Government of Canada
Department of Communications

Gouvernement du Canada
Ministère des Communications

EVALUATION OF THE ANIK-B FEDERAL GOVERNMENT TELECOMMUNICATIONS FIELD TRIAL

DIVISION OF DEVELOPMENT & ENGINEERING

GOVERNMENT TELECOMMUNICATIONS AGENCY

REPORT # 84-7733-001

Canada

Evaluation of the Anik-B Federal Government Telecommunications Field Trial

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Ottawa, Ontario

October 1983

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ACKNOWLEDGMENTS

I am very grateful to Mr. A. Kittur of the Development and Engineering Division of the Government Telecommunications Agency for his assistance and contribution in documenting the findings of the GTA applications tested during the Field Trial.

I am also indebted to Mr. H. Macumber of the Development and Engineering Division of GTA for the time spent reviewing and criticizing this report.

Evaluation of the

Anik-B Federal Government

Telecommunications Field Trial

EXECUTIVE SUMMARY

The Anik-B Federal Government Telecommunications Field Trial was a joint undertaking by the Government Telecommunications Agency (GTA) of the Department of Communications and CNCP Telecommunications to evaluate the suitability of satellite communications to support internal government communications and the delivery of departmental programs to the public.

In Addition to GTA, two other government organizations participated in the field trial as potential users of satellite communication services; the Atmospheric Environment Service (AES) of the Department of the Environment, and the Canada Employment and Immigration Commission (CEIC). The communication applications encompassed by these organizations are typical of the communication requirements of the government as a whole. GTA investigated the areas of telephony, teleconferencing and tested the transfer of text between similar and dis-similar word processors. The AES tested the feasibility of using satellite facilities for the distribution of high resolution analogue facsimile information while CEIC examined the delivery of documents using digital facsimile. Both the AES and CEIC investigated the use of satellite communications for interactive online data enquiry, for remote job entry (RJE) and for bulk transfer of large volumes of data.

In addition to the technical performance tests, the GTA telephony and teleconferencing experiments and the CEIC interactive online data communication experiments were to investigate the behavioural effects of satellite transmission delay on the participants.

Initially the participants believed that the principal effort in the trial would go into dry runs and final evaluation of the planned experiments. As it turned out, the initial phases of the trial were crippled by innumerable technical problems encompassing both the SLIM-TDMA network and the SCPC facilities.

Several major design changes were required to both families of equipment, and some problems eluded resolution for the duration of the trial. As a result, the available testing time was severely curtailed for all applications. Many had to be reduced in scope, and two were effectively abandoned.

Prior to undertaking the field trial, all of the network equipment had been successfully tested in a development environment, and much had been used in previous trials which were technically less demanding. Possibly one of the most important results of the trial was a better understanding of the difficulties inherent in graduating from the laboratory to an operational environment.

The telephony and teleconferencing experiments confirmed the findings of other trials that the delays inherent in single hop satellite communications have a minimal effect on the users. When two satellite hops are used however, participants in both experiments found that conversation became stilted and unnatural.

Both the analogue and digital facsimile experiments found that the satellite network was capable of delivering images with the same (or better) level of quality than could be achieved using terrestrial facilities. The delivery of weather charts to remote northern locations using a double satellite hop through first the TDMA network then an SCPC tail circuit yielded an image quality inferior to that desired, but still superior to the quality normally obtained through the terrestrial network.

Apart from reliability problems, the AES found the response and error rate of the network to be comparable to terrestrial facilities for interactive data use. These findings were shared by CEIC under light line loading conditions. When several active terminals shared a single channel, the effects of the controlling protocol were immediately apparent. The use of a simple poll/acknowledge (ARQ) protocol resulted in excessive response times for the network, even under moderate loading conditions. Under heavy loading, the users found the response so slow that the tests had to be terminated.

The use of a more sophisticated 'group oriented' ARQ protocol provided excellent performance under medium to moderate loading conditions. On site measurements showed that the network response remained inferior to the terrestrial equivalent; however, this difference was too small to be noticed by the users. An alternate approach also tested, was the use of protocol conversion within the network, to transform the proprietary ARQ protocol into a variation of the internationally accepted X.25. The network performance for this test was noticeably inferior to the terrestrial facility, but was judged to be suitable for use as a backup or for service to points of service with modest work loads.

The machine to machine data transfer experiments were the least successful part of the trial. CEIC attempted to implement a remote job entry (RJE) test from Bathurst to Ottawa. For reasons that have yet to be determined, the Bathurst TDMA terminal could not function simultaneously with Ottawa, Toronto and Montreal. Despite all best efforts only 10 minutes of testing time were realized before expiry of the satellite time.

The AES had planned to experiment with the transmission of digitized photo-facsimile images between Downsview and Ottawa. Unfortunately, the complexity of this task was underestimated, and the required hardware and software could not be prepared prior to the end of the trial.

The most successful experiment in the data transfer category was the 'remote batch' test implemented by the AES. This experiment involved the implementation of a distributed processing environment linking Malton and Dorval, and operating under Hewlett-Packard's DS/1000-IV software. It enabled users in Malton to access data and software tools at the Dorval location as if they were local users. The system used HDLC protocol through the satellite network and provided a level of response acceptable to the users.

Evaluation of the

Anik-B Federal Government

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PART I - OVERVIEW OF THE FIELD TRIAL

1 INTRODUCTION

During 1979-80, the Department of Communications made capacity on the 12/14 GHz portion of the Anik-B satellite available to a number of organizations for the specific purpose of developing and testing new telecommunications equipment and applications. Among these projects was the SLIM-TDMA Pilot Project in which the Department of Communications and CNCP Telecommunications jointly developed and tested a medium capacity TDMA terminal. Toward the end of 1980, the decision was made to extend the availability of the Anik-B satellite to accommodate a telecommunications field trial using the communications equipment developed under the SLIM-TDMA Pilot Project.

The objective of the trial was to evaluate the suitability of satellite communication services to support both internal government communications and the delivery of departmental programs to the public. It was designed to identify, and where possible quantify, the properties of the satellite system which directly affect the end user or management of the network.

The participation was solicited from users with communication requirements typical of the government as a whole. The Government Telecommunications Agency (GTA) identified potential applications for TDMA satellite communications in the areas of telephony and teleconferencing. The Atmospheric Environment Service (AES) of the Department of the Environment, and the Canada Employment and Immigration Commission (CEIC) expressed a desire to test various applications pertinent to their respective operations. The communications applications encompassed by these organizations include interactive online data, the transfer of bulk data, remote job entry, and the transmission of digital and high resolution analogue facsimile.

Anik-B Field Trial Evaluation

This document reviews the objectives of the field trial, the test procedures used to meet these objectives and the results of each experiment. It is divided into four parts. The first, contains an overview of the field trial, including its background, objectives, the hardware on which it is based, and the planned schedule. Parts 2, 3 and 4 describe the test procedures and results for the three participating departments, the Atmospheric Environment Service, the Canada Employment and Immigration Commission and the Government Telecommunications Agency respectively.

2 FIELD TRIAL BACKGROUND

2.1 General

Anik-B, launched in December, 1978, is a hybrid satellite supporting commercial 6/4GHz operation as replacement for Anik-A, and non-commercial applications in the 14/12GHz band. The 14/12GHz capacity was leased on a long term basis (two years with a three year extension option) by the Government of Canada "to provide 14/12GHz Telecommunication services to Her Majesty for experimental purposes". The Anik-B Federal Government Telecommunication Field Trial is one of the communication projects undertaken as part of this program.

Communication on the high frequency (14/12GHZ) bands using spot beam transmission from the satellite can be achieved with much smaller, and potentially less costly, ground segment equipment than communication on the 6/4GHz band. Future generations of compact ground segment equipment will make point to point TDMA satellite communication an alternative that offers the user many advantages over traditional satellite and terrestrial communication technologies.

2.2 Overview of Communications Hardware

The SLIM-TDMA network used a Time Division Multiple Access (TDMA) terminal developed for the Canadian Government by Miller Communications Systems Ltd. of Kanata. The terminal was designed for use in conjunction with geostationary satellites, as both a transmission and switching node for synchronous digital data. It provides efficient communications using a partial satellite transponder and low aperture earth stations. Figure I.1 shows the functional block diagram of the TDMA terminal.

Interconnection with terrestrial terminal and communication equipment is provided through three industry standard interfaces; RS-232C (for data rates up to 32k bits per second), CCITT V.35 (for rates from 56k to 168k bits per second), and CCITT G.703 (for T1 carrier at 1.544M bits per second). The field trial used the two lower speed interfaces for data and digitized analogue transmissions respectively. No T1 carrier applications were used. The total throughput capacity of the terminal is approximately 3.1M bits per second.

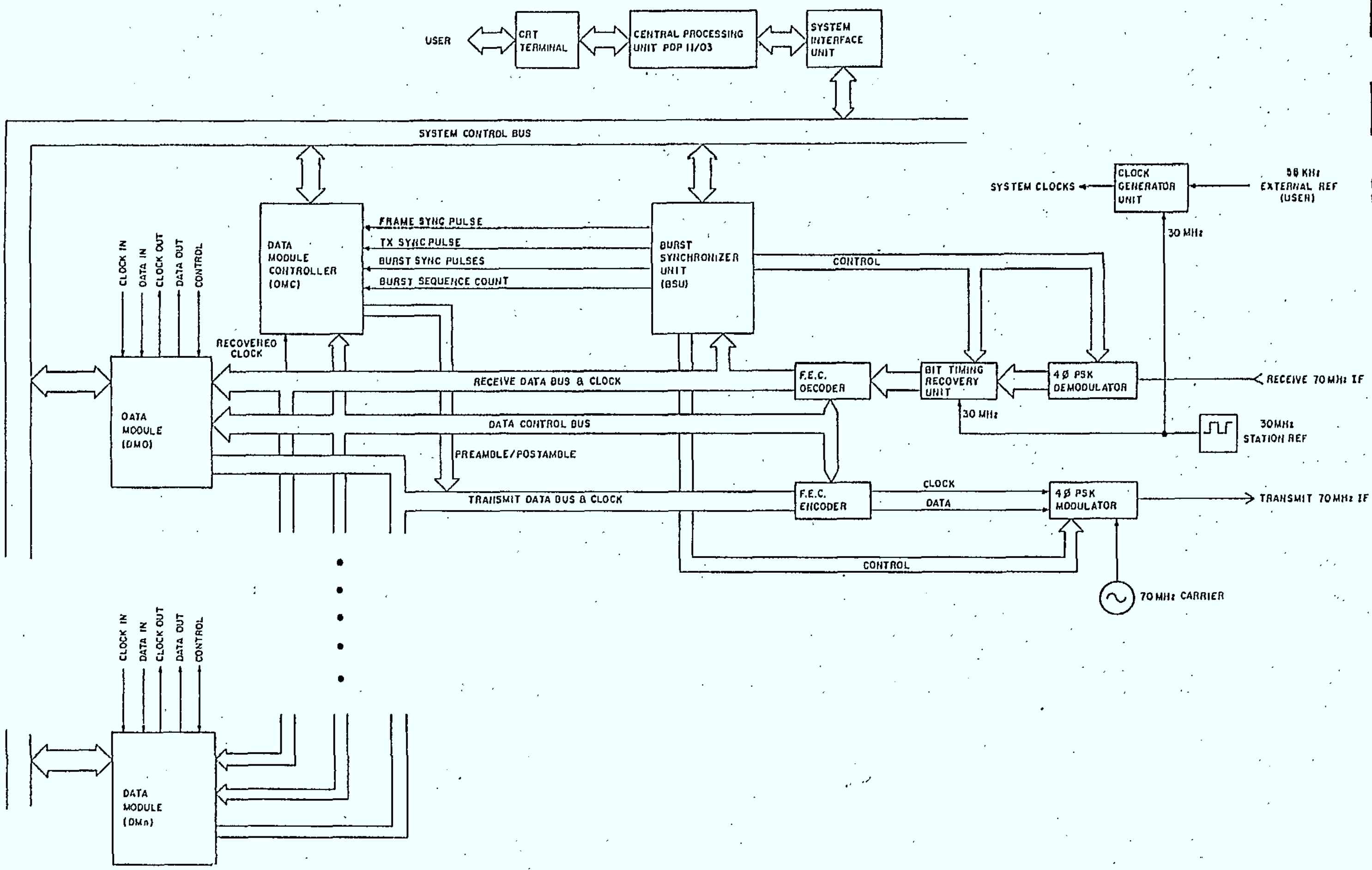
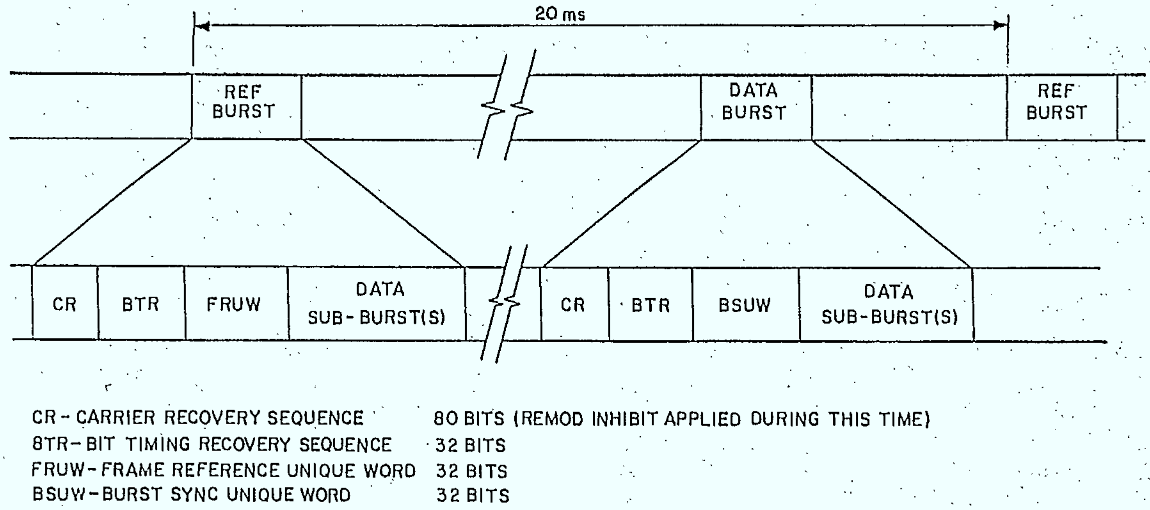


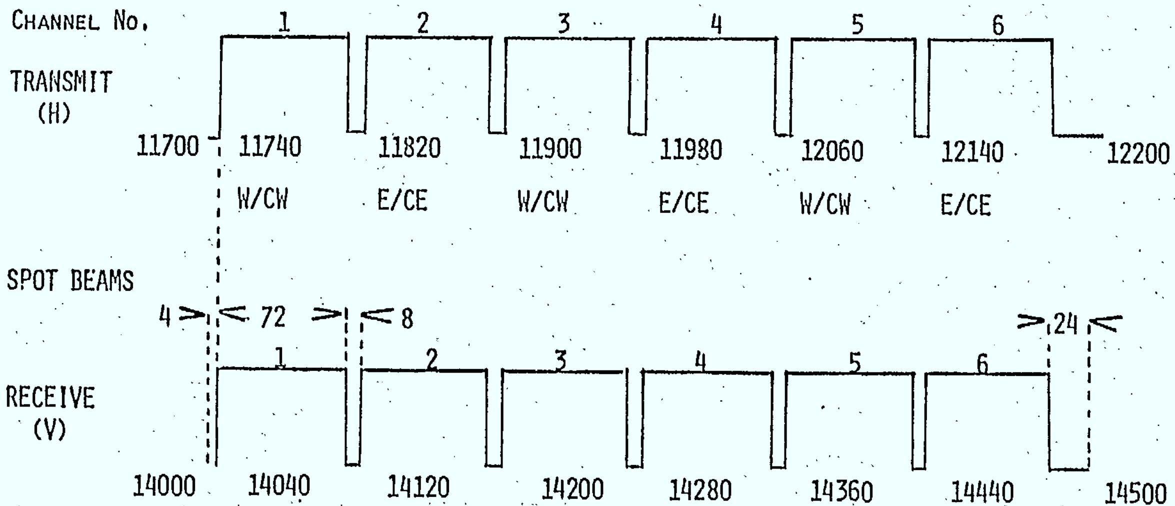
Figure I.1 - TDMA Terminal Functional Block Diagram

The network is synchronized by a Master terminal which derives its timing from the CNCP-Infodat national clock, and establishes a system frame rate of 50Hz. Each terminal in the network transmits its data burst during a specified time slot within the frame, that is assigned periodically by the network manager. The structure of an individual frame and the data bursts it encompasses is illustrated in Figure I.2.

The 14GHz uplink carrier requires a bandwidth of approximately 2.5MHz, and about 1.5 watts of transponder power. Since the TDMA signals require such a small portion of satellite bandwidth and power, the transponder is frequency shared with other users. Allocations have been made for a 30MHz TV carrier centered 22MHz below the TDMA, and several Single Channel per Carrier (SCPC) slots beginning 8MHz above the TDMA. The overall frequency plan is illustrated as Figure I.3. In addition to the TDMA allocation, the field trial also used two of the SCPC channels.



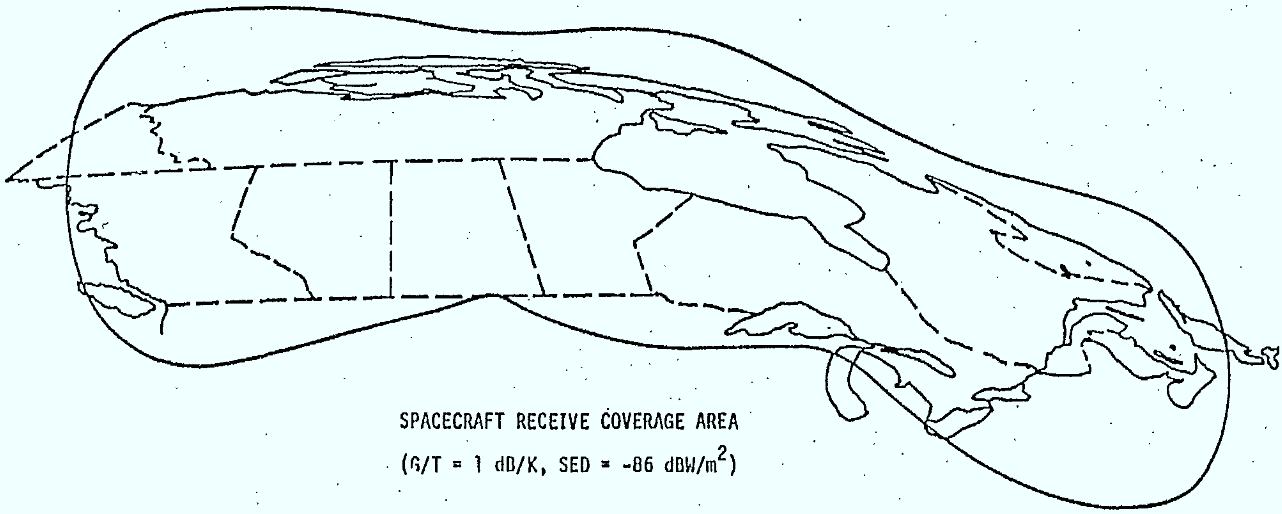
<u>Figure I.2 - Frame and Burst Structure</u>



<u>Figure I.3 - Frequency Plan for the SLIM-TDMA Network</u>

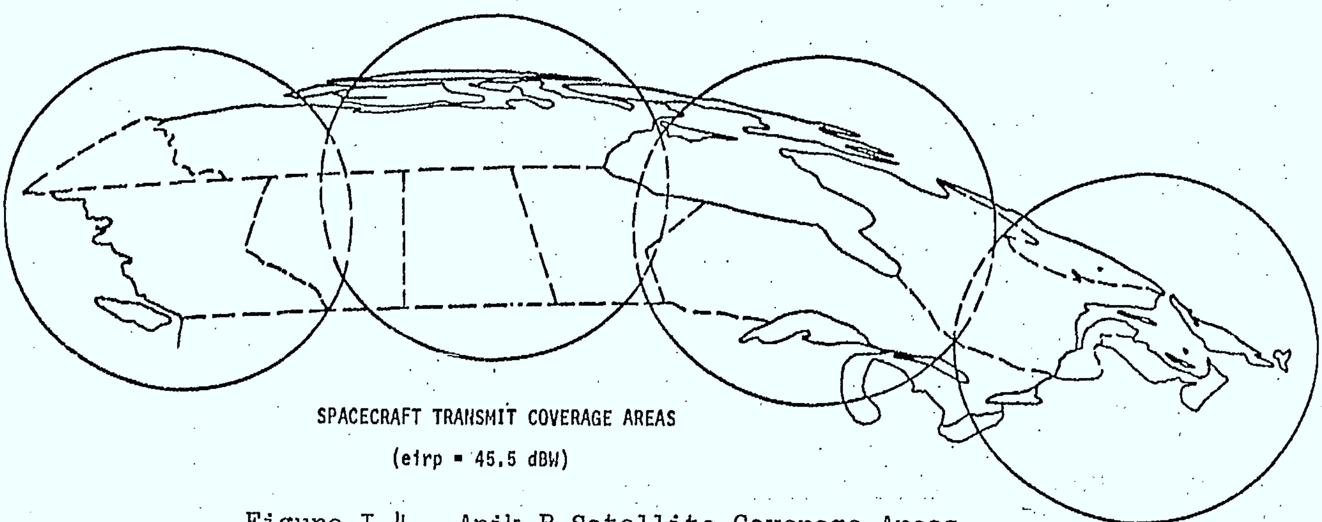
Anik-B Field Trial Evaluation

The Anik-B satellite 12 GHz down-link comprises four spot beams which divide Canada into east (E), center-east (CE), center-west (CW), and west (W) reception zones as illustrated in Figure I.4. Four 14/12GHz transponders support six 72MHz communication channels controlled by onboard switching. This switching directs up-link signals on channels 1, 3 and 5 to corresponding down-links covering the W and/or CW zones. Similarly, signals received by the satellite on channels 2, 4, and 6 can be beamed into the E and/or CE zones. The GTA sponsored Federal Government Field Trial used only one channel, therefore restricting access to points in the E and CE zones. A functional block diagram of the 14/12GHz Anik-B repeater system is shown as Figure I.5.



SPACECRAFT RECEIVE COVERAGE AREA

(G/T = 1 dB/K, SED = -86 dBW/m^2)



SPACECRAFT TRANSMIT COVERAGE AREAS

(eirp = 45.5 dBW)

Figure I.4 - Anik-B Satellite Coverage Areas

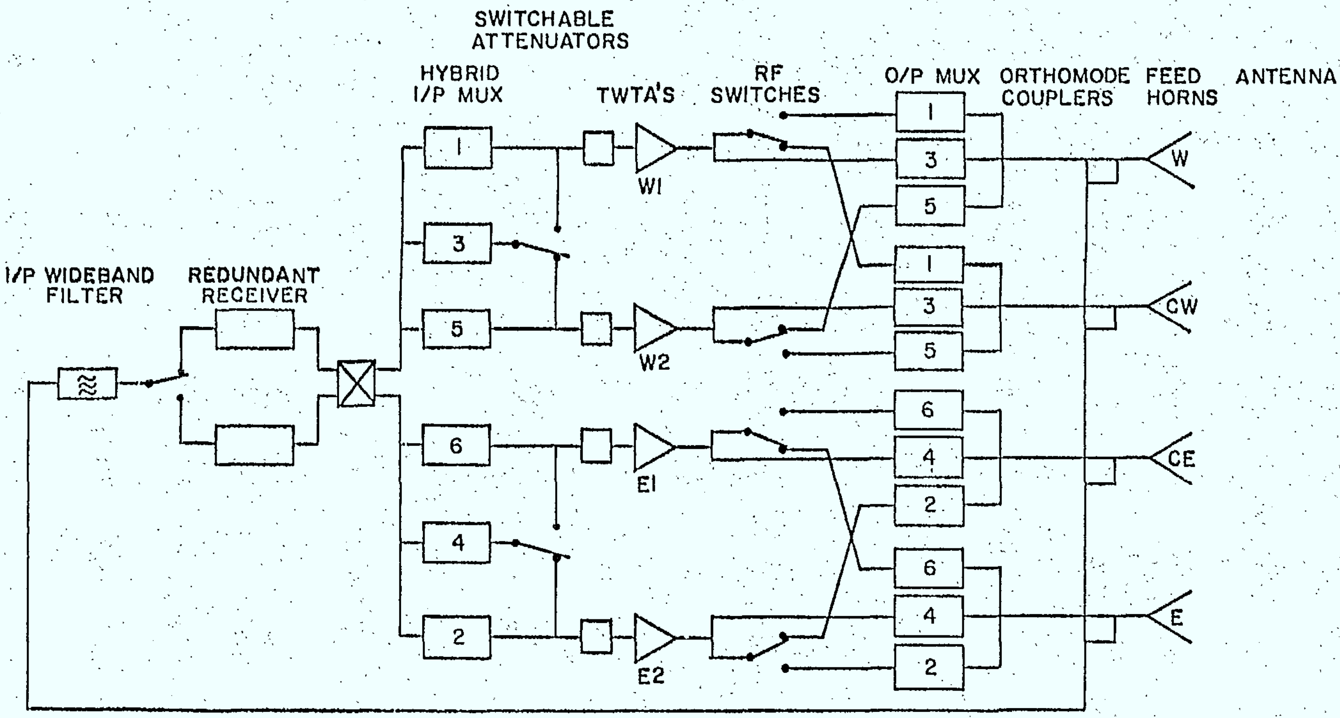


Figure I.5 - Anik-B 14/12GHz Functional Diagram

2.3 Network Configuration

The configuration used for the field trial is illustrated in block form in Figure I.6. Bathurst, Toronto, Montreal, and Ottawa were inter-connected by the TDMA network. All locations except Bathurst received their timing from the CNCP national clock. The Bathurst terminal operated from an internal clock, using closed-loop mode to lock onto the frame timing. The TDMA network was controlled by a central computer system at CNCP headquarters in Toronto. Network management consoles were located at CNCP in Toronto and GTA in Ottawa.

The network included two SCPC channels which could be used in isolation, or in a double-hop configuration with the TDMA portion of the network. One SCPC channel connected the CEIC Canada Employment Center in Newmarket, Ontario to the CEIC Vanier Data Center in Vanier, Ontario. The other, linked the AES Ice Forecast Central in Ottawa to the weather office in Frobisher Bay.

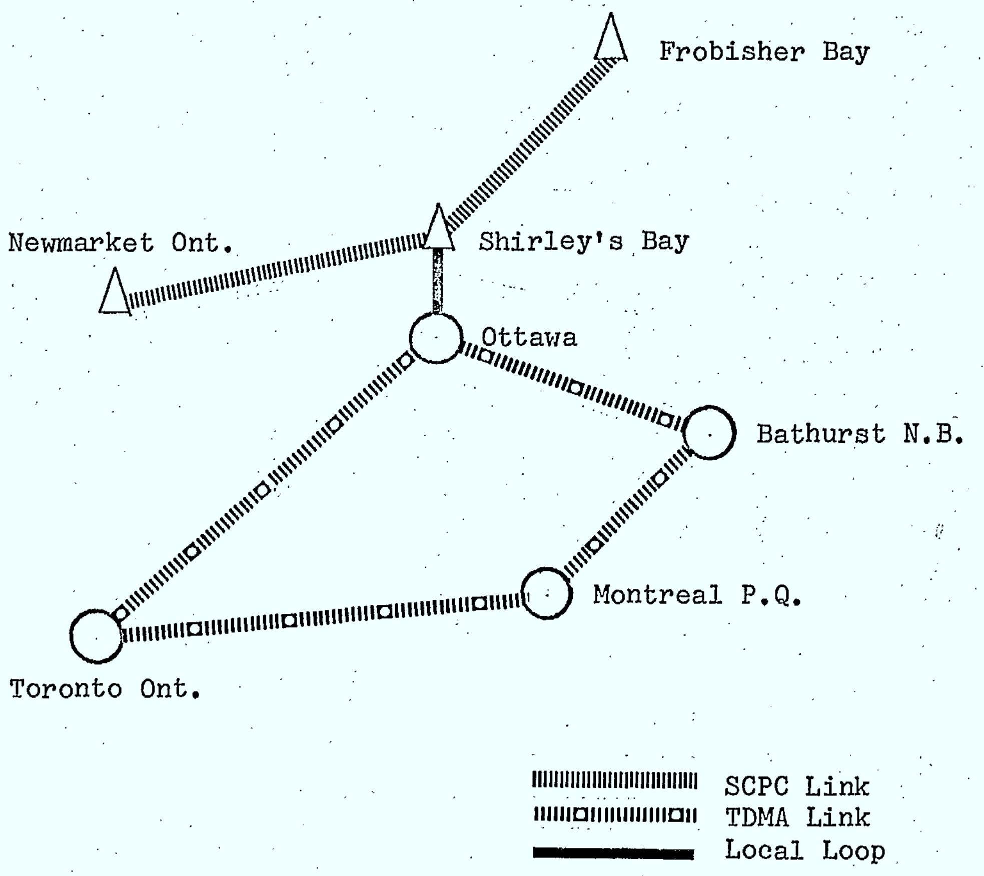


Figure I.6 - Network Configuration

2.4 Test Categories

The field trial encompassed three main categories of communication; voice, data, and facsimile. Each of these, in turn, was divided into subsets of unique user or transmission requirements.

The audio portion of the field trial demonstrated the use of satellite communication in telephony and teleconferencing. Tests were designed to demonstrate the ease with which a satellite network can be reconfigured. They demonstrated the psychological effects on system users of communication properties such as round trip delay, echo, and channel transfer characteristics. Voice experiments were conducted and controlled by GTA. CEIC participated in telephony and teleconferencing experiments, and AES in the telephony trials. The data communication trial examined both machine-machine and man-machine communication.

The SLIM satellite facilities were also used to supplement or temporarily replace existing terrestrial services. AES planned to use the network to transfer digitized photofax from the Satellite Data Lab in Downsview to Ice Central in Ottawa. A second application exchanged remote batch data between Malton and the Quebec Forecast Center in Dorval. The evaluation focused on system availability and channel performance. AES also implemented an interactive inquiry capability giving the Quebec Region SSD terminals access to the Downsview Computing Center through the trial network.

CEIC reconfigured a portion of its online Toronto Metropolitan Order Processing System (MOPS) to use both SLIM-TDMA and SCPC satellite facilities. It compared the performance of alternate protocols in the online environment. The Commission also attempted to evaluate the satellite facilities in an RJE environment wherein bulk data and processed output were to be exchanged daily between Ottawa and Bathurst.

GTA participated in the data communication trials to investigate delay effects on file transfers between communicating word processors.

The third form of communication to use the trial facilities was the transmission of documents using facsimile. AES used both SCPC and TDMA facilities to transfer high resolution weather maps between the Canadian Meteorological Center (CMC) in Montreal, and Frobisher Bay, and between Ice Central in Ottawa and Frobisher Bay. The quality of transmission and ability of the existing facsimile equipment to handshake and maintain a connection through the satellite channel were tested.

CEIC planned to use the trial facilities between Toronto and Ottawa, and Ottawa and Bathurst N.B. to demonstrate similar capabilities, using digital facsimile machines operating at 4800 bits per second. However, only the Ottawa to Toronto portion of this application could be implemented.

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PART II - AES APPLICATIONS

1 INTRODUCTION

Under the SLIM-TDMA Field Trial, the Atmospheric Environment Service investigated four potential applications of satellite communications:

{1} The transmission of high resolution facsimile images in the form of weather charts. Tests included single hop transmission through both the SLIM-TDMA network and SCPC facilities, and double hop transmissions through both the TDMA network and a satellite SCPC tail circuit. Emphasis was placed on the delivery of weather information to remote areas;

{2} Remote Batch data communications encompassed preliminary testing of the Hewlett Packard distributed processing software in a satellite communication environment;

{3} The transmission of satellite photographs as bulk data rather than the photo-facsimile techniques normally used within the Department;

{4} The provision of a dial-up channel through the satellite network to support 'light use' online data enquiry activities.

The following paragraphs review the evaluation plan and trial objectives for each application and present the test results.

2 ANALOGUE FACSIMILE

2.1 Overview

The Weatherfax Network is a nation wide analogue facsimile network for the distribution of weather data and prognoses in chart form. Collectively referred to as 'Circuit 1801', the network serves approximately 140 different users through its five component circuits. Each station on a given circuit receives all charts transmitted on that circuit. Transmission is conducted in accordance with a published schedule allowing the users to receive only those charts that they require. If a particular chart is not required, the user simply turns off his receiver.

Three main types of charts are carried on the network. The majority are of national interest, produced and distributed to all stations from the Canadian Meteorological Center in Dorval, Quebec. Others are local and regional charts produced by the Regional Weather Centers and transmitted only to those stations which have similar geographic and meteorological interests. The third type contains international information that is received from the United States Weather Service and simultaneously distributed to all stations on the network. Of an average of 116 charts received daily by each station, the average user requires only 70-80.

Two main objectives were addressed under the field trial. The first was to demonstrate the ability of TDMA and SCPC satellite communications to carry weather charts in analogue form while providing an image quality equal to, or better than, that normally achieved through the existing terrestrial network. The second was to demonstrate the ability of SCPC satellite communications to send and receive weather charts to the Canadian north where conventional service is often unreliable and low look angles make satellite communication difficult.

Four separate points of service were used in the trial; the Frobisher Bay weather office (YFB), the Ontario Weather Center (OWC) in Malton, Ice Forecast Central (ACIF) in Ottawa, and the Canadian Meteorological Center (CMC) in Montreal. Frobisher Bay was linked to the SLIM-TDMA network through an dedicated SCPC satellite circuit between Frobisher Bay and Shirley's Bay. Local loops provided the final connection between Shirley's Bay and the Ottawa node of the SLIM-TDMA network. The Ontario Weather Center, Ice Forecast Central and the Canadian Meteorological Center were connected through local loops to the Toronto, Ottawa and Montreal nodes of the TDMA network respectively.

2.2 Test Procedure

Three basic combinations of service were evaluated;

{1} The transmission of pure analogue facsimile signals over dedicated SCPC facilities. These tests included the transmission of weather charts in both directions between Frobisher Bay and Ice Forecast Central in Ottawa.

(2) The transmission of charts through the TDMA network facilities after first digitizing the analogue signal. This test transmitted operational charts from the Canadian Meteorological Center in Dorval to the Ontario Weather Center in Malton.

(3) The transmission from an 'on-net' to an 'off-net' location using both the TDMA and SCPC facilities in tandem. For this series of tests, charts were transmitted from the Canadian Meteorological Center, through the TDMA network to the Ottawa node. From there, they continued through the SCPC facility to Frobisher Bay.

A functional diagram of the various test configurations is shown as Figure II.1. The test plan called for the transmission of daily test charts, supplemented by as many operational charts as possible. Each transmission was to be evaluated using normal operational criteria.

Insofar as possible, it was planned to use the communication facilities of the trial network to supplement normal operations by overlaying existing communication links. This would permit the satellite network to be tested in an operational environment without jeopardizing normal operations and would also provide a convenient basis for comparison of the quality of transmission.

In the TDMA portion of the network, the initial plans also called for the forward error correction to be enabled and disabled for selected periods throughout the trial to determine whether transmission errors had any significant effect on the quality of the received images. Technical and logistic problems within CNCP resulted in little use of forward error correction during the trial and no specific tests of its effect on facsimile image quality could be conducted.

2.3 Results

The first step in the evaluation was to determine the ability of the Alden Facsimile equipment to establish and maintain an integral connection in each desired circuit configuration. Once this had been successfully demonstrated performance was measured by evaluation of standard test charts, using the same procedures as for operational charts. The Alden scanners are equipped with a built-in loopback capability that enabled the CMC to monitor the quality of all of its transmissions on an ongoing basis.

Anik-B Field Trial Evaluation

Since the TDMA portion of the network was designed for digital information, the analogue facsimile signal had to be digitized prior to transmission, then converted back to analogue form before being passed to the remote receiver. The accuracy of this process depends on the conversion process as well as errors introduced by the TDMA network. On the basis of experiments conducted during the pre-trial phase of the project to determine the optimal transmission bit rate for a performance-bandwidth trade off, the data rate for the CODECs for this application was increased to 56k bits per second from the 32k bits per second used for the other applications.

The facsimile tests were possibly the most successful and productive of the field trial. The transfer of charts between Ice Forecast Central and Frobisher was operational in early July. The TDMA portion of the experiment was operational by mid-October. The experimental results for each sub application are detailed in the following paragraphs.

<u>SCPC Between Ice Forecast Central and Frobisher Bay</u>

The existing facsimile service to Frobisher Bay is implemented through the Outwats tariff offering of the TCTS. The service is simple to use, but performance is marginally acceptable. On the average 37% of all charts transmitted are judged to be of unacceptable quality. The transmission schedule is very rigid and false transmission starts frequently cause delays that result in lost or missed charts.

The SCPC facilities used for this portion of the network are illustrated in Figure II.2. Following an initial shake-down period, the SCPC link between Ice Forecast Central and Frobisher Bay functioned well. On several occasions ghosting appeared on the received images, but minor equipment adjustments usually eliminated the problem. In mid-November, operational requirements of Telesat necessitated the reassignment of the satellite frequencies used by the trial network. Technical problems associated with this change resulted in serious degradation in the quality of service which persisted with minor exceptions until the end of the trial.

When the trial facilities were operational, the overall service and quality of transmission far exceeded the average performance of the Outwats alternative. The staff at Frobisher rated the quality of received charts as 'generally excellent at 120 RPM and good at 240RPM' transmission speeds, and that reception of charts from Ice Forecast Central was generally 'consistent and without interruption.' Of all charts received at Frobisher Bay, approximately 72% were rated as 'good' or 'very good'. Figure II.3 summarizes the relative numbers of 'good', 'poor' and 'missing' charts received at Frobisher Bay from Ice Forecast Central during the trial period. The deterioration in the level of service during the last three months of the trial is clearly evident from the histogram of 'missing' charts. For comparison of the performance of the trial network to existing terrestrial facilities, evaluation results are also provided for the six week period immediately following the field trial.

Similar evaluation results for the transmission of charts from Frobisher Bay to Ice Forecast Central are presented in Figure II.4. The Frobisher Bay to Ottawa traffic averaged two charts per day in each direction. Good performance was experienced during the early periods of the trial, but degraded significantly during the last three months. No charts were successfully transmitted during December.

When the facilities were operational, the quality of charts received at Ice Forecast Central were consistently judged as 'acceptable' or better. Overall, 49% of all charts received were rated as 'very good'. If the poor performance during January is not taken into consideration, this fraction rises to 58%. Similarly, the fraction of charts judged as 'acceptable' or better was 63% overall, or 74% if the January performance is omitted from consideration.

Figures II.5 through II.8 show portions of test charts sent from Ice Forecast Central to Frobisher Bay, and Frobisher Bay to Ice Forecast Central. The images reproduced here were judged to be of above average quality and are good representations of the potential capability of a satellite distribution system. Figures II.5 and II.6 contain portions [1] of the test chart as received at Frobisher Bay on February 5, 1983. The first was transmitted at low speed (120 RPM), the other and high speed (240RPM). The resolution and clarity of both is very good, however the quality of the image transmitted at high speed is noticeably inferior.

Figures II.7 and II.8 provide a similar comparison for charts received at Ice Forecast Central from Frobisher Bay on February 7, 1983. The superior quality of the southbound transmission is a result of differences in the two receiving

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[1] A minor amount of image degradation also may have been introduced through photocopying of this report.

stations. Frobisher Bay was equipped with a three meter dish which, because of the geographic location had a very low look angle. In contrast, the receiving station at Shirley's Bay not only had the advantage of a more southerly latitude, but was equipped with a tracking 9 meter antenna. From the figures, it can also be seen that the effects of transmission speed, while still present, are less pronounced than for northerly transmission.

TDMA Between The Ontario Weather Office and CMC

The TDMA portion of the facsimile network became usable in early October, 1982. The trial configuration is shown in Figure II.9.

Weather charts were transmitted on a regular basis from the Canadian Meteorological Center in Dorval to the Ontario Weather Center located in Malton. The quality of charts transmitted through the SLIM-TDMA network was judged by the users to be inferior to those sent over the existing terrestrial network, or those transmitted to Frobisher Bay through the SCPC facilities.

