terminals had pointing losses of 1 dB or less and 6 of these had never been re-aligned. Terminals located on the ground could be expected to require re-pointing because of frost heaving and this was found to be true in some cases.

There does not appear to be strong evidence for serious degradation of performance over a time period in the field. A few of the units appear to have degraded noise figures. More information on this question should be available when the post field trial evaluation has been completed.

In summary, the field measurements did not result in any surprising findings. The assumption made prior to the trial regarding the performance appear to have been valid.

7. SERVICE PERFORMANCE

The purpose of this Section of the assessment report is to provide some information and impressions concerning the attitudes and reactions of participants in the PDPP, during and at the end of approximately 12-months of operation. It is important to emphasize that unlike the technical performance Sections of the report, the observations in this Section are based on information which is usually unquantifiable and are a collection of impressions concerning attitudes, trends and potential implications, at the time of writing. Continued operation of the PDPP and the future availability of operational DBS-type systems will result in firmer data at a later time.

7.1 VIEWER REACTION

With the exception of some DOC Regional and District Office staff, little direct contact is maintained by DOC with the end-users of PDPP transmissions. Most operational contacts with end-users are maintained by the program providers (educational and broadcasting organizations) involved in the PDPP. The attitudes and reactions of the viewers of the PDPP signals are, therefore, primarily based on verbal and written communications made available to DOC by the broadcasting organizations and DOC Regional Offices, as well as some supporting correspondence and newspaper articles. Direct contact has been established by DOC in Ontario where extensive technical field tests were conducted and a "Satellite Field Trial Users Survey" questionnaire was administered at the time of the technical testing in October - November 1980.

It is generally reported by all information sources that viewers are very content with the reception of the alternative television programs provided by the PDPP, and no longer view this to be an experiment or trial but a service to which they feel entitled and which they do not wish to have terminated. The termination of this service, after it has been proven technically possible, would result in serious negative public reaction. Numerous petitions, letters and newspaper articles definitely indicate viewer satisfaction with the PDPP and a strong desire to have the service continued until a permanent commercial service becomes available. The suggestion of not extending PDPP beyond the originally planned deadline (17 February 1981) resulted in numerous municipal council resolutions and petitions from sites where receiving terminals are located.

Both the broadcasters and DOC Regional Offices report receiving inquiries from the general public, town councils, communities and various other organizations (even from the United States) concerning means of obtaining or purchasing ANIK-B low-cost earth terminals.

Some broadcasters and the newspaper medium indicate that these Canadian signals are more popular than those pirated from U.S. satellites and in some communities, the PDPP may be preventing the further proliferation of unlicensed earth terminals and transmitters that distribute unauthorized American programming.

Satisfaction with the PDPP is perhaps best illustrated by the fact that in several locations, the PDPP terminal intended for single-home reception has been connected to a transmitter or cable system in order to make the signal available to other residents of the community.

7.2 SATELLITE FIELD TRIAL USERS SURVEY

A questionnaire entitled "Satellite Field Trial Users Survey" was administered in 22 PDPP locations in Ontario during the DOC technical field tests conducted in October - November 1980. This questionnaire was slightly modified and administered by telephone to 14 sites in British Columbia, the Yukon and Northwest Territories. Copies of the survey forms are attached in Appendix E. Appendix E also contains a summary of the results of the questionnaire, categorized by site locations with respect to their position in the inner and outer contours of the satellite beams in the east and the west.

Although the sample size is very small, some conclusions can be drawn. The results obtained indicate that more than one-half of the viewers surveyed had to seek assistance at least once because the satellite signals had been lost due to equipment failure, physical damage or other reasons such as the need to move the terminal. The fact that fewer calls for assistance were required in the west could be interpreted in several ways. The PDPP in the west began later than in the east and more experience had been gained. Also, the western units may be superior to those manufactured during the earlier stages, when the eastern installations were made. Other variables and possible reasons could be identified, but a more complete sampling would be required from the west.

The survey indicates that over 75% of the viewers in all areas experience a consistent quality of television reception. The quality, however, appears to vary greatly. Those located in the inner contour tend to classify the picture quality and sound quality as "good" whereas those in the outer contour tend to define the quality of the picture as "excellent" and the sound as "good". It is not possible to determine the exact cause for these results since there are too many factors involved, particularly the subjectivity concerning the definition of quality, without any standard of comparison. It is possible however, to conclude, that *the 22 sites surveyed* in PDPP East describe the reception quality of the OECA signal in comparison with other signals available as

Excellent	-	45%
Good	-	27%
Fair	-	14%
Poor	-	5%
No Answer	-	9%

Generally, the survey indicates that the quality of reception for the OECA signal is better or equal to that of the other television channels available. The *24 sites contacted* in PDPP West classify the quality as follows

Excellent	-	29%
Very good	-	7%
Good	-	57%
No Answer	-	7%

Those who considered the signal quality to be inconsistent, generally commented that it varied from "good" to "poor". The responses indicated that the loss of signal is most frequent in the outer contour.

The rather poor performance of the AFC circuits led to the need to retune the indoor units occasionally, and especially at the sites where equipment was unattended. Although most sites indicate that occasional returning of the indoor unit was required to improve the quality of the signal, the majority did not feel that this was a problem. Many sites reported the need to perform some maintenance, such as snow or ice removal from the antenna. This is a normal requirement and did not appear to cause difficulties.

Although the majority of users indicated that they watched TV 5 hours or more per day, no conclusions can be drawn since there is no information concerning their watching habits prior to the PDPP.

The majority of the PDPP viewers in Ontario appear to have paid less than $1000 for their present receiving installation (TV set, tower, directional antenna). They appear to be prepared to pay approximately as much as a current monthly subscription to cable ($5-$10/month) to receive good quality television from a variety of different stations. Those in the PDPP West appear to be prepared to pay somewhat more ($15-$20/month) for a similar service. This could be partly due to the number of unlicensed earth stations which for some time have received signals from U.S. satellites and for which the population has already been paying approximately $15-$20/month. It could also be that in some cases only the CBC has been available, and the people are prepared to pay a higher fee for an alternative television programming choice.

It must be emphasized that these observations are drawn from a very small size and can serve only as an indication of the reaction of the viewers.

7.3 BROADCASTERS' REACTIONS

Guided by the viewers, the broadcasters are largely satisfied with the PDPP which they regard as the provision of an alternative television service to areas where they have a mandate to deliver their signal. To them, the PDPP has provided a technical solution to the long-term problem of extending services to remote and isolated areas which cannot be reached in an economically viable fashion by terrestrial means.

OECA currently reaches 85% of the Ontario population through terrestrial broadcasting and cable systems. The PDPP extends this coverage to 47 locations, which include 21 cable systems, 6 institutions, and 19 individual homes. OECA's goal is to make its services available to all of the Ontario population. In its submission to the CRTC Committee on the Extension of Services to Remote and Northern Areas, OECA stated that the only way this can be achieved efficiently is by:

> *a hybrid distribution system using direct broadcast satellite. This means use of the 14/12 GHz service on a regional (or spot) beam satellite to feed the broadcast network currently in place, additional conventional broadcast transmitters, low power re-broadcast transmitters, cable systems and individual homes.....*

...Ideally, OECA would like to continue to provide the experimental service of ANIK-B 14/12 GHz until Anik-C is launched, and the full distribution system can be converted to the hybrid distribution system mentioned above. [7.1]

The CBC, which has a mandate to provide English and French radio and television services to all Canada, already utilizes satellites for the distribution of its signals throughout Canada. The CBC Accelerated Coverage Plan, designed to provide services to remote communities of 500 citizens or more, has also been assisted through the PDPP in western Canada and the CBC is expected to review the regionalization of its services by means of satellite delivery in the 14/12 GHz frequency band, at an appropriate time in the future.

Until the PDPP, BCTV was unable to extend its services to many of the remote locations within its service area. The remaining population to be convered is small, and the additional advertising audience would be too low to justify the expense. The PDPP has, however, proven to be extremely popular and BCTV feels that it is providing a much needed alternate interim television service which should be continued until a Canadian satellite package is permanently available.

It is generally true that all broadcasters are pleased to have the opportunity of "hands-on" experience which will assist them in the development of their future plans.

7.4 PROVINCIAL GOVERNMENT REACTIONS

Various Provincial Government Ministries and Territorial Departments are involved in the PDPP in terms of financial and resource support. Future plans of these Provincial and Territorial agencies with respect to satellite delivered services will be discussed in Section 8 on planning and policy. Generally, the PDPP has stimulated interest, awareness and favourable attitudes at the senior management levels of various Provincial Ministries.

The Ontario Ministry of Northern Affairs (MNA), for example, which originally provided limited funding to the project, now considers the PDPP to be a service which is providing a technological solution to the long-standing and pressing problem of extension of services. MNA currently has plans to assist in the purchase of earth terminals and rebroadcast transmitters in underserved areas of Northern Ontario.