In order to carry the analogue weather charts over the TDMA network, they first had to be converted to digital form. This was accomplished by a coder/decoder (CODEC), co-located with the TDMA terminal in Montreal, which transformed the analogue signal to a 56k bit per second data stream. This stream was converted back to its analogue form by a similar CODEC at the Toronto node of the network. A third CODEC was located at the Ottawa node for use in the double hop transmission tests. The CODECs were a major source of problems throughout this portion of the field trial. Although specific short-comings were never identified, few problems were documented that did not relate in some way to the operation of the CODECs. [1]

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[1] Subsequent tests by the AES in conjunction with a field trial in British Columbia demonstrated that the principal source of ghosting in both the Anik-B trial and the initial phases of the B.C. trial was directly related to the CODEC. Ghosting was found to be present in all images, whether they were transmitted over the satellite link or through land lines. Replacement of the analogue facsimile equipment with equipment designed for digital transmission effectively eliminated the presence of ghosting. (The Alden digital facsimile uses a Bell 208 compatible transmission technique.)

By mid-January it appeared that most problems had been resolved. For the period from January 17 to January 24 the network performance and chart quality were excellent. On January 25, service was disrupted and not restored to an operational condition for the remainder of the trial.

No test charts were retained by the users for inclusion in the evaluation report.

SCPC-TDMA Double Hop from CMC to Frobisher Bay

The network configuration used for the TDMA-SCPC double hop transmission tests is shown in Figure II.10. The performance of the double hop tests corresponded closely to that of the TDMA portion of the network. Good quality charts were received at Frobisher only during those periods when acceptable quality was also being obtained at the Ontario Weather Center. Figure II.11 shows a portion of one test chart received at Frobisher Bay from the CMC. Although the chart is readable, there is clear evidence of transmission problems in the general 'fuzziness' of the image and traces of ghosting. Transmission of the same chart at high speed was unsuccessful. Of its 20" length, only the last 4" were actually received. The remainder was lost in background noise. Figure II.12 shows a portion of the test chart as received at 240RPM.

2.4 Conclusions

In summary, it was found that the transmission of facsimile in analogue form through the SCPC facilities of the network was highly successful and may offer viable service alternatives. Transmission through the TDMA network was unpredictable, dependent on engineering intervention, and not yet suitable for an operational environment. It does appear, however, that the best operational approach is to use scanners with digital transmission capability rather than attempting to digitize an inherently analogue signal. The use of digital equipment would eliminate the conversion process, eliminating one of the main sources of transmission problems.

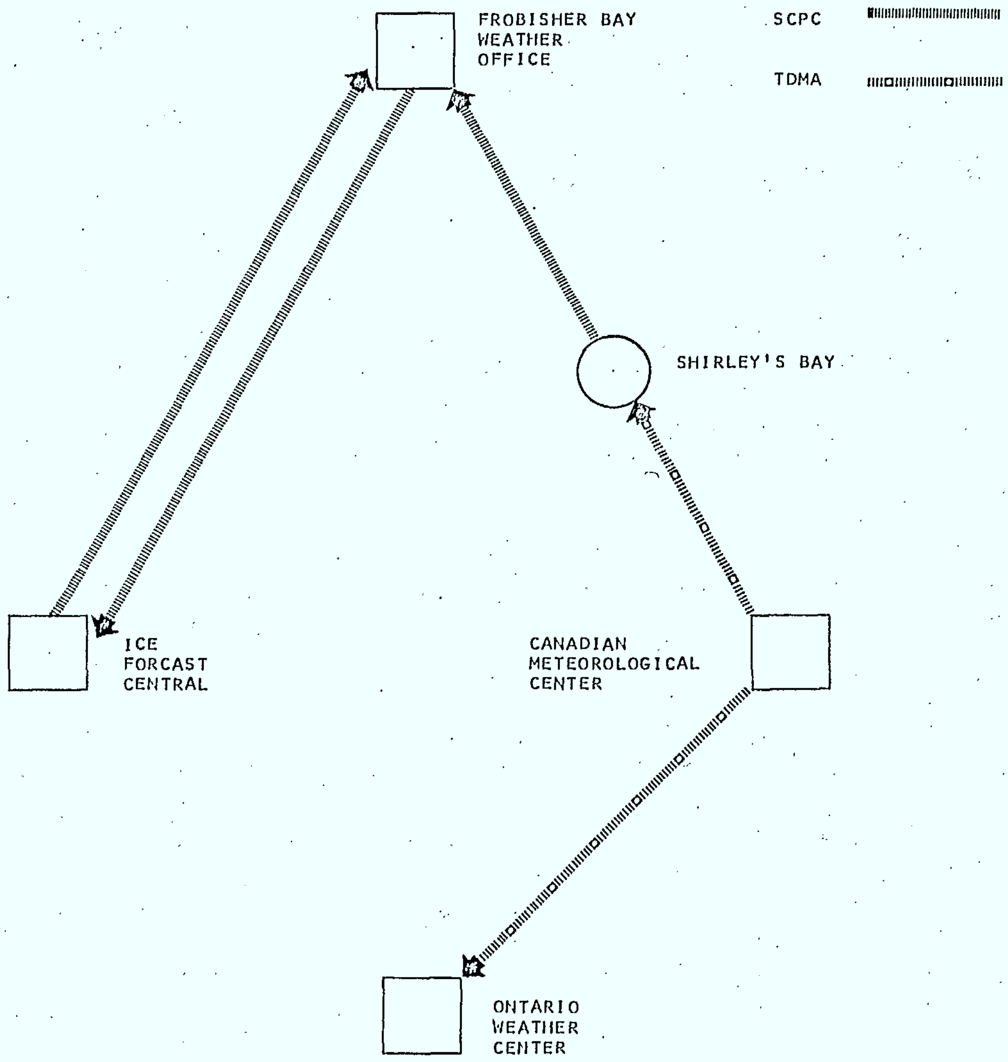

Figure II.1 - Analogue Facsimile Functional Configuration

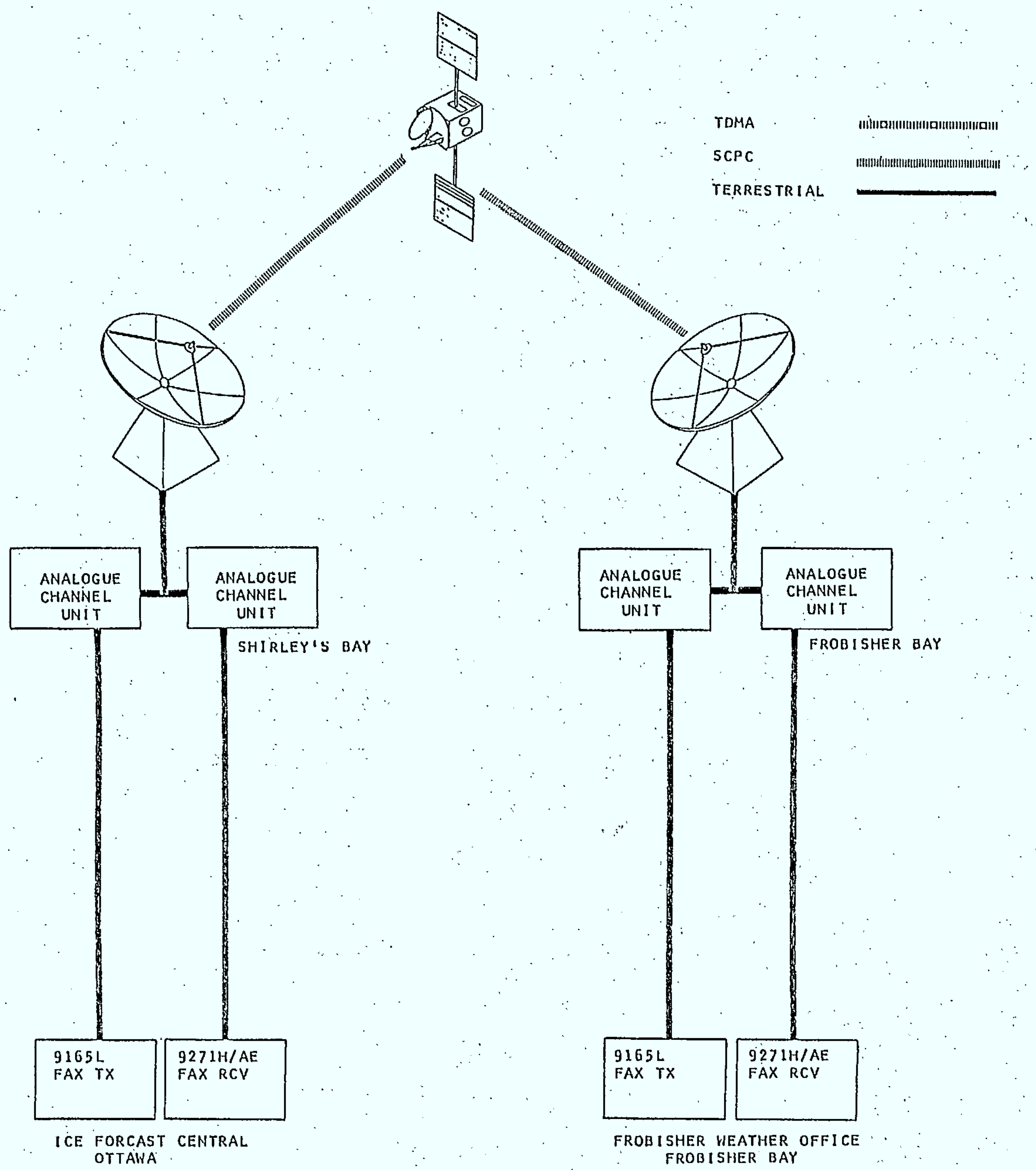

Figure II.2 - SCPC Analogue Facsimile Trial Configuration

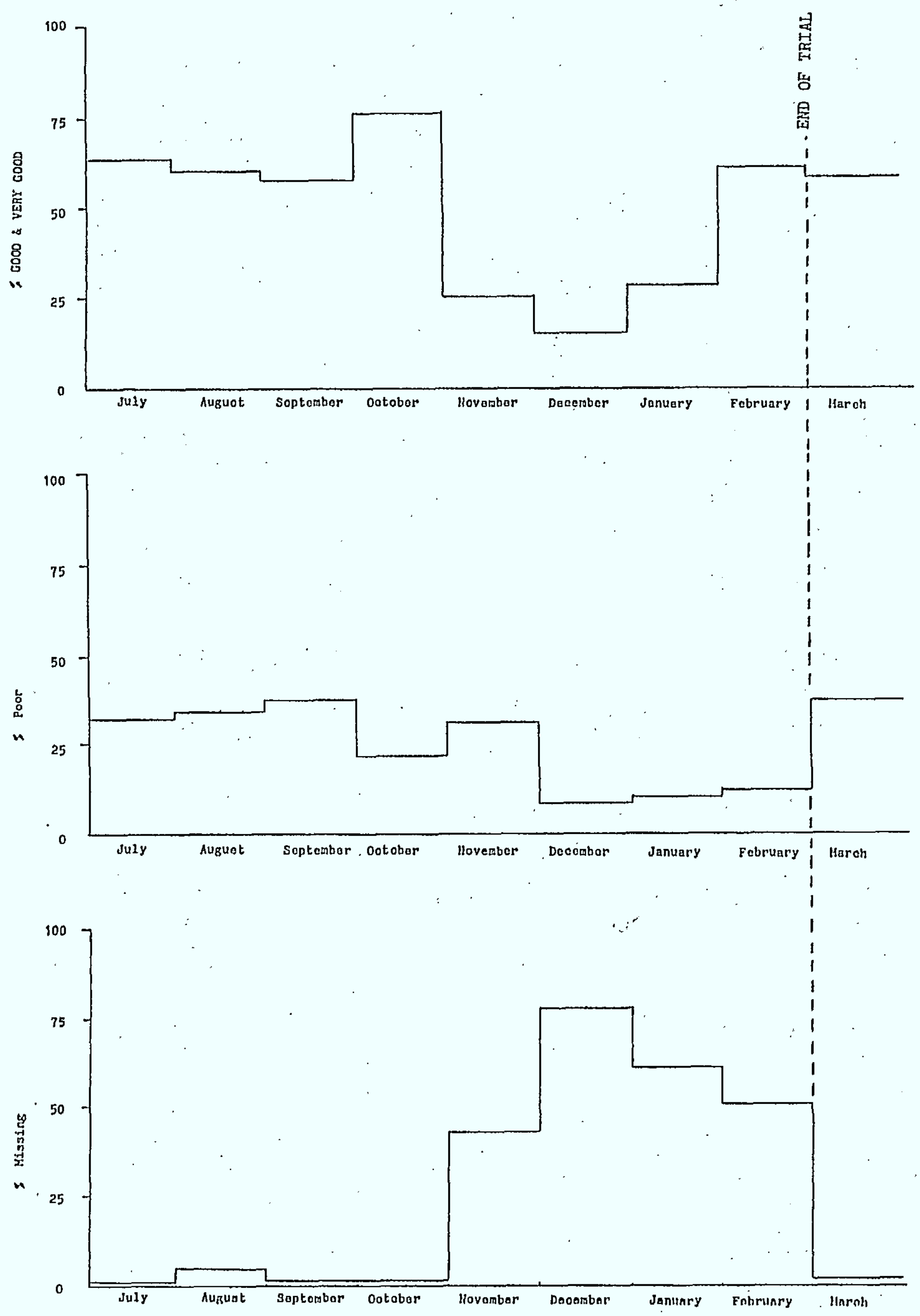

Figure II.3 - Analogue Transmission Quality from ACIF to YFB

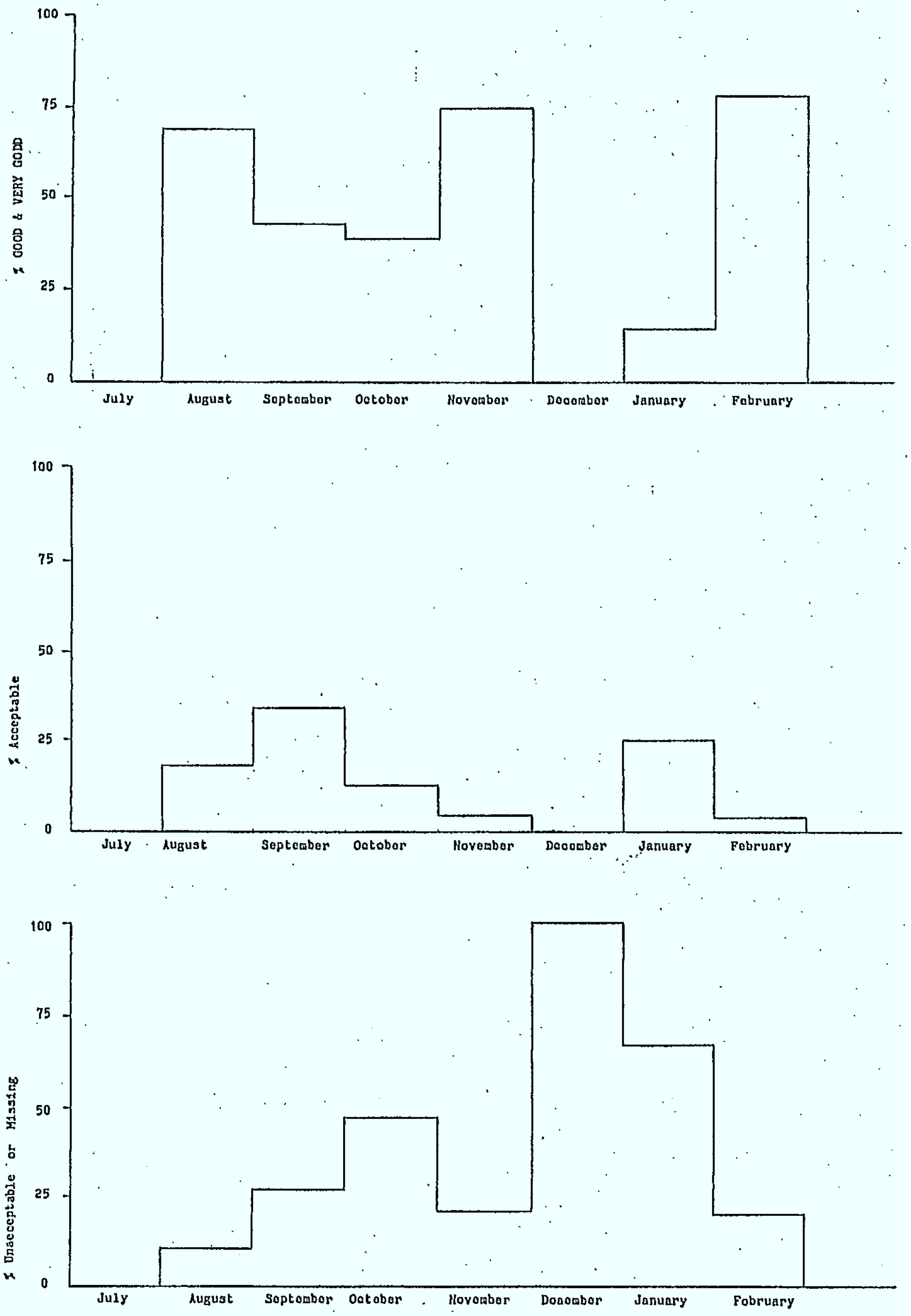

Figure II.4 - Analogue Transmission Quality from YFB to ACIF

Figure II.5 - Test Chart Received at Frobisher Bay (120RPM)

Figure II.6 - Test Chart Received at Frobisher Bay (240RPM)

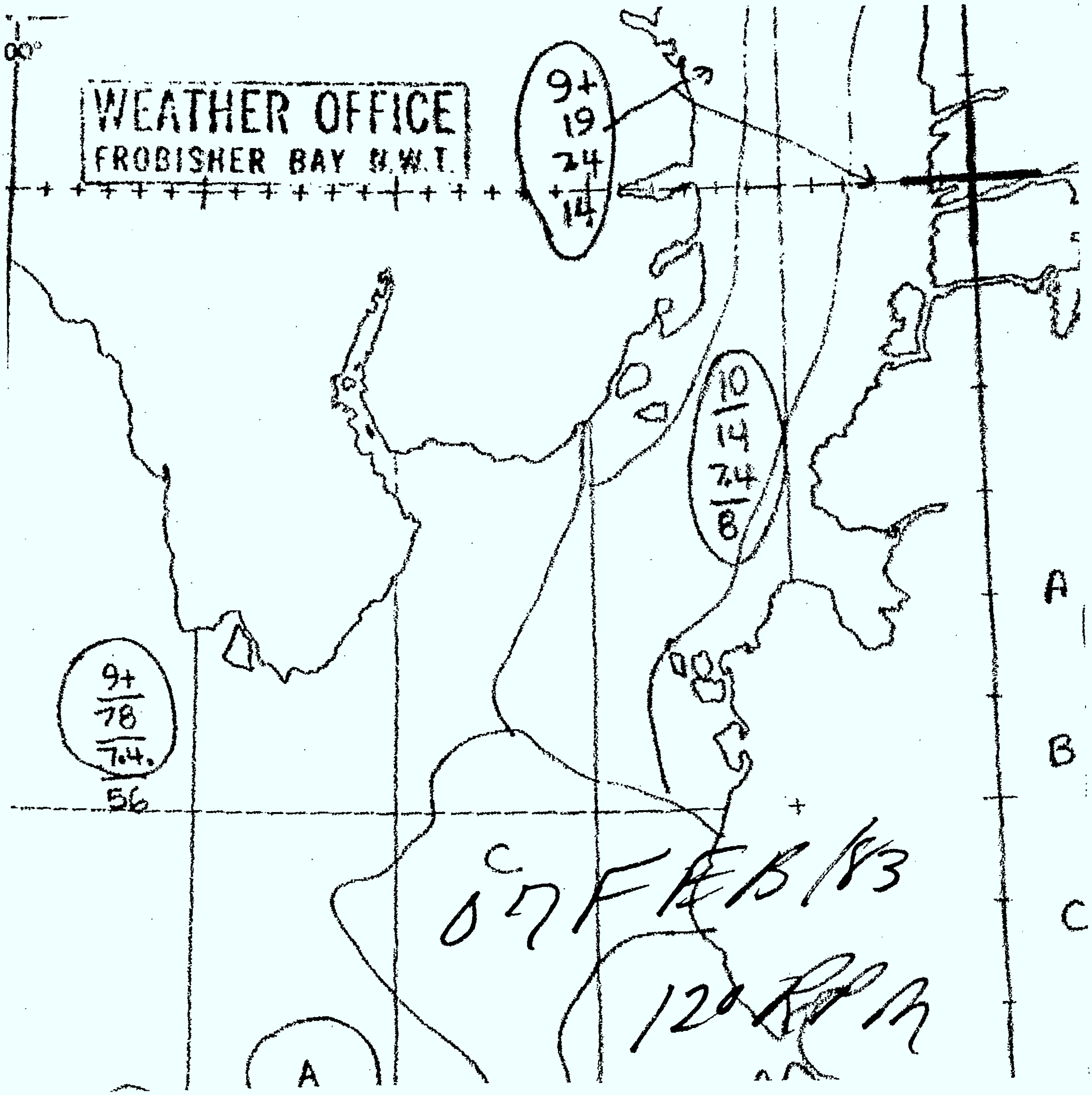

Figure II.7 - Test Chart Received at ACIF (120RPM)

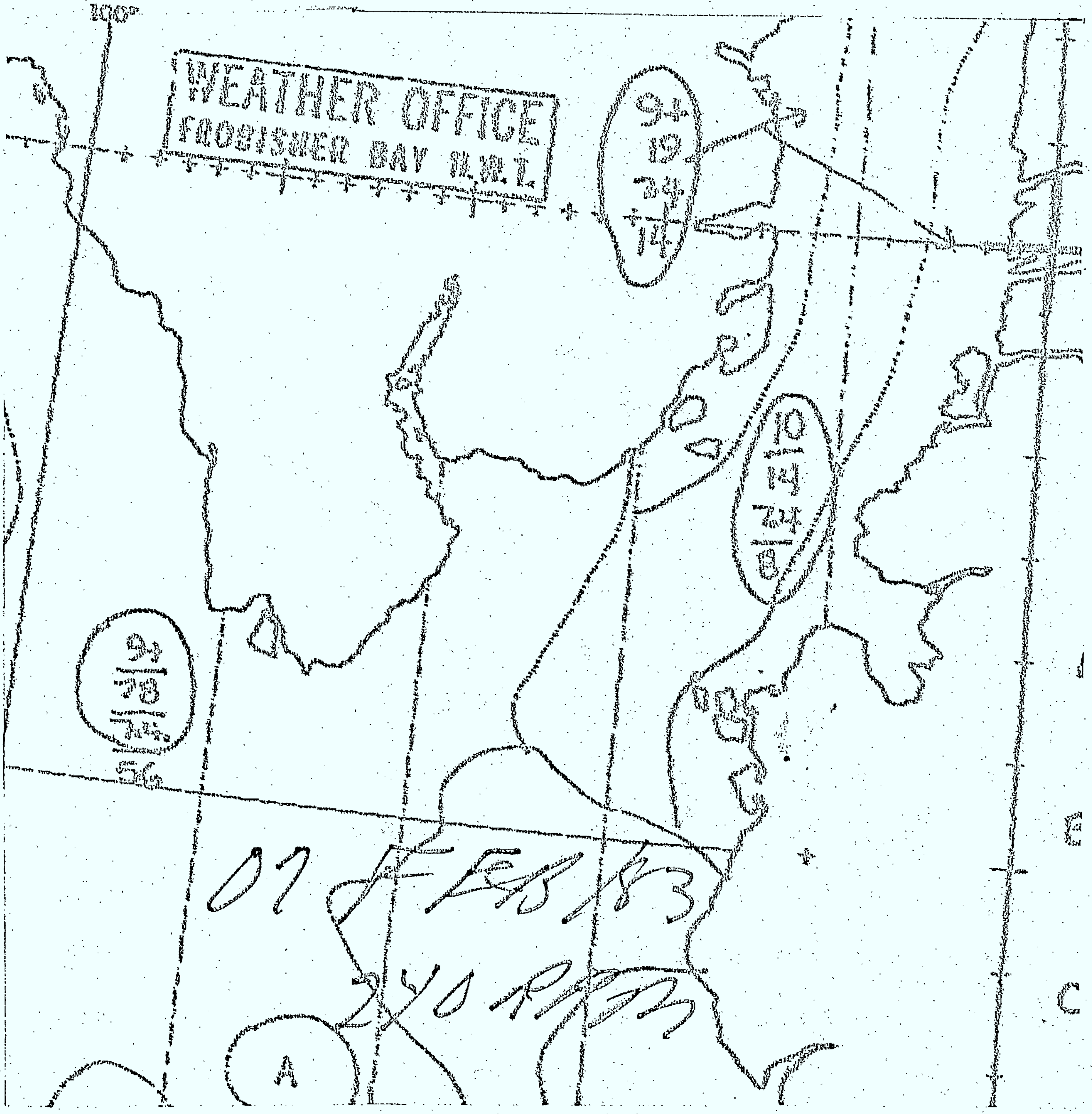

Figure II.8 - Test Chart Received at ACIF (240RPM)

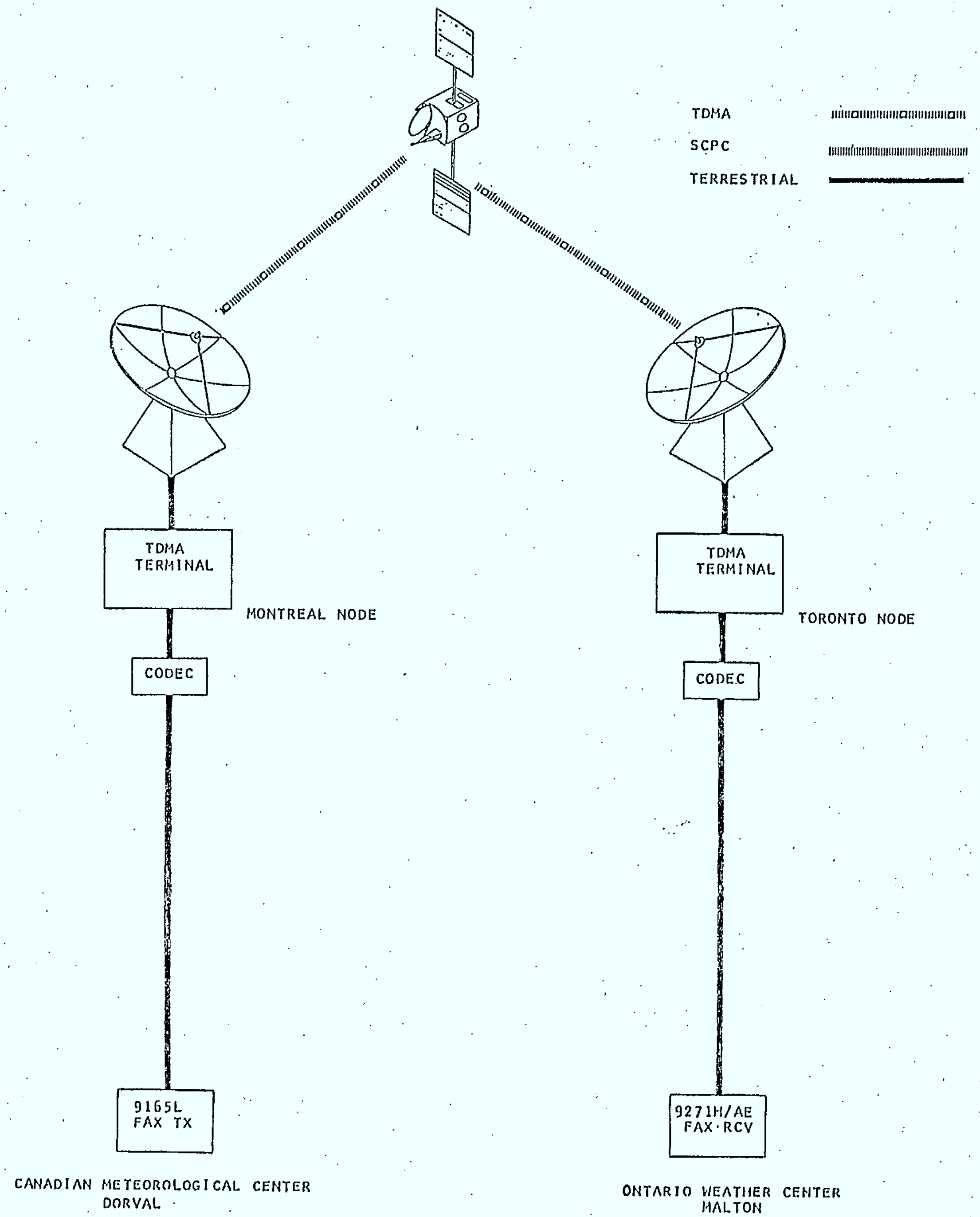

Figure II.9 - TDMA Analogue Facsimile Trial Configuration

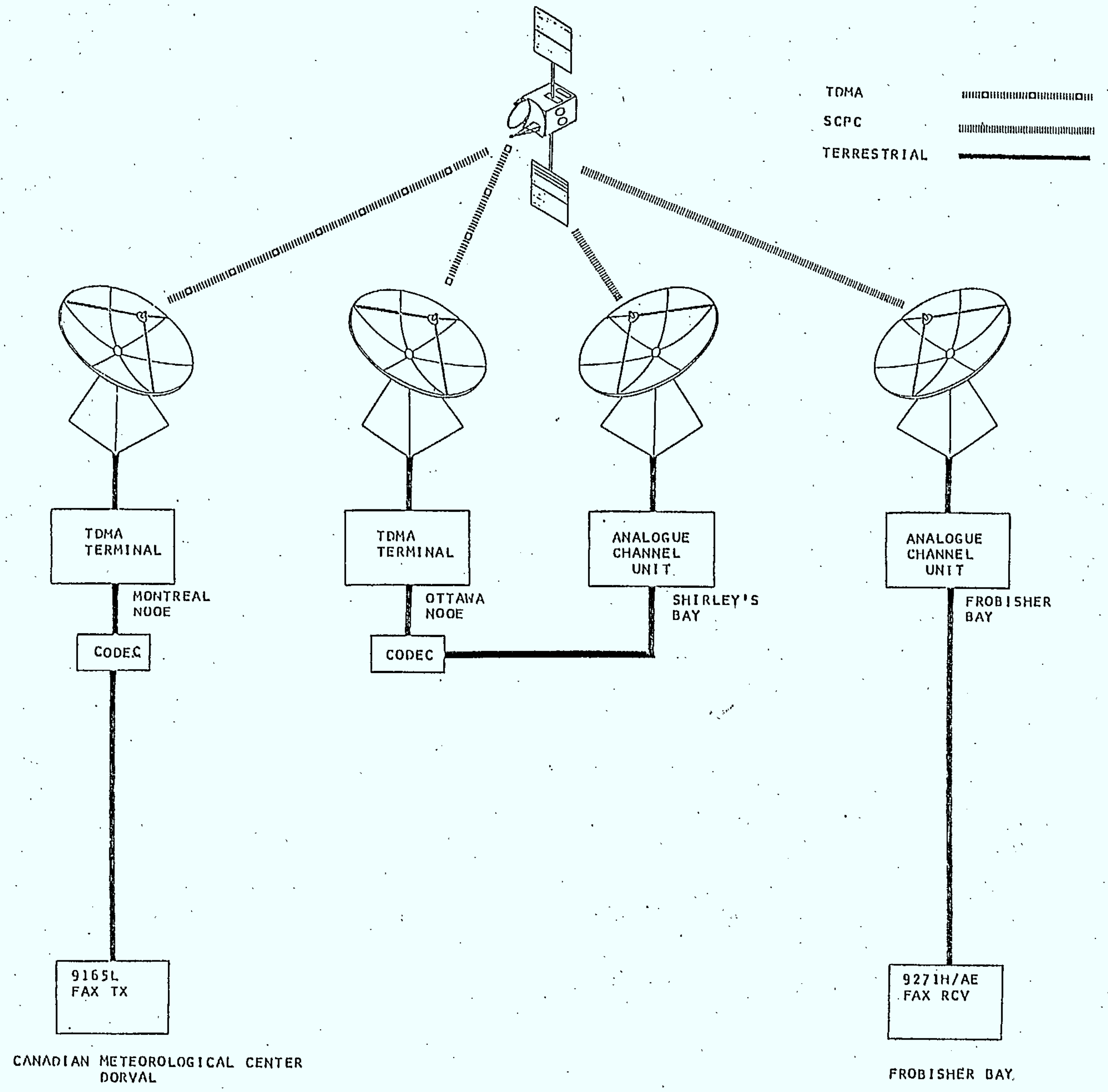

Figure II.10 - Double Hop Analogue Facsimile Trial Configuration

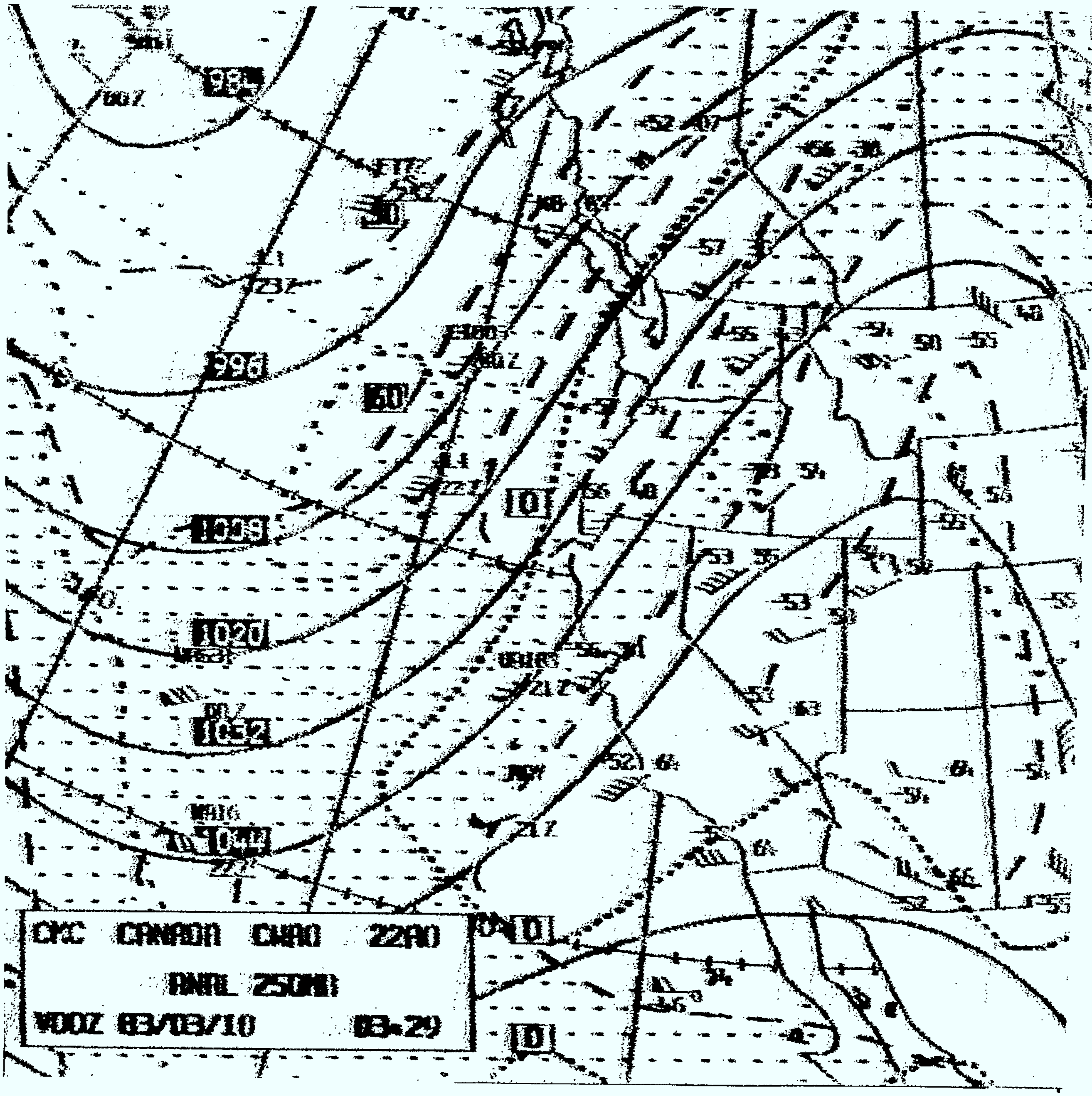

Figure II.11 - Double Hop Transmission from CMC to YFB (120RPM)

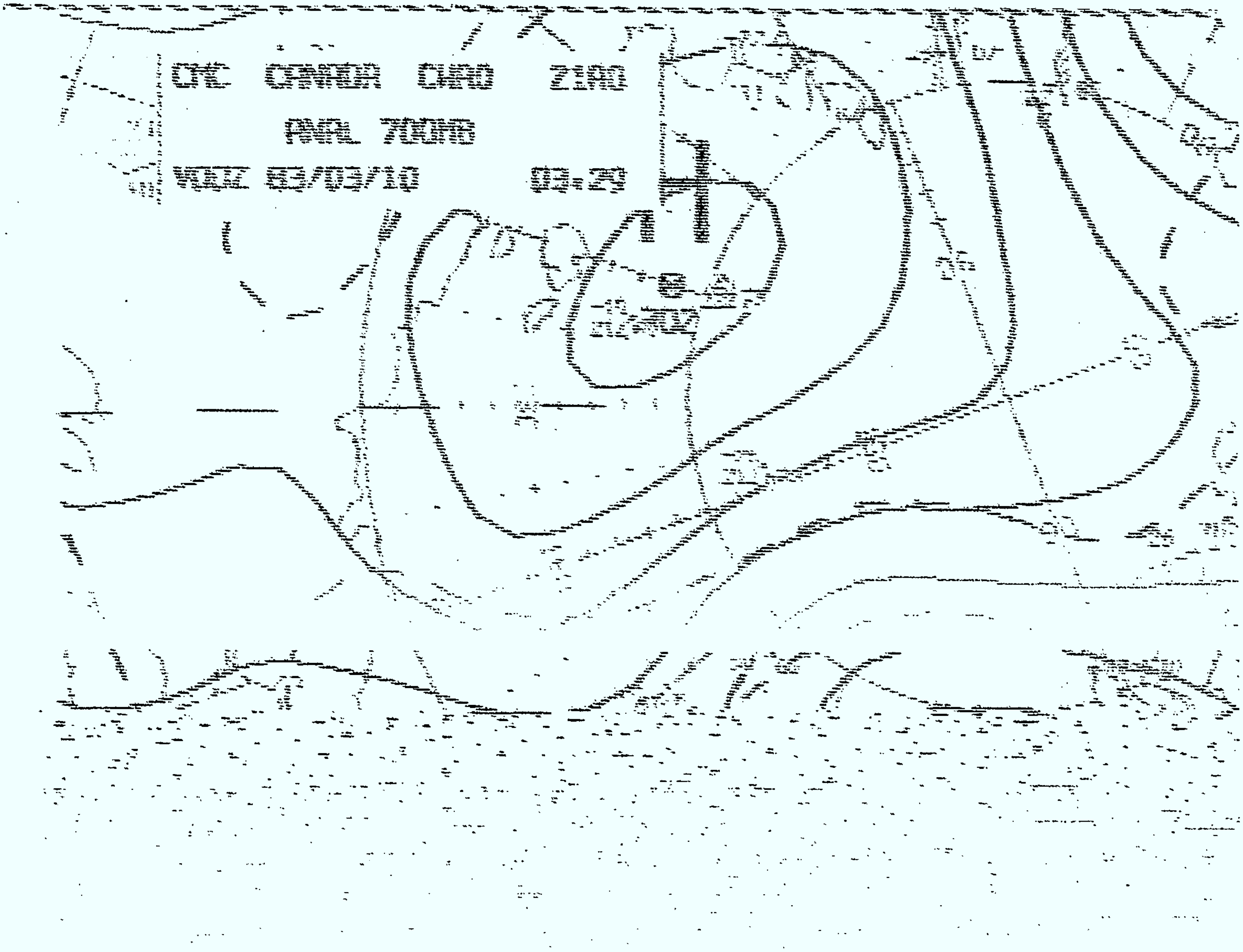

Figure II.12 - Double Hop Transmission from CMC to YFB (240RPM)

3 BULK DATA TRANSFER

3.1 Overview

Satellite photographs are used extensively in weather forecasting and in animation of weather forecasts for television. The AES Photofax Network is a nation-wide network for the distribution of these photographs. It consists of four independent legs, each serving a separate geographic area; the Maritimes, Ontario, Quebec and Western Canada. Each leg carries information that is specifically tailored to the geographic and meteorological needs of the offices it serves. Most satellite photographs are processed and distributed from the Satellite Data Laboratory (SDL) in Downsview, Ontario; however, both Vancouver and Edmonton are also equipped for image transmission.