The Ontario Ministry of Transportation and Communications, with major interests in the extension of basic television services to northern Ontario and the use of satellite telecommunications, has been deeply involved in the PDPP. The Ministry considers the PDPP to be an important element in its decision to recommend to the CRTC Committee on the Extension of Services to Remote and Northern Areas, that

"basic services which, by definition, should be universally available, should be distributed by 14/12 GHz satellite, since this technology can cover the most people in the most flexible manner." [7.2]

In British Columbia, low-cost earth terminals utilized in the PDPP have also been made available to the British Columbia educational pilot project, now a part of the Knowledge Network of the West (KNOW). KNOW has purchased and installed 15 additional low-cost earth terminals to expand its satellite network.

The success of carrying two television channels on one satellite transponder has prompted the Government of British Columbia to consider purchasing 100 receive-only earth terminals for educational purposes and to have the stations equipped to carry entertainment channels, if the communities wish to purchase the additional equipment necessary.

8. IMPLICATIONS FOR POLICY AND PLANNING

8.1 INTRODUCTION

International convention defines two classes of satellite radio communications for the transmission of program-carrying signals by satellite:

(i) *Broadcasting Satellite Services*

A radio communication service in which signals transmitted or retransmitted by space stations are intended for direct reception by the general public, commonly referred to as Direct Broadcasting Satellite (DBS) service, (WARC 1979, Final Acts).

(ii) *Fixed Satellite Services*

A radio communication service between earth stations at specific fixed points when one or more satellites are used (WARC 1979, Final Acts).

A major distinction between these two services is the concept of "point-to-point" communications via fixed satellites as opposed to "direct reception by the general public" from DBS systems. The former refers to signals being carried by a satellite common carrier on behalf of a sender who has contracted the delivery of the signal from a given point to one or more specific destinations. The sender is the proprieter of the signal, without whose permission (and usually payment) the signal cannot be used. DBS service, on the other hand, is characterized by the transmission of a signal intended for the direct reception by the general public.

Other major differences between the types of services are the frequency band in which these satellites operate, their respective power output and corresponding earth station requirements. Traditional DBS system designs incorporate high-powered satellites operating in frequency bands at 12 GHz allocated for this service, thereby enabling the use of television-receive earth terminals which are significantly smaller and less costly than those currently used with fixed satellite systems. DBS systems, therefore have the unique capability to deliver television programming directly from a satellite to individual homes via small earth terminals.

The possible roles of broadcasting satellite services vis-a-vis fixed satellite services are important considerations in the general policy and planning activities concerning Canadian satellite services. The PDPP should play a significant role in determining the nature of a DBS system for Canada and Canada's position at international meetings. The increased awareness and demand for satellite services in Canada, which has been partially stimulated by PDPP, are increasing the need for the clarification of policy and regulatory implications which DBS systems may entail.

8.2 PLANNING FOR DIRECT BROADCASTING SATELLITES

The ANIK-B PDPP is also an integral part of a DOC DBS program aimed at studying the use of a satellite for direct-to-home broadcasting and developing a domestic industry capable of providing most major equipment components. Other facets of the DBS program include earth terminal research and development, industrial stimulation and strategic planning studies on technical, economic, social, demographic and service needs.

In 1977, the World Administrative Radio Conference (WARC) on Broadcasting Satellites adopted radiated power levels (EIRP) in the 61 to 68 dBW range for Regions 1 and 3. Canada belongs to Region 2, and in planning for a Canadian DBS system and the forthcoming Regional Administrative Radio Conference (RARC) in 1983, the DOC has been experimenting with broadcast reception at various EIRP levels. Hermes with an EIRP of 59.5 dBW, provided very good signal quality to earth terminals with antenna diameters as low as 0.6m. The ANIK-B PDPP trials are being carried out satisfactorily with EIRP levels of 50 dBW and less, and earth station antenna diameters as low as 1.2 meters. Parallel laboratory tests of subjective quality have been carried out to obtain user reaction to various types of TV program content at CNRs extending down to the FM threshold and below. Hermes trials, the ANIK-B PDPP and the CNR tests indicate that a much wider range of power levels than originally anticipated can be considered in the planning of DBS systems [8.1]. In addition, PDPP west has demonstrated the acceptability of the transmission of two signals through one transponder.

The results of the ANIK-B PDPP are also significant for Canada since the ANIK-C satellite system, to commence operations in late 1982, will have characteristics similar to the 14/12 GHz portion of ANIK-B. It is, therefore, possible to consider using the ANIK-C system (designed to operate in the fixed satellite service) to provide an interim DBS system both for direct-to-home and community reception purposes. The success of the ANIK-B PDPP consequently prompted a jointly-funded study by Telesat Canada and DOC to examine the possibility of using ANIK-C in this mode. [8.14] Challenging conventional theories of high-powered DBS systems, the PDPP is also playing an important role in terms of developing a Canadian position on DBS service for the RARC which will be convened in 1983. At this Conference, a detailed plan may be developed for allocation of frequencies, orbital slots and radiated power levels to the countries of the North, South and Central Americas (Region 2). One year prior to the Conference, each country of this Region must submit its broadcasting satellite requirements including detailed service area boundaries and the number of channels required for each service area.

Since many countries already have DBS program plans and others are just beginning to plan for DBS, findings in Canada are important not only for the planning of Canada's DBS system and the RARC deliberations of Region 2, but are also significant for potential application in many other nations.

The PDPP experience of using lower EIRPs and two-channels in one transponder allows the planner additional flexibility in overall system evolution. In particular it permits the use of a satellite for both broadcasting and telecommunications services, a flexibility which can be economically important in situations where requirements for both types of service exist, but neither requirement is of large volume, nor easily defined, and is developing incrementally [8.1].

One objective of the PDPP was to provide a prototype testing ground and a small initial market to help stimulate the industrial sector to develop a line of internationally competitive products for TV program delivery. Opportunities available to Canadian industry are substantial at this time. The DOC has stimulated the initial market by specifying and funding prototype development, and procuring 100 low-cost earth terminals. SED Systems Limited of Saskatoon manufactured the 100 low-cost earth terminals with a sub-contract to Electrohome Limited of Kitchener for the 100 indoor units; SPAR Aerospace Limited of Toronto manufactured ten 3-metre earth stations and Andrew Antenna Limited of Toronto provided the antennas for all terminals. During the initial stages of the PDPP implementation, SED Systems Limited decided to manufacture another 100 low-cost earth terminals. It is reported that to date many of these have been sold to educational institutions, broadcasters and cable operators.

The major difficulties encountered during the assessment of the earth terminals, as reported by the DOC Regional and District Offices, are evidence of inadequate quality control of some components during manufacturing, and very lengthy intervals for equipment returned to the manufacturer. These repair delays became particularly frustrating because limited PDPP resources did not allow for adequate spare field units to replace those in repair.

In recent years several countries including France, Germany, Australia, the Scandanavian countries, Japan, India, Arab countries and the United States have established plans for direct-to-home broadcasting or DBS programs. Some of these have already expressed interest in Canadian technology and demonstrations have been conducted for many interested nations. In Canada,

> *".....enquiries from communities and individuals indicate that an LCET market has been created by the program. Those who have terminals want to know how they can obtain them on a permanent basis. Those who do not have terminals want to know where they can get them. The interest is extremely high....."* *

The major constraints to the development of a large market in Canada at this time are the absence of a commercial 14/12 GHz satellite system and as yet undefined policies and plans concerning future broadcasting satellite systems.

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* *Evaluation of ANIK-B Pilot Project B-1, Director, Pacific Region, DOC, 6 November 1980, p. 1.*

8.3 POLICY AND REGULATORY CONSIDERATIONS

The ANIK-B PDPP is not only providing technical information for space policy development at the national and international levels, but is accelerating discussions of other policy and regulatory concerns related to Canadian satellite services and the role of a future DBS system in Canada.

The extension of basic television services to remote and rural areas has been a long term problem and a federal government priority. Following extensive consultations between the DOC and provincial governments, as well as all sectors of the communications industry, the CRTC established a Committee on the Extension of Service to report on how the number and variety of television services to these areas might best and most expeditiously be increased. As a result of some 400 submissions and five public meetings, the Committee issued its report to the CRTC [8.2].

The general mood conveyed in the report is that of a sense of urgency:

> *We cannot stress too strongly the immediacy of the problem: alternative television programming must be provided from Canadian satellites with no further delay.* [8.3]

The success of the PDPP has undoubtedly played a significant role in the submissions and public interventions. The Committee feels that while the ANIK satellites will alleviate the immediate problem of extension of service to all but the smallest communities, thousands of people scattered throughout Canada may not be able to afford the 6/4 GHz terminals. To meet the needs of the people, satellites using higher power will have to be used so that signals can be received on smaller and less expensive dishes. [8.4]

The PDPP has demonstrated for nearly one year the feasibility of using conventional technology to solve a long-term problem by providing alternative television programming in undeserved locations, including a drillship in the Beaufort Sea. It has highlighted the potential of DBS which is capable of respecting regional native, cultural and linguistic concerns of many undeserved areas and has created a pressing market demand.

> *Judging from the high interest in using satellites for broadcasting to the whole of Canada, a large number of DBS channels will be required.* [8.5]

Although the PDPP is carried on the 14/12 GHz ANIK-B, the net effect appears to be an increased demand for both 14/12 GHz and 6/4 GHz satellite services. With the approach of the 1983 RARC and availability of ANIK-C as a possible interim DBS satellite, the nature of services to be carried by the Canadian satellite systems to meet national, regional and sub-regional needs must be determined. "Early consultation with broadcasters and other potential DBS users is essential...in drawing up the firm Canadian position for the 1983 RARC". [8.6]

These findings have led to the development of scenarios for a Canadian DBS system which might begin with the ANIK-C satellites, already being constructed, followed later by a more optimum DBS satellite. The study and development of the DBS technology is only one aspect of the overall DBS program.

The introduction of a DBS system in Canada will have significant implications for the entire telecommunications system of the country. It is for this reason, and in preparation for the 1983 RARC, that the Government has undertaken a comprehensive program of multi-disciplinary studies to examine not only the long-range technology development, but also user service requirements and the economic, regulatory and institutional issues involved. Consultation with all interested parties of the communications industry, the CRTC and provincial government authorities are planned or already underway.

The economic factors are of utmost significance. The impact of a DBS system on the broadcasting industry, the potential impact of the U.S. DBS services on Canada and the economic feasibility of DBS programming require analyses to determine the potential opportunities, as well as negative factors which will have to be taken into consideration.

One of the major constraints for the pilot project sponsors in making a transition from experimental to operational services will undoubtedly be financial. The Committee on the Extension of Service noted that "the success of these experiments has demonstrated that DBS technology can already be used; only the operational and economic aspects remain to be worked out". [8.7] Although the Federal Government does not, at this time,have an intervention policy to assist the users beyond the ANIK-B Communications Program, it is committed to ensuring, as much as possible, a successful transition of service delivery activities from pilot projects to operational services. The mechanisms required for this transition to occur will, therefore, have to be examined in further detail.

In addition to financial considerations, pertinent policy and regulatory issues require analyses in order that necessary changes or modifications be made to facilitate the introduction of DBS service in Canada. The institutional arrangements for a DBS system must also be reviewed with an intent to determine the various options and roles as related to Telesat Canada, the carriers, broadcasters, cable operators, program supplies, etc.

Although the situation in Canada is admittedly different from that in the United States, the trend toward deregulation and encouragement of competition in the U.S., as well as the potential impact of U.S. DBS services in Canada, necessitate consideration. Some policy and regulatory changes are already evolving in Canada but further modifications may prove necessary. The most obvious is in the area of earth station ownership. In the United States, anyone can own a receive-only earth station and no licence is required to operate the TVROs unless users wish to have frequency co-ordination and protection. Satellite system ownership can also be shared by commercial and non-profit organizations, as is the case with the Public Broadcasting System who own the earth stations, and Western Union, the satellite capacity.

In March 1979, the DOC issued a new earth station ownership policy which permitted the ownership of TV receive-only earth stations by telecommunications carriers and licensed broadcasting undertakings. In November 1980, the licensing process was simplified to avoid administrative delays and excessive costs and earth station ownership was extended to include educational authorities. This policy is now being reviewed with further liberalization in mind. The Committee on the Extension of Services to Remote and Northern Areas recommended "ownership and operation of receive-only earth stations by

educational and other non-commercial institutions for internal use; community groups ; and by private citizens for exclusive use by them and their households". [8.8] In the United States, anyone can obtain a licence to own and operate a transmit earth station, as long as the technical criteria and socio-economic goals, as judged by the Federal Communications Commission (FCC), are met, and the earth station owner can demonstrate that he has made arrangements with the satellite carrier for transponder usage. In Canada, only Telesat and the regulated common carriers are permitted to own and operate uplink earth stations. Nevertheless, PDPP participants (BCTV, CBC and OECA) have been successfully operating experimental uplink terminals which are on loan to them. The Committee on the Extension of Services to Remote and Northern areas has recommended that a review be undertaken with the aim of permitting broadcasting undertakings to own uplink earth stations [8.9]. The advantage of this would be that the overall cost of satellite usage would fall, since the cost of uplinking, now charged by Telesat and the common carriers, could be absorbed within the operating expenditures of the organization involved. This mode of operation could, however, pose management problems due to the increased probability of interference.

The feasibility of aggregated delivery of services has been proven through the PDPP where both the eastern and western participants are sharing satellite time and earth station hardware. Although Telesat has filed, with the CRTC, a variety of service offerings including fully protected and non-protected transponders, pre-emptible and non pre-emptible services and the leasing of partial transponders on a continuing or occasional-use basis for ANIK-B, it may be necessary to examine further assistance in order to identify user requirements, distribution options, access to satellite distribution systems and to facilitate negotiations with common carriers.

Technical experimentation and subsequent planning for the implementation of a DBS system must be paralleled and supported by the policy and regulatory developments required for the successful introduction of this technology.

8.4 FUTURE PLANNING

In the absence of firm DBS policies, PDPP participants and other interested agencies and institutions face uncertainties which impact upon their planning activities. Although it is difficult to attribute current developments directly to the PDPP, the effect on the broadcasters participating in the project is significant. It has already been stated that PDPP viewers are satisfied, consider the project to be a service, and do not wish to have it terminated. All the broadcasters involved in PDPP continued with the project into the second phase of the ANIK-B Communications Program. The CBC is interested in fulfilling its role as the national broadcasting agency and ensuring that its service is available to 100% of the Canadian population. CBC now considers 14/12 GHz service to be a serious contender in its future planning activities, particularly with respect to the regionalization of CBC services.

Until the PDPP, BCTV was unable to extend services to remote areas in British Columbia, the Yukon and the Northwest Territories. Although the project permitted extension of program coverage and revealed BCTV's great popularity, BCTV considers that satellite service would only become economically viable

in its case when a national satellite television package is implemented. As a member of CANCOM, which has been licensed by the CRTC to provide the extension of television services to remote and rural areas, BCTV will be continuing with operational satellite services in the very near future.

The most concrete impact of the PDPP is visible in PDPP East, where OECA has decided to deliver its programming via ANIK-C in the future. With existing terrestrial systems, OECA is available to 85% of the Ontario population. The PDPP has demonstrated that DBS service works, and the OECA can fulfill its mandate of 100% coverage. The "hands-on" experience with the PDPP appears to have provided the data-base to convince OECA that the satellite system, rather than terrestrial microwave, is the cost-effective means of extending its service to the yet unserved 15% of the population. The decision to transfer OECA programming to satellite when ANIK-C is available has been approved in principle by the Government of Ontario.

The PDPP has also resulted in a greater political and institutional awareness, at both the federal and provincial levels of government, regarding the potential of DBS, and has contributed to the planning processes for future systems. In Ontario, the Ministry of Transport and Communications (MTC) and the Ministry of Northern Affairs (MNA), and the Ministry of Culture and Recreation (MCR) (co-sponsors of the PDPP), report that the PDPP has resulted in a more informed population, and a new awareness and involvement at the senior government levels [8.10]. In order to make the currently satellite-delivered programming available to as many people as possible, three broadcast transmitters have been installed at PDPP earth station sites. MNA is planning to build studios in Northern Ontario and to purchase rebroadcast transmitters and earth stations for future delivery of TV service via satellite. The PDPP has played a major role in the Ontario provincial government decision to discard terrestrial microwave for the further expansion of services in northern Ontario. In his submission to the CRTC Committee on the Extension of Services, James Snow, Minister of Transportation and Communications, Government of Ontario recommended that: "Basic services should be available universally and should be distributed *via* 14/12 GHz satellite..." [8.11]

Other ANIK-B Communications Program pilot projects using PDP-type terminals have resulted in concrete plans for continued provision of services on a 14/12 GHz satellite system. In British Columbia an educational pilot project has led to the creation of the Knowledge Network of the West, (KNOW). A government subsidized organization, KNOW plans to consolidate all communications systems into a hybrid network which will include terrestrial, as well as satellite modes of delivery for all educational telecommunications activities in British Columbia. Committed to the 14/12 GHz satellite mode, KNOW has already purchased several earth stations to expand its network to remote areas of the Province. The Alberta Educational Communications Corporation (ACCESS) has also purchased earth stations for the educational pilot project in Alberta.

As a result of the provincial educational pilot projects and the interest of the provincial authorities in the future use of satellites for educational purposes, a Federal-Provincial Task Force on Satellites and Education was created in October 1979 by the then Minister of Communications, the Honourable David McDonald, and the former Chairman of the Council of Ministers of Education, Canada, Patrick McGeer, to examine the use of satellites in education. On 27 January 1981 the Task Force presented its final report to the Minister of

Communications and the Council of Ministers of Education, Canada. The report indicated that discussions among federal, provincial and Telesat Canada officials were underway with a view to securing ANIK-C capacity for educational needs defined by the provinces.

Northstar Home Theatre, Inc., a newly formed company has an interest in providing new programming services, including pay TV, to uncabled homes and particularly the 1.6 million households that are beyond the reach of cable systems. Northstar assumes that when ANIK-C1 comes into operation "hundreds of thousands of satellite receiving terminals may be installed in Canada". [8.12]

All-View Network One, Inc. proposed that the "14/12 GHz satellite system should be designated as the preferred method of carriage for the transmission of television services throughout Canada. All-View would provide a national service for the supply and servicing of direct-to-home antennas for the 14/12 GHz transmission..." [8.13].