At the present time, all photograph transmission is analogue in nature, using UPI photo-facsimile transmission and reception equipment. The objective of this portion of the field trial was to demonstrate the feasibility of applying digital techniques to the transmission of satellite photographs. The particular application selected for testing was the transmission of photographs from the Satellite Data Laboratory to Ice Forecast Central (ACIF) in Ottawa.

Ice Forecast Central has recently acquired a sophisticated graphics display system which, coupled with an on-site HP1000 mini-computer, will be used to enhance the desired features of the satellite images and applied to improve the reliability of ice forecasts. Under the current operating conditions, images are received, processed and stored at the SDL in digital form on magnetic tape. When a specific image is required at Ice Forecast Central, the appropriate tape is sent from the SDL by courier. The objective of this portion of the field trial was to investigate the feasibility of using satellite communications to deliver these satellite images on a demand basis. The delivery system would use an Interdata 7/16 mini-computer equipped with a digital/photo-facsimile converter to format and transmit each photograph to Ottawa through the satellite TDMA network.

3.2 Test Procedure

The network configuration used for the bulk data transmission portion of the field trial is shown as Figure II.13. Plans called for the transmission of satellite images as blocks of pure binary data, with neither a controlling protocol, nor error detection, correction or recovery mechanisms. Each byte would be looped back to the transmit side of the modem by a special interface cable, and returned immediately to the SDL over the satellite facility.

At the SDL, the echoed data would be compared byte by byte to the original. Transmission errors would be tabulated for each image and compared to anticipated error rates.

The quality of transmission through the satellite portion of the network was expected to be at least an order of magnitude better than that of the local circuits through which it is accessed. This limitation, coupled with the absence of a protocol, would make a meaningful analysis of the TDMA bit error rate performance unfeasible. This application was therefore regarded as a demonstration rather than a quantitative evaluation.

The satellite images to be used for the trial were those received from the NOAA weather satellites. Each one is divided into five channels which, when combined, cover the entire visible spectrum from infrared to ultraviolet. The various channels can be used alone or in combinations to produce any desired enhancement of the final photograph. Each channel image is formatted as 956 lines of 1050 pixels, and provides an eight bit grey scale resolution for each pixel. Each transmitted character therefore encodes a single pixel. All five channels were to be transmitted through the network, requiring a total image transmission time of approximately 90 minutes.

The satellite image was assembled by the Interdata 7/16 development system at the SDL, from data provided on magnetic tape, and output through a conventional, asynchronous serial communication port at 9600 bits per second. The network converted the asynchronous data stream to the synchronous format required for transmission, then restored it to asynchronous mode prior to delivery at Ice Forecast Central.

The information stream was structured as eight bit characters of binary data, with single start-bit and stop-bit framing. No parity was provided within the character frame for error detection, and no high level protocol was used to manage the flow of information or provide error recovery mechanisms.

3.3 Experimental Results

Several factors combined throughout the trial to prevent this application from fulfilling its objectives. Initial problems centered on the type of equipment used at each end of the circuit to convert the asynchronous transmission format of the terminal equipment to the synchronous format required by the network. Problems with the TDMA stations themselves made it very difficult for the users to initiate any type of testing that could be conducted independently from the activities of the carrier. Finally, the complexity of the data handling software needed at either end of the link, and the level of effort required for its production were under-estimated by the users. This was compounded by the sudden departure of two key members of the project team. Suitable control software could not be designed, written and tested in the remaining time of the trial.

Two alternate tests were conducted during the trial using the configurations shown in Figures II.14 and II.15. One was the transmission of ASCII data from a terminal at the SDL to the HP1000 mini-computer located at Ice Forecast Central in Ottawa and transmission to the SDL from a terminal in Ottawa. The second test was the transmission of ASCII data from a display terminal at the SDL to a display terminal at Ice Forecast Central.

Transmission tests from a terminal to the mini-computer began in July 1982, and continued without success for approximately one month. Unable to resolve the problem, CNCP recommended a terminal to terminal test over the TDMA network. CNCP finally corrected the communication problems, and the terminal to terminal tests continued off and on over the next four months - for about 4 hours per week. Under the terminal to terminal test, all data typed on the terminal was passed through the network without error at the planned data rate of 9600 bits per second.

3.4 Conclusions

Although the link did not provide the level of availability that would be expected in an operational environment, it was recognized that this was related to the largely experimental nature of the network. In general, users at the SDL [1] found

[1] E. G. Morrissey - Memo to H. Kruger January 24, 1983. ARMA file 8790-1

that TDMA satellite communications 'could be very useful for receiving near real-time satellite imagery at Ice Forecast Central'.

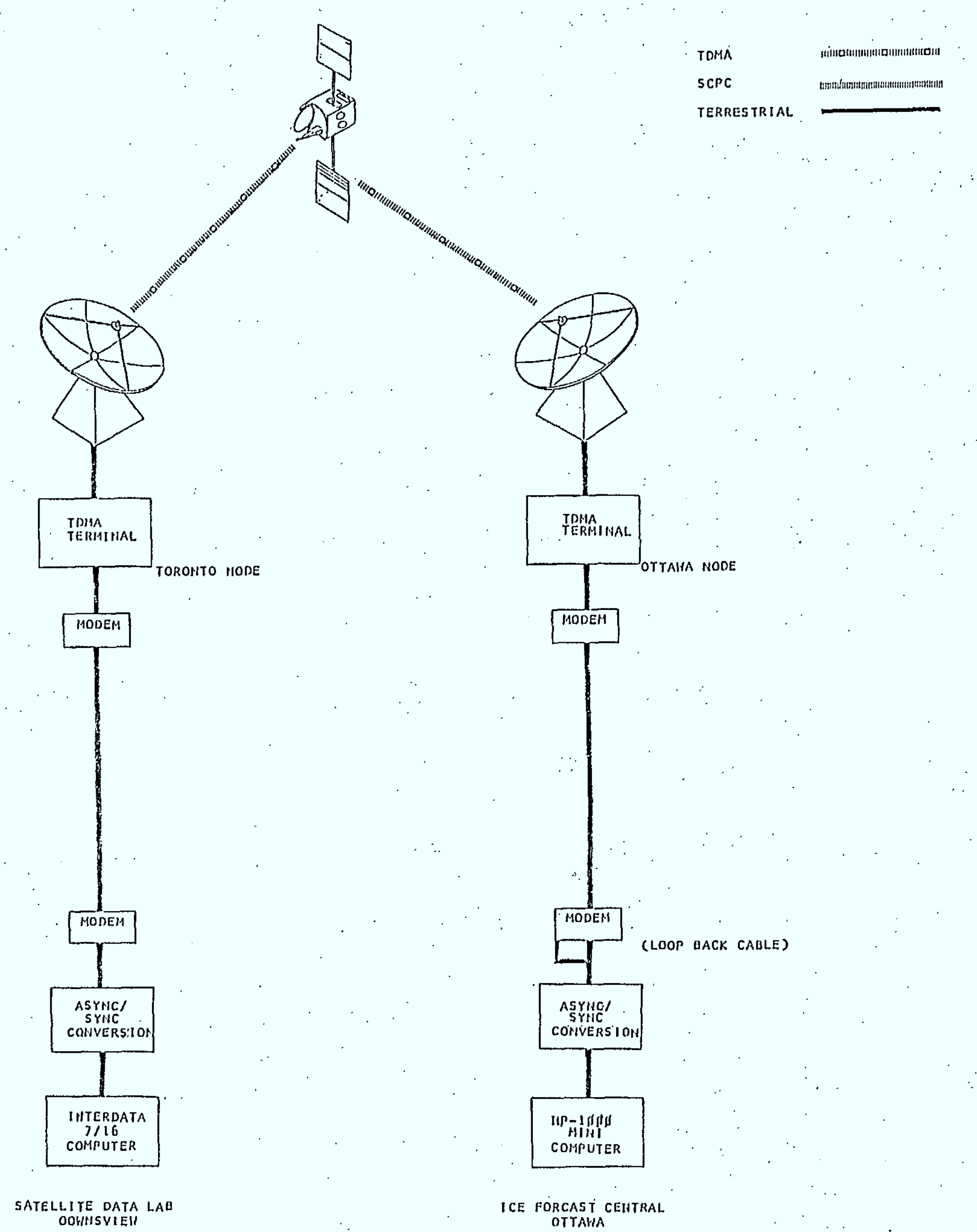

Figure II.13 - Network Configuration for Bulk Data Transfer

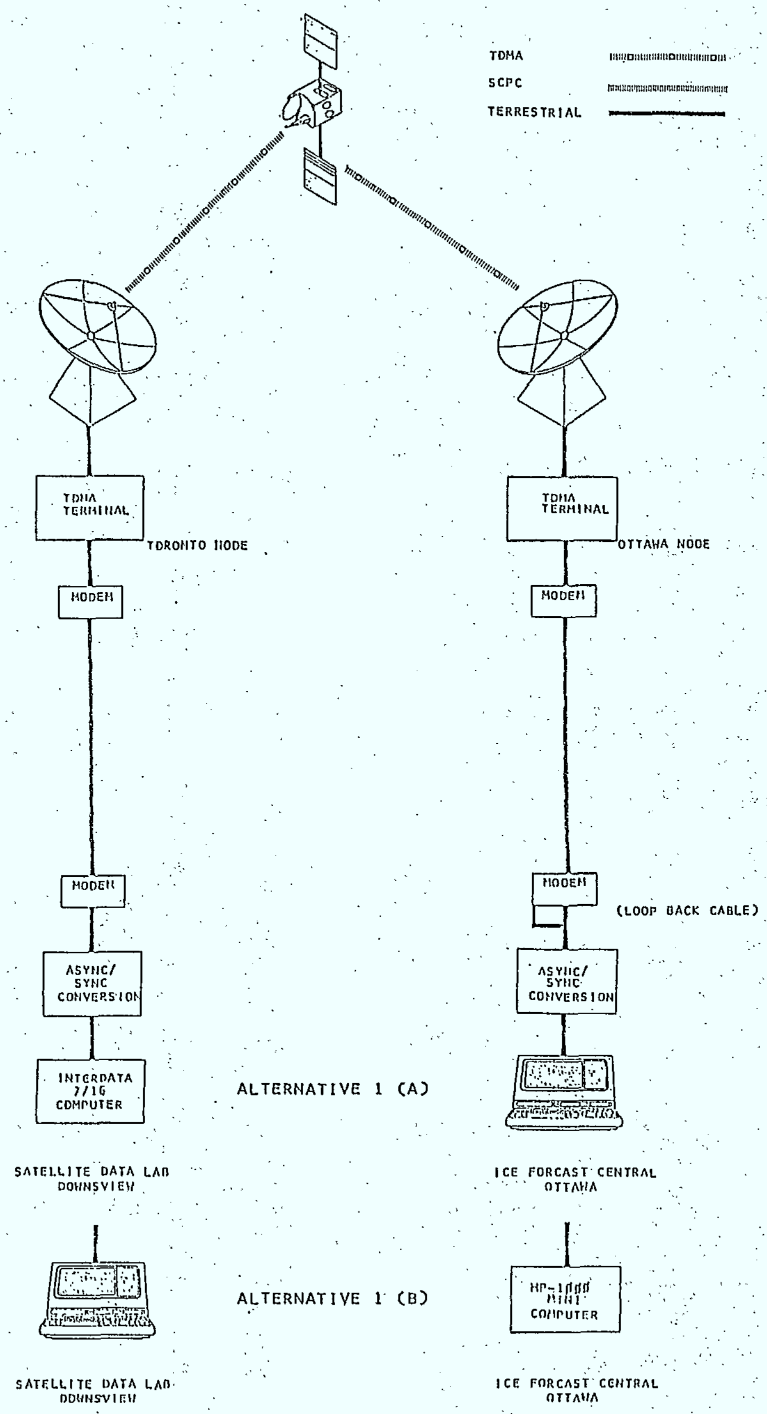

Figure II.14 - 'Bulk Data' Alternate Configuration 1

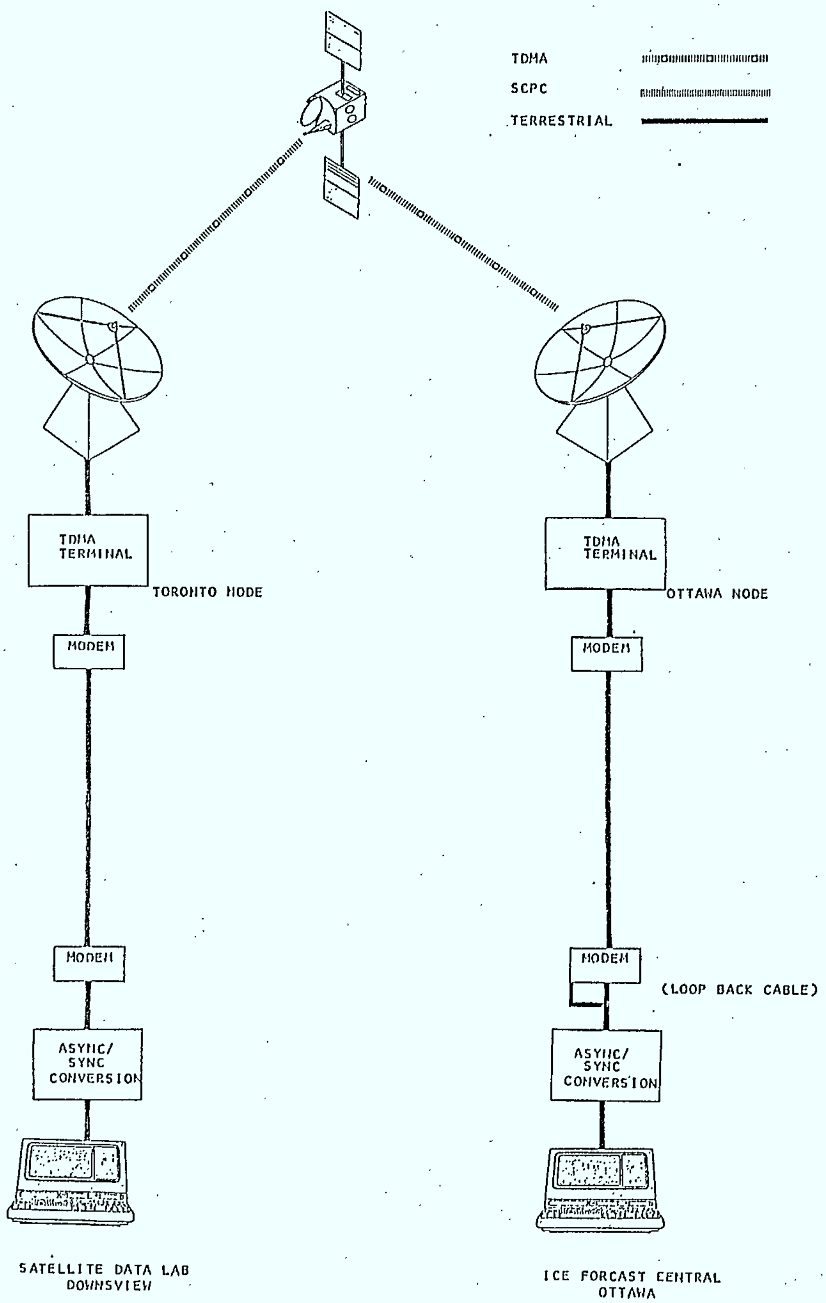

Figure II.15 - 'Bulk Data' Alternate Configuration 2

4 REMOTE BATCH

4.1 Overview

The provision of remote batch processing facilities under the field trial was a new service that was not available to users under the normal operating environment. It was intended to provide meteorologists in Toronto with access to the computer-aided forecasting tools developed by the Quebec Forecast Center, as well as atmospheric source data from the Canadian Meteorological Center. The other objective of this portion of the field trial was to demonstrate the ability of the SLIM-TDMA network to provide the communication required to support a distributed processing environment.

Several side benefits of the field trial were also identified. These included the demonstration of inter-office program debugging and verification; mutual back-up of offices in the event of circuit failure; and, providing the staff at the Ontario Weather Center with an opportunity to gain real-time experience with many of the products of the CMC.

Four distinct prerequisite tasks were identified as essential to the successful undertaking of the remote batch portion of the trial:

{1} Implementation of the TDMA satellite communication facilities;

{2} Implementation of the DS/1000-IV software and HDLC interfaces in the HP1000 computers at the Ontario Weather Center (OWC) and Quebec Forecast Central (CMQ) respectively.

{3} Modification of the NUTRM software at the CMQ to permit terminals at the OWC to access the Cyber computer at the CMC.

{4} Development of suitable application programs in both the Cyber and CMQ computers which would provide outputs that are operationally useful to users at the Ontario Weather Center.

A functional representation of the use of the remote batch facilities is given as Figure II.16. The physical network configuration used for the remote batch satellite communication trial is given in Figure II.17. In practise, the application was an interactive enquiry type that used the distributed processing capabilities implemented as part of the field trial.

Each node of the distributed processing trial comprised an HP1000 minicomputer operating under the real time executive RTE-VI/E and the distributed system management software DS/1000-IV. The communication protocol used by DS/1000-IV was HDLC, with each link in the system managed by a dedicated hardware interface. All data was transmitted synchronously over the SLIM-TDMA network at 2400 bits per second.

4.2 Test Procedure

The original test plan called for a series of controlled command and enquiry entries which accessed the HP1000 computer at the CMQ then the Cyber at the CMC through the HP1000. This test had two primary objectives:

{1} to identify and record the occurrence of errors in transmission, and

{2} to measure the differences in response times between commands that use only the facilities of the HP1000, and those that require additional processing by the Cyber.

A second step in the evaluation was to install those programs used at the CMQ in the HP1000 system at OWC and repeat the tests, observing any difference in response times when commands were processed locally rather than through the satellite network. For the remainder of the field trial the facilities of the CMQ and CMC would be made available for the general use of the staff of the Ontario Weather Center.

Prior to commencement of the trial, AES decided that a systematic evaluation and recording of the link performance would be too great a disruption of the operating environment, and that these tests should therefore be omitted. The primary basis of evaluation would be the users impression of response times which were to be recorded after each session.

The Ontario Weather Center and Quebec Forecast Central each agreed [1] to dedicate one user terminal that would be programmed to access data only in the other office's computer. However, rather that provide real time access to products in the Cyber, the desired product outputs would be identified in advance by the users at the Ontario Weather Center. These were to be

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[1] Field Trial Project Meeting - November 1, 1983 at CPQ. Chaired by H. Kruger.

'retrieved and stored by CPQ, so that the OWC could access them by giving the appropriate name, file, etc.'

4.3 Results

The installation of the DS/1000-IV distributed processing software and supporting interfaces was completed and tested locally prior to the network installation by CNCP. CNCP did not turn over the network facilities as complete until early September, 1983. Preliminary testing was started at that time and continued until the end of the trial in mid-February. The link was never truly turned over for full trial operations.

The subsequent testing and experimentation involved a considerable amount of disagreement between the AES and CNCP as to the source of the transmission problems. The net results of this application are perhaps best summarized in the following excerpt from a departmental progress report [1].

"A simple yet thorough procedure for testing communication integrity was implemented at the CMQ. This test consisted of operating the DS/1000-IV remote access control (REMAT) software in batch mode to dump a file of test data from the CMQ system to the OWC system. The data would then be dumped back to the CMQ and compared to the original data for integrity. At the same time the DS/1000-IV program, DSINF, was used after each pass to display telecommunication error information. This testing was carried mostly during office hours and occasionally overnight.

"Over the duration of the testing period the link failed an average of 4 times per week. Each failure was of 12 hours average duration and occasionally lasted 7 days. Each failure was reported to S. Tsang and most failures were reported to CNCP through regular channels.

"Apart from complete communication failures, data transmission failures plagued the trial continuously. Only for two distinct occasions, for brief periods, were CRC errors kept below a ratio of 1 in 600. Typically, CRC errors for HDLC frames were 1 in 10 or worse. This extremely high and unacceptable error rate slowed communication due to re-try activity of DS/1000-IV to such an extent that the apparent rate of data transfer was reduced to 300 baud.

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[1] J. Sadubin to S. Tsang - Anik-B GTA/CNCP Field Trial, Project 6, February 17, 1983.

"An estimated 3 person-days per month were invested by the CMQ in order to supervise, co-ordinate and trouble shoot the network. We co-operated with S. Tsang and on occasion with OWC to react in real-time to make the best effort possible to advance the trial into an operational mode. If any responsibility for the failure of operational implementation is to be assigned, it must be assumed by CNCP and/or our co-ordination with CNCP to identify the weakness of the communication set-up.

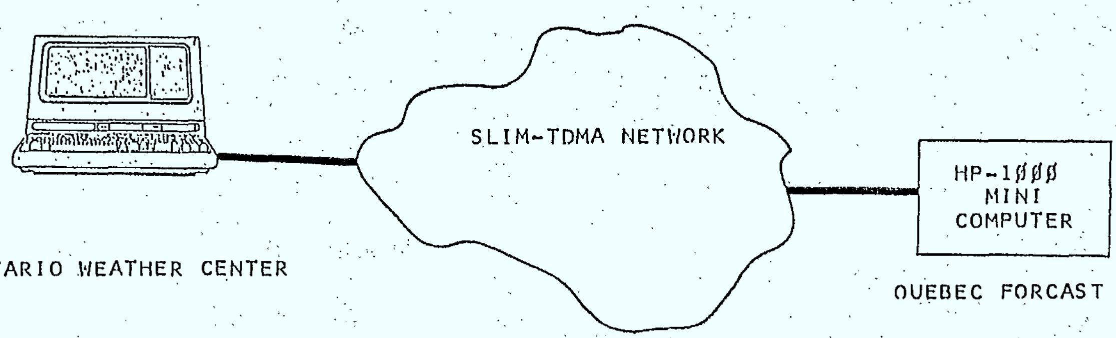
"When the network communication errors were low, the HP1000\DS/1000-IV\HDLC subsystem performed well. Several contacts were made with HP by us and I am satisfied that the HP portion of the trial worked as advertised without any faults. We did request at the November meeting that a parallel terrestrial line be temporarily made available to confirm the HP product, but this facility was never provided.

"Due to the inability to obtain a reliable, error free data link between the two HP machines, the modification of the NUTRM software to provide access to the Cyber, and the design and implementation of user support software in the HP1000 and Cyber computers did not progress beyond the planning stages, and were not implemented by the respective responsible parties in the trial."

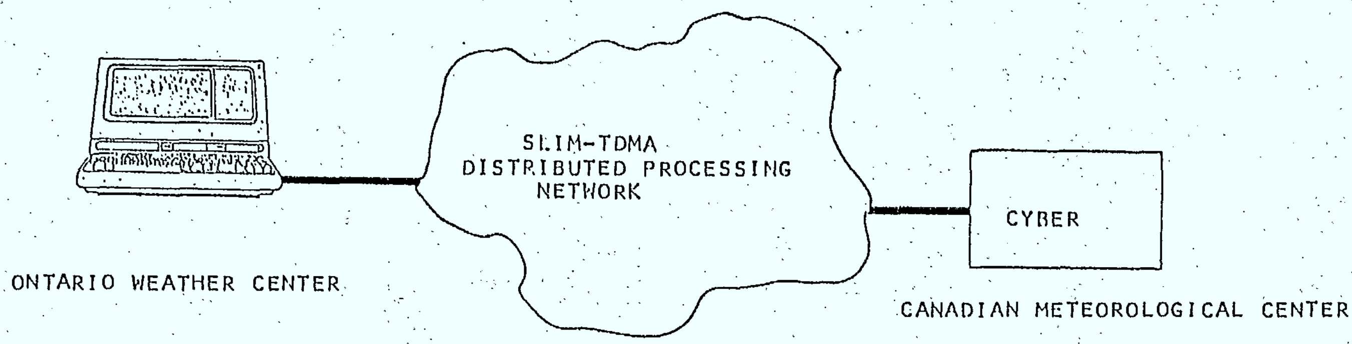
4.4 Conclusions

It is apparent that the major source of problems and frustration with this part of the field trial related directly to the reliability of the satellite facility. When the transmission error rates were low, it was found that the DS/1000-IV subsystem performed well. Therefore the tests cannot be regarded as unsuccessful. Unfortunately the periods of low transmission errors were too infrequent to form the basis of any positive recommendations.

It does appear, however, that the provision of remote access capabilities from one system to another through a satellite network remains a feasible objective. A great deal of further testing will be required however, before this capability could be considered for an operational environment.



ACCESS TO FORCASTING TOOLS AT THE QUEBEC FORCAST CENTER



INDIRECT ACCESS TO FORCASTING TOOLS AT THE CMC

Figure II.16 - Remote Batch Tests - Functional Configuration

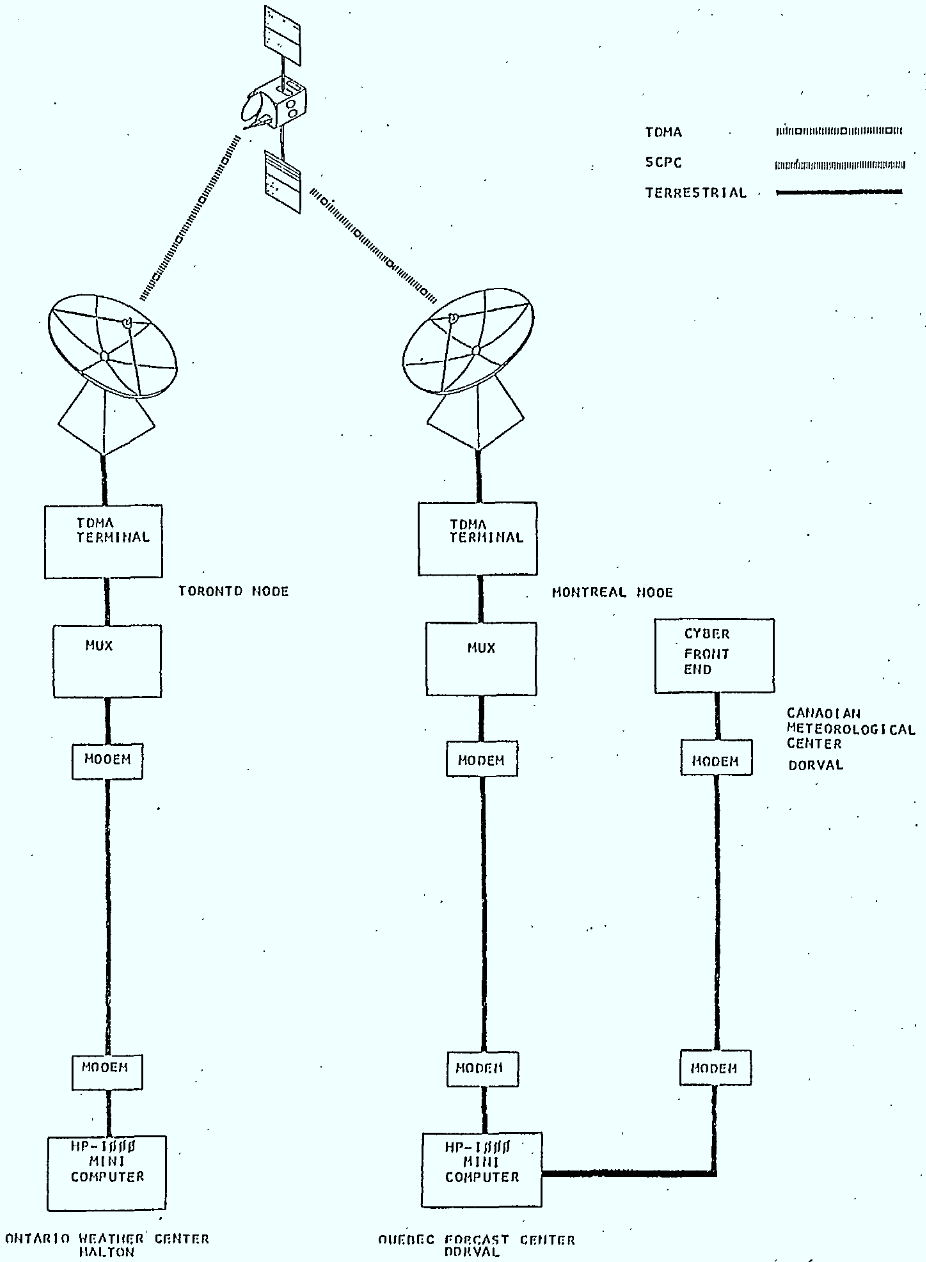


Figure II.17 - Network Configuration for 'Remote Batch'

5 INTERACTIVE ENQUIRY

5.1 Overview

The Downsview Computing Center provides data processing services and support for a wide range of departmental activities and programs. At the present time it supports approximately 150 local and remote users through both dial-up and dedicated private lines. It is believed that this type of online access to a remote computer could be provided cost effectively through the department's New Communication System. The objective of this portion of the trial was to determine the feasibility of supporting a typical, light use, interactive enquiry application through a satellite network.

The Quebec Region Scientific Services Division (SSD) agreed to participate in the field trial as a potential user of such a service. Lawyers and engineers from this division frequently use the programs and data available on the system to determine possible effects or influences of environmental factors on legal cases, planned construction or other activities. Typical enquiries include requests for information about snow loading in specific areas and weather conditions at the time of an accident.

Under the field trial, the link between the user and the computer center was also established on a demand basis using conventional dial access procedures. The user dialed a local telephone number connecting his terminal to the Montreal node of the SLIM-TDMA network. A dedicated virtual circuit through the satellite network then provided access directly to the AS/6 computer in Downsview. In addition to the satellite channel, a dedicated terrestrial link was also implemented for the duration of the field trial using Dataroute. This link was intended to serve as a 'control' channel and to provide a basis against which performance measurements could be compared. The network configuration implemented for the interactive data communications application is illustrated in Figure II.18.

It was expected that large variations in computer response time caused by fluctuating user load would make transmission delay a difficult component to identify within the overall response time. The availability and reliability of the satellite facility, compared to conventional terrestrial service were therefore selected as the primary evaluation criteria.

5.2 Test Procedure

The many variables and informal working environment associated with the interactive enquiry portion of the trial made a formal evaluation and testing unfeasible. The main objective was to use the facility as frequently as possible and to have the various users maintain a log of operating anomalies and any other characteristics that they believed worthy of recording.

It was recommended that identical command sequences be entered simultaneously through both the satellite and terrestrial control circuits to see whether the response time was consistently greater through the satellite facilities. Unfortunately, there is no record of the users attempting any such direct comparison. The primary emphasis of the users was placed on the availability of the service rather than its level of performance when it was operational.

5.3 Results

The Dataroute service was installed at the beginning of September 1982, and remained in service until the end of the trial on February 15, 1983. Throughout this period it functioned normally with no service disruptions reported.

The communication channel through the TDMA network was initially installed in late August, 1982; however, AES experienced recurring communication problems which were not resolved by CNCP until October 12. From mid October until late November a variety of problems plagued the facility including excessive line noise, high error rates, loss of the channel during a session, and an inability to establish a solid connection through the TDMA network. Frequently, the telephone access was found to be busy, although this condition may have been caused by unauthorized users accessing the reserved port, or by trunk busy conditions through the TDMA/DDD interconnections.

Between November 20 and December 13, no serious problems were encountered, and the facility was fully operational. Throughout the remainder of the trial, however, the level of service deteriorated steadily and eventually became so low that the users would attempt its use only if the control circuit was unavailable.

The users' frustration with the network availability was usually foremost in their reaction to the field trial and tended to over-shadow their impressions of the system when it was performing as planned. The following observations were typical of most users:

{1} 'The link was unreliable and a permanent source of frustration'; [1]

{2} CNCP was 'courteous and apparently attentive but was unable to ensure satisfactory service through the link'. [1]

5.4 Conclusions

From the Quebec Region's assessment of the trial, it can be concluded that when the circuit was operational, it performed at least as well as the terrestrial control circuit. The reliability of the service and the length of time required by CNCP to isolate and correct failures detracted significantly from the perceived success of the satellite service.

It can be concluded from the findings of Quebec Region that if circuit reliability, availability and mean time to repair were consistent with the terrestrial circuit, interactive data operation through satellite service could be considered feasible. The delays associated with satellite transmission were not noticed by the users, or at least were not objectionable to them.

In evaluating the overall performance of the interactive application, several factors should be considered which were not apparent to the users in the Quebec Region. The terrestrial 'control' channel was implemented as a digital private line through the Dataroute network. The Trial service on the other hand depended on the DDD network, the TDMA facilities and a final local loop in Toronto. Dataroute, as a digital service, should provide superior performance to the analogue links in key portions of the trial network. Dataroute is also monitored continually by Bell staff. Failures are identified and corrected or bypassed quickly. The trial network, on the other hand, was entirely experimental in nature. It did not receive the full attention of CNCP operational staff and was regarded primarily as an engineering exercise.

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[1] Field Trial Assessment Report, R. Mailhot (QAESS), February 18, 1983.

Anik-B Field Trial Evaluation

A final but important consideration is the makeup of the trial circuit itself. This portion of the network is equivalent to a Foreign Exchange (FX) circuit operated in tandem with DDD connections and private line extensions. It is well known that such 'tandem' circuits are prone to unpredictable end-to-end channel characteristics that make them unsuitable for data applications. Therefore, the trial network suffered from several distinct disadvantages not shared by the terrestrial, digital private line service used as a control.

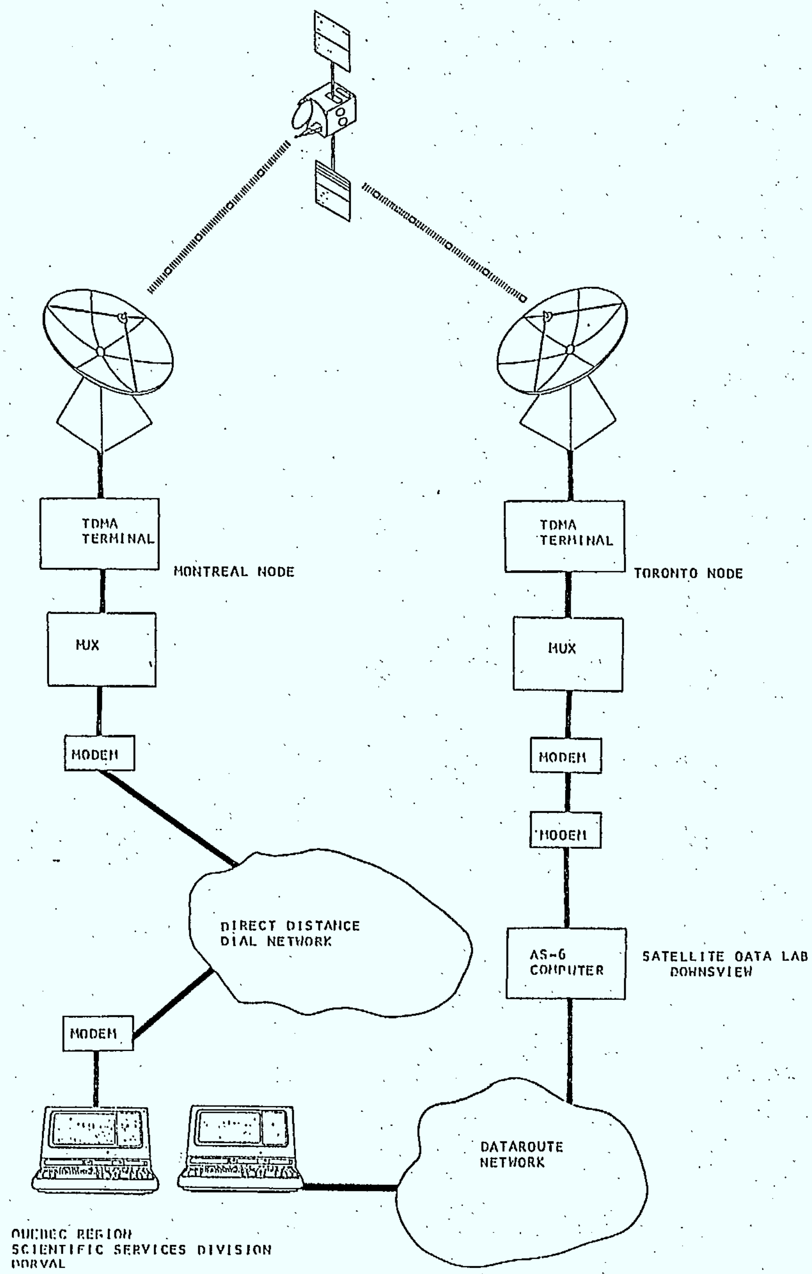

Figure II.18 - Configuration for Interactive Enquiry Trial

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PART III - CEIC APPLICATIONS

1 INTRODUCTION

CEIC operates three information systems which are potential users of satellite communications. Two of these, the Online Insurance System (OIS) and the Metropolitan Order Processing System (MOPS) are regionally managed and controlled from computer centers located in Vancouver, Winnipeg, Belleville, Vanier[1], Moncton and Bathurst. A third application, the Immigration Field Operational Support System (FOSS) operates from the national computer center in Hull, P.Q. In addition to these online applications, satellite communications may offer several benefits for the delivery of administrative communications presently carried by TELEX and the Government Data Network (GDN).

The Online Insurance System must serve both high density urban areas and smaller population centers across Canada. The need for this service in small and remote communities is often greater than in the large cities. Similarly, many small centers could benefit from access to larger markets of employment opportunities made possible through the services of MOPS. FOSS, although centrally controlled, must support almost all ports of entry to Canada, both remote and in large centers.

For each of these applications satellite communications could provide direct access from the various remote locations to the regional computer center. Where information must be passed from these sites to a different region or the national computer center, it could be transferred through a common user backbone network linking regional SCPC facilities. This backbone network would be implemented using either terrestrial or satellite TDMA facilities, whichever is more cost effective.

The cost of conventional terrestrial communication facilities is distance sensitive. This makes communications very expensive for online systems reaching outside of the national population 'core' where digital services and bulk rate tariffs are unavailable. The capital and ongoing costs of TDMA satellite communications would be prohibitive in remote and low traffic locations where the potential benefits are greatest. SCPC

[1] The Vanier center is a temporary installation which will be replaced by a computer system in Montreal during 1984.

satellite communications, based on low cost ground segment equipment and bandwidth sharing under protocol control could, under favourable tariffs, significantly reduce the cost of delivering CEIC's services to the non-urban Canadian public.

CEIC identified four test applications that were of particular interest; interactive online data using both TDMA and SCPC satellite communication technology, remote job entry through TDMA facilities, and the transmission of administrative documents using digital facsimile. Wherever possible, the satellite facilities overlaid portions of existing terrestrial networks so that the network characteristics could be examined in an operational environment. The following experiments were designed to measure the performance of the trial network in each of these applications.

{1} The first experiment used satellite TDMA technology to support the Toronto Metropolitan Order Processing System (MOPS) at the North York Canada Employment Center (CEC). The 22 online terminals at this site were divided into two groups - one group used the Trial network, the other, a control group, used the existing terrestrial facilities.

{2} The second experiment provided online MOPS operation to Newmarket, Ontario, a small community 30 miles north of Toronto. This experiment had two main objectives. First, it demonstrated the feasibility of using on-site satellite terminals. Second, it demonstrated a method of sharing a single satellite channel among several geographically separated points of service.

{3} The third experiment investigated the feasibility of using 'off the shelf' TDMA technology to support remote job entry (RJE) and bulk data transfers. Daily RJE transfers between Bathurst, N.B. and Ottawa were to be carried over the SLIM-TDMA network using an 'on-site' TDMA network node in Bathurst.

{4} The fourth experiment involved testing the feasibility of transmitting documents through the satellite network between Ottawa and Toronto, and Ottawa and Bathurst using digital facsimile. The experiment was designed to demonstrate the ability to re-assign the same satellite channel to fulfill both requirements.