Discussions and planning activities for the use of Canadian satellite systems for broadcasting are gaining momentum in government and in industry. The general public is also increasing its demands for choice and for more and better television programming. Technical and service proposals are being advanced but without the necessary framework for the introduction of broadcasting satellite services. Certain sectors of the communications industry and the regulatory bodies are already actively involved in Government studies and planning activities for a DBS system. There is no doubt, however, that a concrete plan is required for the introduction and use of DBS in order for Canadian manufacturing industry, the carriers, the broadcasting and cable organizations and other interested parties to undertake significant strategic planning with respect to future DBS systems.

9. CONCLUSION

The ANIK-B Program Delivery Pilot Project has demonstrated in over one year of operation that the concept of a low EIRP direct broadcasting satellite system utilizing low-cost earth terminals is feasible.

The basic precepts of the system design have been shown to be valid. Although the transmission margins have been small, signal reception has been consistent and there has been virtually no criticism of outages due to rainfall. Reception quality within the design coverage area has been generally equal to or better than that of any other available signals. It has also been sufficiently good that pressure has been generated to expand the system by installation of terminals outside the design area, and by doubling the signals transmitted over that originally intended (i.e., two TV signals rather than one) in the west.

The low-cost TVRO terminals have performed well in the field and considerable confidence has been gained that an operational system with user purchase and installation of terminals is workable. There has been a higher incidence of failures and malfunctions in the terminals than would be tolerable in an operational system, but the performance is not inconsistent with the first production of 100 units with very modest prior development efforts. The

field trials have not revealed any major flaws, although a small increase in system temperature since initial testing (averaging about 60K) has been measured. This may be attributable to differences in the reference noise sources. The antenna sizes of 1.2m and 1.8m have not been a major problem. However, the larger antenna does cause difficulties in transportation and shipping and for this reason is in the upper range of acceptability for individual reception. There have been no significant difficulties in installation and operation of the terminals at individual homes, cable head-ends and rebroadcast transmitters.

All participants, including broadcasters, government departments, the general public and DOC, have gained experience and expertise concerning the transportation, installation and operation of low-cost earth terminals.

The project has increased general awareness concerning satellites and in particular the possibility of direct-to-home satellite broadcasting which has the potential of solving a long-term problem of service coverage in many parts of Canada and abroad. This increased awareness is evidenced also in industry, and various levels of policy and regulatory environments of the country.

The extensive field experience has provided much data concerning the system performance which will be a strong foundation for planning DBS systems for Canada, as well as elsewhere. The project provides considerable experience to support the potential use of ANIK-C as an interim DBS in Canada. It also, very importantly, provides much information for the development of Canada's position at the 1983 Regional Administrative Radio Conference (RARC), where Canada will be the only country with this type of field experience.

DBS projects on Hermes and ANIK-B have stimulated design and development of necessary space and ground segment components for a DBS system and have generated great public and institutional interest in Canada. They have provided Canadian industry with the experience and expertise to become a strong contender for the home terminal market on an international basis. In Canada, further market development for this technology is dependent upon policy developments and plans concerning broadcast satellite systems for Canada.

The success of the PDPP, as well as the increasing demand for improved broadcast services in remote and rural areas, have led the DOC to undertake a program of planning studies, in close co-operation with all the interested parties of the Canadian communications industry concerning the potential role of DBS service in Canada. Thorough analyses of the implications and changes which DBS service would entail are imperative in examining the feasibility and mechanisms for the introduction of DBS systems. Implications related to programming, social, economic, institutional and regulatory questions, as well as technology and manufacturing concerns, need to be examined in the development of long range plans.

10. ACKNOWLEDGEMENTS

The Program Delivery Pilot Project (PDPP), east and west, is a co-operative undertaking involving the DOC, including its Pacific, Central and Ontario Regional Offices, Provincial Government Ministries and Institutions,

the Territorial governments and broadcasting organizations and members of the public in Ontario, British Columbia, the Yukon and Northwest Territories. The collaborative nature of the project is reflected in this 12-month performance assessment which is the result of discussions and exchanges held over the past year between DOC and the many persons involved with PDPP.

The authors would like to record their appreciation of the contributions made by:

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- Ontario Ministry of Northern Affairs
- Ontario Ministry of Culture and Recreation
- Canadian Broadcasting Corporation
- British Columbia Television Broadcasting System Ltd.
- Government of the Province of British Columbia
- Government of the Yukon Territory
- Government of the Northwest Territories
- Members of the Public

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APPENDIX A

DESCRIPTION OF THE LOW-COST DIRECT BROADCAST TERMINAL

The Direct Broadcast Terminal, or low-cost earth terminal (LCET), developed for the PDPP by SED Systems Limited of Saskatoon allows the end-users to receive television programming directly from a broadcasting satellite. The terminal consists of three major components: a parabolic dish antenna on a mount, an Outdoor Unit, and and Indoor Unit. In addition there is a 21 metre cable which is used to interconnect the Indoor and Outdoor Units.

The Outdoor Unit mounts at the focal point of the antenna and has several functions. It has a built-in feed horn, a low-noise amplifier which amplifies the signal received from the satellite, and an internal oscillator which generates a signal to mix with the satellite signal to produce an intermediate frequency.

The intermediate frequency is further amplified and fed to the Indoor Unit via the flexible cable. The Indoor Unit, which is about the size of an audio amplifier of the type used in the average home high-fidelity sound system, is used to tune the system to the desired frequency in the same manner as a radio receiver is tuned.

The output of the Indoor Unit is connected to the T.V. set, either directly in the case of a T.V. monitor, or through a built-in remodulator which allows the standard T.V. receiver to be tuned to channel 3 or 4 for display of the satellite signal.

The satellite terminal requires only a standard household power supply (115V, 60 cycle) for operation. The only special consideration is the requirement that the antenna have an unobstructed line-of-sight to the satellite, clear of obstructions such as hills, buildings or trees. This is relatively easy to accommodate at most sites.

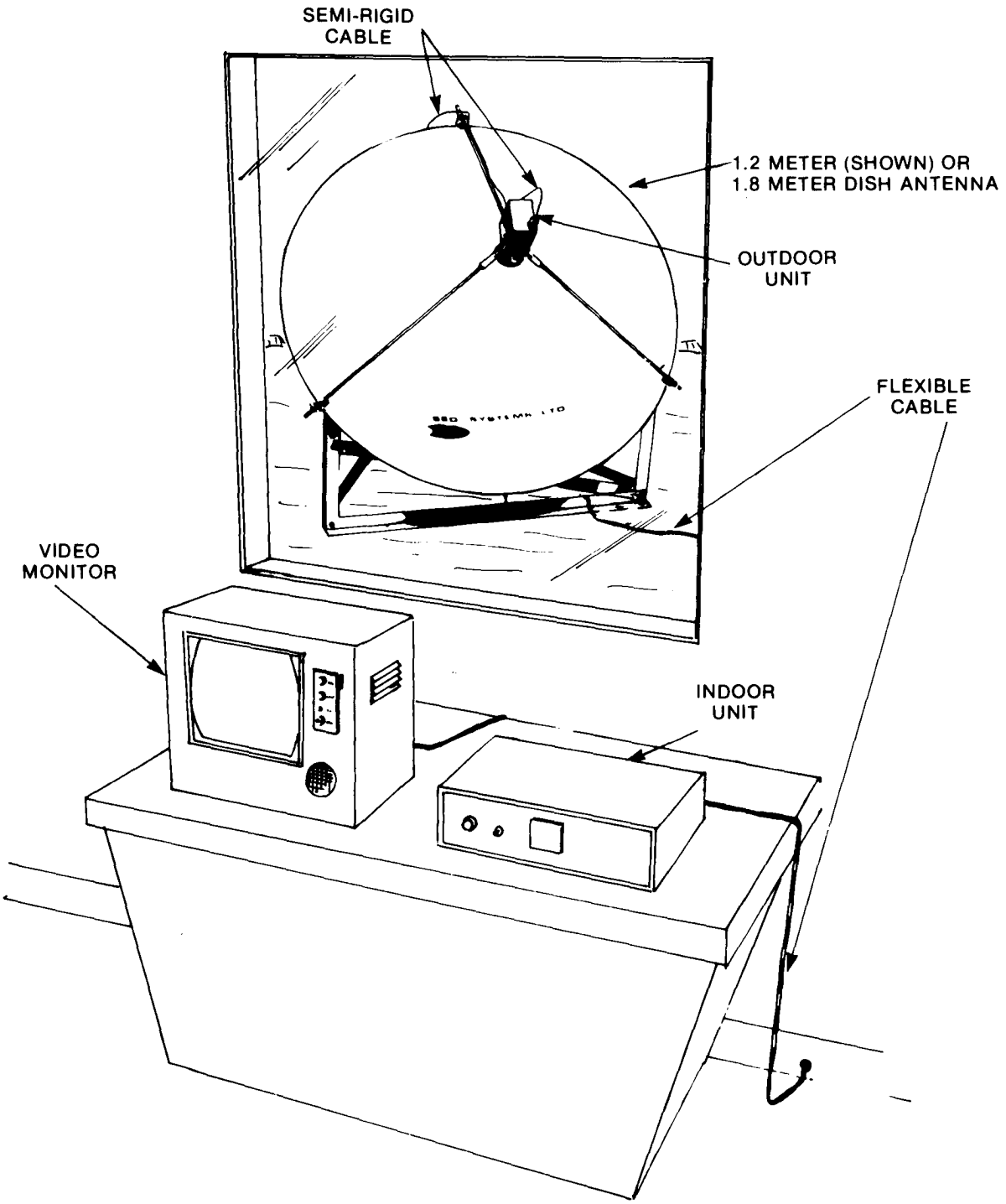

Figure A1-1. Direct Broadcast Terminal

APPENDIX B

TABULATION OF TERMINAL LOCATIONS, OPERATIONAL DATA AND TYPE OF UTILIZATION

PDPP Terminal Locations as of 30 November 1980

East (Ontario)