2 INTERACTIVE ONLINE DATA (TDMA)

2.1 Overview

The objective of this portion of the field trial was to demonstrate the ability of satellite TDMA communications to deliver MOPS service to a high density metropolitan area from a computer center located in another city. The trial network was super-imposed over a segment of the Toronto MOPS communication network serving the North York Canada Employment Center at 4900 Yonge St. Toronto. The existing terrestrial service remained in place as a backup for the terminals used in the trial, and to support the control group of terminals to provide a reference for comparing various parameters.

Three different communication control techniques were examined:

{1} Use of a virtual circuit through the TDMA network as a simple private line connection, controlled by the normal Burroughs protocols.

{2} Implementation of a packet switched network in which the computer center and the North York office access the network through interface machines in Ottawa and Toronto respectively. Both the computer and terminals continued to use Burroughs' proprietary protocols. All protocol conversion and traffic routing was carried out by Burroughs CP9500 communications computers.

{3} The use of a dedicated virtual circuit and optimal protocols within the network, while providing all conversions as an internal network service. Operational details of the end to end connection were transparent to both the users and the computer center.

The existing terrestrial network serves twenty-two terminals at the North York Employment Center with two, synchronous analogue private lines, operating at 4800 bits per second. Terminals at various locations throughout the complex are supported by intra-building circuits linked to the inter-city facilities through digital splitters. Each inter-city circuit carries approximately half of the total traffic and has a similar mix of message types. As a result, either could be used as a control against which the satellite network could be compared. Because MOPS is a live application providing service directly to the public, its availability is paramount. All terrestrial facilities remained fully operational throughout the trial. Transfer from the satellite to terrestrial network was accomplished, when required, by EIA transfer switches co-located with the modems in Vanier and the 4900 Yonge St. office.

The first experiment was a direct replacement of the existing terrestrial facilities with a dedicated virtual circuit through the SLIM-TDMA network. The communications protocols presently used in all of CEIC's online systems ('Burroughs Contention' 'Burroughs Poll/Select') were retained. These enquiry/response protocols are designed for relatively local (intra-city), high speed, multi-point communication facilities. The addition of propagation delays by the satellite network was expected to degrade the system's performance significantly, especially under heavy line loading conditions. The portion of the terrestrial network serving the North York CEC is shown along with the satellite equivalent as Figures III.1 and III.2 respectively.

For the second experiment, the Commission developed a multi-level packet switched communication 'network' based on the Burroughs CP9500 communication computer. This network consisted of communication nodes in Hull and Toronto, joined by a backbone trunk through the SLIM/TDMA network. The MOPS computer center in Vanier accessed the network through the Hull node, and the MOPS terminals at the North York office through the Toronto node. All communications between the network nodes used Burroughs' BDLC protocol [1]. A variation of Burroughs' RJE protocol was used for communications between the Vanier Data Center and the Hull node. In Toronto, the user terminals continued to use Burroughs' Contention protocol for all communications. The performance of this system was to have been measured against that of the existing terrestrial facilities.

The final test configuration replaced the Burroughs' CP9500 communications processors with stand-alone protocol conversion units supplied by Christian-Rovsing, and installed and maintained by CNCP. One protocol converter was installed at the CEIC test facility in Hull, the other, at the CNCP Switching Center on Front St. in Toronto. This experiment was intended to demonstrate the provision of end to end user transparency through the network while using a bit oriented protocol (X.75) over the satellite link.

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[1] BDLC is Burroughs' adaptation of HDLC.

For each experiment, the network was to be evaluated in terms of availability, reliability, propagation time and error rate. The test procedure called for continual monitoring by CEIC's network control to determine whether performance differed significantly from terrestrial facilities, or was significantly altered by the use of the forward error correction capabilities of the TDMA network.

The SLIM-TDMA network configuration used for testing with the Burroughs equipment is shown in functional form as Figure III.3. The implementation details are shown in Figure III.4. The B6700 computer was connected through a full-duplex local loop to a Burroughs CP9500 mini-computer located in the Hull computer center. The CP9500 in turn, was connected to the satellite TDMA terminal through a full duplex local loop. The CP9500 was used as a network interface machine (NIM), providing a gateway to the satellite network, performing both data concentration and protocol conversion.

The Toronto node of the TDMA network was located at the CNCP operations center on Front St. From there, the data passed over a local loop to a CP9500 NIM installed in the Burroughs office at 2191 Yonge St. This NIM provided services similar to that in Hull, buffering the data in both directions as required, and converting the protocol between Contention/Specific Select required by the user terminals, and BDLC used through the SLIM-TDMA network. A full duplex local loop provided the final link between the NIM and the North York Employment Center.

The network configuration used for the Christian-Rovsing protocol converter is shown in functional form in Figure III.5, and as it was implemented in Figure III.6. The operation with the Christian-Rovsing equipment was similar to that with the Burroughs CP9500. The intent of this portion of the trial was to test a complete 'carrier provided' service that is functionally transparent to the user protocol. All equipment would be installed and operated by the carrier as an integral part of the network.

2.2 Results

The original schedule called for installation of equipment in early 1982, with operational tests beginning about April 1, 1982. A progression of technical problems delayed the actual testing over the TDMA facilities until the end of January, 1983. Experimentation continued until the satellite lease expired on

February 14. Even during this short period innumerable service failures occurred. Although several were attributed to equipment failure, most were traced to finger problems or unauthorized 'tinkering' with the facilities by CNCP Telecommunications. As a result, the productive test time was severely limited.

Part of the planned trial was a behavioural evaluation of the network performance. This evaluation would have required the distribution of a performance questionnaire to users of the satellite network and to the control group at 4900 Yonge St. Shortly before this test was to begin, the Advanced Systems Division of National Systems and Services objected strongly to any form of performance evaluation by the user. This part of the evaluation was therefore abandoned.

2.2.1 Evaluation Results (Direct Terrestrial Replacement)

Initial testing used a virtual channel through the TDMA network with no protocol conversion. It was found that transmission delays using the Burroughs' contention protocol were not noticeable when a single test terminal was used on the circuit. However, when ten operational terminals and a printer were switched to the satellite circuit, the response time increased to the point where it rendered the system unusable. As a result, no performance measurement experiments were carried out using this configuration.

2.2.2 Evaluation Results (Burroughs Equipment)

Two different sets of experiments were conducted under this portion of the trial. Response time and block error measurements were conducted by CEIC personnel. Burroughs carried out performance and network management tests to evaluate the network performance, and to develop communication control procedures required in the CP9500. The findings of the latter tests are still being evaluated by Burroughs.

The response time test for the TDMA network was similar to that used for the SCPC facilities. The 'Who Are You' (WRU) command requesting the system to return the terminal identity was entered approximately 150 times on a terminal using the TDMA network, and a similar number of times for a similar terminal attached to the terrestrial network. The time from depression of the 'XMIT' key to the appearance of the response was measured with a stopwatch and recorded.

The WRU command is processed by the B6700 computer in Vanier the same as any other command entered on a MOPS terminal. Therefore, the response times measured reflect the response of the entire system; including, the mainframe, CP9500 nodes and delay through the TDMA network itself. The method of testing makes it impossible to quantize the portion of the delay caused by the network. In addition to the difficulty of resolving the components of the delay, all testing was performed during normal working hours, with many other users active on the same circuit. No information is available to enable the identification of loading effects or increased delay caused by this traffic.

The response time tests could not be carried out for both terrestrial and satellite facilities on the same day. Since both weekly and monthly traffic cycles are known to exist, two test days were selected approximately one month apart. To minimize the impact of other users traffic on the measurements, all tests were carried out at the end of the week when normal traffic is low.

The results of the response time tests are shown in the form of a histogram as Figure III.7. Figure III.8 shows the best fit curve for the same experimental results. Despite the shortcomings of the test itself, the response time measurements are very interesting. The response time distribution for both the terrestrial and satellite resembles the expected Poisson distribution[1]. The average response delay over the terrestrial network was 3.18 seconds, with a 90% confidence level of 7.32 seconds. The average response through the satellite TDMA network was found to be 6.83 seconds with a 90% confidence level of 15.7 seconds.

From the overall shape of the distributions the variation in delay through the satellite is much greater than through the terrestrial network. This was probably caused by one or more of the following factors:

{1} The delay through the satellite increases the response time for each message. The impact of this would be smaller for BDLC than for Group Poll/Specific Select, but present nevertheless. This effect on the elemental message delay would have been compounded by the presence

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[1] The large number of independent parameters affecting the response time for both the TDMA and SCPC tests makes it unrealistic to compare the measured results to a specific theoretical distribution.

of other traffic on the line and the processing time required for each of these other messages.

{2} Delays caused by the retransmission of messages found to contain errors would also be exaggerated by the effects of satellite delay.

{3} Depending on the traffic volume and the error rate over the satellite channel, message queues may build up in both of the CP9500's. Any such queuing would tend to spread the response time distribution.

The second test conducted by CEIC measured the error performance of the TDMA network in a loopback mode. Using a dataline monitor, a test message was sent repeatedly, looped through the TDMA network and then checked for errors. The test message used comprised alternating strings containing the complete upper and lower case alphabets. Each string was 32 characters long and consisted of the complete alphabet followed by a '*U*U*U' sequence. The message began with four 'SYN' characters followed by 'STX'. Ten strings were then transmitted, alternating upper and lower case letters. Next a series of 22 periods (.) was transmitted. The message was terminated by a block check sequence followed by four trailing 'SYN' characters. In all, each message was approximately 350 characters long.

Over a period of several days approximately 130,000 blocks (45 million characters) were transmitted. Of these, a total of 482 block errors were detected, giving a measured block error rate of approximately 3.7/1000 blocks.

If it can be assumed that the error performance is limited by the local loop through which the TDMA network is accessed, a bit error rate in the order of 1/100,000 should be expected. Based on a test block of 350 characters, this translates to a block error rate of approximately 3.53/1000 blocks. Within reasonable limits therefore, it can be said that the overall error performance was similar to the predicted values.

On detailed examination of the test log sheets, it was noted that the test runs could be divided into two groups, one with very few errors - the other with a considerable number. In fact, the high group had about 2.5 times as many errors as the low error rate group. It is possible that the high error rate group resulted from some undetected operational problem associated with the experimental nature of the TDMA network. When the block error rate is calculated using the low error group alone, it drops to 1.99/1000 blocks.

Based only on the overall error performance measurements it could be concluded that the limiting element of the network might have been the quality of the local loop through which the TDMA was accessed. However, in view of the fact that two distinct error rate groups were encountered, and that the performance of the low error group was significantly better than the estimated local loop performance, it can be deduced (with reservations) that the TDMA facility and not the local loop was the dominant influence in error performance.

2.2.3 Evaluation Results (Christian-Rovsing Equipment)

Engineers from Christian-Rovsing delivered and installed the protocol converters at both the Ottawa and Toronto access points to the SLIM-TDMA network. Within hours of the scheduled testing they were notified by their office in Denmark that firmware errors had been discovered in the implementation of the X.75 protocol. The planned tests were cancelled pending resolution of the problem and local bench testing at Christian-Rovsing.

The problems could not be resolved prior to the end of the allocated satellite time.

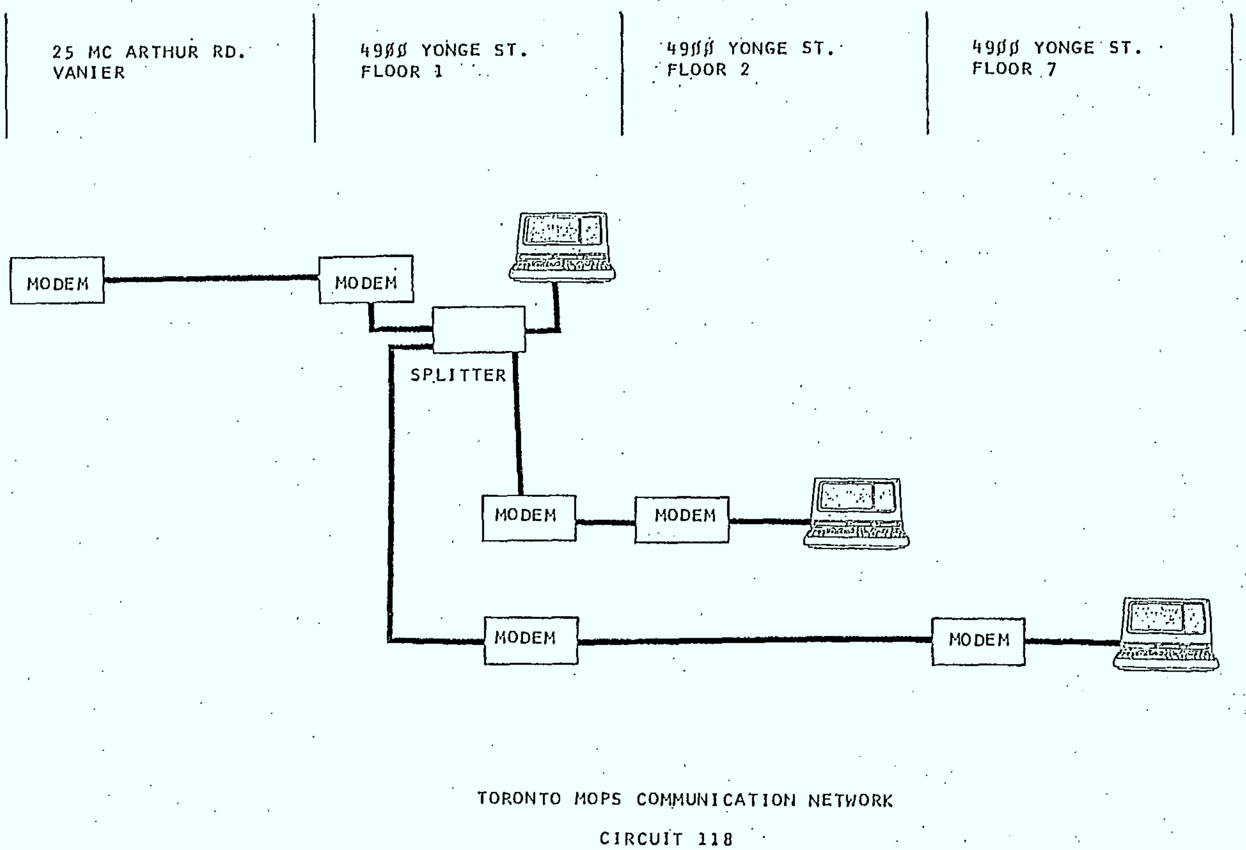

Figure III.1 - Existing Terrestrial Network

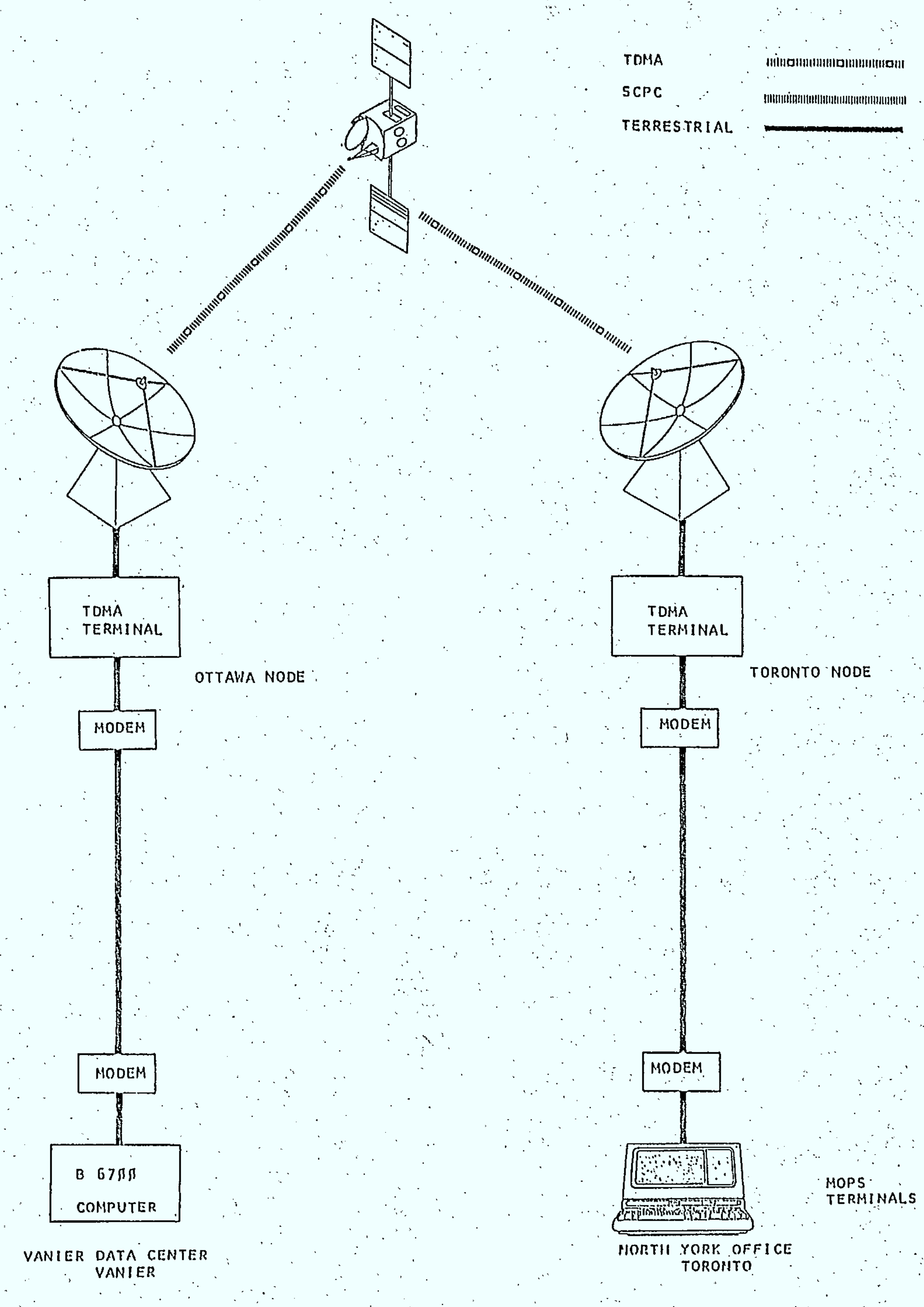

Figure III.2 - TDMA Replacement of Terrestrial Network

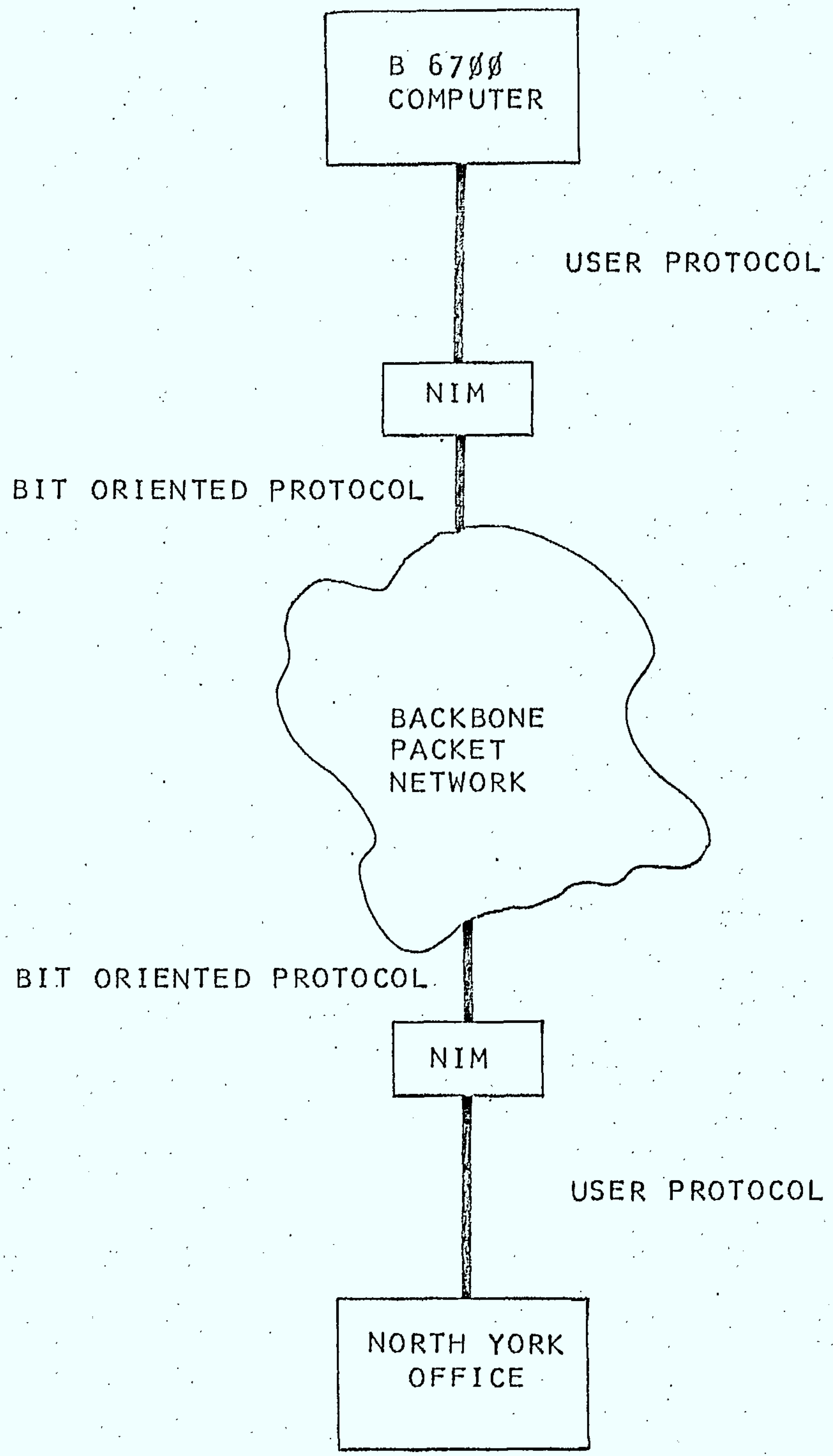

Figure III.3 - TDMA Functional Configuration (Burroughs)

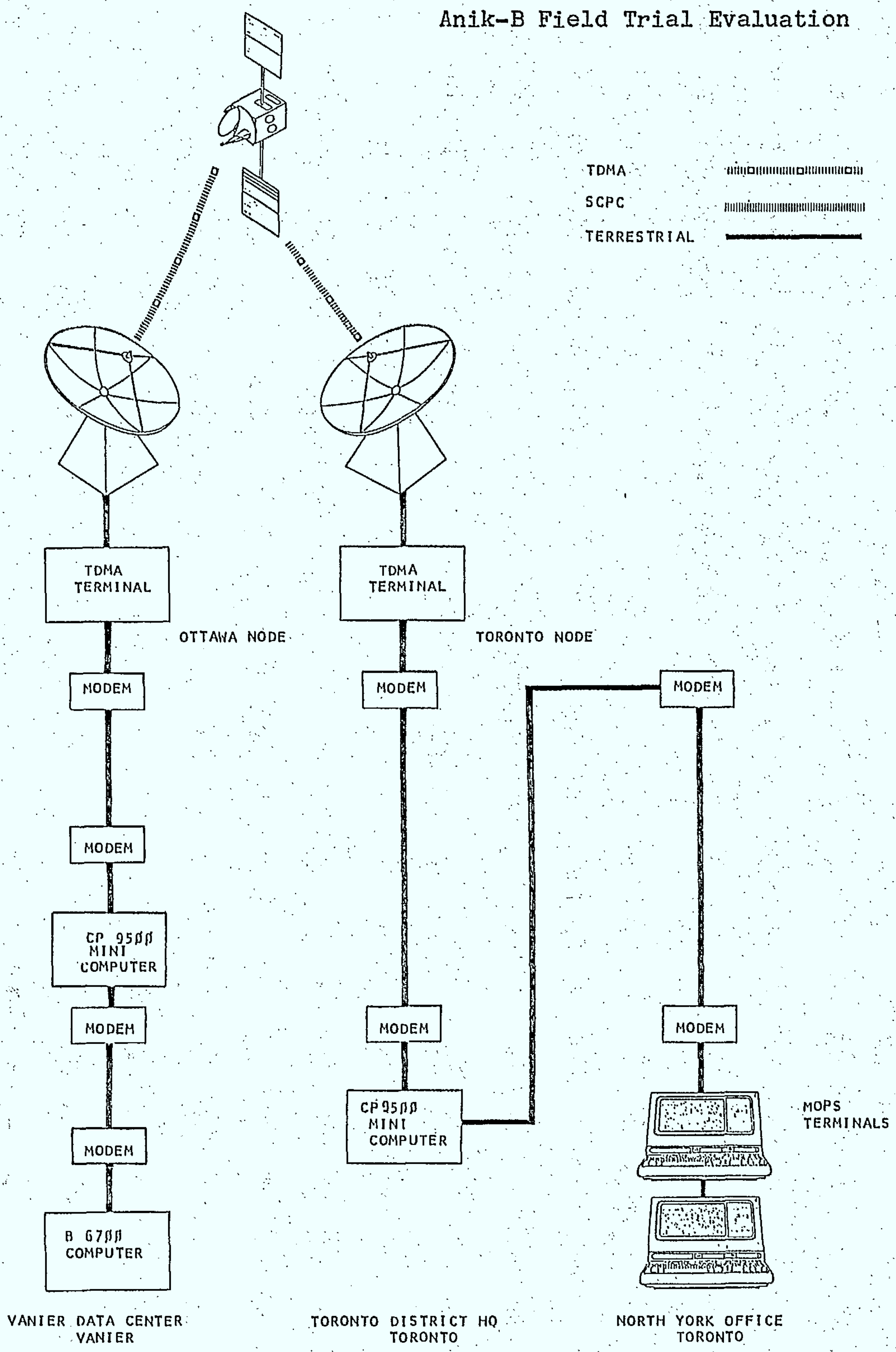

Figure III.4 - TDMA Configuration (Burroughs)

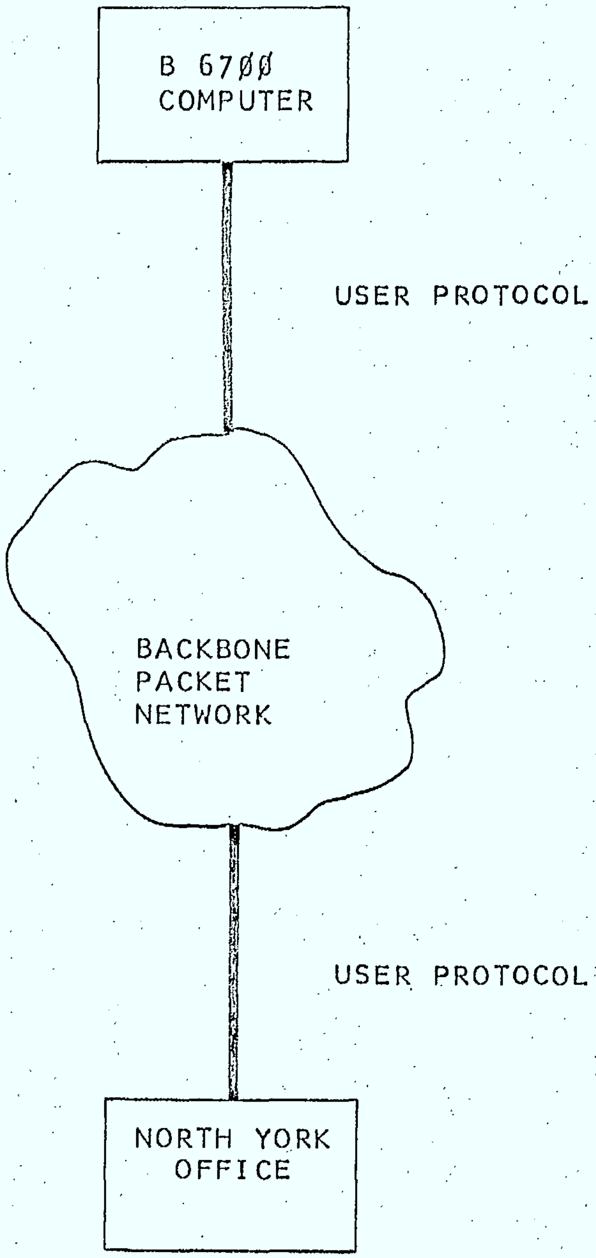

Figure III.5 - TDMA Functional Configuration (Christian-Rovsing)

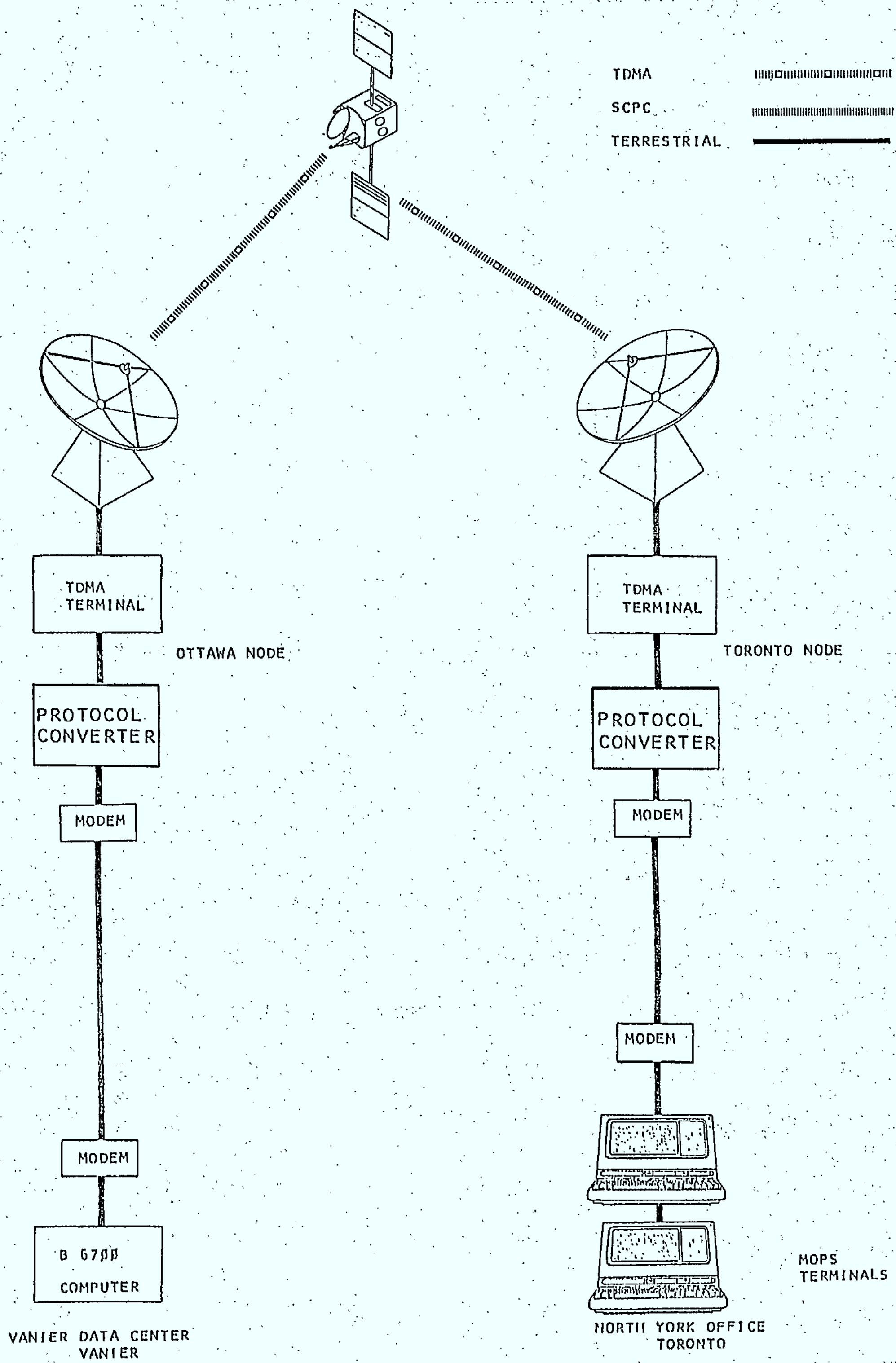

Figure III.6 - TDMA Configuration (Christian-Rovsing)

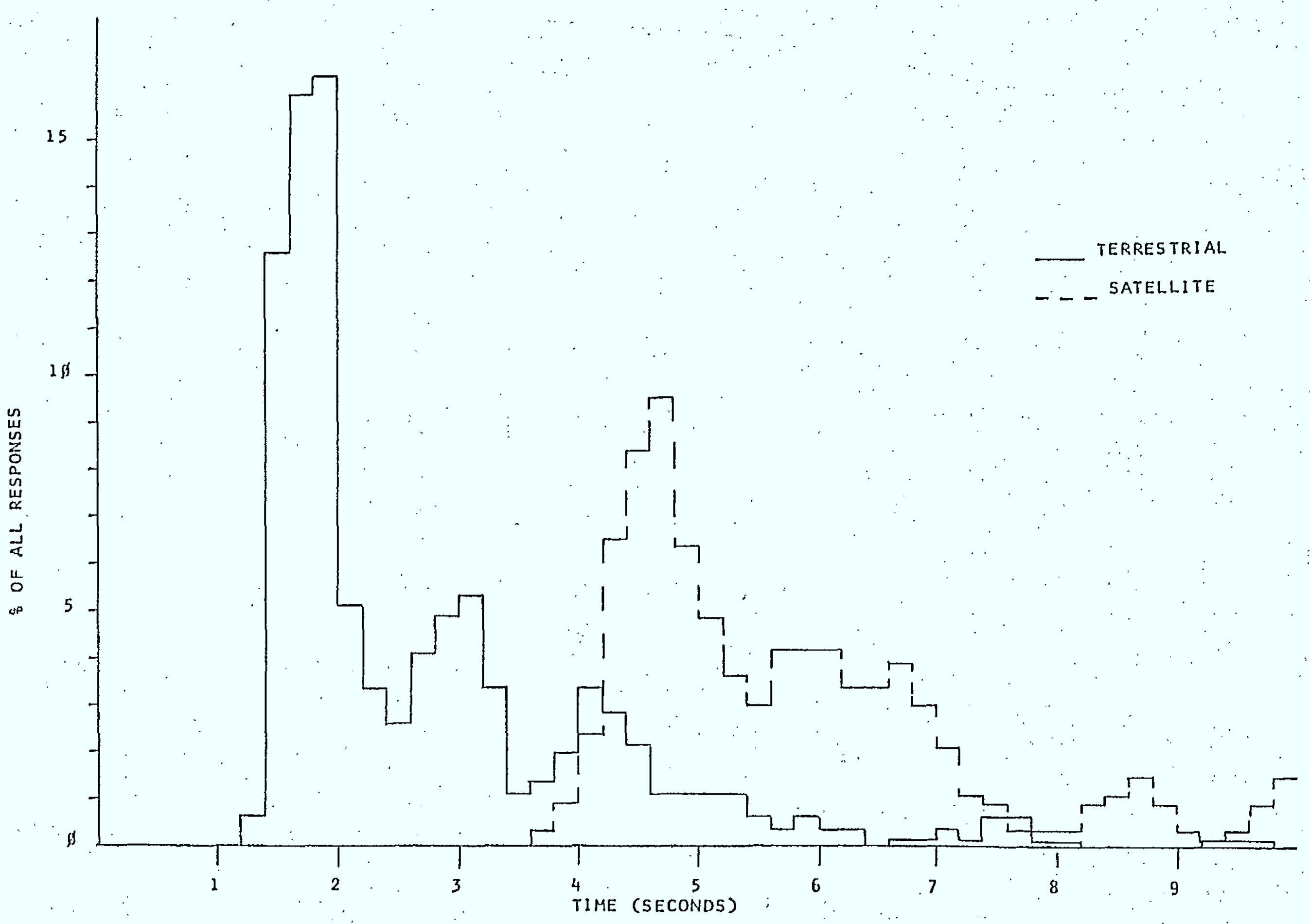

Figure III.7 - Satellite/Terrestrial Response Time

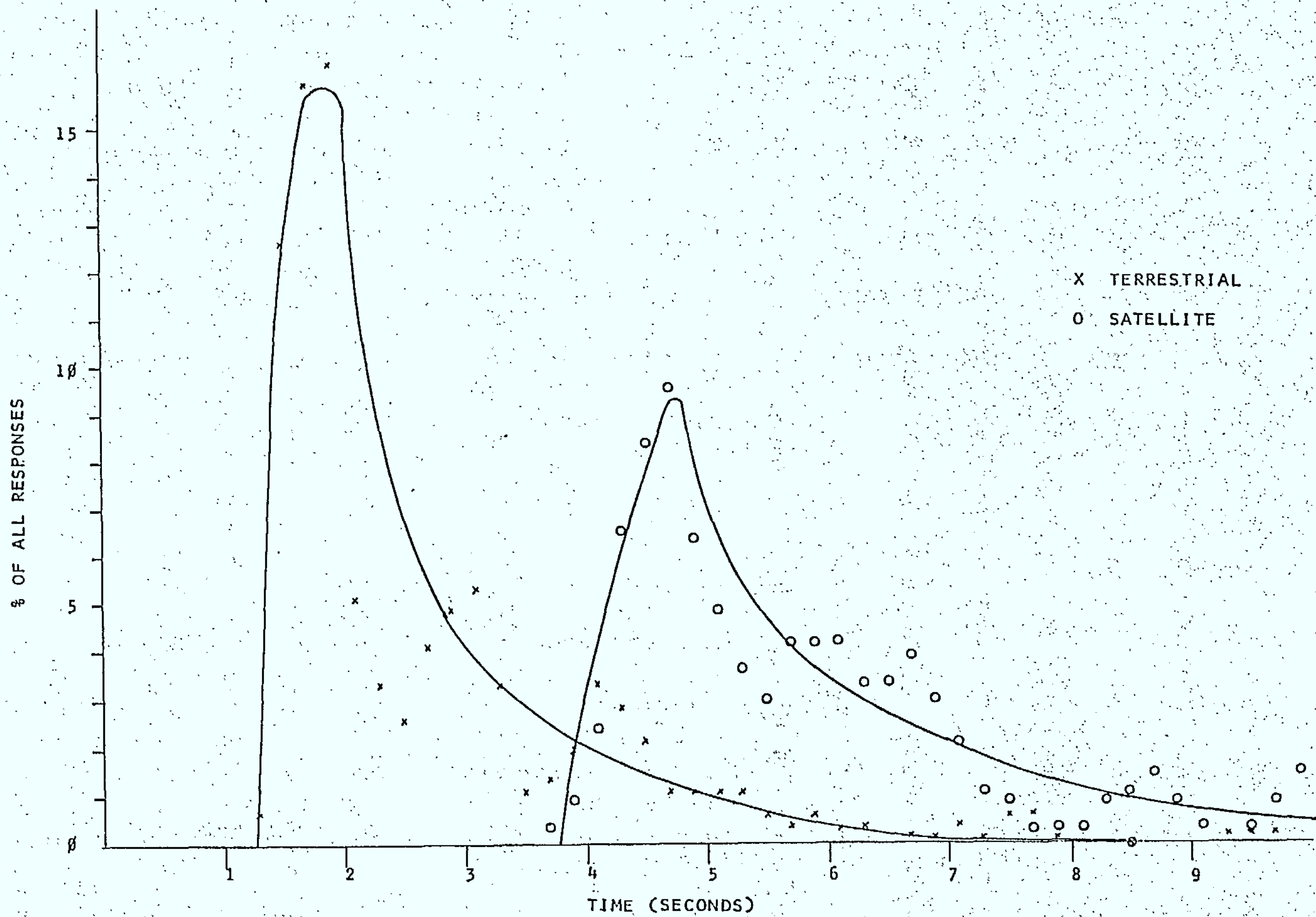

Figure III.8 - Satellite/Terrestrial Response Time

3 INTERACTIVE ONLINE DATA (SCPC/TDMA)

3.1 Overview

Two principal objectives were addressed in this segment of the field trial. The first was to demonstrate the provision of MOPS service to a typical 'rural' Canada Employment Center, using SCPC satellite communications through an on-site earth station. This application demonstrated a technique whereby a single SCPC channel could be used in a multi-point configuration to support several online users simultaneously in different geographic locations. The second, was to measure the performance of SCPC communications used in tandem with the TDMA network. This would simulate a configuration in which a user accesses a remote application through an interconnecting backbone network.

The office participating in the trial was the Canada Employment Center in Newmarket, Ontario. It is a full service office, typical of a small community, but one that also offers clients access to the job market of a large metropolitan center.

3.2 Test Procedure

The single hop SCPC circuit was evaluated in terms of network delay, transmission error rate, and overall reliability as determined when operating under the Burroughs' Group Poll/Select protocol. Planned tests included examination of transmission characteristics using the facilities of the network control center in Vanier, and a survey of the users, designed to determine whether any improvement or degradation in operation was perceived. Similar evaluation criteria and tests were identified for the SCPC/TDMA double hop communications.

MOPS service to Newmarket is currently supported by a single, multi-drop, synchronous data circuit, operating at 4800 bits per second. The normal communication protocols are Burroughs Group Poll and Specific Select. The office operation is spread over two floors, each of which is supported by one leg of the communication circuit. A terminating modem on each floor feeds four video terminals and a single printer, all interconnected by an EIA concatenation arrangement. Response time was reduced by using continuous carrier outbound from the computer center and controlled carrier inbound from each leg. The design of the existing terrestrial circuit is shown as Figure III.9.

The SCPC portion of the trial network duplicated the existing terrestrial service, replacing the inter-city leg with a satellite channel. EIA transfer switches installed at each modem location enabled the office to switch from the satellite to terrestrial circuit in the event of a network failure. By using the local modems' carrier to control the voice activation circuitry of the SCPC terminal, the rf carrier was switched on and off under protocol control to simulate the operation of the terrestrial circuit. Figure III.10 shows the satellite SCPC configuration used for the single hop tests.

3.3 Results

3.3.1 SCPC Single Hop Results

The SCPC single hop experiments were one of the most successful parts of the Anik-B field trial and successfully demonstrated the feasibility of satellite channel sharing. The users reported no noticeable difference in response time between the existing terrestrial circuit and the satellite facilities.

As with the other parts of the satellite network, the SCPC circuit was difficult to debug. In all, less than three weeks of operational test time was achieved. Nevertheless, it is believed that the results found are typical of those that would be encountered in a fully operational environment. The most serious and persistent problem related to the reliability of the RCA/SPAR earth station. At least three units failed immediately after installation, with much time lost in the repair-replacement cycle. Finally, a complete set of spares was stored at the Newmarket office, and CNCP's technicians trained to install and test them.

Distortion of the modem waveform for several milliseconds following turn-on, caused excessive numbers of transmission errors over the link. After several weeks of investigation at the Communications Research Center, it was concluded that this problem resulted from a basic deficiency of the voice channel unit (VCU). [1]

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[1] This conclusion was re-enforced by the recollection of a former RCA technician involved in the original design that 'the voice activation never had worked reliably'.

Anik-B Field Trial Evaluation

A new, CRC developed, voice channel unit incorporating an analogue delay line at its baseband input was tested. This feature allowed the rf carrier to turn on and stabilize for a few milliseconds before being modulated by the information signal. After another considerable period of testing, the CRC unit was able to fulfill all of the control requirements and still provide an acceptable error rate.

The initial tests centered on loopback testing using both 511 bit and 2047 bit pseudorandom patterns. Using the SPAR/RCA VCU, daily tests averaged between 35 and 150 block errors per 1000 blocks - an unacceptably high error rate. The maximum permissible average error rate for a 2047 bit pattern is 21 blocks per thousand in error. This is a typical value that could be expected using a terrestrial circuit operating at a bit error rate of 1/100,000. In addition to bit errors, the modems frequently lost carrier synchronization, causing the tests to abort. In fact, most tests were terminated prematurely by a loss of modem synchronization.

Replacement of the VCU with the CRC model resulted in dramatic improvements. Several tests were run in which 2047 bit patterns were looped through the satellite facilities and back again with no transmission errors. The longest test consisted of 7.5 hours of error free continuous loopback transmission.

The response time measured through the satellite facilities was expected to be slightly longer than that through the terrestrial equivalent. The method used to measure the response time was to enter a WRU command on a selected terminal at regular intervals throughout the day. The time elapsed between the depression of the 'XMIT' key and the display of the response was measured with a stopwatch and recorded.

Approximately 250 measurements were taken on the satellite circuit, and a similar number on the terrestrial circuit. Since the two could not be done at on the same day, two Fridays, approximately one month apart were selected. It was hoped that this selection of days would minimize the effects of system loading that is known to vary in both weekly and monthly cycles. The mean response time over the terrestrial circuit was found to be 2.91 seconds, while the mean response time through the satellite was 5.28 seconds. The results of these response time tests are summarized in Figures III.12 and III.13.

The response time tests are subject to two limitations.

{1} They were carried out while the office was 'live'. That is, nine other terminals and two printers were also using the circuit during the response time tests. The effect of other users can be seen by comparing the shape of the response time distribution curves given in Figure III.13. During the satellite testing, the office was in normal operation. During the terrestrial tests however, a staff meeting had been called that significantly reduced the local traffic generation. From the graph it can be seen that the range of response times is much greater with more users present.

{2} The WRU command is processed as any other command by the system. It is not handled by the system front end. This means that the measured times also include the system transaction processing time and depend on the overall system load. Therefore, the measured values represent comparative views of the system performance as seen by the user - not the performance of the network itself.

A formal subjective evaluation by the users was omitted at the request of Toronto District. Informal discussions with the office staff, however, indicated that no difference in performance was observed between the terrestrial and satellite circuits.

3.3.2 Double Hop Evaluation Results

The planned SCPC/TDMA double hop configuration is shown in Figure III.11. For this series of experiments the SCPC facility was to be configured as a tail circuit extending from a TDMA backbone network.

Data from the B6700 computer would be passed to a CP9500 mini-computer which operated as a switching node in a 'backbone' TDMA network. The CP9500 would determine the destination of the message, translate the protocol to to BDLC protocol, then send it to the Ottawa node of the TDMA network. The message would pass through the satellite to a second data module at the Ottawa node. It would then return over a local loop to the CP9500 computer where it would appear as a message in transit on the 'backbone' network.

The CP9500 would identify the message as one destined for the Newmarket office, a point of service it controls. Accordingly, it would acknowledge receipt of the message, convert the protocol to Burroughs Specific Select, then forward it to Newmarket using the SCPC facility.

Messages bound from Newmarket to Vanier would follow similar procedures and transformations. They would first be received through the SCPC facilities using Burroughs Group Poll protocol, then forwarded from one 'backbone' network node to the other using BDLC. From there, the message would be passed to the destination system in Vanier.

Difficulties encountered with the SLIM-TDMA equipment were not resolved in time to undertake the double hop experiments between Vanier and the Canada Employment Center in Newmarket. No test results are available for this part of the field trial.

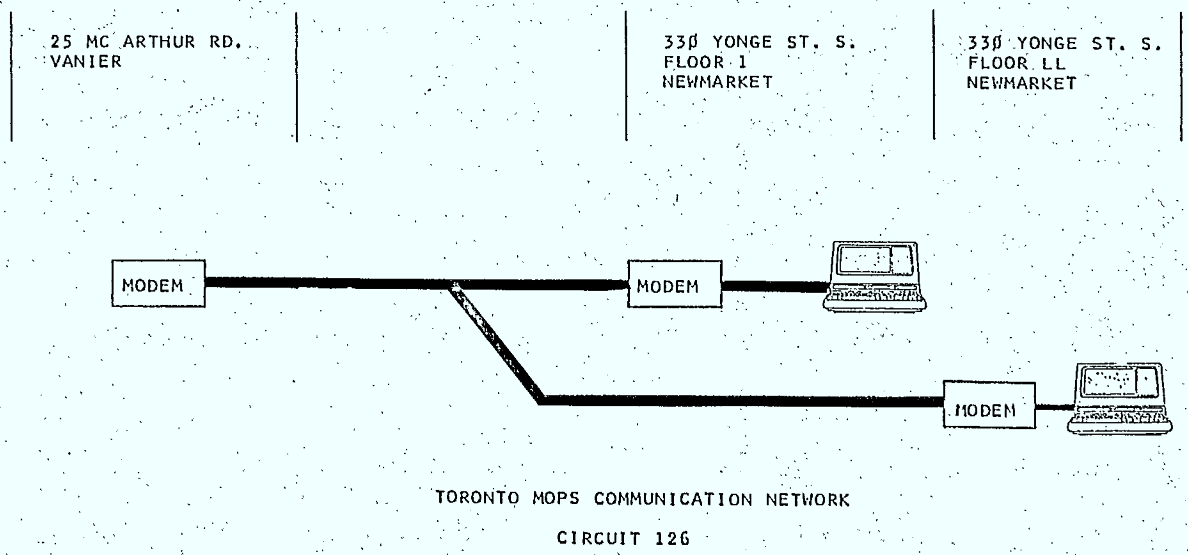

Figure III.9 - Existing Terrestrial Network Configuration

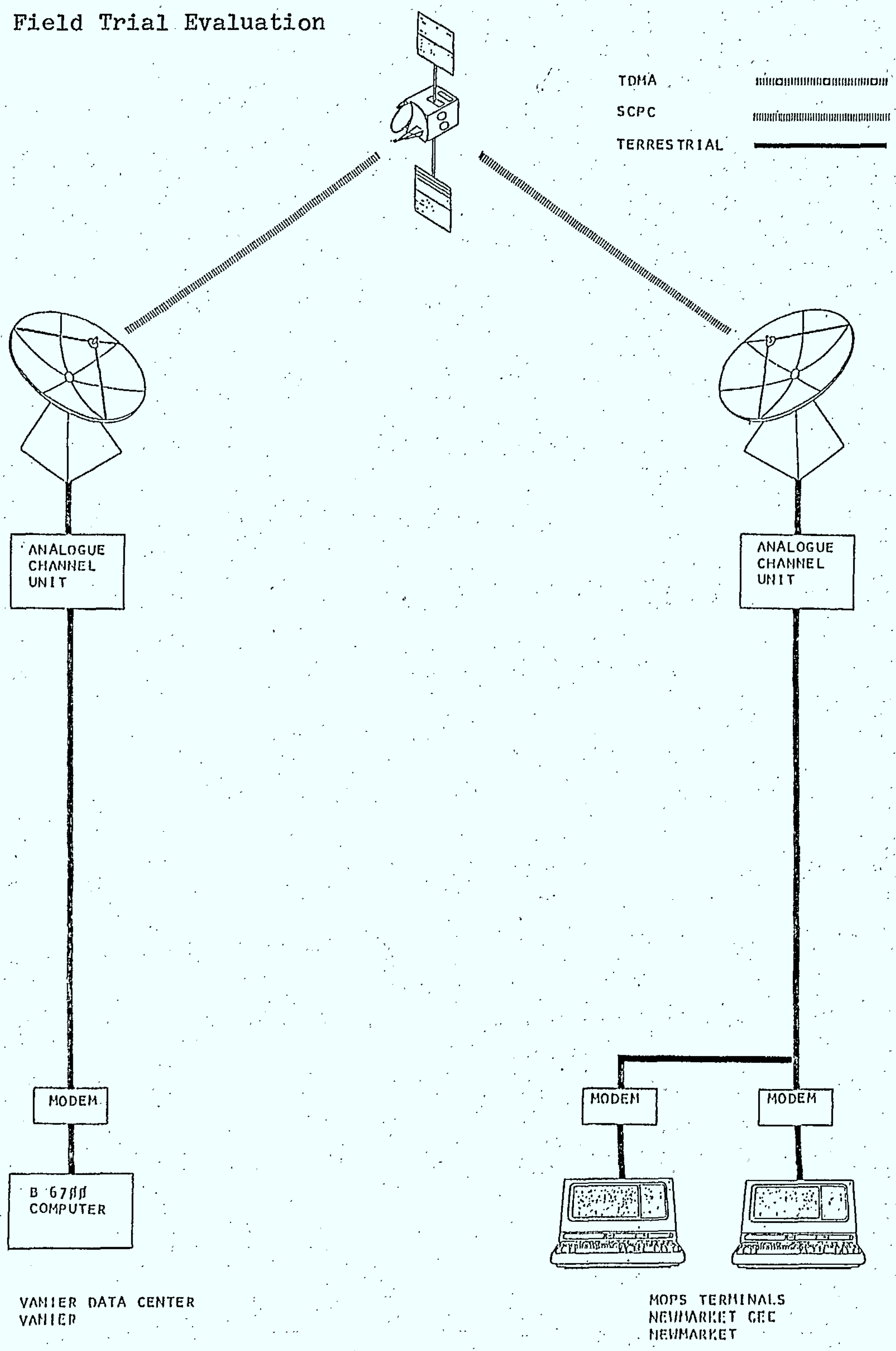

Figure III.10 - Configuration for SCPC On-line Data

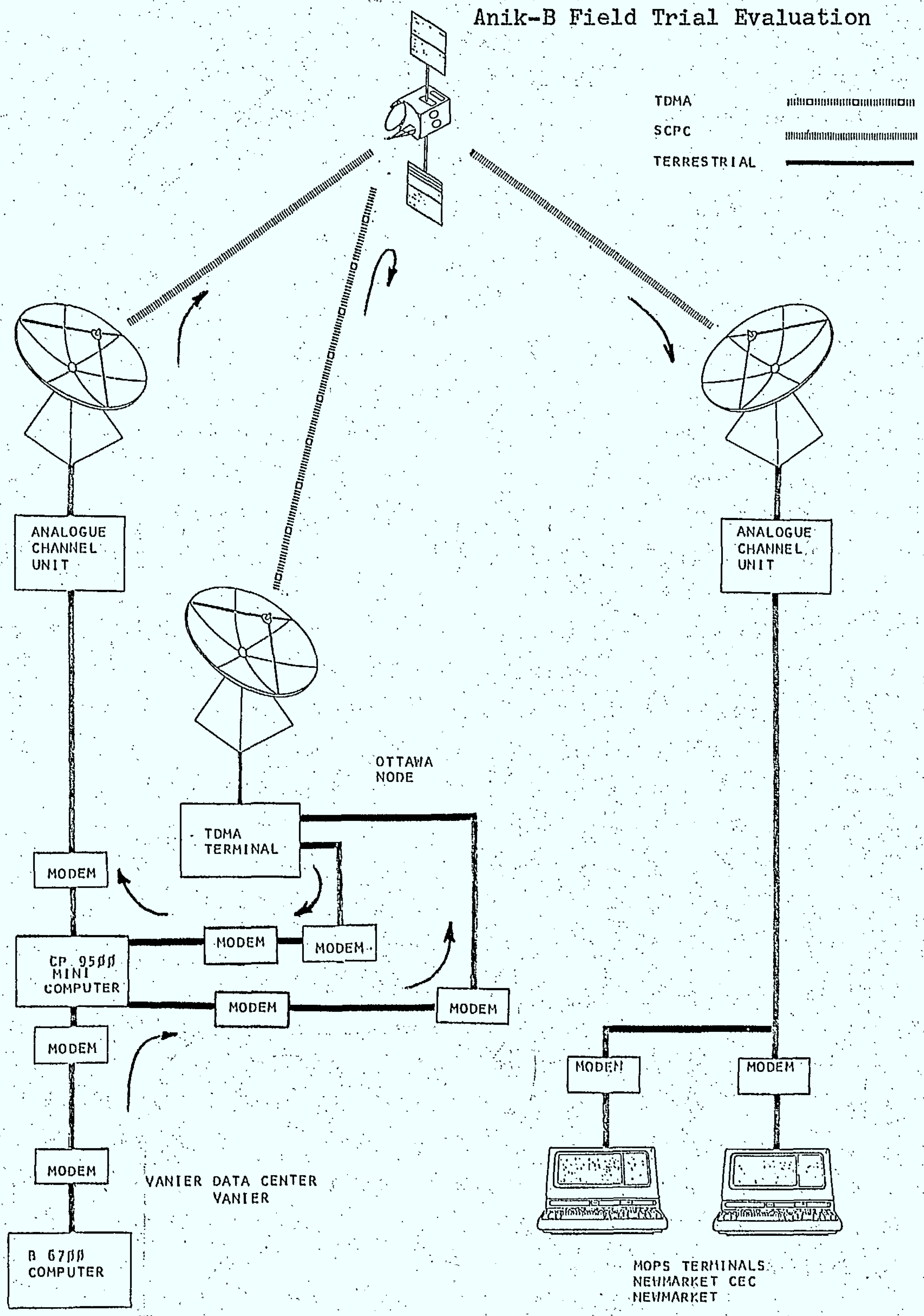

Figure III.11 - Configuration for SCPC/TDMA On-line Data

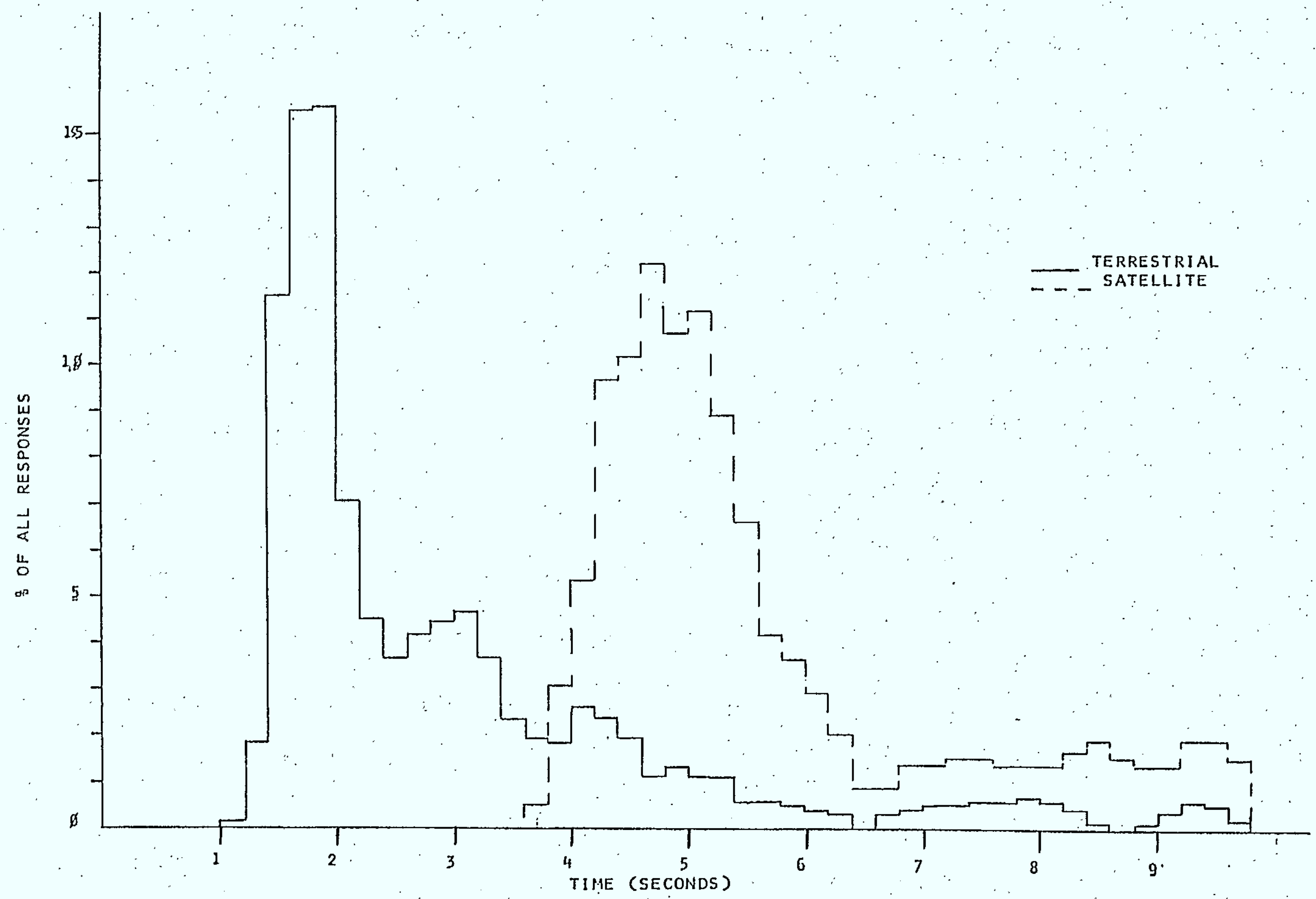

Figure III.12 - SCPC Satellite/Terrestrial Response Time

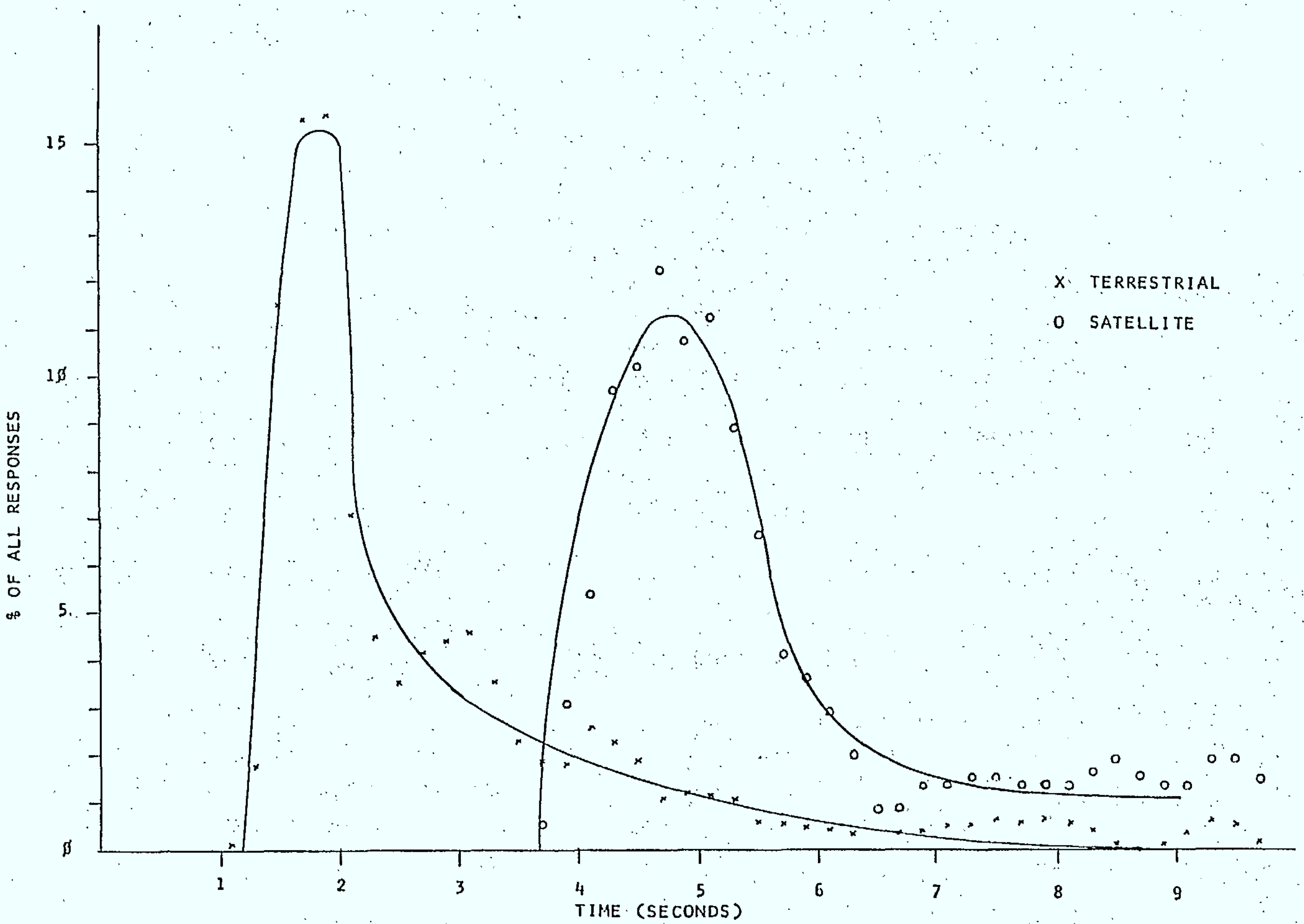

Figure III.13 - SCPC Satellite/Terrestrial Response Time

4 REMOTE JOB ENTRY (RJE)

4.1 Overview

The decentralization of the unemployment insurance system resulted in the transfer of responsibility for five major systems from Ottawa to Bathurst, New Brunswick. These include:

- The Social Insurance Register (SIR);
- Annuities - Vested (VESTAN) and Individual (INDVAN);
- Wage Loss Insurance (WLI);
- Income Tax for U.I.C. Benefit Claims (T4ENQ);
- Record of Employment (ROE), Third Copy

Since the Bathurst computer center does not have facilities capable of supporting these applications, all data processing is done on the B6800 computer located in Hull, P.Q. Each day the source data is input from a remote job entry (RJE) terminal in Bathurst, processed in Hull, Quebec, then transmitted back to Bathurst for printing, card punching, or storage on magnetic tape.

There were two objectives of this portion of the trial:

{1} To investigate the effects of satellite transmission delay on the performance of the Burroughs' RJE protocol; and,

{2} To demonstrate the ability of the SLIM-TDMA network to allocate the required communication capacity on a scheduled basis, by releasing the Bathurst-Ottawa channel capacity to other users when not needed for this application.

4.2 Test Procedure

A channel was to be established from the RJE terminal located in Bathurst N.B., through the SLIM-TDMA satellite network to the B6800 computer at the Hull Data Center. The evaluation procedure called for offline testing using taped data and the facilities of the network control center in Hull. After the circuit operation had been verified, operational experiments were scheduled using live data. The evaluation criterion for this application was a comparison of the TDMA channel throughput and error rate, with that of the existing terrestrial facilities.

Under normal operating conditions many variables were expected to influence the performance of the RJE protocol. Both the quantity and type of input data varies widely from day to day. Other data processing activities at the Hull Data Center could result in delays not easily distinguished from those attributable to the communication network. Minor software or computer hardware malfunctions which normally pass undetected, could also result in misleading interpretations of the TDMA performance. Using only live data, a controlled experiment comparing the performance of the TDMA network to terrestrial facilities was not possible.

To avoid this problem, the tests were divided into two parts; a quantitative performance evaluation, and an operational demonstration of the SLIM-TDMA network. The quantitative evaluation would transmit a tape containing a snapshot sample of a single days' traffic, both Ottawa to Bathurst and Bathurst to Ottawa. No processing would be performed, on the data other than that needed for control of the protocol.

Once the operational capability of the TDMA satellite network had been verified, it would be used to carry normal operational data for the duration of the trial, and monitored closely for deviations from performance measured during the initial test phase.

4.3 Results

The remote job entry trial comprised two separate communication requirements which were regarded as independent applications; the transfer of input from Bathurst to Hull, and the return of final output from Hull to Bathurst. The existing terrestrial facility supporting this operation is a single, 4800 bits per second Infodat circuit linking the B6800 in Hull to the B1825 system in Bathurst. Communications backup is provided by means of a 2400 bits per second Multicom II access at each site. The transmission in both directions is controlled by Burroughs' RJE protocol.

The field trial configuration was a virtual private line through the SLIM-TDMA network as shown in Figure III.14. The B6800 in Hull was connected to the Ottawa TDMA terminal through a full duplex, synchronous local loop, operating at 4800 bits per second. All transmission timing was provided through the local loop from the SLIM-TDMA network. The Bathurst TDMA terminal was located on the roof of the Regional computer center, with access to the RJE terminal provided by a four-wire intra-building loop.

The transmission block size for both directions was fixed at approximately 400 bytes, the default block size for the system. The existing hardware/software configuration and operational requirements prevented optimizing the transmission block size.

Bathurst to Hull transmissions usually occur between 1500h and 1630h eastern time, and contain an average of 1.4 million bytes of data. The Hull to Bathurst transmissions normally occur between 0800h and 1030h Eastern time and average 2.5 million bytes of data.

The SLIM-TDMA network comprised four separate nodes; Toronto, Montreal, Ottawa and Bathurst. For technical reasons that were never isolated during the trial period, the full operation of all four nodes was not achieved, with Bathurst, in particular, presenting persistent problems.

The Bathurst node was unable to lock onto the burst timing transmitted by the master station. As a result communications could not be established over that portion of the network. On several occasions CNCP sent engineers or technicians to Bathurst to isolate the problems but to no avail. A few minor problems were uncovered, however, their correction did not alter the overall performance. When CNCP failed to resolve the problems, the manufacturer, Miller Communications Ltd. was called in to assist. Their engineers were also unable to activate the station.

Finally, the entire ground station was returned to Ottawa for intensive examination by both Miller Communications and CNCP Telecommunications. In Ottawa, the equipment was swapped into the local ground station and found to be fully operational. Upon its return to Bathurst, however, it was again unable to function.

Throughout the entire period of the field trial, only 10 minutes of transmission time was achieved under the RJE protocol. Unfortunately, this transmission was used solely to test continuity of the virtual circuit through the SLIM-TDMA network and was not documented in the context of protocol testing. No results of any significance were achieved.

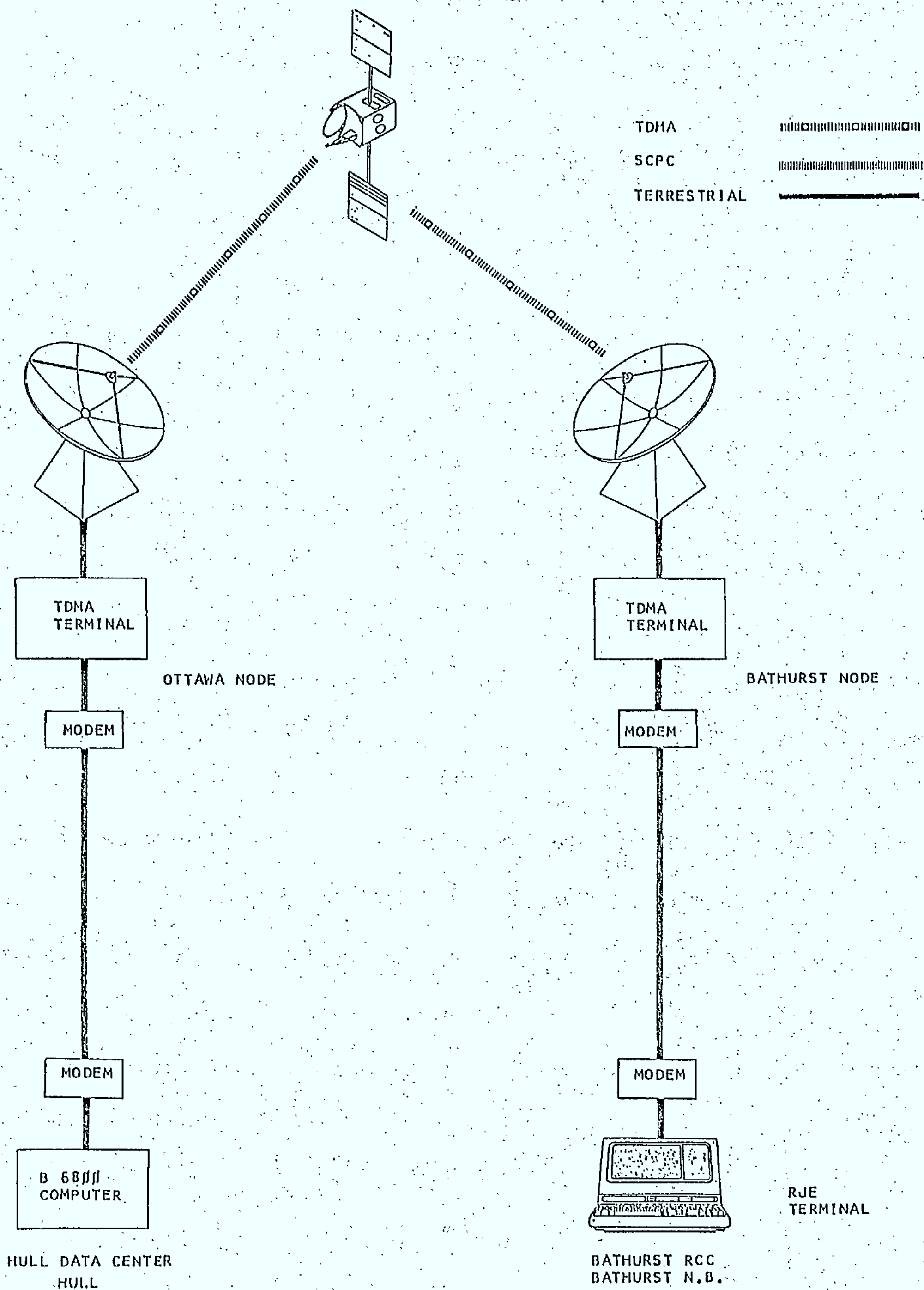

Figure III.14 - Network Configuration for RJE Tests

5 DIGITAL FACSIMILE

5.1 Overview

Digital facsimile is frequently used within CEIC for transmission of administrative documents between regional centers and national headquarters in Ottawa. Its main application is for the transmission of documents which require authorizing signatures, or where the information contained is largely pictorial in nature.

Initial plans for demonstrating the transmission of facsimile images through the SLIM-TDMA network called for the implementation of two channels; one between Bathurst N.B. and Ottawa, the other between Toronto and Ottawa. The planned configuration is shown in Figure III.15.

Three principal objectives were identified for this application:

{1} To demonstrate the ability of the network to deliver facsimile images transmitted in digital form. This required the re-digitizing of the voice frequency signal from the facsimile machine by a 32k bits per second CVSD codec prior to transmission through the TDMA network, and the recovery of the original signal from the digitized stream before delivery to the receiver.

{2} To demonstrate the ability of the network to be reconfigured on a scheduled basis by reassignment of the termination points of a single virtual circuit through the network. At certain times the network would provide a bi-directional channel between Ottawa and Bathurst. The rest of the time, it would link Ottawa and Toronto.

{3} To investigate any improvement in the quality of the transmitted image that could be attributed to the use of forward error correction within the network.

Unfortunately, as described in Section 4.3, technical problems plagued the Bathurst terminal throughout the trial period. Neither CNCP nor Miller Communications (the manufacturer of the TDMA terminal) were able to resolve these problems before the end of the trial. Facsimile testing could be carried out only between Ottawa and Toronto.

It was originally planned to carry out the tests so that on alternate days the Forward Error Correction (FEC) feature of the codec on the satellite trunk would be operational. For various reasons which were not made clear to the users, CNCP did not follow through with this aspect of the testing. Therefore, all tests were carried out without the use of forward error correction.

5.2 Test Procedure

Tests were carried out daily on weekdays between the telecommunications centers of CEIC NHQ and Toronto from 28 January 1983 to 14 February 1983; both locations used Rapicom 1000 facsimile machines which process the source information digitally but have a built-in modem to present an analogue interface directly with the voice frequency 3001 type channel. The typical document transmit time was 45 seconds.

Each day, Hull transmitted a facsimile test chart to Toronto, first using the satellite dial-up trunk and then repeating the transmission over a government interoffice terrestrial trunk. Toronto then repeated the process in the opposite direction but using a typical office memorandum rather than the test chart. During the course of the tests Toronto also transmitted samples of printed text combined with photographic material from magazines. For operational reasons all tests were restricted to the hours 0900 - 1000.

5.3 Results

Table III.1 summarizes the success of facsimile transmissions between Hull and Toronto. The satellite circuit was available only on 4 of the 13 days during which the tests were to be carried out. During this time approximately 16 documents were transmitted. Of these, all were judged to be successful by the user.

Figures III.16 to III.23 show test documents received at Toronto and Hull [1]. In each case, the smeared half inch black strip across the samples at Toronto are due to malfunction of the facsimile machine and not to transmission problems.

---

[1] The photocopying process used for this report may have introduced some degradation in all examples of facsimile transmission.

5.4 Conclusions

The following conclusions can be drawn from the facsimile reproductions received at Toronto and Hull.

{1} The propagation delay of the satellite circuit has no adverse effect on the communications protocol of the Rapicom 1000 facsimile machines.

{2} Transmission via satellite trunks using 32 kbps delta modulation had no perceptible effect on the quality of the received facsimile reproduction in terms of either graphic distortion or transmission error related effects when compared with similar reproductions obtained via terrestrial transmissions. Both were deemed to be of good quality.

{3} The half-tone photographs suffered from a characteristic degradation that was similar for all images sent over both the satellite and terrestrial networks. (refer to Figures III.19 through III.23) It can be concluded that this degradation was caused by the processing technique used by the Rapicom 1000 machines rather than by any property of the communications network.

{4} From a service point of view the availability of the satellite circuit used for facsimile tests was unacceptable.