No.	Site	Terminal Type	Serving	Operational	Comments
1	Marathon	1.8m	Cable System	September 1979	640 subscribers, Lakeshore Community Television Ltd. CBC is received from Geraldton via a chain of rebroadcast transmitters which has a microwave drop. CBC and CTV are received poorly off-air from Thunder Bay. Two American networks from Michigan are received with very poor quality.
2	Dryden	1.8m	Cable System	September 1979	2000 subscribers. CBC/CTV is received with a good signal. Two American channels are distributed but signal quality is very poor.
3	Atikokan	1.8m	Cable System	September 1979	1245 subscribers. CBC/CTV is available off-air from Thunder Bay; signal is good. CBC if also received from Winnipeg. Four American networks are received from Duluth, Minnesota with good signals.
4	MacDiarmid	1.2m	Home	September 1979	Signals from Thunder Bay are received here but quality is not good.
5	Thunder Bay	1.8m	Spare	September 1979	DOC District Office.
6	Horne Payne	1.8m	Cable System	October 1979	460 subscribers. CBC is received here by microwave drop but there are gaps when no signal is received. Two American channels are also distributed.

PDPP Terminal Locations as of 30 November 1980

East (Ontario)

No.	Site	Terminal Type	Serving	Operational	Comments
7	Armstrong	1.2m	Low Power Repeater Transmitter	November 1979	The satellite signal is distributed by a Low Power Repeater Transmitter, to the viewers in the immediate area.
8	Manitouwadge	1.8m	Cable System	November 1979	700 subscribers. Programming is essentially the same as Marathon (Site No. 1).
9	Geraldton	1.2m	Cable System	November 1979	850 subscribers. Toronto is received via microwave drop with gaps in this program.
10	Mattice	1.2m	Cable System	November 1979	123 subscribers. CBC is received from Timmins; CTV is received from Sudbury; both signals are poor.
11	Beardmore	1.2m	School/Cable	November 1979	
12	Ignace	1.2m	Apt. Bldg.	December 1979	Twelve apartments using MATV system.
13	Sioux Lookout	1.2m	Indian Social Center	December 1979	Located at the local high school, which is open to the public.
14	Savant Lake	1.2m	Motel/Home	December 1979	MATV distribution to 20 rooms. CBC available (poor) from Winnipeg; CTV available from Thunder Bay.
15	Pickle Lake	1.2m	Recreation Centre	December 1979	TV set in library.
16	Kenora	1.8m	Cable system	December 1979	7000 subscribers. CBC available from Winnipeg and locally; several American off-air signals are poor.

PDPP Terminal Locations as of 30 November 1980

East (Ontario)

No.	Site	Terminal Type	Serving	Operational	Comments
17	Rossport	1.2m	Home	January 1980	Receives CBC and CTV off-air from Thunder Bay. No cable service available.
18	Jellico	1.2m	Home	January 1980	Only CBC available.
19	Longlac	1.2m	Home	January 1980	
20	Caramat	1.2m	Home	January 1980	
21	Nakina	1.2m	Home	January 1980	
22	Nagagami	1.2m	MATV	January 1980	MATV distribution to 5-6 locations.
23	Quetico Centre	1.2m	MATV	January 1980	Site is a Study Centre.
24	Mine Centre	1.8m	Store/Home	January 1980	
25	Norembega	1.8m	Home	January 1980	
26	Fort Frances	1.8m	Cable System	January 1980	2400 subscribers. CBC is available via off-air pick-up — signals are good.
27	Emo	1.8m	Home	February 1980	
28	Rainy River	1.8m	Home	February 1980	CBC and 2 American stations available.
29	Nestor Falls	1.8m	Home	February 1980	CBC available.
30	Huntsville	3m	Cable System	February 1980	2100 subscribers. CBC, CTV and Global are available. Signals from two American stations are received via microwave. OECA has been available via tape replay.

PDPP Terminal Locations as of 30 November 1980

East (Ontario)

No.	Site	Terminal Type	Serving	Operational	Comments
31	Parry Sound	3m	Cable System	February 1980	1700 subscribers. Programming as at Huntsville (Site No. 30).
32	Owen Sound	3m	Cable System	February 1980	9000 subscribers. Programming as at Huntsville (Site No. 30).
33	Gore Bay	3m	Cable System	February 1980	168 subscribers. Present service is CBS off-air from Sioux, Michigan and CBC/CTV from Elliot Lake or Sudbury.
34	Moonbeam	1.2m	Home	February 1980	
35	Opasatika	1.2m	Home	February 1980	
36	White River	1.2m	Cable System	February 1980	130 subscribers. Served by company that also serves Marathon and Manitouwadge, with similar programming (Sites 1, 8).
37	Wawa	1.2m	Home	February 1980	CBC available.
38	Chapleau	1.8m	Cable System	March 1980	450 subscribers. CBC is good; CTV via Sudbury is poor. American signals via off-air are poor. American satellite signals are also distributed.
39	Foleyet	1.2m	Home	March 1980	CBC-English and French available from Timmins, off-air.
40	Moosonee	1.2m	Educational Centre	April 1980	TV viewed in library, distributed also to educational-centre classroom.

PDPP Terminal Locations as of 30 November 1980

East (Ontario)

No.	Site	Terminal Type	Serving	Operational	Comments
41	Monteith	1.8m	Institution	April 1980	This site is a correctional institution. Number of viewers varies.
42	Ear Falls	1.8m	Recreation Centre	April 1980	TV set in common room. CBC available.
43	Fraserdale	1.2m	Home	May 1980	
44	Oba	1.2m	Hotel	May 1980	
45	Dubreuilville	1.2m	Home	October 1980	CBLFT and CHOT (Hull, P.Q.) distributed via cable via 7 day tape-delay from Hearst, Ontario.
46	Red Lake	1.8m	Home	October 1980	School viewing area is available to public in evenings and on weekends.
47	Sultan	1.8m	Home	October 1980	
48	Winnipeg	1.8m	Cable System	April 1980	OECA signals used for Manitoba Telephone Systems (M.T.S.) "Project IDA", in cooperation with and permission of OECA.

PDPP Terminal Locations as of 30 November 1980

West (British Columbia)

No.	Site	Terminal Type	Serving	Operational	Comments
1	Cassiar	1.8m	Home	December 1979	
2	Dease Lake	1.8m	Home	December 1979	
3	Telegraph Creek	1.8m	Indian Band Administration Bldg.	December 1979	Re-broadcast.
4	Tatla Lake	1.8m	Home	December 1979	Water-Wheel Power.
5	Hazelton	1.8m	Hospital (MATV)	January 1980	
6	Stewart	1.8m	Home	January 1980	
7	Strathcona	1.8m	Outdoor Educational Centre	January 1980	
8	Atlin	1.8m	Home	March 1980	
9	Courtenay	1.8m	CBC Repeater	May 1980	
10	Premier Lake	1.8m	Home	May 1980	
11	Bella Bella	1.8m	Indian Council Cable	June 1980	
12	Anahim Lake	1.8m	Home	June 1980	
13	Juskatla	1.8m	CBC Tape Rebroad	June 1980	Site located on Queen Charlotte Islands.
14	Meadow Creek	1.8m	Home	June 1980	
15	Grand Forks	1.8m	Home	June 1980	
16	Blue River	1.8m	Home	July 1980	

PDPP Terminal Locations as of 30 November 1980

West (British Columbia)

No.	Site	Terminal Type	Serving	Operational	Comments
17	Gutah Camp	1.8m	Rail Work Camp	July 1980	Site is British Columbia Railroad Camp if N.E. British Columbia.
18	MacKenzie	1.8m	BCTV Rebroad	July 1980	
19	Bull Harbour	1.8m	Coast Guard Station (MATV)	July 1980	Situated on north tip of Vancouver Island.
20	Vancouver	1.8m	Spare		Available for use (located at RDP).
21	Unassigned	1.8m	Spare		Available for use.