Day/Month	Hull to Toronto Successful?	Toronto to Hull Successful?
28/1	No	No
31/1	No	No
1/2	Yes	Yes
2/2	No	No
3/2	No	No
4/2	No	No
7/2	No	No
8/2	No	No
9/2	No	No
10/2	Yes	Yes
11/2	Yes	Yes
14/2	Yes	Yes

Table III.1 - Summary of Daily Facsimile Tests

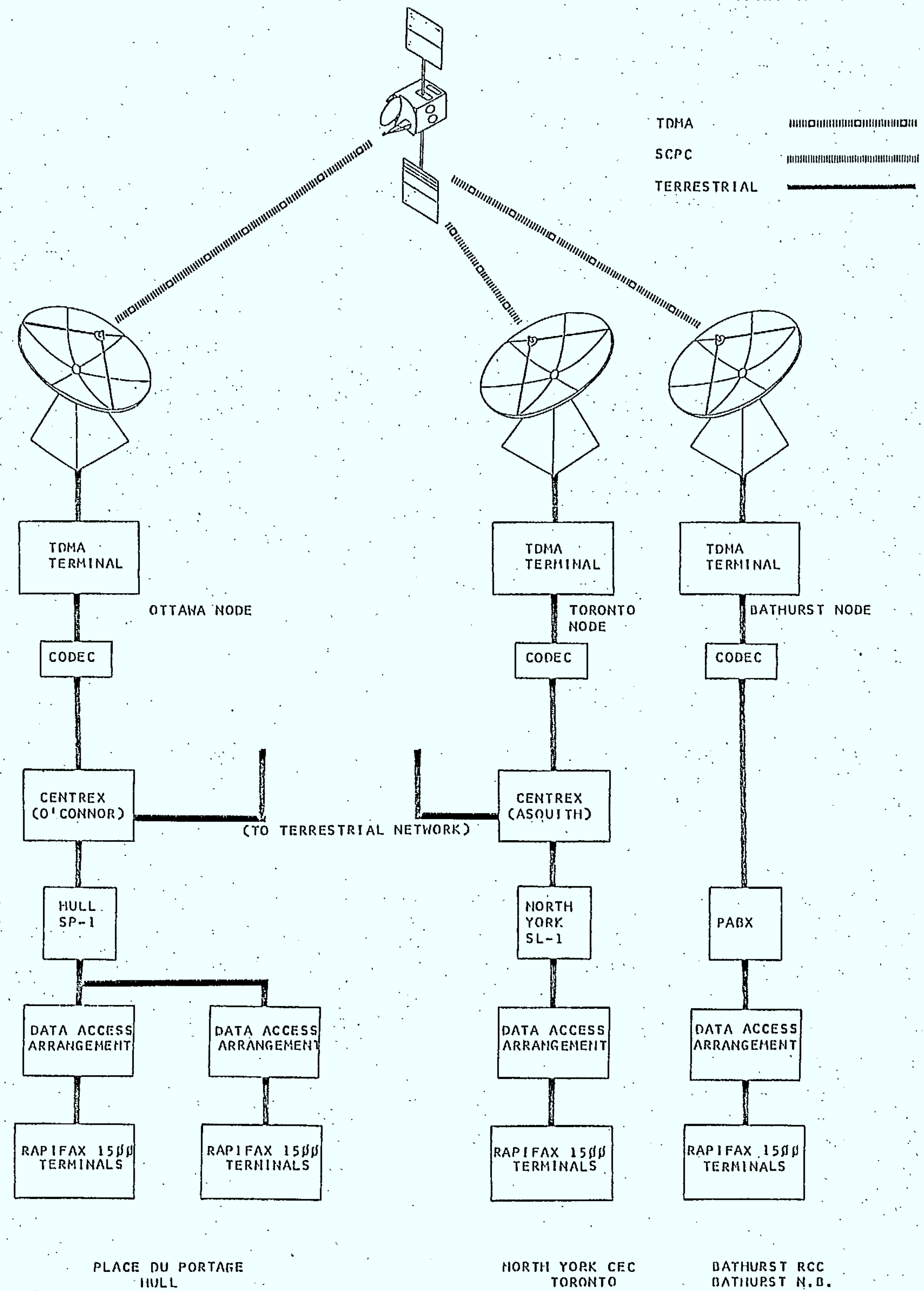

Figure III.15 - Trial Configuration for Digital Facsimile

Anik-B Field Trial Evaluation

FACSIMILE EVALUATION TEST SHEET

SERIAL NO. ____________ PAPER ____________ TONER ____________ RESOLUTION ____________

DATE ____________ TEMP. ____________ REL/HUM ____________ SEG.V. ____________ STY.V. ____________

SOLID	BLACK	THE QUICK BROWN FOX JUMPED OVER THE LAZY BLACK DOG'S BA
80%	BLACK	THE QUICK BROWN FOX JUMPED OVER THE LAZY BLACK DOG'S BA
60%	BLACK	THE QUICK BROWN FOX JUMPED OVER THE LAZY BLACK DOG'S BA
40%	BLACK	THE QUICK BROWN FOX JUMPED OVER THE LAZY BLACK DOG'S BA
[illegible]	[illegible]	THE QUICK BROWN FOX JUMPED OVER THE LAZY BLACK DOG'S BA

RAPICOM 2972 STENDER WAY, SANTA CLARA, CA. 95051
7 KINGSBRIDGE RD., FAIRFIELD, N.J. 07006

12 Pt Serif

n o p q r s t u v w x y z
1 2 3 4 5 6 7 8 9 0

6 Pt San Serif

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m
n o p q r s t u v w x y z
1 2 3 4 5 6 7 8 9 0

8 Pt San Serif

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

Figure III.16 - Fax Test Sheet (Hull to Toronto - Satellite)

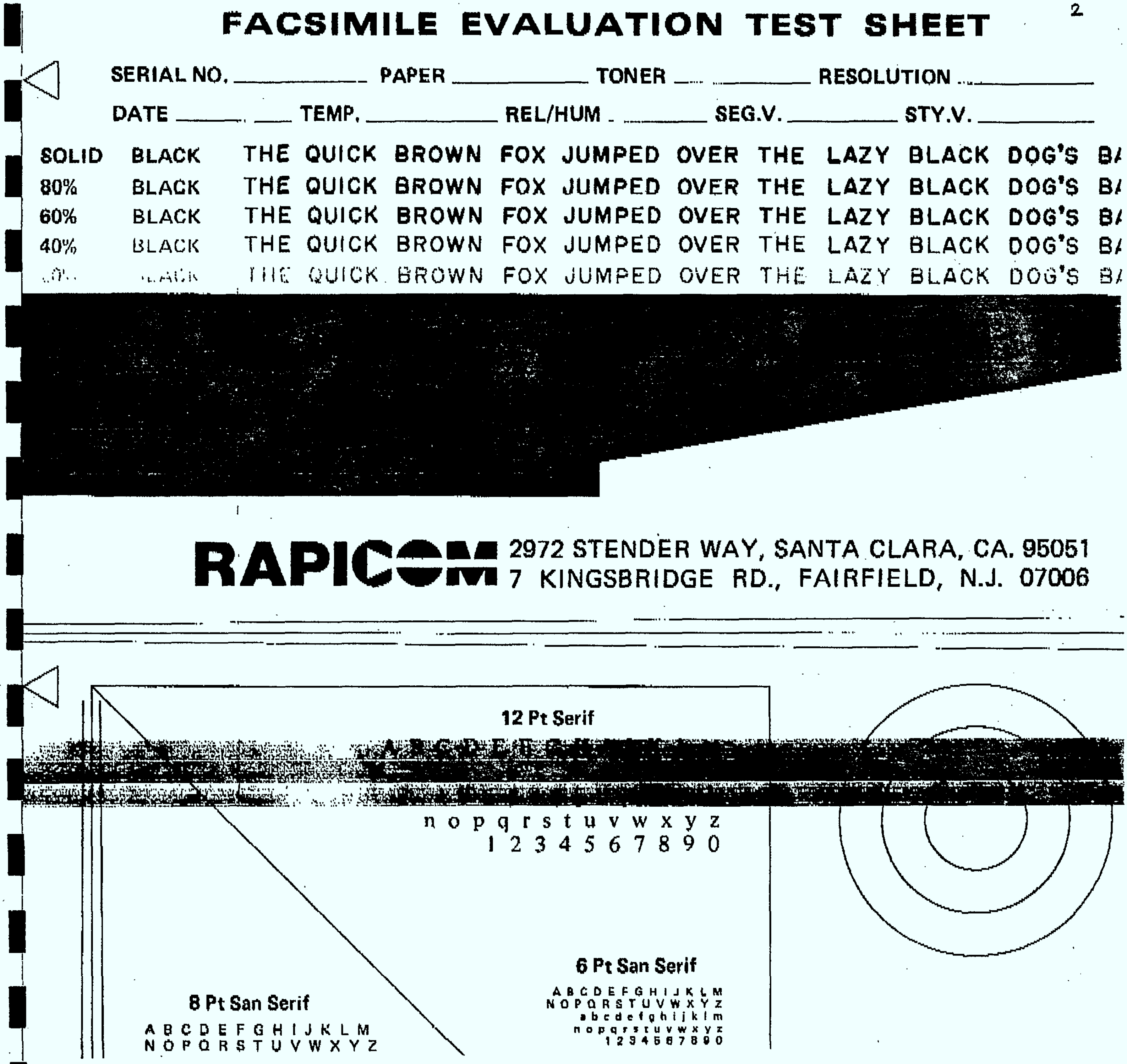

Figure III.17 - Fax Test Sheet (Hull to Toronto - Terrestrial)

Employment and Immigration Canada | Emploi et Immigration Canada

Memorandum · Note de service

3

Classification
Cote sécuritaire

TO / POUR: See Distribution

Your File / Votre référence

Our File / Notre référence: 230-11-1

FROM / ORIGINE: A/Director
Telecommunications

Date: 21 January, 1983

SUBJECT / OBJET: ANIK-B FIELD TRIAL OF FACSIMILE TRANSMISSIONS

The attached instructions, for the facsimile operators during the ANIK-B field trial, were prepared in concert with GTA.

The voice coordination identified in step 2 is designed to avoid unnecessary attempts by the Hull operator to transmit via satellite should the Toronto facsimile equipment not be available, however, should either facsimile machine be inoperative, this information must be reported in the log sheet as explained in step 5.

This exercise is to begin on January 27 and continue until February 14, 1983.

G. Parent

Figure III.18 - Fax Test Memo (Toronto to Hull - Satellite)

Employment and Immigration Canada · Emploi et Immigration Canada

Memorandum · Note de service

TO / POUR: See Distribution

Classification / Cote sécuritaire:

Your File / Votre référence:

Our File / Notre référence: 230-11-1

FROM / ORIGINE: A/Director
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G. Parent

Figure III.19 - Fax Test Memo (Toronto to Hull - Terrestrial)

7

CREATURES

ANIK TEST
FM TORONTO

ROXANNA SAYRE

FEB 10, 1982.

Columbian ground squirrel: 1080 target.

A Montana rancher claims that ground squirrels cost him $10,000 in crop losses last year, according to *High Country News*. He says he fired 50,000 rounds of ammunition at the rodents one year and tried strychnine another year, both to no avail. But, the newspaper notes, he and other ranchers in nineteen western Montana counties now will be able to use Compound 1080 against the ground squirrels.

Conservationists who have the impression that 1080 is being used only to kill city rats—or in the experimental anti-coyote collar for sheep—may be puzzled. Indeed, many uses of 1080 were banned in 1972 when President Nixon issued an executive order halting its use on federal lands against predators and also against rodents where it would cause secondary

not harm an egg. The female went on to successfully raise the chick that hatched. Here are the events that three observers reported in a recent issue of *The Passenger Pigeon:*

A U.S. Fish and Wildlife Service biologist and two companions were routinely monitoring a perennially successful bald eagle nest in north-central Vilas County. In mid-April, as they flew over the nest in a small plane, they saw an incubating adult. Early in June, in another check, they found a bird still on the nest, but there also was what looked to be the body of a dead adult.

Investigating the nest tree from the ground, the men found two adults raising a healthy chick that appeared to be about five weeks old. The dead male, which they estimated to have died at least a month earlier, was still in the nest.

What had happened? The biologists theorize that lightning struck the nest tree, breaking off several branches and killing the male bird. The egg must have hatched about this time, and the female almost immediately recruited an unmated male in the area to help her raise the chick.

Could a foreign plant fifteen feet high, with three-foot-long leaves, be taking over New York State? A recent headline warned, "Dangerous Weed Spreads Upstate," and Cornell University's experts urged residents of a dozen counties to be on the lookout for the giant hogweed and report the location of any plants to the nearest Cooperative Extension agent.

The giant hogweed, a perennial native to the Caucasus Mountains of Russia, may sound like a candidate for a horror

Striped skunk: easy to drown.

For the past couple of years, Texas has been having one of the periodic outbreaks of rabies that occur in some western and border states. There are always carriers of the disease in wild populations; the infection breaks out from time to time, reaching domestic animals and—occasionally—people. In Texas there appears to have been a skunk population explosion and a high percentage of rabid animals found have been skunks.

So great numbers of skunks have been killed, and in some areas irrational fear has triggered the slaughter of all small wild mammals. This despite the fact that the epidemic is being well controlled by vaccination of pets and livestock.

But a single sheet of paper distributed by the Texas Agricultural Extension Service, with directions on "How to Catch a

Figure III.20 - Publication Sent Toronto to Hull (Satellite)

CREATURES

ANIK TEST
FM TORONTO

ROXANNA SAYRE

FEB 10, 1982

Columbian ground squirrel: 1080 target.

A Montana rancher claims that ground squirrels cost him $10,000 in crop losses last year, according to *High Country News*. He says he fired 50,000 rounds of ammunition at the rodents one year and tried strychnine another year, both to no avail. But, the newspaper notes, he and other ranchers in nineteen western Montana counties now will be able to use Compound 1080 against the ground squirrels.

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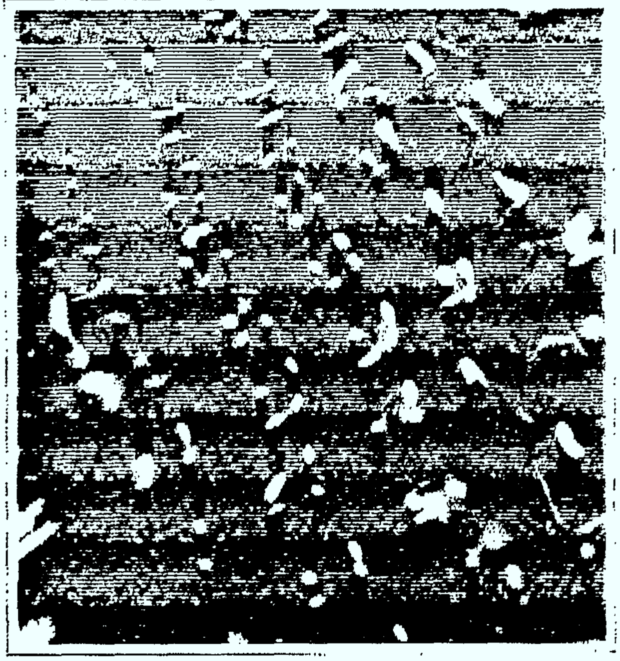
But a single sheet of paper distributed by the Texas Agricultural Extension Service, with directions on "How to Catch a

Figure III.21 - Publication Sent Toronto to Hull (Terrestrial)

TOR-OTT- ANIK TEST
FEB 11, 1983.

January 1981/Volume 83, Number 1



11

AUDUBON

The magazine of the National Audubon Society

ARTICLES

Figure III.22 - Publication Sent Toronto to Hull (Satellite)

TOR-OTT- ANIK TEST
FEB 11, 1983.

12

January 1981/Volume 83, Number 1

AUDUBON

The magazine of the National Audubon Society

ARTICLES

Figure III.23 - Publication Sent Toronto to Hull (Terrestrial)

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PART IV - GTA APPLICATIONS

1 INTRODUCTION

The Government Telecommunications Agency (GTA) of the Department of Communications is one of the largest users of voice and data communication services in Canada. In its primary role as a centralized procurement agency for telecommunication services, it is responsible for the specification and acquisition of a complete range of facilities including voice, data, teleconferencing and wide band systems.

Under the field trial, the application of satellite communication to four specific areas was investigated; telephony, teleconferencing, office automation and data messaging. The following series of experiments was identified to address each of these main areas of responsibility. In all cases the facilities implemented using the satellite network were provided in addition to normal terrestrial services. Wherever possible, the network was used in a controlled environment to monitor its use and facilitate the collection of data.

{1} GTA is responsible for the procurement of administrative telephone services used within the Federal government. At the present time, an extensive inter-city private line network interconnects most communities where services are provided directly to the public, or where required to support various government activities. One of the Agency's main objectives was to investigate the feasibility of using satellite communications as a building block for its inter-city network.

{2} In recent years, travel costs within the Federal government have risen dramatically. One means of reducing these costs is through the use of teleconferencing. Using the facilities provided under the field trial, the Agency conducted a series of teleconferencing experiments to determine whether a satellite network can be used for this application and to identify any limitations that it imposes on the users of such a service.

{3} The Department of Communications is actively involved in the promotion and development of office communication technology; both to streamline its own operation and to improve its understanding of the impact of this technology in the Canadian economy. A series of experiments was therefore developed to investigate the ability of a satellite network to interconnect word processors and deliver documents between offices in different cities.

{4} GTA operates a nation-wide Telex-like network, the Government Data Network (GDN), that serves over 500 different government offices across Canada. The forth series of experiments investigated the ability of the satellite network to support this type of application by enabling work stations in Ottawa to access directly the CNCP Infoswitch network, and through that facility, the Telex network. The experiments demonstrated the ability of the work station to send messages to, and receive from other work stations on both the Infoswitch and Telex networks.

A detailed description of each experiment is presented in the following paragraphs along with an analysis of the findings.

2 TELEPHONY

2.1 Original Test Plan

The original plan for the subjective evaluation of the telephony application in the CNCP Satellite SLIM-TDMA Network Trial was a compromise procedure based on the practical considerations of implementing each of the four proposed procedures within the limited time and resources available. The recommended procedure was that a pre-selected group at the middle-management level within each of the participating government departments be asked to fill in questionnaires after placing a call to another city using a special access code to that city and again, after placing a call to the same city using the normal government inter-city network. All calls would be made by participants during the normal course of their work.

This procedure had several shortcomings which were known apriori and were detailed in the test plan. The main shortcomings were the following:

{1} Since the participants were required to use a special telephone code to access the satellite network, the experiment was not 'blind'. The effects on the test results could be minimized, however, by not revealing the nature of the test condition to the participants.

{2} Expected limited sample size due to the limited resources available.

{3} Pre-selection of the sample by middle-management personnel. These individuals probably selected those persons who most often make inter-city telephone calls. Heavy telephone users tend to be more critical of quality, and therefore may not necessarily be representative of the general government population.

2.2 Modified Test Plan

The limited time available between the delayed start of the trial caused by technical equipment problems and the extended trial cut-off date (February 15, 1983) presented a real danger that little or no data would be collected for the telephony application. The original intent was to allow 6 months for the data collection. In reality, only six weeks were available. GTA/DDE therefore developed and implemented a supplementary procedure to enable controlled yet more rapid data collection. The original test procedure was also used for a limited group of participants to collect the data that would be available as a result of the normal numbers of real calls occurring during the trial period. To distinguish between the two test procedures, the original was termed 'Handout Questionnaire', the other, the 'Interview Questionnaire'.

The procedure followed for the 'Interview Questionnaire' selected individuals at random from the Ontario Region telephone directories of the participating government departments (CEIC, AES, DOC). Each was called by an interviewer at the GTA/DDE office at 300 Slater Street; once over the satellite circuit, and once over the government inter-city terrestrial network. Both times, the participant was asked to answer a set of questions regarding the quality of the connection. The tests were scheduled so that half of the participants received their first call through the terrestrial facilities, and half through the satellite facilities. Insofar as possible, each participant completed both questionnaires on the same day.

Interviews were conducted between January 26, 1983 and February 11, 1983, involving 102 participants from DOC, CEIC and AES in Toronto. Each subject was called twice, once in the morning between the hours of 0930 and 1100, and once in the afternoon between the hours of 1330 and 1500.

Five responses were rejected; either because the interview was interrupted by a disconnection (satellite circuit), or because the interviewer accidentally called the subject twice using the satellite connection mode. This left a total of 97 statistically valid subjects; 56 male and 41 female.

Thirty-five subjects were selected to participate in the other test using the procedure and Handout questionnaire as originally planned. These individuals were selected from AES and CEIC both in Toronto and Ottawa. On January 24, 1983, each participant was sent two copies of the questionnaire, with instructions to complete one copy after using the regular access code (terrestrial communication link), and the other after using the experimental access code (satellite link).

Twenty-three questionnaires had been returned by the trial cut-off date on February 15, 1983. Six responses were rejected; either because their questionnaires were incomplete, or because they had inadvertently used the satellite circuit for both copies of the questionnaire. This left a total sample size of seventeen for the handout questionnaire; 1 female and 16 males.

2.3 Results

A copy of the Interview Questionnaire and the descriptive preamble used by the interviewers is presented as Appendix A. The Handout Questionnaire and its covering explanatory letter is attached as Appendix B. Both questionnaires address the following aspects of communications link quality:

{1} The overall impression of circuit quality,

{2} The quality of the current connection as compared to similar calls over the government inter-city network.

{3} The classification of any difficulties experienced in the current connection.

{4} The impression of any hesitation or awkwardness in conversation compared to similar calls over the government inter-city network.

The Handout questionnaire also questioned each participant about the occurrence of conversational interruptions and the ease with which one person could interrupt the other. This area of investigation was not possible with the Interview questionnaire because of the controlled nature of its delivery.

The overall results of the portions of the Interview and Handout questionnaires dealing with the quality of the communication link are summarized in Tables IV.1 and IV.2 respectively. Shown for each question is the absolute number of respondents for each of the possible answers, along with the percentage of respondents that number represents.

The findings for each of the four key areas of communications quality that were measured during the field trial are examined in detail in the following paragraphs.

2.3.1 Overall Circuit Quality

The overall quality of the communications channel was measured on a four point rating scale by each user as being excellent, good, fair or poor. The distribution of responses to the Interview and Handout questionnaires is shown in Figures IV.1 and IV.2 respectively.

Each of the possible ratings was assigned a weighting of 4, 3, 2 or 1 respectively, in accordance with CCITT recommendations for the determination of the Mean Opinion Score. The Mean Opinion Score was then determined for each channel type (satellite or terrestrial) and each type of questionnaire. Within each of these categories the ratings were also sorted by the gender of the participant.

It was found that the channel type was the only variable that caused a significant difference in the Mean Opinion Scores. The terrestrial channel achieved a score of 2.96, indicating a much better transmission quality than through the satellite channel which had a score of 2.22. No significant difference was detected in the perception of channel quality by male and female participants.

The method of presenting the questionnaire to the participants (that is, Interview or Handout) also appeared to have little affect on the Mean Opinion Scores of similar communication channels. This finding is interesting for the government, in that it indicates that telephone surveys may be more effective than those conducted by mail. Telephone surveys using the government inter-city network would ensure that enough subjects will be surveyed and would provide a higher respondent level than a questionnaire that is mailed. In the present experiment, a little more that 50% of the Handout questionnaires were returned.

The detailed breakdown of the Mean Opinion Scores and the levels of confidence that can be associated with each is summarized as Table IV.3. Table IV.4 summarizes the analysis of variance in the Mean Opinion Scores for each of the three independent factors present in the test; the channel type, method of presenting the questionnaire and the gender of the participant.

2.3.2 Quality of the Current Connection

The participants were asked to rate the quality of the 'current' connection as being better than, the same as, or worse than the quality of connections normally achieved between the same cities through the government inter-city network. The distribution of these ratings for the Interview and Handout questionnaires is shown in Figure IV.3 and Figure IV.4 respectively. Overall, 61% of the respondents felt that the terrestrial connection was the same as, or better than a 'normal' connection between the same cities. Only 10% believed that the quality of the connection was worse.

When the question was applied to a connection between the same cities through the satellite network, 63% of all respondents felt that the connection was the same as or better than normal, while 37% believed that the quality of the connection was worse.

From this, it can be concluded that the satellite connection was generally perceived as being of similar or poorer quality than the terrestrial connection.

2.3.3 Classification of Difficulties Experienced

Both questionnaires attempted to classify the forms of channel degradation that were experienced by the participants. The major factors were expected to be noise, distortion, fading, echo and cross talk. The characteristics of channel degradation actually experienced by the participants are summarized in Table IV.5, with results shown separately for the Handout and Interview questionnaires. The various degradation factors are grouped according to the frequency with which they were reported. The percentage distributions of difficulties experienced by the participants using the Interview and Handout questionnaires are shown as Figures IV.5 and IV.6 respectively.

By far the largest complaint (for both satellite and terrestrial circuits) was 'noisy transmission'. Of those participants receiving the Interview questionnaire, 54% experienced this problem through the satellite circuit and 40% found it with the terrestrial channel. The corresponding results from those receiving the Handout questionnaire were 64.7% and 29.4% respectively.

In the Interview questionnaires responses, the pattern of the difficulties experienced were very similar for satellite and terrestrial circuits. Among the responses to the Handout questionnaire, however, there were no complaints of distortion, crosstalk, echo or fading for the terrestrial circuits. It is unlikely that none of these problems were present in the terrestrial calls. The most probable reason for the discrepancy is the participants' awareness of the test condition. Since a special access code was required to use the satellite channel, the users would be expecting different channel characteristics and would pay more attention to these calls.

For both forms of the questionnaire, subjects listed distortion and echo as the major problems with the satellite circuit.

2.3.4 Hesitation or Awkwardness in Conversation

Satellite communications has an inherent transmission delay caused by the large distance between the earth and the communication satellite. Although the delays are small, they can have a psychological effect on the user; especially if the conversation is highly interactive in nature. Both questionnaires addressed this phenomenon by asking the participant to identify and rate any unusual hesitation or awkwardness present in the conversation. The findings for the Interview and Handout questionnaires are summarized as Figures IV.7 and IV.8 respectively.

In the Interview, 30% of the respondents felt that they experienced more hesitation or awkwardness when using the satellite circuits as compared to usual communications (using terrestrial circuits). Only 9% believed that the terrestrial circuit caused more hesitation or awkwardness than a 'normal' connection (also a terrestrial circuit).

On the handout questionnaire, 58.8% of the subjects reported more hesitation or awkwardness on satellite circuits but none felt the same for terrestrial circuits.

A significantly higher percentage of respondents reported awkwardness or hesitation when using the satellite channel for the Handout questionnaire than for the Interview questionnaire. This was probably caused by the interview procedure followed. The interview process was strictly a Question-Answer sequence with little necessity for either party to interrupt. On the other hand, the Handout questionnaire involved opinions about real interactive conversations.

There was, however, a significantly higher percentage of the Handout questionnaire respondents who reported that satellite communication caused more awkwardness or hesitation in communication than did terrestrial communications. It seems that this pattern of response is related to ease and frequency of interruptions that is discussed in the following section.

2.3.5 Frequency and Ease of Interruption

The questions related to frequency of interruption by the called party and ease of interruption by the calling party were only posed for the Handout questionnaire as they had little relevance to the structured communication pattern of the interview procedure.

Each participant was asked if, during the normal course of conversation, he was interrupted by the called party more often, less often or about the same amount as normally experienced with a call placed through the usual government inter-city network. Participants were requested to differentiate between interruptions caused by the nature of the conversation and those believed to be caused by some property of the connection. The findings for both satellite and terrestrial calls are summarized in Table IV.6, and illustrated as Figure IV.9. Almost half of the respondents (47.1%) perceived the satellite link as causing the called party to interrupt more frequently than normal. None of the participants felt the same way for terrestrial circuits.

Each participant was then asked to rate the ease with which he could interrupt the called party during the test call, as compared to a 'normal' call. The three classifications provided were 'more difficult', 'no difference' and 'greater ease'. The findings for both terrestrial and satellite circuits are detailed in Table IV.7, and are illustrated in histogram form as Figure IV.10.

23.5% of the respondents were of the opinion that satellite circuits presented more difficulty in their ability to interrupt the called party. On the other hand, 41.1% felt there was no difference, and 5.9% felt it was less difficult to interrupt on satellite circuits. 23.5% of the respondents were not sure whether there was any difference.

The corresponding percentages for the terrestrial facilities were that none felt it was more difficult, 76.4% experienced 'no difference', 11.8% felt it was less difficult to interrupt and 5.9% were unsure.

2.4 Conclusions

Based on the results of the questionnaires, the following conclusions can be drawn about the use of satellite communications for telephony applications in a government environment.

(1) Overall Quality of Circuits - The satellite circuits as provided in the trial for the telephony application were rated inferior to the government inter-city private terrestrial facilities.

(2) Circuit Quality - (Compared to similar calls over government network.) The satellite communication was perceived as being of similar or inferior quality than terrestrial communication.

(3) Classification of Difficulties Experienced - The largest complaint was "noisy transmission" for both satellite and terrestrial circuits. Distortion was considered more of a problem or equal to echo for the satellite circuits.

(4) Hesitation or Awkwardness in Conversation - (Compared with similar calls over the government network.) The satellite circuits were perceived as causing more hesitation or awkwardness in conversation compared to terrestrial circuits.

(5) Frequency and Ease of Interruptions. - It was perceived that the called party tended to interrupt more frequently on satellite circuits than on terrestrial. The ease of

interrupting the other party was perceived to be more difficult on satellite than on terrestrial circuits. An equal number of participants however, noticed no difference.

{6} Satellite Availability - The availability (63.7%) experienced in the trial for telephony is unacceptable for operational service.

Despite its title, the Anik-B 'field trial' was largely experimental in nature. The primary objective of the common carrier was to ascertain which types of real applications could migrate easily to satellite networks. Gaining operational experience in providing these services to real customers was clearly secondary. In this respect the field trial differed from a conventional 'trial' in which the carrier identifies a target market segment, and designs the system to satisfy it - usually after limited concept and technology testing.

Similar trials have been carried out by TCTS in Canada, and Bell Laboratories together with the Long Lines department of A.T.& T. in the United States. Both these tests were extensive, but placed more emphasis on the application to telephony. They differed from the CNCP SLIM-TDMA trial in two major aspects. First they compared Satellite transmission versus the public telephone terrestrial transmission (DDD). Second, the tests were carried out separately, to enable comparisons with short haul and long haul terrestrial transmission. Since the telephony tests in the CNCP trial were between Toronto and Ottawa, meaningful comparisons can be made only with the short haul test results of these trials and specifically where echo suppressors rather than echo cancellers were used [1].

The results of the Anik-B trial are compared to the results of similar tests conducted under other trials in Table IV.8. The absolute values of the Mean Opinion Scores cannot be compared directly because of experimental differences; however, a relative comparison can be made of results within each experiment. The SLIM-TDMA results are consistent with the findings of other organizations.

---

[1] Satellite facilities which require two-wire to four-wire conversion (such as those used in telephony) are susceptible to echoes. The telephony portion of the Anik-B field trial used low cost echo suppression techniques rather than full echo cancelling that would be required in an operational environment.

Test Condition	Finding	Satellite Responses #	Satellite Responses %	Terrestrial Responses #	Terrestrial Responses %
Overall Circuit Quality	Excellent	5	5	23	24
	Good	32	33	50	52
	Fair	41	42	20	21
	Poor	19	20	4	4
How Does Channel compare to Similar Calls	Better	13	14	36	38
	Same	50	52	51	53
	Worse	33	34	9	9
Difficulties with Present Connection	Noise	52	54	39	40
	Loudness	14	14	9	9
	Distortion	37	38	19	20
	Crosstalk	3	3	5	5
	Echo	15	15	8	8
	Fading	12	12	8	8
	Other	6	6	10	10
Hesitation &/or Awkwardness	Not Sure	3	3	3	3
	Same	58	60	68	70
	Less	7	7	17	18
	More	29	30	9	9

Table IV.1 - Results Summary of the 'Interview' Questionnaire

Test Condition	Finding	Satellite Responses #	Satellite Responses %	Terrestrial Responses #	Terrestrial Responses %
Overall Circuit Quality	Excellent	1	6	3	18
	Good	9	53	12	71
	Fair	2	12	1	6
	Poor	5	29	1	6
How Does Channel Compare to Similar Calls	Better	4	24	3	18
	Same	6	35	12	71
	Worse	7	41	2	12
Difficulties with Present Connection	Noise	11	65	5	29
	Loudness	4	24	1	6
	Distortion	3	18	0	20
	Crosstalk	1	6	0	0
	Echo	3	18	0	0
	Fading	4	24	0	0
	Other	1	6	1	6
Hesitation &/or Awkwardness	Not Sure	3	18	1	6
	Same	3	18	13	76
	Less	1	6	3	18
	More	10	59	0	0

Table IV.2 - Results Summary of the 'Handout' Questionnaire

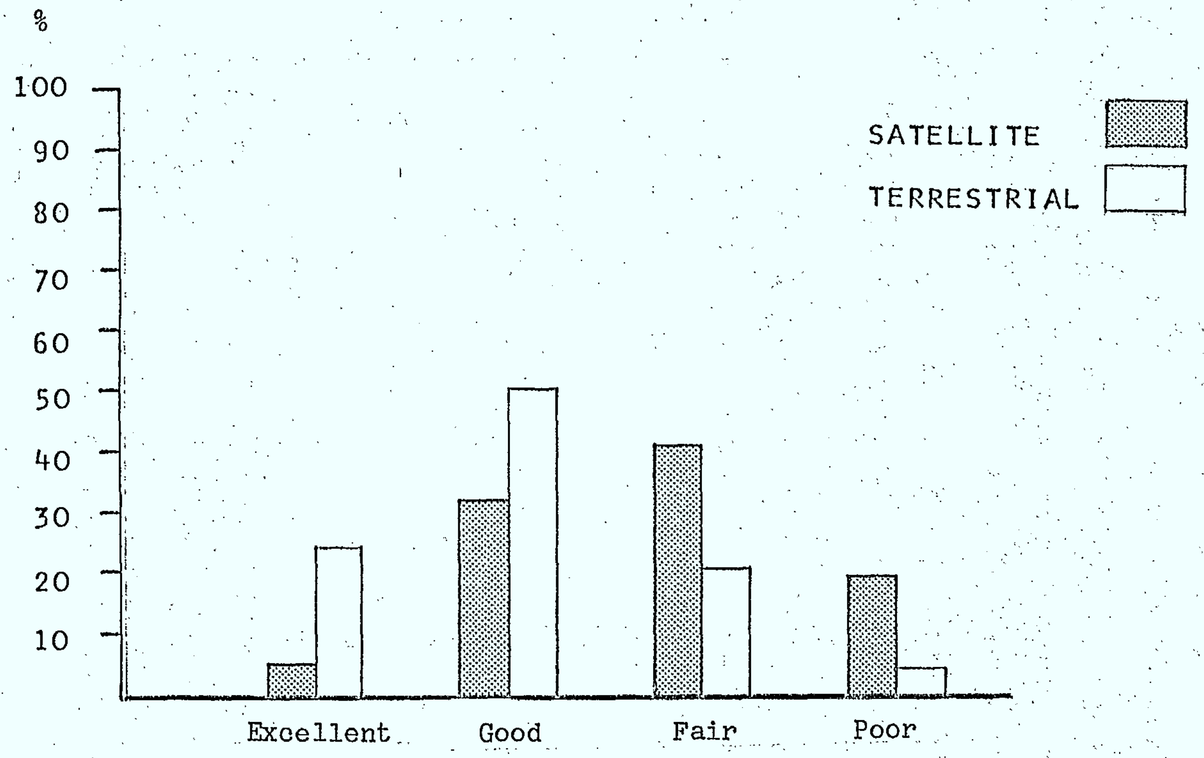

Figure IV.1 - Opinion of Overall Quality (Interview)

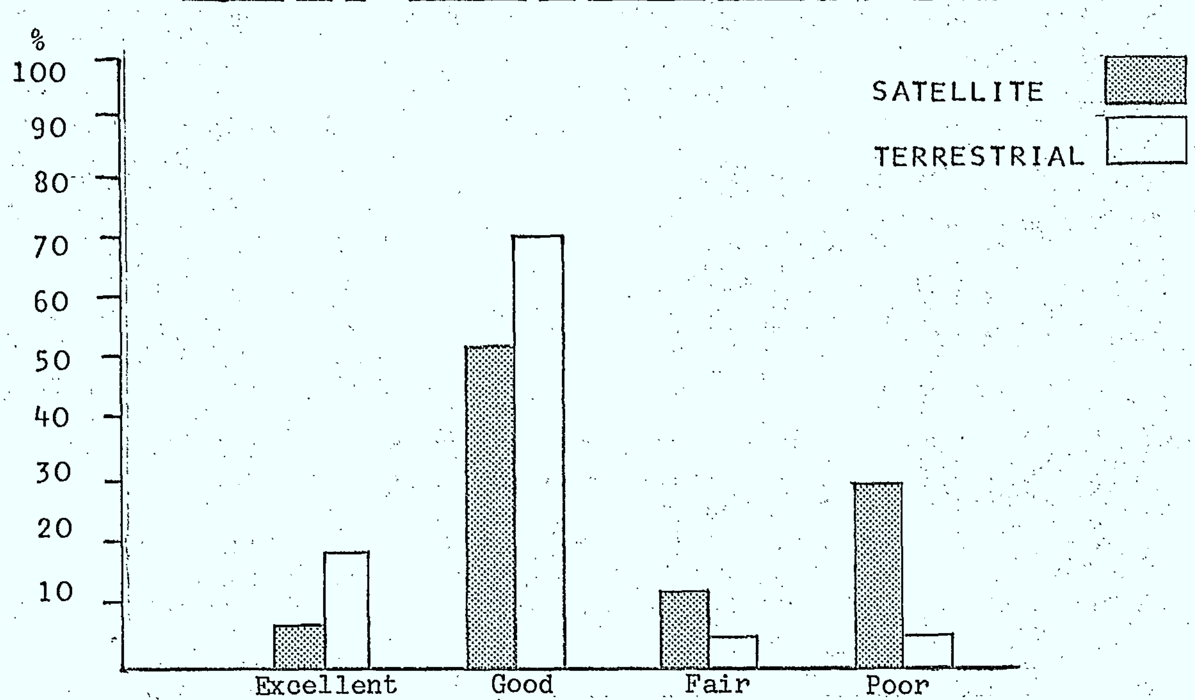

Figure IV.2 - Opinion of Overall Quality (Handout)

Statistic	Interview Sat.	Interview Terr.	Handout Sat.	Handout Terr.
Mean Opinion Score	2.24	2.95	2.12	3.00
Standard Deviation	0.822	0.778	0.995	1.63
Confidence Limits				
95% (Upper)	2.40	3.10	2.32	3.33
(Lower)	2.08	2.79	1.92	2.68
99% (Upper)	2.45	3.15	2.38	3.43
(Lower)	2.02	2.74	1.86	2.57
Estimated Sample Size for MOS +0.1 OS @ 95% Confidence Level	260	230	66	180

Table IV.3 - Overall Channel Quality, Mean Opinion Score

Factors Considered	Degrees Freedom	Sum of Squares	Mean Square	F Ratio	Significance
F [1]	1	0.192	0.192	0.218	No Sig. Diff
G [2]	1	0.020	0.020	0.023	No Sig. Diff.
F & G	1	0.025	0.025	0.028	No Sig. Diff.
Residual	110	96.924	0.881	-	-
T [3]	1	9.390	9.390	19.643	p<0.01 [4]
F & T	1	0.385	0.385	0.805	No Sig. Diff.
G & T	1	0.645	0.645	1.349	No Sig. Diff.
F, G & T	1	0.899	0.899	1.882	No Sig. Diff.
Residual	110	52.586	0.478	-	-

[1] F = Form of Questionnaire(Interview or Handout)
[2] G = Gender of Participant
[3] T = Type of Media (Satellite vs Terrestrial)
[4] There is a 1% probability of a significant difference between the means of this factor.