PDPP Terminal Locations as of 30 November 1980

West (Yukon)

No.	Site	Terminal Type	Serving	Operational	Comments
1	Whitehorse	1.8m	Cable System	December 1979	3000 subscribers. Receives CBC Northern and Vancouver signals, also several American signals from N.W. U.S.A.
2	Eagle Plains	1.8m	Lodge (MATV)	March 1980	Site is a motel/restaurant/fuel/grocery stop on highway from Whitehorse to Inuivik.
3	Johnsons Crossing	1.8m	Home	March 1980	
4	Ross River	1.8m	Home	July 1980	
5	Stewart Crossing	1.8m	Home	July 1980	
6	Watson Lake	1.8m	Airport Lounge/Restaruant and MOT Housing in Area	July 1980	
7	Whitehorse	1.8m	DOC District Office		Spare

PDPP Terminal Locations as of 30 November 1980

West (Northwest Territories)

No.	Site	Terminal Type	Serving	Operational	Comments
1	Yellowknife	1.8m	Cable System	December 1979	2000 subscribers. Distributes 2 Edmonton signals and local programming.
2	Echo Bay	1.8m	Mine Recreation Centre	February 1980	Site also known as Port Radium; on east shore of Great Bear Lake.
3	Inuvik	1.8m	Community TV Association	February 1980	
4	Fort Simpson	1.8m	Community Hall	February 1980	
5	Fort Providence	1.8m	Settlement Office	March 1980	
6	Norman Wells	1.8m	Settlement Office	April 1980	
7	Fort Smith	1.8m	Adult Vocational School	May 1980	
8	Talison River Dam	1.8m	Home	July 1980	
9	Beaufort Sea	1.8m	Drill Ship	August 1980	
10	Yellowknife	1.8m	DOC District Office		Spare unit available.

APPENDIX C

SPECIFICATION FOR LOW-COST TV RECEIVE ONLY EARTH TERMINALS

C1. SPECIFICATION FOR LOW-COST TV RECEIVE ONLY EARTH TERMINALS

C1.1 System Specifications

	1.2m Antenna (Model DBT-12-01)	1.8m Antenna (Model DBT-12-02)
Antenna Size 55% effy.	41.1 dB	44.6 dB
System G/T	13.0 dB	16.5 dB
Focal Distance	45.7 cm (18")	68.6 cm (27")
Antenna Polarization	Linear	
Antenna Noise Temperature	50 K	
Receiver Noise Temperature	600 K	
System Noise Temperature	650 K	

C1.2 Outdoor Unit (ODU) Model OU-12-11

Receiver Gain to First IF	≥35 dB
SHF Local Oscillator Frequency	10.8 GHz
SHF Local Oscillator Stability over Temperature	±10 MHz
ODU Output at 1 dB Compression Point	0 dBm
L.O. Radiation Rejection	≥40 dB
SHF Image Rejection	≥60 dB
Output VSWR in band	2:1 max.
Gain Ripple over 10 MHz Band	<0.5 dB

C1.3 Interfacility Link

Cable Type (21m)	RG-213
Cable Loss	8 dB
Cable Impedance	50 ohms

C1.4 Indoor Unit (IDU) Model EL-3

Input Frequency	Tunable 915 MHz to 1385 MHz
Input Noise Figure (SSB)	12 dB max.
IF Frequency including AFC at band center for ±5 MHz change in input frequency	70 MHz ± 0.2 MHz
AFC Hold-In Range	±20 MHz
IF Noise Bandwidth	18 MHz
Image Rejection	15 dB in band, 10 dB out of band
Input Impedance	50 ohms (N-Female)
Input VSWR	3:1
Input Power Level	-35.0 dBm max.
Input Power Operating Range	-70 dBm to -40 dBm
Differential Phase (10%-90% APL)	8° max.
Differential Gain (10%-90% APL)	15% max.
Chrominance-to-Luminance delay inequality	150 ns
Chrominance-to-Luminance gain inequality	20 IRE max.
Video Signal to Noise Ratio at C/T = -143.5 dBW/K (p-p excluding sync. tip to RMS weighted noise CCIR REC. 421-1)	>40 dB
Audio Signal to Noise Ratio at C/T = -143.5 dBW/K (audio RMS TT/N weighted)	>44 dB
Audio to Video Crosstalk: 5.14 MHz present at video output of receiver	-30 dBm max.
Video to Audio Crosstalk (75% saturated colour bar test signal) below T.T. level with program weighting and high C/T	-45 dB min.
Video Bandwidth (nominal)	4.2 MHz

Video Peak Deviation	6 MHz
Horizontal Sync. Pulse	Negative
Video Output Level adjustable for 4.2 MHz bandwith, 6 MHz peak deviation	1V p-p, 75 ohms
Video De-emphasis	CCIR REC. 405-1 525
Audio Subcarrier Frequency	5.14 MHz
Subcarrier peak deviation for 8 dBm T.T.L. at 1 KHz	60 KHz
Energy Dispersal of RF Carrier	30 Hz triangular wave 400 KHz peak
Energy Dispersal Suppression Down to	2 IRE max.
Video Hum below 4 KHz	2 IRE max.
Periodic Noise at Output of Receiver 4 KHz to 4.2 MHz	-40 dBm max.
Video Response Using Multiburst Test (90 IRE Multiburst)	
500 KHz	80 IRE min.
3.0, 3.58 MHz	70 IRE min.
1.5, 2.0, 4.2 MHz	60 IRE min.
No multiburst to exceed 100 IRE p-p	
Short Time Pulse (2T $\sin^2$ 0.25 usec) Distortion and Overshoot	10 IRE max.
Horizontal Line Tilt Using Pulse and Bar Window Test	4 IRE max.
Vertical Field Square Wave Tilt	15 IRE max.
Sync. Pulse Distortion 40 IRE Normal	±10 IRE max.
Video Gain Stability per 24 Hours	±5 IRE max.
Audio Gain Stability per 24 Hours	±1 dB max.
Demodulator -1 dB Static Threshold* Point at 18 MHz Bandwidth C/N	9.5 dB

* *Static Threshold is defined, the point of 1.0 dB departure from nominally linear S/N versus C/N characteristic measured in the absence of video modulation.*

Audio Harmonic Distortion at 1 KHz T.T.L.: 8 dBm	5% max.
0 dBm	2% max.
Audio Bandwidth, 4 dB peak-to-peak	100 Hz to 10 KHz
Audio De-emphasis	75 usec RC time constant
Peak Deviation of Video Carrier by Audio Subcarrier (5.14 MHz)	1.09 MHz
Audio T.T.L.	+8 dBm (600 ohms balanced 1 KHz T.T.L.)
Limiter/AGC Performance	
Limiting	
Limiter input level change of ±5 dB should cause variation in video white level	<±2 IRE
AGC	
AGC amplifier output level variation with indoor unit input level variation -70 dBm to -40 dBm	<5 dB
UHF Tuner/Bandpass Filter/IF Amplifier	
Inband Ripple	<1 dB p-p
Gain Slope over 16 MHz Band	0.125 dB/MHz

C1.5 Environmental Specifications

Outdoor Unit and Antenna	
Operating Temperature	-45°C to +40°C
Humidity	5% to 100%
Wind	Steady 50 kmph gusting to 75 kmph
Sun Exposure	Full exposure to sun at all ambient temperatures and under no wind conditions

Survival:

Survives the following environmental extremes, which with minor external adjustment, will return to its normal performance

Temperature	-55°C to +55°C
Wind	120 kmph gusting to 160 kmph

In addition, the terminal must be capable of withstanding 1 cm radial ice load without damage.

Indoor Unit

Temperature	5°C to +40°C
Operating Survival	-55°C to +55°C
Humidity	5% to 100%

C1.6 Power Requirement

Outdoor Unit	18 ± 0.5 volts at 420 mA applied through IFL cable
Indoor Unit	115 ± 10V/60 Hz ± 10%

APPENDIX D

FIELD NOTES ON GROUND TERMINAL SITES VISITED FOR MEASUREMENTS

1. *Moonbeam* -

1.2M - Home use; installed on ground weighted down by concrete blocks; interface cable damaged with repair attempted by user - resulted in shorted ODU power supply; repointed once by user by use of a spirit level to regain initially installed conditions; significant distortion on video was apparent - caused by audio subcarrier intermods; connected to 75Ω splitter to combine with an off-air antenna feed. IDU had to be turned off when viewing off-air signals to prevent interference. AFC lock-up not functioning upon initial turn-on; antenna repeaked once by DOC and once by user.

2. *Mattice* -

1.2M - Cable head-end; installed on a platform fastened half way up a wall of a small hut but simply resting on the earth, i.e., no foundation; unit left on at all times but daily curtailment of transmissions requires AFC on-off switch to be exercised to regain AFC lock (done by automatic momentary relay switch on a 27 minute timer); severe herringbone distortion present, eventually traced to over-deviation of the audio subcarriers on the uplink; antenna re-aligned twice by DOC, once by user.

3. *Nagagami* -

1.2M - MATV distribution to 5-6 locations; antenna mounted on solid wooden platform base; LCET left on continuously; antenna repointed twice by DOC.

4. *Jellico* -

1.2M - Home use; antenna installed on wooden platform resting on earth and weighted down by concrete blocks; some hum was noted on video, eliminated by slightly increasing voltage to ODU; ODU malfunctioned above 90°F ambient, solved by use of ice packs placed on ODU by user; IDU output feeds a 75Ω splitter feeding two homes; antenna repeaked once by DOC.

5. *Geraldton* -

1.2M - Cable head-end; antenna mounted on top of concrete blocks, then weighted down with more blocks; antenna repeaked once by user in the spring; experience AFC lock-up problems when transmissions begin.

6. *Longlac* -

1.2M - Home use; installed on base made of laminated 2x10 inch planks, bolted to planks; two 300 ohms baluns hooked in parallel to conventional TV

set; TV set is tuned to Channel 8 to pick up OECA because of interference from a local Channel 4 when tuned to Channel 3; LCET remodulator puts out same signal on Channel 8, about 10 dB down from proper signal on Channel 3; DOC repeaked the antenna twice.