Table IV.4 - Overall Channel Quality, Analysis of Variance

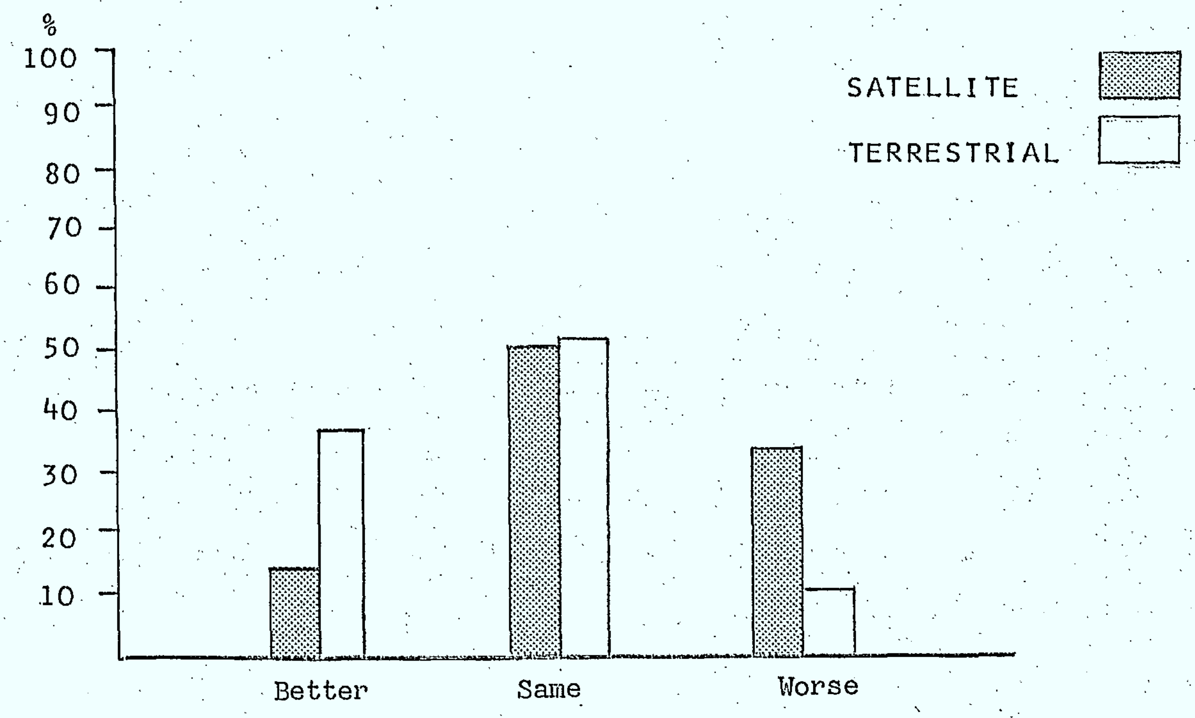

Figure IV.3 - Current vs Typical Connection Quality (Interview)

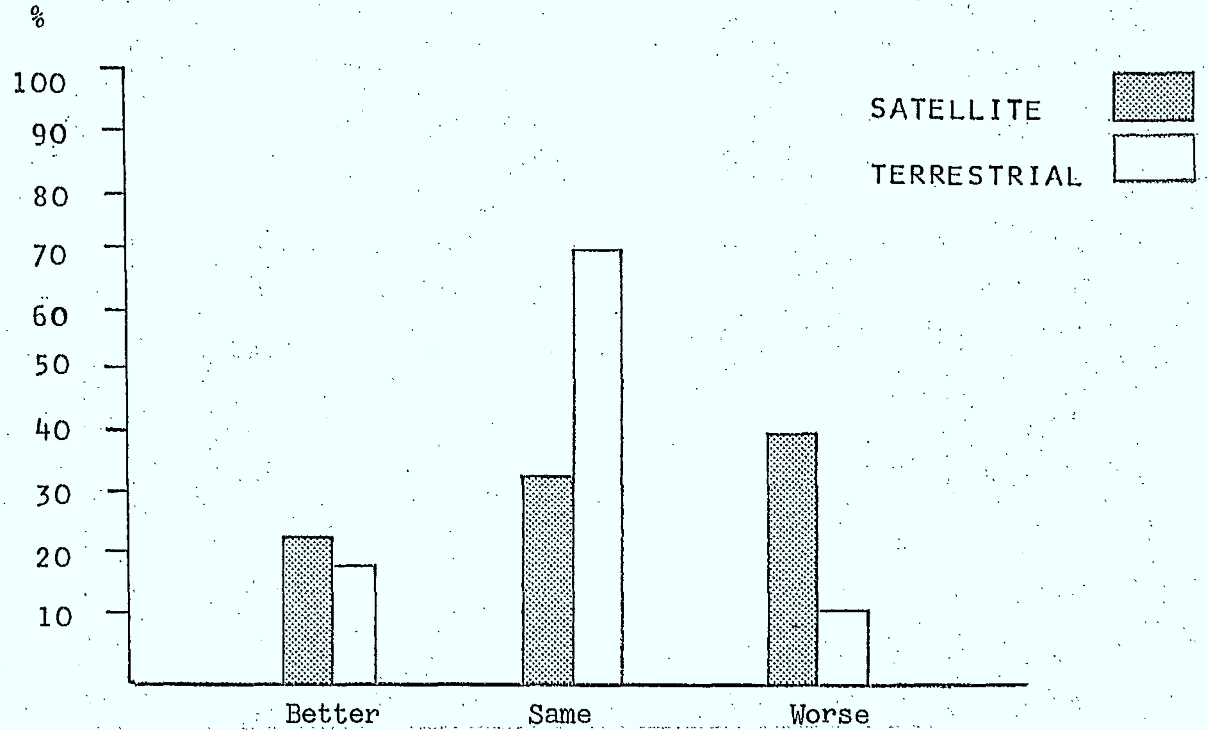

Figure IV.4 - Current vs Typical Connection Quality (Handout)

Rank	Interview Questionnaire Satellite	Interview Questionnaire Terrestrial	Handout Questionnaire Satellite	Handout Questionnaire Terrestrial
1	Noise	Noise	Noise	Noise
2	Distortion	Distortion	Loudness, Fading	Loudness Fading
3	Echo	Other	Distortion Echo	
4	Loudness	Loudness	Crosstalk, Other	
5	Fading	Fading, Echo		
6	Other	Crosstalk		
7	Crosstalk			

Table IV.5 - Classification of Connection Difficulties

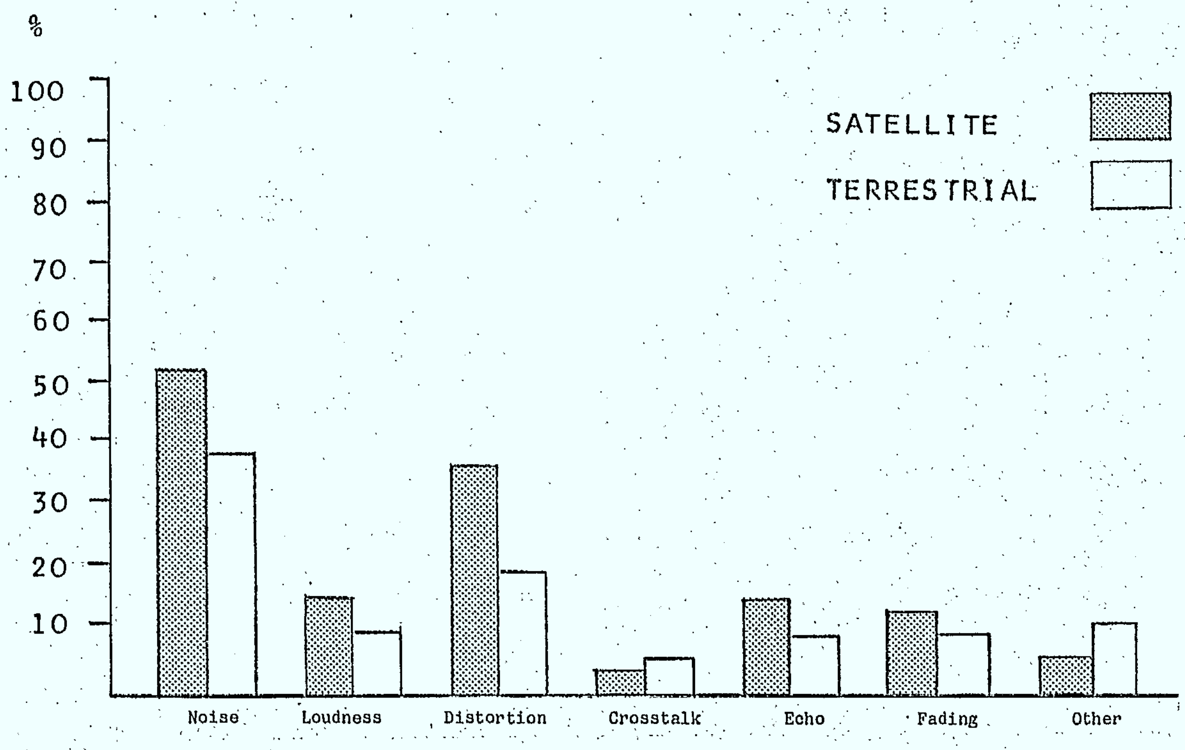

Figure IV.5 - Classification of Difficulties (Interview)

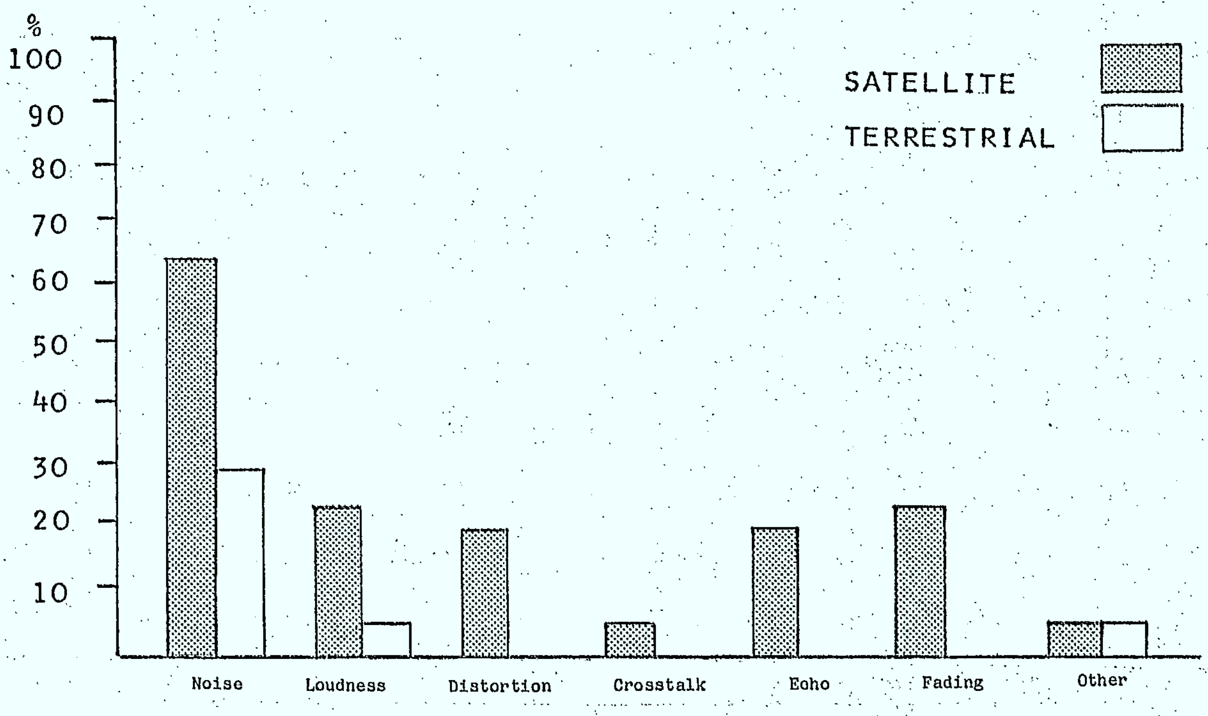

Figure IV.6 - Classification of Difficulties (Handout)

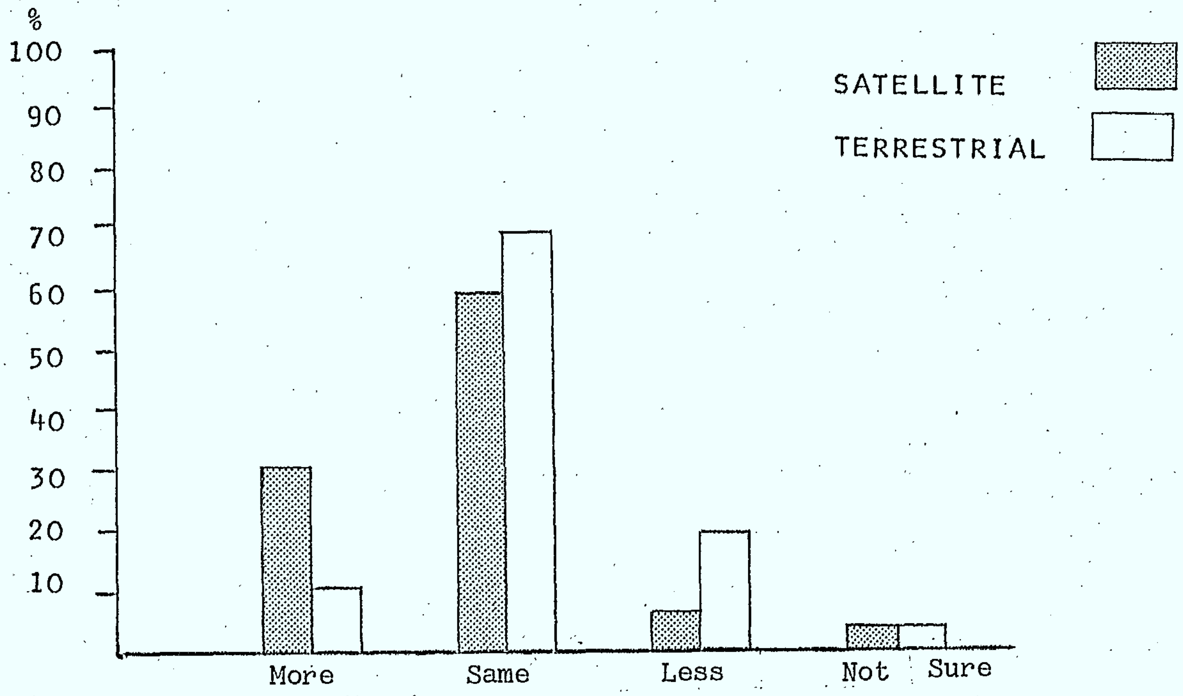

Figure IV.7 - Experience of Hesitation & Awkwardness (Interview)

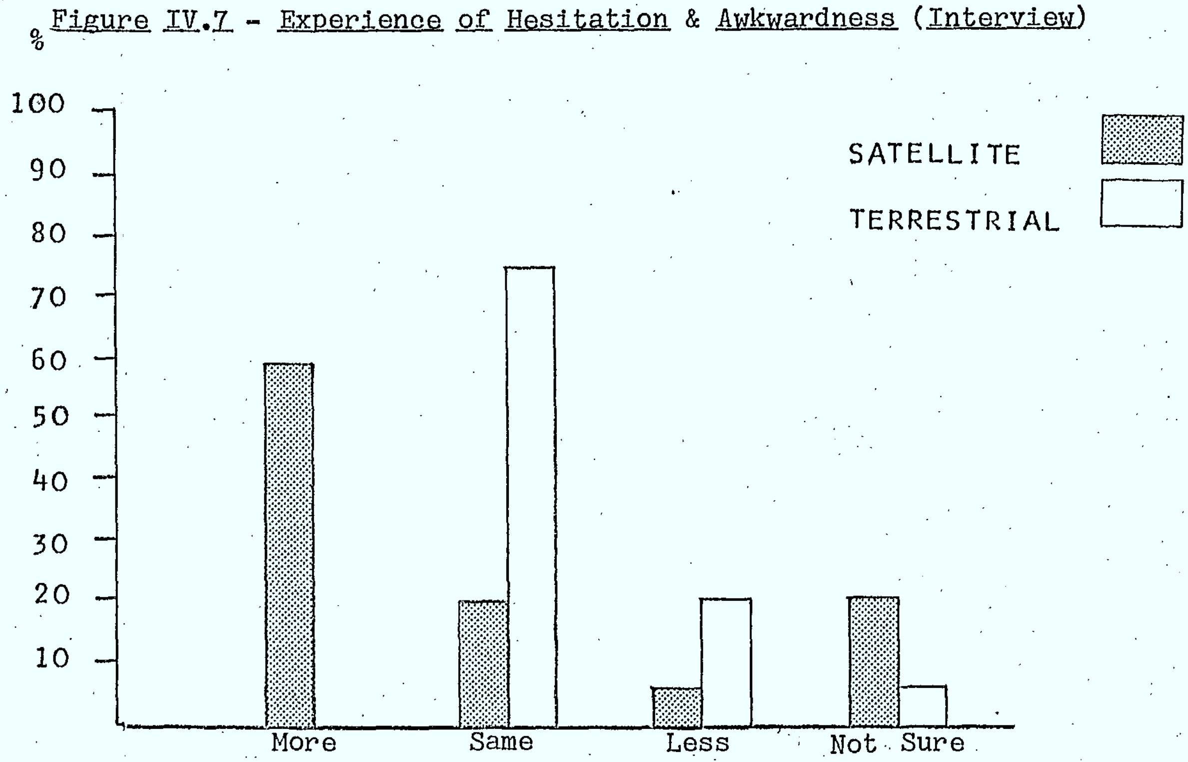

Figure IV.8 - Experience of Hesitation & Awkwardness (Handout)

Test Condition	Satellite Frequency	%	Terrestrial Frequency	%
Interrupted More Often	8	47	0	0
About the Same Number	7	41	14	82
Interrupted Less Often	1	6	3	18
Not Sure	1	6	0	0

Table IV.6 - Interruptions by Called Party

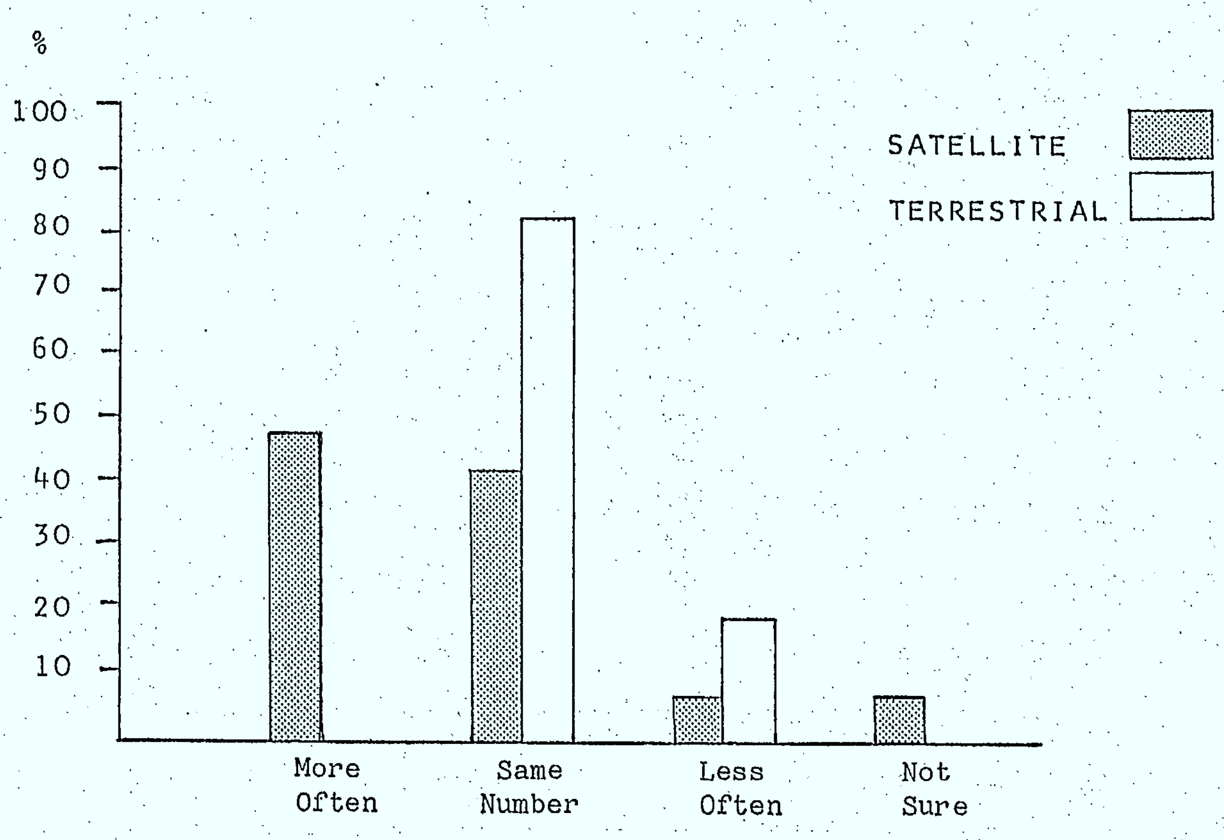

Figure IV.9 - Interruptions by Called Party

Test Condition	Satellite Frequency	%	Terrestrial Frequency	%
More Difficult to Interrupt	4	24	0	0
No Difficulty Interrupting	7	41	13	76
Greater Ease	1	6	2	12
Not Sure	4	24	1	6

Table IV.7 - Ease of Interrupting by Caller

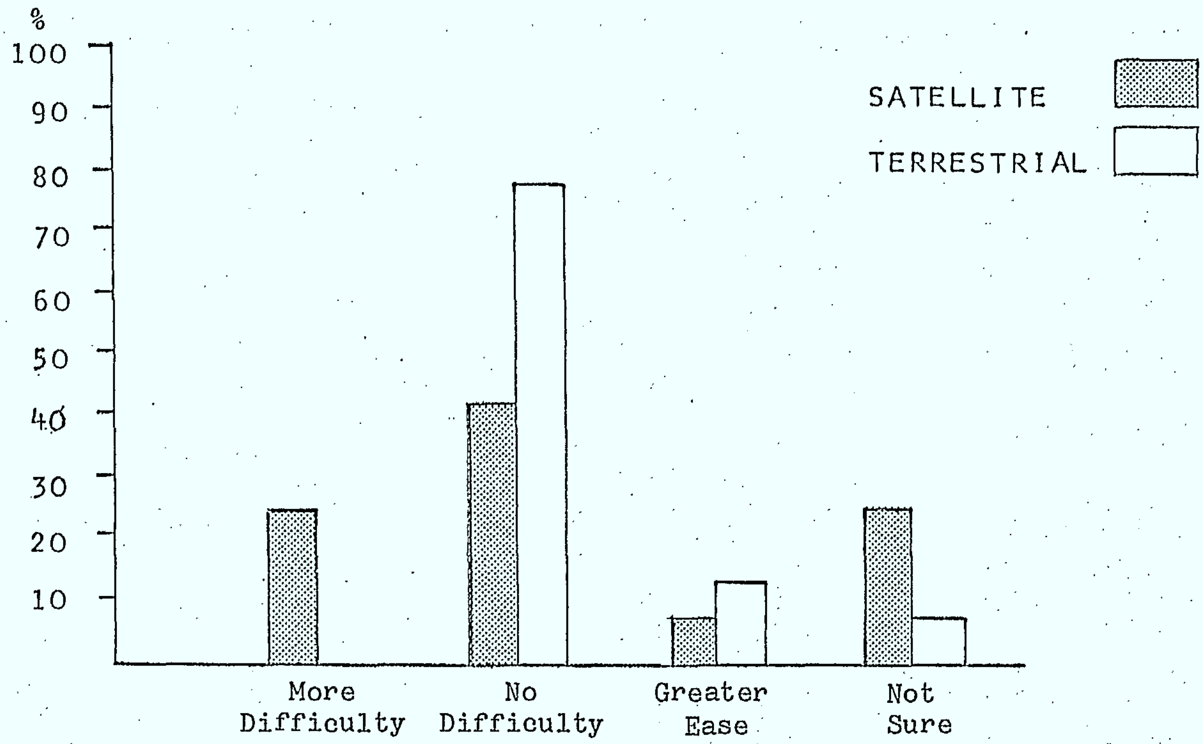

Figure IV.10 - Ease of Interrupting by Caller

Trial/Test Condition	Mean Opinion Score		% Poor or Fair	
	Satellite	Terrestrial	Satellite	Terrestrial
CNCP/SLIM-TDMA				
Interview Quest.	2.24	2.95	62	25
Handout Question.	2.12	3.00	41	12
TCTS Short Haul (Toronto-Halifax with echo suppression)	2.70	3.44	39	8
Bell Labs/AT&T Short Haul (Atlanta-S.Francisco with echo Suppression)	-	-	33	10

Table IV.8 - Comparison with other Trials

3 TELECONFERENCING

3.1 Overview

The methodology developed for testing teleconferencing in a satellite communications environment involved the cooperative solving of predetermined problems by the participants. It was designed specifically to compare the effects of satellite transmission on audio teleconferencing rather than to evaluate the concept of teleconferencing itself. Each session used either the satellite teleconferencing network or a 'control' terrestrial network. Only the co-ordinator was aware of the underlying communications medium used for the session.

Tests were to be conducted using both two and three test site configurations, with two participants at each test site. The same participants went through each test twice, completing a subjective evaluation questionnaire after each session.

The original plan called for testing to be carried out between Montreal, Ottawa/Hull and Toronto using the CNCP 4-wire bridge in Toronto when using the satellite facilities, and the operator handled 2-wire bridge in Ottawa for the terrestrial tests. Technical problems encountered by CNCP with the 4-wire bridge prevented its use in the trial. By a coincidence of scheduling, a 2-wire 'meet-me' bridge (located in Ottawa) was available to GTA under the Bell Canada 'Conference 300' Market Trial program. The test plan was modified to use this bridge for both the satellite and terrestrial tests. For a variety of operational reasons, it was decided to replace the Montreal test site with a second test site in Toronto.

As a result of the technical delays, only the first test phase could be completed. The findings are therefore not statistically meaningful, but do reveal the overall impression of the co-ordinators and the limited number of participants.

The network configuration used for the teleconferencing trial is shown in Figure IV.11. Each location used a standard conference room or office equipped with a 'Darome Convener' audio teleconferencing terminal. The Darome equipment consisted of a loud-speaker cum electronics box connected to a set of 'daisy chained' microphones which were continuously 'live'. The 'meet-me' bridge was connected to the regular Bell local dial network. For terrestrial access, the two Toronto test sites used the government inter-city network. For the satellite tests they used voice circuits of the SLIM-TDMA network.

3.2 Evaluation Tests

Two different types of tests were developed to observe and evaluate the performance of the teleconferencing network; both in a satellite and terrestrial communication environment. The first and most elementary was a 'reading test' intended mainly to verify the basic operation of the teleconferencing network. The second, was a problem solving task designed to measure the participants' subjective reaction to the teleconferencing network.

The 'reading task' was a rigidly controlled test designed to enable the co-ordinators to observe the effects of the channel delay through the satellite. It involved the reading of a predetermined script by the participants at each test site. At designated points throughout the script, the reading would be taken over by a different participant. The activity was analogous to the reading of a play in which each participant portrays a different character.

Two variations of this test were used. In the first, each participant read his or her assigned passage, then stopped. The next participant would begin reading as soon as this break occurred. In the second version, the first reader would continue reading past the designated stop point until interrupted by the second participant.

The problem solving task consisted of a path finding exercise using a set of city maps, each marked with a unique and mutually exclusive set of road blocks. The object was to find, through interaction among the participants, the unique road block free path between two designated points. A 'route director', initially selected at random, called out what he believed was a clear path by specifying the direction to be taken at each intersection. Any other participant finding a road block indicated on the specified street, declared the block, then assumed the role of route director, continuing to give verbal directions until another participant encountered a road block and interrupted. Upon completion of the route (or after 20 minutes) the participants stopped and completed the supplied questionnaires.

For each route finding test, the same participants were used for both the satellite and terrestrial evaluations. The instructions, materials and maps used for the tests are attached as Appendix C.

3.3 Test Procedure

GTA/DDE developed a detailed test procedure that was based on the initial test plan, but adapted to the revised equipment configuration. The procedure was divided into three separate phases; pre-trial testing, teleconferencing experiments, and real, unconstrained teleconferencing. All tests were designed to provide a direct comparison of teleconferencing through satellite and through terrestrial facilities. At any point, the decision to proceed with the next phase of the trial depended on the success achieved to that point. The main elements addressed in each phase were as follows:

Phase 1 - Pretrial Tests

The pre-trial portion of the evaluation consisted of a series of tests, first to establish the technical operability of the equipment, then to test its basic performance with real users, and finally, to dry run the user interaction test. The decision logic and relationship among the various tests in Phase 1 is illustrated in Figure IV.12.

{1} Determine the system is technically functional in each of the required network arrangements.

{2} Co-ordinators carry out preliminary testing with the 'reading tests' to verify the operation of each teleconferencing configuration with 'real users' and observe the presence of transmission delay.

{3} Single-Hop 'Reading' Test with 3 nodes - This was a preliminary test of the teleconferencing network using the 'reading' test. The participating locations were Ottawa, Hull and the GTA office at 55 St. Clair in Toronto. Ottawa and Hull accessed the bridge through local terrestrial facilities and Toronto through the satellite network. The test was later repeated with all sites accessing the bridge through the terrestrial network.

{4} Single-Hop 'Problem Solving' Test with 3 nodes - This was a dry run of the 'path finding' test carried out by 6 participants, 2 at each location. The participating locations were Ottawa, Hull and the GTA office at 55 St. Clair in Toronto. Ottawa and Hull accessed the bridge through local terrestrial facilities and Toronto through the satellite network. The test was later repeated with all sites accessing the bridge through the terrestrial network.

Each participant completed an evaluation questionnaire immediately after the termination of the test.

{5} <u>Double-Hop 'Reading' Test with 2 nodes</u> - This was a preliminary test of the teleconferencing network in a double-hop environment using the 'reading' test. The participating locations for this test were the two Toronto offices. For the first part, both accessed the bridge in Ottawa over the satellite network. The experiment was then repeated using the government terrestrial inter-city network.

{6} <u>Double-Hop 'Problem Solving' Test with 2 nodes</u> - This was a dry run of the route finding test carried out by 6 participants, 2 at each location, and using a double-hop network configuration. The participating locations for this test were the two Toronto offices. For the first part, both accessed the bridge in Ottawa over the satellite network. The experiment was then repeated using the government terrestrial inter-city network. Questionnaires were completed by all participants immediately after the test.

{7} Based on the evaluation of the dry run tests, decide whether to proceed to phase two.

<u>Phase 2 - Experimental Test</u>

{1} Full or partial implementation depending on the results of Phase 1.

{2} Controlled tests with 12 sets of participants for paired satellite and terrestrial tests.

{3} Develop a statistically meaningful conclusion on the differences between satellite and terrestrial teleconferencing.

<u>Phase 3 - Real Teleconferences</u>

{1} Depending on the outcome of Phases 1 and 2, and the time constraints of the trial.

{2} Uncontrolled real teleconferences, after which the participants complete a Phase 3 questionnaire.

3.4 Results

Because of the technical difficulties with the teleconferencing equipment, only Phase 1 of the test plan could be completed before the end of the trial. Table IV.9 summarizes the findings of the preliminary tests carried out by the co-ordinators. The single-hop tests were conducted using 3 test sites, and double-hop tests were done in a 2 test site configuration. All tests were then repeated using the same geographical configuration, but with the terrestrial network throughout.

It was found that the losses experienced over the satellite link were noticeably less than the losses through the terrestrial network. This caused a problem for the 3-test site testing in that the teleconferencing terminal in Ottawa could not be adjusted to obtain approximately equal sound levels from both Toronto and Hull when the satellite link was one arm of the network.

Some voice distortion was also encountered during the single-hop tests, but was probably caused by the users speaking too closely to the microphones rather than by the network itself.

When teleconferencing with a single satellite hop, the transmission delay caused by the satellite was noticeable, but not found to be objectionable. When a double satellite hop was used in the network, the delay was immediately apparent; however, due to the structured nature of the reading test, the double-hop delay was not perceived to be objectionable.

Table IV.10 compares the results of the evaluation questionnaires for the route finding exercise conducted in a 3-test site, single hop satellite and 3-test site terrestrial teleconference configuration. Table IV.11 compares the responses to the evaluation questionnaires for the same 'path finding' exercise conducted in a 2-test site satellite double hop and 2-test site terrestrial configuration.

3.5 Conclusions

Two main conclusions can be reached as a result of the teleconferencing experiments conducted under the trial:

(1) A single-hop connection between any two test sites of an audio teleconference network performs as well as the

terrestrial equivalent, even in a highly interactive meeting environment. The single-hop delay was not consciously noticed by the participants and did not seem to affect the real or perceived ease with which remote participants could interrupt each other.

{2} From the double-hop tests it would appear that the participants found it more difficult to interrupt each other than when the equivalent terrestrial configuration was used. This result may be somewhat clouded by the fact that it was the first test in the dry run of the route finding exercises, and the participants had not yet become thoroughly familiar with the procedure.

{3} In an operational teleconferencing environment, considerable care must be taken to assure that the accumulated loss at each test site from every other test site is the same. A significant difference in the signal levels received from two test sites can be very distracting to the users.

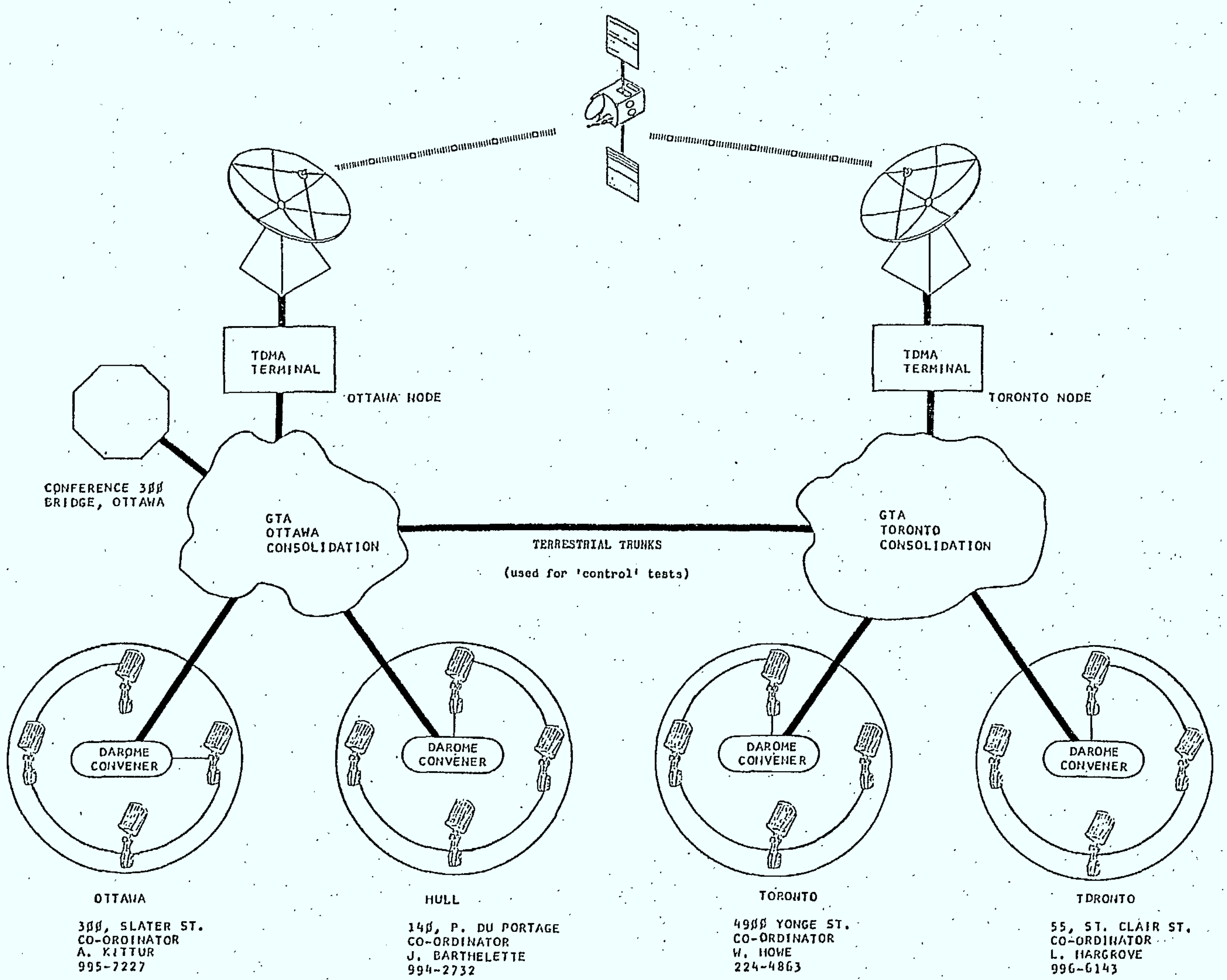

Figure IV.11 - Teleconferencing Network Configuration

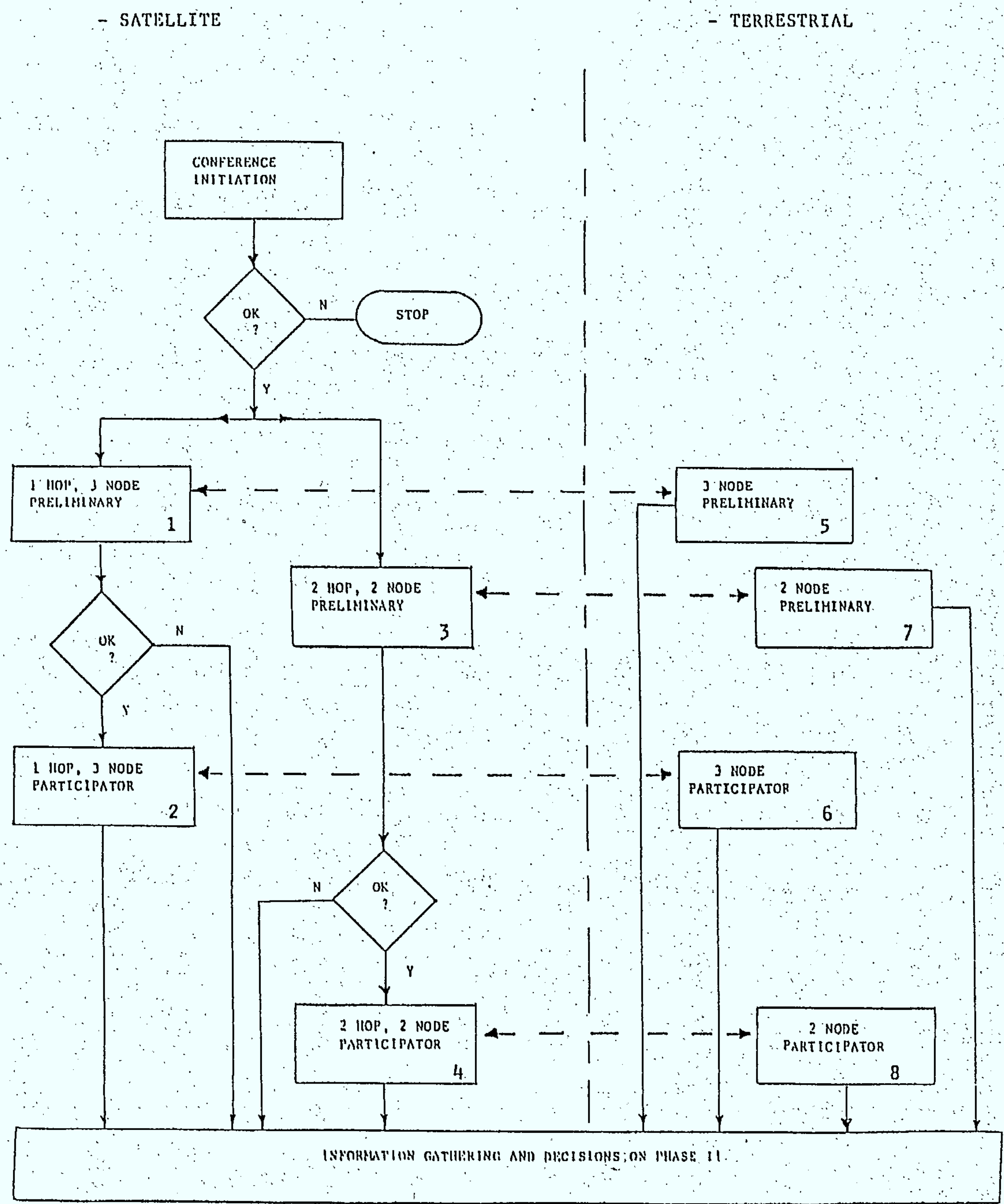

Figure IV.12 - Teleconferencing Phase 1 Test Plan

Test Condition	Co-ordinator Comments
3-test site (Single-Hop)	HULL - Ottawa received at lower volume than Toronto. Ottawa was not as clear as Toronto. OTTAWA - Received Hull at a lower volume than Toronto. Hull came through distorted. TORONTO - Received Ottawa and Hull at a similar volumes but Hull was distorted. All users noticed a delay in interaction between Ottawa-Toronto and Hull-Toronto as compared to that between Hull-Ottawa.
3-test site (Terrestrial)	Levels at all three locations were about equal. No delay in interaction was perceived.
2 test site (Double-Hop)	Levels were much better than for the single-hop test. The double-hop delay was definitely noticeable. Some distortion was experienced at both locations.
2 test site (Terrestrial)	Clearer reception than in the double-hop test. The lack of delay was immediately noticed.

Table IV.9 - Results of Preliminary Tests

Participant #	Location	Previous Teleconf. Experience	Overall Rating Question 15		Difficulties Experienced Question 17		Ease of Interruption by Remote Locations Question 18	
			Satellite	Terrestrial	Satellite	Terrestrial	Satellite	Terrestrial
1	Ottawa	none	good	good	little noisy	little noisy static	as easy	as easy
2	Ottawa	none	good	good	noise	-	as easy	as easy
3	Toronto	none	fair	good	low level noise clicks	-	as easy	as easy
4	Toronto	Some;audio	good	excellent	Hull low level	-	as easy	as easy
5	Hull	none	good	good	local noise from construction	low level of one participant	as easy	as easy
6	Hull	none	excellent	excellent	clicks on line	low level of one participant	as easy	as easy

Table IV.10 - Results of Single-Hop/3 Node Tests

Participant #	Location	Ease of Interrupting Remote Locations Question 21		Ease of Following Ongoing Interaction Question 24		Nature of Difficulty in Following Interaction Question 25		Additional Comments Question 26	
		Satellite	Terrestrial	Satellite	Terrestrial	Satellite	Terrestrial	Satellite	Terrestrial
1	Ottawa	as easy	as easy	moder. easy	very easy	-	-	dist from mic. may cause level variation	-
2	Ottawa	as easy	as easy	moder. easy	moder. easy	-	-	video teleconf. would aid task	-
3	Toronto	as easy	as easy	some diff.	some diff.	difficulty finding names on map	difficulty finding names on map	Difficulty assoc. voices with people	-
4	Toronto	as easy	as easy	moder. easy	very easy	-	-	-	-
5	Hull	as easy	as easy	some diff.	moder. easy	trouble orienting map	-	-	-
6	Hull	as easy	as easy	very easy	very easy	-	-	local const. noise made it hard to	variation in talker levels

Table IV.10 - Results of Single-Hop/3 Node Tests (cont'd)

Participant #	Location	Previous Teleconf. Experience	Overall Rating Question 15		Difficulties Question	Experienced 17	Ease of Interruption by Remote Locations Question 18	
			Satellite	Terrestrial	Satellite	Terrestrial	Satellite	Terrestrial
1	Toronto St. Clair	some audio & visual	fair (Excessive delay)	fair (low level)	noisy, clicks low level, distorted	noisy, fading low level	less easy	as easy
2	Toronto St. Clair	none	good	poor (low level)	too many people speaking @ once	fading - one person dominates	as easy	as easy
3	Toronto Yonge St.	none	fair sound not clear	good	sound not clear	more echo than system 'C'	more easy	not sure
4	Toronto Yonge St.	none	fair static, low level	fair noticeable delay	static, distortion low level, fading echo	distortion echo	less easy	less easy

Table IV.11 - Results of Double-Hop/2 Node Tests

Participant #	Location	Ease of Interrupting Remote Locations Question 21		Ease of Following Ongoing Interaction Question 24		Nature of Difficulty in Following Interaction Question 25		Additional Comments Question 26	
		Satellite	Terrestrial	Satellite	Terrestrial	Satellite	Terrestrial	Satellite	Terrestrial
1	Toronto St. Clair	some diff. not disturbng	as easy	some diff.	some diff.	understanding directions map congested	following street names & directions	-	experience helped in this test
2	Toronto St. Clair	some diff.	some diff.	moder. easy	moder. easy	-	-	some didn't follow rules going too fast	moderator req if people inexperienced
3	Toronto Yonge St.	not sure	more easy	moder. easy	moder. easy	-	-	Difficulty assoc. voices with people	-
4	Toronto Yonge St.	some diff.	some diff.	some diff.	moder. easy	-	-	-	easier than before. voices clear

Table IV.11 - Results of Double-Hop/2 Node Tests (cont'd)

4 COMMUNICATING WORD PROCESSORS

4.1 Overview

Word processors are used extensively within the Federal government and are rapidly replacing the ordinary typewriter for the production of memos, reports and administrative documents. At the present time, most of these documents are distributed through the mail in final hard copy form. The availability of low cost communication facilities could make it feasible to speed delivery by transferring documents between word processors as text files, to be printed on a machine that is closer to the recipient(s).