7. *Caramat* -

1.2M - Home use; 2 planks on earth, concrete block weighting; user had moved houses and dish and ODU were sitting in back yard; set up and aligned antenna but found that IDU was not functioning properly and had to be replaced.

8. *MacDiarmid* -

1.2M - Home use; sitting on earth with rock weighting; antenna has not been peaked since original installation.

9. *Quetico Centre* -

1.2M - MATV distributed to about 7 points within 1 kilometer; mounted on carport with bolts and a few concrete blocks; converted from Channel 3 to Channel 13 to prevent interference on local Channels 2 and 4; AFC not functioning on unit that was here, another unit was left and it had to be tuned daily when signal came on/ terminal has not been repointed since installation.

10. *Atikokan* -

1.8m - Cable company; roof installation, concrete block weighting; signal is degraded substantially by the cable system; requires daily tuning when OECA first comes on. The terminal was moved once by DOC and peaked once by the user.

11. *Fort Frances* -

1.8M - Cable company; installed on 2 wooden planks, concrete patio-stone weighting; peaked once by DOC and once by users; children have been seen climbing on dish but there was no apparent damage.

12. *Emo* -

1.8M - Home use; installed on small boards, concrete block weighting; signal from LCET is summed a couple of times with other signals, consequently, it is very noisy on user's TV set. Terminal was moved once by DOC.

13. Rainy River -

1.8M - Home use; 2x4 inch boards on earth, concrete block weighting; unit never needs tuning if left on. Terminal has not been repeaked since installation.

14. Nestor Falls -

1.8M - Home use; wooden beams on earth, bolted to beams; remodulator changed from Channel 3 to Channel 4 and there was substantial improvement. Terminal has not been repeaked since installation.

15. Kenora -

1.8M - Cable company; large 8x10 inch timbers on sidewalk, weighted down with another beam; no tuning required if unit left on. Terminal has been repeaked once by DOC.

16. Dryden -

1.8M - Cable head-end; sits on three large cable spools with rock weighting; needs tuning every day but note that IDU was in an unheated hut. The antenna was repeaked several times by the user but the change in signal level was small.

17. Ignace -

1.2M - MATV; distributed to twelve apartments; sitting on earth with long nails holding it in ground; semi-rigid cable had been broken at ODU and user attempted a repair resulting in a shorted cable and burned but still usable connector on ODU. The terminal has not been repeaked since installation.

18. Beardmore -

1.2M - Cable company; roof installation, concrete block weighting; never repeaked since installation.

19. Rossport -

1.2M - Home use; boards on earth with brick weighting; hum noticeable during tests but not on user's set.

20. Manitouwadge -

1.8M - Cable company; roof mounted, concrete block weighting; IDU not working properly, has to be replaced; this antenna has blown over, straight forward breaking the semi-rigid cable and bending the struts. The terminal has been repeaked once by user and once by DOC.

21. Marathon -

1.8M - Cable company; roof mounted, concrete block weighting; LCET left on at all times; antenna has never been repeaked.

22. White River -

1.2M - Cable company; installed on roof of small shed; sand bag weighting; daily tuning required. The terminal was repeaked once by DOC.

23. Wawa -

1.2M - Home use; sitting on concrete window well, no weighting; audio was very bad on arrival at site, with some adjustments it improved but there is still something wrong with the audio. The terminal has never been repeaked.

24. Chapleau -

1.8M - Cable company; roof installation, bolted down; when connected to cable system it was very noisy until we realized that the user was attenuating OECA Channel 3 from the remodulator to prevent interference with other channels. By removing some attenuation OECA can be made acceptable and still not interfere with other channels. The terminal has never been repeaked.

25. Foleyet -

1.2M - Home use; earth with concrete block weighting; unit is turned off when not in use because it interferes with other channels; antenna peaked once by user while observing TV set.

APPENDIX E

RESPONSE OF USERS TO QUESTIONNAIRE

PDPP EAST

SATELLITE FIELD TRIAL USERS SURVEY

(Administered During DOC Field Test)

Date

Name of User

Address

Terminal Size

Serial Number

The following questions should be answered by the person who is most familiar with the satellite TV system. Please use the back of a page if you need more room to answer any question than is given.

1. Use a check mark to show how many times you had to get help because the satellite signal failed.

   never _____

   once or twice _____

   three times or more _____

2. Not counting the times when you had to get help because the signal failed, use a check mark to show how consistent or even in quality the satellite signals have been.

   quite consistent _____

   somewhat uneven _____

   very uneven _____

3. If you checked that the signals have been "quite consistent" in question 2, please describe the quality of the signals you have been getting. Note both the good and bad features, if any, of the pictures and sound. Use the spaces on the next page.

   PICTURE QUALITY

(question 3, continued)

SOUND QUALITY

4. If you checked that the signals have been "somewhat uneven" or "very uneven" in question 2, please describe the quality of signals you have been getting at best and at worst. Note both the good and bad features of the pictures and sound for both the best and the worst signals.

AT BEST – PICTURE QUALITY

AT BEST – SOUND QUALITY

AT WORST – PICTURE QUALITY

AT WORST – SOUND QUALITY

5. Below, please list all the stations that you can get on your TV set. Identify each of them in whatever is the most convenient way (for example, by channel number, or by call letters, or by network, etc.).

6. The words below are meant to describe the quality of TV signals. Think of these five words as being equal steps from the best picture you can imagine ("excellent") to the worst ("bad"). Place the identification of each station you listed in question 5 beside the one word of the five words below that best describes the overall quality of picture and sound that you normally get from that station. Include the satellite station (but ignore those times when its signal failed and you had to send for help).

   Each station should be listed beside only one word.

EXCELLENT

GOOD

FAIR

POOR

BAD

7. Please write down any further comments you may have about the quality of any of the signals you get on your TV set.

8. Use a check mark to show how often you need to retune the indoor unit to get an improved satellite signal.

never _____

occasionally _____

regularly _____

9. If you need to retune "occasionally" or "regularly", please indicate how much trouble it is.

no trouble _____

somewhat annlying _____

very annoying _____

10. Check how often you have needed to do anything to the outdoor dish (for example, remove ice or snow) in order to improve the satellite signal.

never _____

occasionally _____

regularly _____

11. If you have needed to do something to the outdoor dish "occasionally" or "regularly", please describe the things you have had to do.

12. Check if there are obstructions in the direction the outdoor dish is pointing.

tree _____

building _____

other _____

If "other", please indicate what.

13. Please list any comments you may have about the appearance or any other features of the indoor unit and the outdoor dish.

INDOOR UNIT

OUTDOOR DISH

14. Have other people made any comments about your outdoor dish? If so, please list the comments.

15. On the average, how often is your TV set on each day?

less than 1 hour	_____
1 to 2 hours	_____
2 to 4 hours	_____
5 hours or more	_____

16. Roughly how much money have you spent in purchasing and installation of your complete TV receiving system? Place a check for the indoor parts of the system and a separate check for the outdoor parts.

	INDOOR	OUTDOOR
less that $200	_____	_____
$200 to $400	_____	_____
$400 to $600	_____	_____
$600 to $800	_____	_____
$800 to $1,000	_____	_____
more than $1,000	_____	_____

17. If there was a satellite service with good pictures and sound that had a variety of different stations, how much money do you think people in your area would be willing to spend per month to get the service?

less than $5	_____
$5 to $10	_____
$10 to $15	_____
$15 to $20	_____
$20 to $25	_____
more than $25	_____

18. On the back of this page, please list any other comments you may have about TV signals and the satellite system.

PDPP WEST

SATELLITE FIELD TRIAL USERS SURVEY

(Conducted by Telephone)

Date

Name of User

Address

Terminal Size

Serial Number

The following questions should be answered by the person who is most familiar with the satellite TV system.

1. How may times have you had to get help because the satellite signal failed?

   never _____

   once or twice _____

   three times or more _____

2. Not counting the times when you had to get help because the signal failed, how consistent or even in quality have satellite signals been?

   quite consistent _____

   somewhat uneven _____

   very uneven _____

3. If quite consistent – Please describe the quality of the signal you have been getting, both the good and bad features, of the pictures and sound.

PICTURE QUALITY

(question 3, continued)

SOUND QUALITY

4. If "somewhat uneven" or "very uneven", please describe the quality of signals you have been getting at best and at worst. Note both the good and bad features of the pictures and sound for both the best and worst signals.

AT BEST – PICTURE QUALITY

AT BEST – SOUND QUALITY

AT WORST – PICTURE QUALITY

AT WORST – SOUND QUALITY

5. Below, please list all the stations that you can get on your TV set. Identify each of them in whatever is the most convenient way (for example, by channel number, or by call letters, or by network, etc.).

6. Is the quality of _____, _____, _____, _____, _____

EXCELLENT

GOOD

FAIR

POOR

BAD

7. Do you have any further comments about the quality of any of the signals you get on your T.V. set? (We are particularly interested in the quality since there are 3 signals available).

8. How often do you need to retune the indoor unit to get an improved satellite signal?

never _____

occasionally _____

regularly _____

9. If you need to retune "occasionally" or "regularly", how much trouble is it?

no trouble _____

somewhat annoying _____

very annoying _____

10. How often have you needed to do anything to the outdoor dish (for example, remove ice or snow) in order to improve the satellite signal?

never _____

occasionally _____

regularly _____

11. Do you have any comments about the appearance or any other features of the indoor unit and the outdoor dish?

INDOOR UNIT

OUTDOOR DISH

12. Have other people made any comments about your outdoor dish?

13. Have you noticed any problems receiving good T.V. signals in bad weather? What were the conditions?

14. On the average, how often is your TV set on each day?

less than 1 hour	_____
1 to 2 hours	_____
2 to 4 hours	_____
5 hours or more	_____

15. Roughly how much money have you spent in purchasing and installation of your complete TV receiving system?

	INDOOR	OUTDOOR
less than $200	_____	_____
$200 to $400	_____	_____
$400 to $600	_____	_____
$600 to $800	_____	_____
$800 to $1,000	_____	_____
more than $1,000	_____	_____

16. If there was a satellite service with good pictures and sound that had a variety of different stations, how much money do you think in your area would be willing to spend per month to get the service?

less than $5	_____
$5 to $10	_____
$10 to $15	_____
$15 to $20	_____
$20 to $25	_____
more than $25	_____

SATELLITE FIELD TRIAL USERS' SURVEY

SUMMARY OF RESULTS

The total number of sites surveyed in PDPP East was 22 (8 in the inner and 14 in the outer contour). In PDPP West, a total of 14 sites were surveyed (9 in the inner and 5 in the outer contour).

The results are summarized as follows:

1. Use a check mark to show how many times you had to get help because the satellite signal failed.

	East		West	
	Inner	Outer	Inner	Outer
Never	38%	36%	44%	80%
Once or twice	62	50	33	20
Three times or more	0	14	23	0

2. Not counting the times when you had to get help because the signal failed, use a check mark to show how consistent or even in quality the satellite signals have been.

	East		West	
	Inner	Outer	Inner	Outer
Quite consistent	75%	65%	88%	100%
Somewhat uneven	12.5	28	12	0
Very uneven	12.5	7	0	0

3. If you checked that the signals have been "quite consistent" in question 2, please describe the quality of the signals you have been getting. Note both the good and bad features, if any, of the pictures and sound. Use the spaces on the next page.

	East		West	
	Inner	Outer	Inner	Outer
Good	38%	21%	66%	
Very good	25	14	11	
Excellent	12	36	23	
No Answer	25	29	0	

* *14% observed some threshold noise during precipitation.*

(question 3, continued)

SOUND QUALITY

	East		West	
	Inner	Outer	Inner	Outer
Fair	0%	21%	0%	0%
Good	38	29	0	20
Very good	25	7	67	60
Excellent	12	14	11	0
No answer	25	29	22	20

4. If you checked that the signals have been "somewhat uneven" or "very uneven" in question 2, please describe the quality of signals you have been getting at best and at worst. Note both the good and bad features of the pictures and sound for both the best and worst signals.

AT BEST – PICTURE QUALITY

	East		West	
	Inner	Outer	Inner	Outer
Good	12.5%	21%	No significant data	
Very good	12.5	21		
Excellent	0	14		
No answer	75	44		

AT BEST – SOUND QUALITY

	East	
	Inner	Outer
Good	12.5%	21%
Very good	12.5	14
Excellent	0	14
No answer	75	44

(question 4, continued)

AT WORST – PICTURE QUALITY

	East	
	Inner	Outer
Poor	25%	7%
Very poor	0	0
No picture	0	29
No answer	75	50

AT WORST – SOUND QUALITY

	East	
	Inner	Outer
Poor	25%	21%
Very poor	0	0
No sound	0	22
No answer	75	57

5. This question asked for identification of all TV channels available. Question 6 addressed the comparison of quality. No comparison was made in PDPP West when viewers described the quality of the satellite signal only. In the East, the OECA (satellite) signal quality, in comparison with the quality of these channels is documented in Question 6.

6. The words below are meant to describe the quality of TV signals. Think of these five words as being equal steps from the best picture you can imagine (("excellent") to the worst ("bad"). Place the identification of each station you listed in Question 5 beside the one word of the five words below that best describes the overall quality of picture and sound that you normally get from that station. Include the satellite station (but ignore those times when its signal failed and you had to send for help).

   Each station should be listed beside only one word.

East

	Total Available Channels	OECA Quality *	Percent of Available Channels of Specified Quality					
			Excellent	Good	Fair	Poor	Bad	No Answer
INNER SITES	5	NA	40	0	40	0	0	20
	3	E	33	33	33	0	0	0
	3	E	66	0	0	33	0	0
	5	G	40	60	0	0	0	0
	3	E	33	0	66	0	0	0
	3	E	33	33	33	0	0	0
	9	F	0	55	11	0	33	0
	3	E	33	0	33	0	33	33
OUTER SITES	4	G	75	25	0	0	0	0
	4	G	0	25	0	0	0	75
	4	E	25	25	25	0	25	0
	5	G	20	20	20	40	0	0
	4	E	25	25	50	0	0	0
	2	E	100	0	0	0	0	0
	9	G	33	22	22	22	0	0
	10	E	70	0	0	20	10	0
	4	NA	25	0	50	0	0	25
	9	F	0	55	11	0	0	0
	4	F	0	75	25	0	0	0
	4	P	25	25	25	25	0	0
	5	G	0	40	40	0	0	20
	4	E	25	25	25	0	25	0

* *NA – No Answer*

7. Further comments on the quality of signals too general to document.

8. Use a check mark to show how often you need to retune the indoor unit to get an improved satellite signal.

	East		West	
	Inner	Outer	Inner	Outer
Never	0%	23%	12%	20%
Occasionally	87.5	35	44	60
Regularly	12.5	42	44	20

9. If you need to retune "occasionally" or "regularly", please indicate how much trouble it is.

	East		West	
	Inner	Outer	Inner	Outer
No trouble	62%	50%	56%	80%
Somewhat annoying	25	14	33	20
Very annoying	13	14	11	0
No answer	0	22	0	0

10. Check how often you have needed to do anything to the outdoor dish (for example, remove ice or snow) in order to improve the satellite signal.

	East		West	
	Inner	Outer	Inner	Outer
Never	12%	50%	67%	20%
Occasionally	76	35	33	60
Regularly	12	15	0	0
No answer	0	0	0	20

11. Check if there are obstructions in the direction the outdoor dish is pointing.

	East		West	
	Inner	Outer	Inner	Outer
No obstruction	88%	77%	No data	
Tree	0	7		
Building	0	0		
Other	12	16		

If "other", please indicate what.

East Inner * Large hill or mountain

Outer * Telephone and transformer

* Hydro line and tree

12. On the average, how often is your TV set on each day?

	East		West	
	Inner	Outer	Inner	Outer
Less than 1 hour	0%	0%	0%	0%
1 to 2 hours	0	0	0	0
2 to 4 hours	12.5	29	11	20
5 hours or more	75	71	89	80
No answer	12.5	0	0	0

13. Roughly how much money have you spent in purchasing and installation of your complete TV receiving system? Place a check for the indoor parts of the system and a separate check for the outdoor parts.

	Indoor Unit		Outdoor Unit	
	East			
	Inner	Outer	Inner	Outer
Less than $200	25%	14%	38%	29%
$200 to $400	0	14	0	8
$400 to $600	12.5	8	0	0
$600 to $800	12.5	22	0	0
$800 to $1000	12.5	8	12	0
More than $1000	12.5	8	0	29
No answer	25	26	50	34

No data from West

14. If there was a satellite service with good pictures and sound that had a variety of different stations, how much money do you think people in your area would be willing to spend per month to get the service?

	East		West	
	Inner	Outer	Inner	Outer
Less than $5	0%	0%	23%	0%
$5 to $10	62	56	33	20
$10 to $15	0	37	11	20
$15 to $20	6	0	11	60
$20 to $25	0	0	0	0
More than $25	6	0	11	0
No answer	26	7	11	0

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17 Navigation, Communications, Detection and Countermeasures

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8. ABSTRACT: This report provides an assessment of the Program Delivery Pilot Project (PDPP), one of the most significant projects of the ANIK-B Communications Program of the Department of Communications (DOC). This project is a field trial involving the reception of television signals at 12 GHz from the 20 watt rf channels of ANIK-B using low cost TV receive-only earth terminals with antenna diameters of 1.2 and 1.8m. The PDPP has been in operation since late September 1979 with approximately 80 receive only terminals located in the two geographically distinct regions of northwestern Ontario and British Columbia, the Yukon and Northwest Territories. The objectives of the project are to demonstrate, evaluate and gain field experience with direct-to-home and small community satellite broadcasting, to provide a testing ground and small initial market for terminals, to contribute to policy development and plans for future operational use of broadcasting satellites and to provide information to the various interested agencies. This report describes the pilot project, documents the technical results obtained, summarizes the reaction of the participants, including members of the general public and draws conclusions regarding the implementation of future direct broadcasting satellite systems.

9. CITATION:

ANIK-B PROGRAM DELIVERY PILOT PROJECT : A 12 MONTH PERFORMANCE ASSESSMENT

Government of Canada Gouvernement du Canada