The plan for testing the operation of communicating word processors in the satellite field trial was designed to determine the net effect of satellite transmission from the user's perspective. The objectives were twofold; first, to demonstrate the feasibility of communication between word processors through a satellite channel, and second, to compare the effect of satellite propagation delay on the transmission time of the text file compared to the transmission time of the same file delivered through terrestrial facilities.

The test configuration, shown as Figure IV.13, consisted of two AES 'PLUS' word processors, one located at GTA in Ottawa, the other at the GTA regional office in Toronto. The experiment used the same dial-up facilities through the SLIM-TDMA network as the telephony experiments.

4.2 Test Procedure

All tests were conducted daily during the lunch hour when the machines were otherwise idle, and involved the transmission of a pre-determined text file. The file was transmitted from the AES word processor in Ottawa to the receiving word processor in Toronto, first using the dial-up facilities of the SLIM-TDMA network, then the government's inter-city terrestrial network. Transmissions were attempted every day from November 22, 1982 until February 11, 1983, for a total trial period of 30 days. All communications were managed by AES' proprietary point to point communications protocol, and recorded for later analysis with an Interview 4500 dataline monitor located in Ottawa. The total time required to transmit the test file was recorded for each transmission run.

The test file comprised a total of 16 pages of text divided into two sections. The first part was a continuous alternating pattern of the characters 'U' and '*', a sequence used frequently in communications testing. The ASCII representation of this character string is an alternating bit pattern (10101010....) that can be susceptible to transmission errors. The second part of the test transmission was the standard 'quick brown fox' message sent alternately in upper and lower case.

The beginning and end of the transmission sequence were denoted by the key words 'BEGIN' and 'END TEST' respectively. The monitoring equipment was programmed to recognize these character strings as markers for transmission timing.

The AES synchronous, point to point communication protocol transmits the text in blocks. A positive acknowledgment must be received for each block before the next can be sent. If a negative acknowledgment is received, the block size is divided in two and the sender tries again. The block size is halved each time a transmission error occurs. If it becomes shorter that a predetermined limit, the machine automatically stops transmitting, and breaks the connection.

4.3 Results

The test results of the communicating word processor transmission tests are summarized in Table IV.12. The satellite facilities were accessed a total of 42 times during the 30 days available for testing. On 5 days the facilities were found to be inoperative; however, during the other 25 days, a total of 37 valid connections were established over the satellite facilities. In 2 cases testing could not be done because the receiving machine was in use, leaving 35 actual transmission tests over the satellite facilities. The terrestrial circuit was available on each attempt and a total of 33 transmissions were carried out. The availability of the satellite circuit was therefore 83.3% compared to 100% for the terrestrial equivalent.

The mean transmission time through the satellite network was found to be 482.5 seconds with a standard deviation of 13.2 seconds. The mean time through the terrestrial network was 449.8 seconds with a standard deviation of 14.0 seconds. Overall, the transmission times for both networks ranged from 440 seconds to 530 seconds. Figure IV.14 illustrates the distribution of these times in histogram form for both the satellite and the terrestrial connections.

During 20 transmissions of the test file through the satellite facilities, a total of 7 block errors were detected. Based on a total of 978 blocks in each transmission, this translates to a block error rate of 0.358 errors per thousand blocks with a 95% confidence of the error rate falling between 0.07 and 0.64 errors per thousand blocks.

A total of 10 block errors were detected in the 30 file transmissions sent through the terrestrial facilities. This corresponds to an average error rate of 0.341 errors per thousand blocks with a 95% confidence that the actual error rate falls between 0.11 and 0.57 errors per thousand blocks.

Of those connections that were successfully established through the satellite network, only 57.1% were completed without an abnormal termination. The successful completion rate using the terrestrial network was 90.9%.

4.4 Conclusions

The following conclusions can be drawn from the results of the communicating word processor tests:

{1} The AES synchronous, point to point communications protocol functions with the delay encountered over single hop satellite transmission circuits. The higher number of abnormal terminations encountered with the satellite facilities, however, would indicate that recovery is less likely than when using terrestrial communications.

{2} The propagation delay of the satellite circuit increases the transmission time by about 7.3% compared to the terrestrial equivalent.

{3} Averaged over several days, the variation in transmission time to deliver the same text file was approximately the same for both satellite and terrestrial facilities.

{4} There is no significant difference in the block error rate of the terrestrial and satellite circuits.

{5} Over 40% of all transmissions through the satellite network were abnormally terminated after the connection had been successfully established. This level of reliability would not be acceptable in an operational environment.

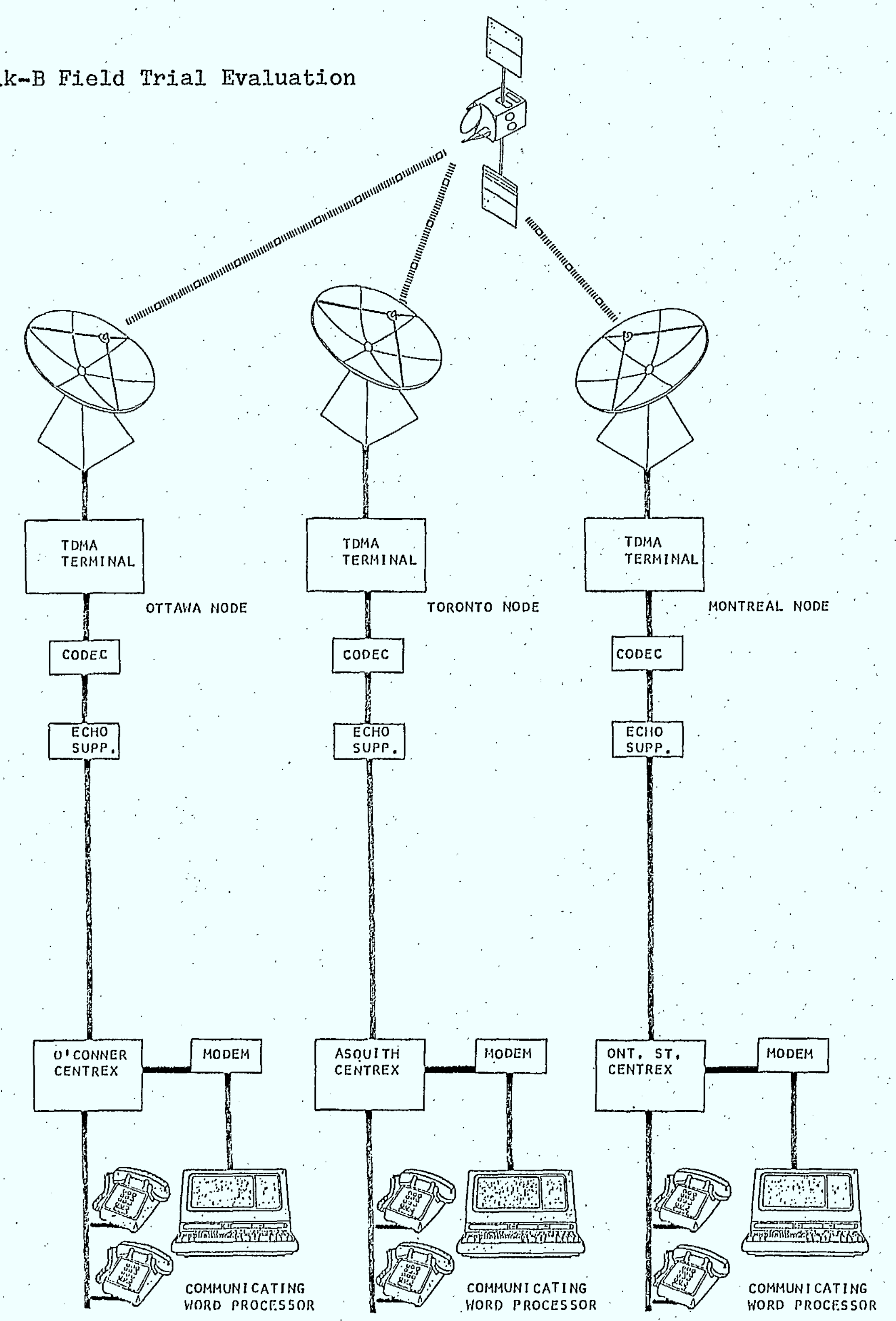

Figure IV.13 - Communicating Word Processor Configuration

Description	Satellite	Terrestrial
Total Transmission Attempts	35	33
Completed Transmissions		
Total Completed	20	30
Percentage of Total Attempts	57.1	90.9
Transmissions Aborted or Failed		
Total Aborted	15	3
Percentage of Total Attempts	42.9	9.1
Error-Free Transmissions		
Total	15	22
Percentage of Total Attempts	42.9	66.7
Summary of Retransmissions		
Total Completed with 1 Retransmit	4	6
Total Completed with 2 Retransmits	0	2
Total Completed with 3 Retransmits	1	0
Total Retransmits	7	10

Table IV.12 - Communicating Word Processor Test Results

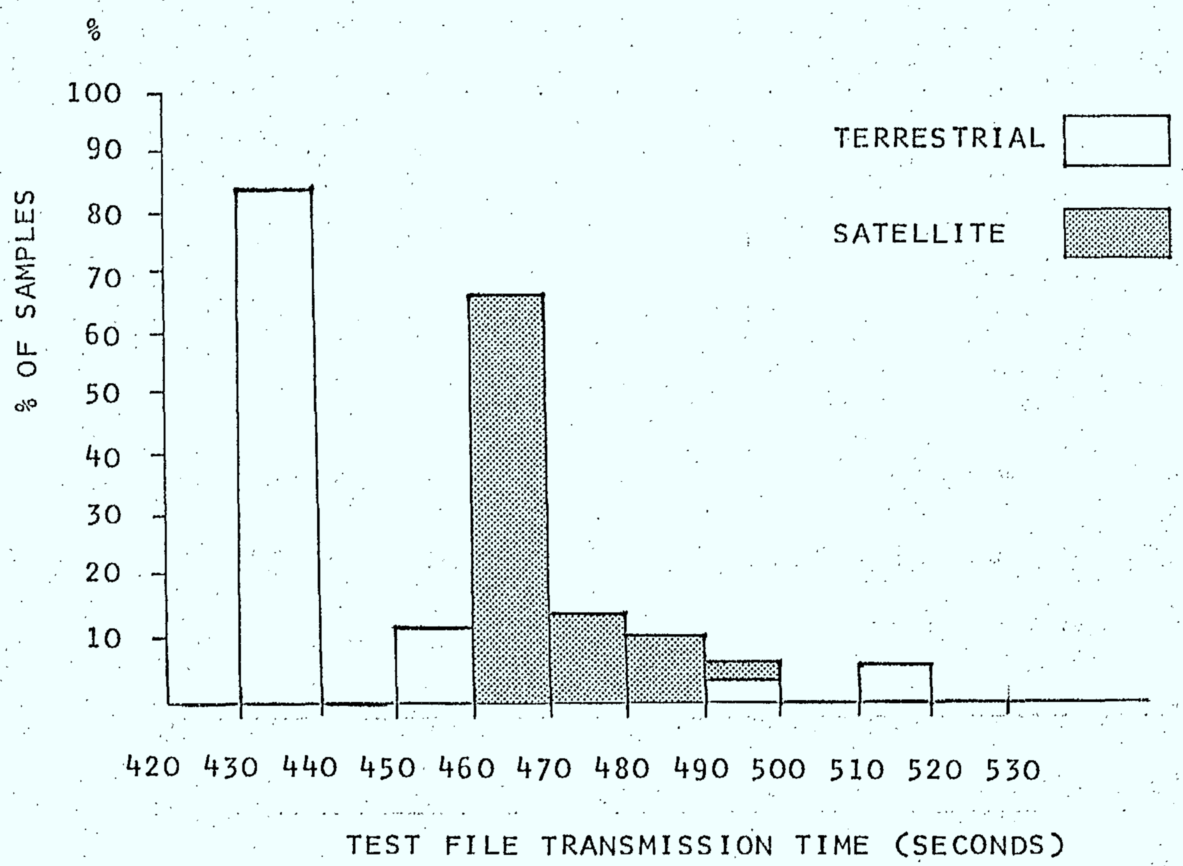

Figure IV.14 - CWP Transmission Time Distribution

5 INFOTEX

5.1 Overview

Infotex is a value added, electronic store and forward service provided by CNCP. It is normally accessed and used by specially equipped communicating word processors, but also provides a gateway for access by terminals on the TELEX network. The objective of the test was to demonstrate the feasibility of communication between Infotex terminals where one of the devices accesses the network through satellite facilities.

5.2 Test Procedure

In the trial, tests were carried out using 3 terminals, all located at the Division of Development and Engineering in GTA headquarters at 300 Slater St., Ottawa. The communications configuration used for this application is illustrated as Figure IV.15. The terminals used for the test were:

{1} Micom 2001 (communicating word processor)

{2} Nelma (communicating word processor)

{3} Extel (Telex terminal)

The Micom terminal was hardwired to a satellite trunk, the remote end of which terminated on an Infoswitch access port in Toronto. The Nelma terminal was hardwired through terrestrial facilities to an access port of the Infoswitch network in Montreal. The Extel terminal was connected to the commercial Telex network. A gateway between the Telex network and the Infotex network provides bi-directional access through the Infoswitch facilities in Toronto.

Test sessions were conducted each weekday from January 10, 1983 until February 11, 1983. Each session consisted of five different tests involving all three terminals.

Two standard messages, denoted 'A' and 'B' were defined. Message 'A' comprised approximately 150 words using both upper and lower case characters as well as numerals. Message 'B' consisted of approximately 25 words of text in upper case only. It was intended for transmission from the Telex terminal since this service uses only upper case characters.

The daily transmission sequence was as follows:

{1} Send message 'A' from terminal 1 to itself (Micom only)

{2} Send message 'A' from terminal 1 to terminal 3 (Micom-Extel)

{3} Send message 'B' from terminal 3 to terminal 1 (Extel-Micom)

{4} Send message 'A' from terminal 2 to terminal 1 (Nelma-Micom)

{5} Send message 'A' from terminal 1 to terminal 2 (Micom-Nelma)

A daily log of the tests was kept. Since the delay between sending and receiving the message depends primarily on the service loading, rather than the propagation delay, this factor was not recorded, except for the occasional spot check to gauge the typical variation.

5.3 Results

The results of the daily testing are summarized in Table IV.13. A total of 100 tests were conducted over a total of 20 testing days. Eleven tests experienced major difficulties that prevented reception of the message. Of these, 7 were caused by being cut off during transmission, 2 were directly attributed to failure of the satellite system, and in 2 cases, the transmission appeared to proceed normally but the messages never arrived at the receiving end.

Table IV.14 shows the total number of transmission attempts made for each type of message, the proportion of successful attempts, and a classification of the reason for failure as caused either by satellite or terrestrial facilities.

Overall, the delay from sending a test message to its reception ranged from a minimum of slightly under one minute, to a maximum of 47 minutes.

An idiosyncrasy was observed in both tests 2 and 5 which did not appear to be related directly to the satellite facilities, but which, nevertheless, deserves comment. In test 5, two strings of control characters consistently appeared imbedded in the received text as part of the text. In each case they had to be edited from the received message prior to printing. Failing to erase the strings caused the Nelma terminal to issue a system control error.

The first string ('PrW085'), a printer control sequence, always occurred at the head of the received message (Position 000 000). The second string ('PrS1.0.'), a system control sequence, immediately followed the first string in cases where the text did <u>not</u> begin on the first line. Where the message text began on the first line of output, the control string always appeared after the first word on the <u>second</u> line.

In test 1, a sequence of 13 spaces was found to be inserted into each of the received messages. Where the message text began at the beginning of the first line (Position 000 000), the sequence appeared at the end of the first sentence. Where the text began on the first line, but did not start at the beginning of the line, the sequence was inserted ahead of the text (in Position 000 000).

5.4 Conclusions

It can be concluded from the test results that the use of a satellite channel to access the Infoswitch network and Infotex facilities is feasible, and offers approximately the same level of performance as found using terrestrial facilities.

Based on the limited amount of testing carried out, the availability of the system was found to be 94.7% for the satellite facilities. The overall availability, however, considering both terrestrial and access failures was only 88%.

During the tests, strings of control characters were erroneously and consistently imbedded in the messages received by both the Micom and Nelma terminals. It can be concluded that this was a problem within the Infotex software and had no direct relevance to the evaluation of satellite access.

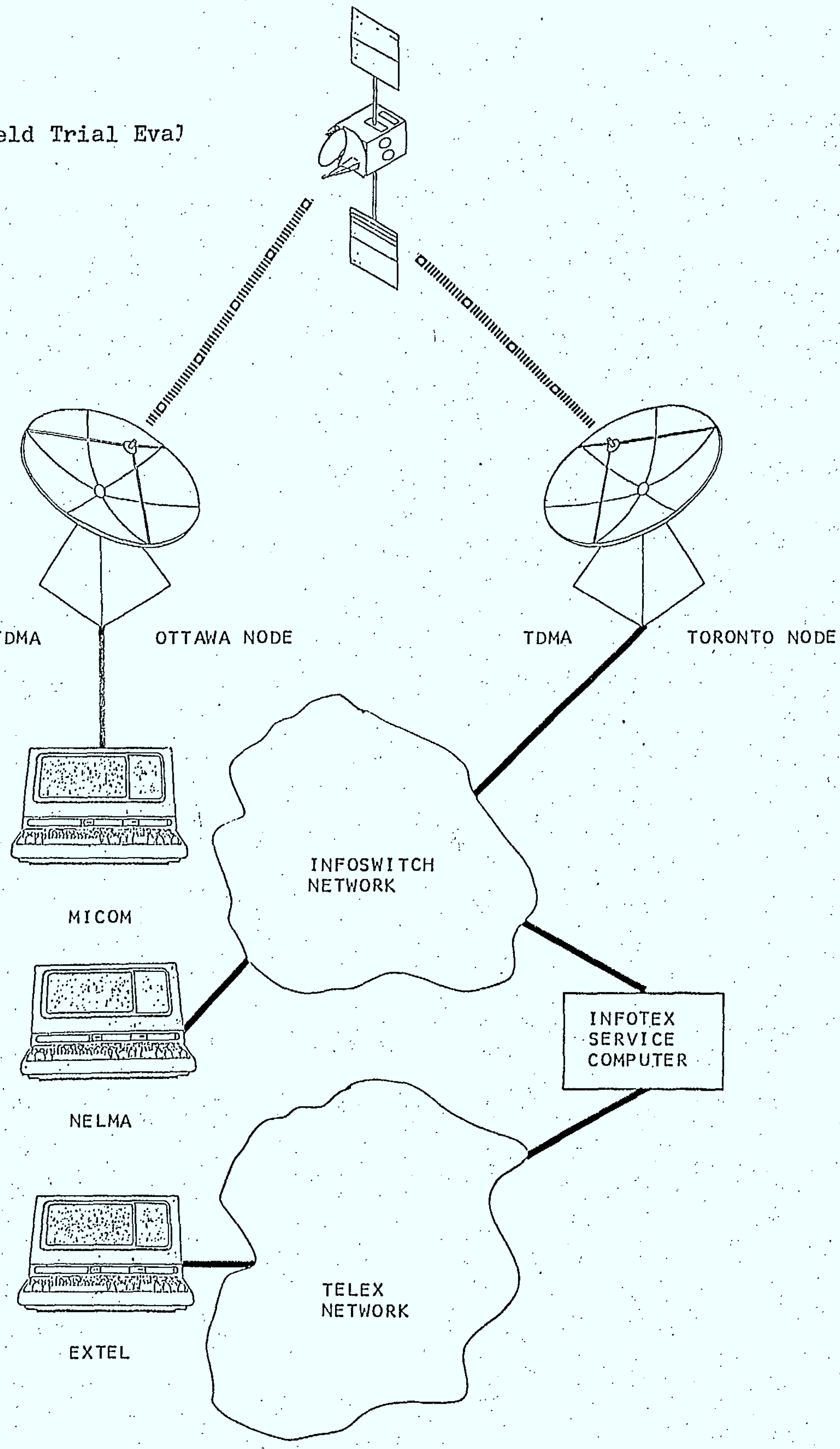

Figure IV.15 - Infotex Communications Configuration

Date	Test # 1	Test # 2	Test # 3	Test # 4	Test # 5
Jan 10	Passed	Passed	Passed	Failed	Passed
Jan 11	Passed	Passed	Failed	Failed	Failed
Jan 12	Passed	Passed	Passed	Passed	Passed
Jan 13	Passed	Passed	Passed	Passed	Passed
Jan 14	Passed	Passed	Passed	Passed	Passed
Jan 17	Passed	Failed	Failed	Failed	Failed
Jan 18	Passed	Passed	Passed	Passed	Passed
Jan 19	Passed	Passed	Passed	Passed	Passed
Jan 20	Passed	Passed	Passed	Passed	Passed
Jan 21	Passed	Passed	Passed	Passed	Passed
Jan 24	Passed	Passed	Passed	Passed	Passed
Jan 25	Passed	Passed	Passed	Passed	Passed
Jan 27	Passed	Passed	Passed	Passed	Passed
Jan 31	Passed	Passed	Passed	Passed	Passed
Feb 1	Passed	Passed	Passed	Passed	Passed
Feb 2	Passed	Passed	Failed	Failed	Passed
Feb 3	Passed	Passed	Passed	Passed	Passed
Feb 4	Passed	Passed	Passed	Passed	Passed
Feb 10	Passed	Passed	Failed	Passed	Passed
Feb 11	Passed	Passed	Passed	Passed	Passed

Table IV.13 - Summary of Infotex Test Sessions

Test Number	Number of Attempts Made	Number of Terrest. Failures	Number of Satellite Failures	Successful Attempts (Total) Qty	Successful Attempts (Total) Percent	Success Rate Excluding Terres. Failures
1	21	0	0	21	100.00	100.00
2	22	0	2	20	90.91	90.00
3	22	2	2	18	81.82	88.89
4	22	3	1	18	81.82	94.44
5	22	3	0	19	86.36	100.00
Overall Averages					88.07	94.79

Table IV.14 - Summary of Infotex Failures and Availability

APPENDIX A

TELEPHONY INTERVIEW QUESTIONNAIRE

QUESTIONS A-G TO BE COMPLETED BY SURVEYOR. (DAILY TELEPHONY TEST)
(These are not questions to be asked over the telephone connection).

A. Name of Participant: -

B. Department (check mark): - AES ____
CEIC ____
DOC ____

C. Date and Time of 1st call: - Day ____ Month ____ Year ____
Hour ____ Minutes ____

D. Access code used for 1st call
(check mark) :- 186 ____ ; XXX ____

E. Date and Time of 2nd call: - Day ____ Month ____ Year ____
Hour ____ Minutes ____

F. Access code used for 2nd call
(check mark; must not be same as
that in question D): - 186 ____ ; XXX ____

G. Surveyor Initials: - ____________

FIRST CALL

(For questions which list alternatives, place a check mark beside the best answer. Some questions have a response that has to be written instead of or in addition to providing alternatives to check. If you need more space for any answer, please use the reverse side of the page.)

1. Typically, how frequently do you make long distance calls at work?

almost every day	_______
2 to 4 times per week	_______
once a week	_______
less often than once per week	_______

2. In your opinion which of the following words best describes the overall circuit quality during this call?

excellent	_______
good	_______
fair	_______
poor	_______

3. (This question to be asked only if response is 'fair' or 'poor'.)

How would you describe any problems with this connection?

4. How does this call compare in circuit quality with typical calls you have received from the same city previously over the government network? Would you rate this as

better	________
same	________
worse	________

5. The following words describe some of the difficulties sometimes found in telephone connections. Which words, if any in your opinion describe the present connection (check on left and write comments in right if necessary)

________	noise	________________________
________	loudness	________________________
________	distortion	________________________
________	other voices on the line	________________________
________	echo	________________________
________	fading	________________________
________	other	________________________

6. Due to the circuit, does there seem to be any more or any less hesitation or awkwardness in the conversation during this call than you have experienced in typical calls from Ottawa when you used the government network?

more	________
same	________
less	________
not sure	________

7. (Ask this question only if answer to question 6 was 'more')
How disturbing did you find the hesitation or awkwardness?

more difficult	________
no difference	________
easier	________
not sure	________

8. Do you have any further comments you wish to make about the quality of the circuit during this call, or about any other relevant matters?

APPENDIX B

TELEPHONY HANDOUT QUESTIONNAIRE

INSTRUCTIONS

The attached questionnaires are part of a test of long-distance telephone circuits. The first questionnaire page contains a few general questions needed for data analysis. Subsequent pages contain two identical sets of questions, one set for each of two calls that you are asked to evaluate. These are calls that you will make, as described below. It is important for test purposes that the questionnaires be filled out as soon as possible after completing each call.

The two calls you are asked to make and evaluate are preferably ones that you would have made anyway, in the normal course of a work day, and not calls that you make especially for this test. You are free to choose any normal long distance call that you would have placed over the government network as the first test call. For this call, use the special long distance access code that you have been given for the city you are calling. Immediately after finishing this call, please complete the questionnaire which is labelled "first test call".

The second test call, preferably, should be the very next one you make to the same city as the first call, regardless of how little or how much time elapses between the first and second test calls. But, for this second test call, use the usual government access code for that city that you normally use (as listed in the front of the government telephone directory) and not the special code you used for the first test call. Immediately after finishing this call, please complete the questionnaire labelled "second test call".

For the second test call, it does not matter whether the person you call is or is not the same person as in the first test call. This second test call will, of course, use the normal government long distance network. However, in completing the questionnaire, make your judgements of the second test call in the same way as you did for the first test call, regardless of whether the connection quality of this second test call is or is not typical of calls that you have made to that city in the past.

The questionnaires are coded so that they can be treated as both coming from the same person. This is necessary for statistical analysis of the data. But your actual identity does not enter analysis and will not be known by anyone dealing with your specific questionnaire responses.

After completing the questionnaires for both calls, please return them in the addressed envelope provided.

Thank you for your cooperation.

GENERAL QUESTIONS

The questions on this page are necessary for various statistical breakdowns of the data.

Sex   Male ___

       Female ___

Age
20 - 30 ___
31 - 40 ___
41 - 50 ___
51 - 60 ___
61 - 70 ___
over 70 ___

Typically, how frequently do you make long distance calls at work?

almost every day ___
2 to 4 times per week ___
once a week ___
less often than once per week ___

FIRST TEST CALL

For questions which list alternatives, place a check mark beside the best answer. Some questions ask for a brief written answer, instead of or in addition to providing alternatives to check. If you need more space for any answer, please use the reverse side of the page.

1. Origin of this call
   - Montréal ___
   - Ottawa ___
   - Toronto ___

2. Destination of this call
   - Montréal ___
   - Ottawa ___
   - Toronto ___

3. Time of successful placement of call
   - calendar date ______________
   - clock time ______________
     - a.m. ___
     - p.m ___

4. Long distance access code that you used for this call ___________

5. Have you ever spoken to the other party by telephone before this call?
   - yes ___
   - no ___
   - not sure ___

6. Approximately how long did this call last?
   - less than one minute ___
   - 1 - 2 minutes ___
   - 2 - 3 minutes ___
   - 3 - 4 minutes ___
   - 4 - 5 minutes ___
   - more than 5 minutes ___
   - not sure ___

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7. Which word best describes the overall circuit quality during this call?

excellent ___
good ___
fair ___
poor ___

8. If your answer was "fair" or "poor" to the question above, briefly describe any problems with the circuit.

9. How did this call compare in circuit quality with typical calls you have made to the same city previously when you used the government network? This call was better ___
same ___
worse ___

10. The following alternatives describe some of the difficulties which may be found in telephone circuits. Check any that apply to this call at the left of the alternative. Further describe the difficulty briefly in the space to the right of each alternative that you checked.

___ noise ______________________________

___ loudness ______________________________

___ distortion ______________________________

___ other voices on the line ______________________________

___ echo ______________________________

___ fading ______________________________

___ other ______________________________

Sometimes due to circuit conditions, people experience various problems in carrying on normal conversation. The following questions (numbers 11 to 17) refer to problems of this type.

11. Due to the circuit, did there seem to be any more or any less hesitation or awkwardness in the conversation during this call than you have experienced in typical calls to the same city when you used the government network?

more ___
same ___
less ___
not sure ___

12. If you checked "more" in the question above, how disturbing did you find the hesitation or awkwardness?

very disturbing ___
somewhat disturbing ___
not disturbing ___
not sure ___

13. Due to the circuit, did the party you called interrupt you while you were speaking, more often, less often or to about the same degree as in typical calls to the same city when you used the government network?

more often ___
same ___
less often ___
not sure ___

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14. If you checked "more often" in the question above, how disturbing did you find these interruptions?

very disturbing ___
somewhat disturbing ___
not disturbing ___
not sure ___

15. In your own natural conversational attempts to interrupt the other party while they were speaking, did you experience more difficulty, greater ease, or no difference in ease or difficulty of interrupting than in typical calls to the same city when you used the government network?

more difficulty ___
no difference ___
greater ease ___
not sure ___

16. If you checked "more difficulty" in the question above, how disturbing was this?

quite frustrating ___
somewhat frustrating ___
not frustrating ___
not sure ___

17. Do you have any further comments you wish to make about the quality of the circuit during this call, or about any other relevant matters?

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SECOND TEST CALL

For questions which list alternatives, place a check mark beside the best answer. Some questions ask for a brief written answer, instead of or in addition to providing alternatives to check. If you need more space for any answer, please use the reverse side of the page.

1. Origin of this call
   - Montréal ___
   - Ottawa ___
   - Toronto ___

2. Destination of this call
   - Montréal ___
   - Ottawa ___
   - Toronto ___

3. Time of successful placement of call – calendar date ______________
   – clock time ______________
   - a.m. ___
   - p.m ___

4. Long distance access code that you used for this call ___________

5. Have you ever spoken to the other party by telephone before this call?
   - yes ___
   - no ___
   - not sure ___

6. Approximately how long did this call last?
   - less than one minute ___
   - 1 – 2 minutes ___
   - 2 – 3 minutes ___
   - 3 – 4 minutes ___
   - 4 – 5 minutes ___
   - more than 5 minutes ___
   - not sure ___

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7. Which word best describes the overall circuit quality during this call?

excellent ___

good ___

fair ___

poor ___

8. If your answer was "fair" or "poor" to the question above, briefly describe any problems with the circuit.

9. How did this call compare in circuit quality with typical calls you have made to the same city previously when you used the government network? This call was

better ___

same ___

worse ___

10. The following alternatives describe some of the difficulties which may be found in telephone circuits. Check any that apply to this call at the left of the alternative. Further describe the difficulty briefly in the space to the right of each alternative that you checked.

___ noise ______________________________

___ loudness ______________________________

___ distortion ______________________________

___ other voices on the line ______________________________

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___ echo ____________________

___ fading ____________________

___ other ____________________

Sometimes due to circuit conditions, people experience various problems in carrying on normal conversation. The following questions (numbers 11 to 17) refer to problems of this type.

11. Due to the circuit, did there seem to be any more or any less hestitation or awkwardness in the conversation during this call than you have experienced in typical calls to the same city when you used the government network?

    more ___
    same ___
    less ___
    not sure ___

12. If you checked "more" in the question above, how disturbing did you find the hesitation or awkwardness?

    very disturbing ___
    somewhat disturbing ___
    not disturbing ___
    not sure ___

13. Due to the circuit, did the party you called interrupt you while you were speaking, more often, less often or to about the same degree as in typical calls to the same city when you used the government network?

    more often ___
    same ___
    less often ___
    not sure ___

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14. If you checked "more often" in the question above, how disturbing did you find these interruptions?

very disturbing ___
somewhat disturbing ___
not disturbing ___
not sure ___

15. In your own natural conversational attempts to interrupt the other party while they were speaking, did you experience more difficulty, greater ease, or no difference in ease or difficulty of interrupting than in typical calls to the same city when you used the government network?

more difficulty ___
no difference ___
greater ease ___
not sure ___

16. If you checked "more difficulty" in the question above, how disturbing was this?

quite frustrating ___
somewhat frustrating ___
not frustrating ___
not sure ___

17. Do you have any further comments you wish to make about the quality of the circuit during this call, or about any other relevant matters?

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APPENDIX C

TELECONFERENCING HANDOUT MATERIALS

THREE NODE (THREE GEOGRAPHIC LOCATION) AUDIO TELECONFERENCING TASK (6 PERSON)

GENERAL INSTRUCTIONS (Ph.1.pt.1.1Hp)

Purpose and nature of task

You are asked to trace a route between two points on a map by following a set of rules. The aim of this task is to test out a three node (or geographic location) audio teleconferencing system. The task is designed to ensure a high rate of verbal communication flow, with frequent interruption of, and by, all participants, and with equal sharing of listening and talking roles. Very little skill is involved in carrying out the task so that participants can focus on receiving and sending verbal communications.

The teleconferencing task is carried out using a set of six maps. The six maps are identical to each other ("Scarborough") except as noted later below. Each of six persons will use one and only one map of the set of six and should not see any of the other five maps during the course of working on the task. The maps are clearly labelled "1st person" to "6th person" at the lower left.

The task consists of discovering the unique route from one location to another. The two locations are each marked with a small circle. One is at "Warden Ave" and "Fairfax Cr." toward the bottom right of the map. The other is at "Railside Rd" and "Codeco Ct." at the left side of the map about half way up.

Supplementary instructions specify a time limit for tracing out a route. It is very unlikely that the route will be completely traced out within the set time limit. The important thing for the teleconferencing test is that the route tracing process is engaged in according to the rules stated below. Thus participants should not approach the test as a speed task. Speed is totally irrelevant here. The communication process is the only important factor.

Rules

Each of the short double lines which intersect many of the streets on each of the four maps represents a road block. A route cannot go through any road block. When a road block goes through more than one street, it blocks all those streets. Each road block applies only to that place on a street at which it is located. Thus, it is sometimes possible to go around a road block by using intersecting and adjacent streets.

Each of the six maps of the set contains a different set of road blocks from the other five maps. As mentioned above, the six maps are distinguished by the labels "1st person" through "6th person" at the lower left. Participants should make sure that the maps are correctly distributed so that no persons have the same maps. The task must involve all six maps of the set or else the one unique route from one location to another cannot be found.

As mentioned above, supplementary instructions will set a time limit. The supplementary instructions will also specify which of the two locations of the assigned route (the upper location or the bottom one) will constitute the "start" location. The other location will then be the "goal" or "finish" one. Participants should agree amongst themselves on which person will begin the route tracing task.

The beginning person should proceed to trace a route, announcing aloud the description of the attempted route, street block by street block, using compass directions (shown at the right on each map), and/or street names, and/or any other descriptions he or she wishes to use. It is very important that the person tracing the route does not skip ahead more than one street block at a time. Skipping ahead will only result in confusion and may defeat tracing out the unique correct route. It is highly recommended that compass directions, "left-right", "up-down" and the like are relied on as the primary descriptions since street names are sometimes difficult to locate unambiguously due to the nature of maps and due to the fact that the road blocks sometimes obscure words on the maps. Street names will need to be used, but as secondary, rather than primary descriptions.

The other participants should closely follow the beginning person's attempted route on their own maps. As soon as one of the participants detects a road block on his or her map which prevents the route being traced from proceeding, that participant should announce the existence of the road block immediately. Then, the person who detected and announced the road block should take over the task of tracing out a route, beginning from the place that was reached before the road block was announced. The person who has taken over tracing the route should also announce aloud the description of his or her attempted route, street block by street block, just as the beginning participant had done. He or she should continue until another participant detects and immediately announces a road block and takes over attempting the tracing of a route, and so on. Throughout the task, participants may mark their own maps with the route and with announced road blocks if they wish.

It is important to realize that the road blocks have been arranged so that it is not possible to progress along any street block that is not part of the correct route. There are no blind alleys. The only occasion where a street block must be abandoned is when a road block is detected. Whenever a road block is encountered it is never necessary to go back beyond the previous intersection. Wherever participants have reached on the map at any point in time is correct since no other route is possible. Any street block along which participants can progress is correct or else there would be a road block across it.

The process should continue, either until the time limit specified in the supplementary instructions has elapsed, or until the "goal" or "finish" location is reached. But the latter is very unlikely to occur. Road block detections and the consequent taking over of route tracing by different persons will occur with high frequency. Thus, there will be a continual and rapid shifting among the participants between the role of map observation and that of attempted route tracing. As mentioned before, there is one and only one correct route and its discovery should never entail going back to an earlier location reached previously. However, it is absolutely essential that all road blocks are correctly detected and announced for the correct route to be found. Otherwise the task cannot be done. This means that very close attention to their maps by all participants at all times is required. It also implies that all participants know exactly where on the map the route is at all times. Whoever is tracing the route at the moment should always ensure that everyone knows where he or she is, and should pause and clarify his or her location whenever necessary for any participant. Remember, speed is irrelevant so that nothing is lost by ensuring that all participants are following appropriately. Everything is lost if any one participant is not clear about location for then he or she will not be able to detect and announce a road block and the task will flounder.

The purpose of the above rules is to ensure that each participant shares equally in listening and talking, and in interrupting and being interrupted.

Therefore you are asked to follow the rules strictly and not yield to the temptation to allow any one person to play a dominant route tracing role. The latter might be more efficient but would defeat the aim of exposing each person equally to the critical features of teleconferencing systems which are being explored.

Completion

After completion of the teleconferencing test session, each participant should fill out a questionnaire. The responses to the questionnaire will form an important part of the basis of evaluation of the three node audio teleconferencing system that was used. Except for purely factual questions on the questionnaire, each participant should complete it without consultation with anyone else. Your own evaluation, and not a group consensus, is sought.

THREE NODE (THREE GEOGRAPHIC LOCATION) AUDIO TELECONFERENCING QUESTIONNAIRE

(ph.1. pt.1.1Hp)

1. Name of participant ____________________

2. Check any forms of teleconferencing in which you have been involved before participation in the present series of tests.

audio teleconferencing ____

video telconferencing ____

computer conferencing ____

other (please specify) ____________________

none ____

3. If you checked anything other than "none" above, how frequent has your past involvement in teleconferencing been?

quite frequent ____

moderate frequency ____

rare ____

only once ____

4. Geographic location of your node in the test session just completed

____

5. Geographic locations of the other nodes in the test session just completed

Location No. 1 ____________________

Location No. 2 ____________________

6. Calendar date of the test session just completed ____________________

7. Clock time - at the beginning of the test session just completed

____________ a.m.

____________ p.m.

- at the end of the test session just completed ____________ a.m.

____________ p.m.

8. Was the test session just completed the first or second one of the present series of tests in which you are a participant?

1st _____

2nd _____

9. What name or identification was given to the technical teleconferencing system used in the test session which you just completed?

10. How many participants, including yourself, were at each location in the test session just completed?

At my geographic location, there were _____ participants.

At the geographic location numbered "1" in question 5, there were _____ participants.

At the geographic location numbered "2" in question 5, there were _____ participants.

11. Before the present series of tests, how many of the participants in the series were relatively or totally unknown to you?

At my geographic location ____ participants were unknown to me before this series of tests.

At the geographic location numbered "1" in question 5, ____ participants were unknown to me before this series of tests.

At the geographic location numbered "2" in question 5, ____ participants were unknown to me before this series of tests.

12. Which maps were used at each location during the test session just completed?

(check as appropriate) At my geographic location - "1st person" map ____

"2nd person" map ____

"3rd person" map ____

"4th person" map ____

"5th person" map ____

"6th person" map ____

At the other geographic location - numbered in "1" in question 5

"1st person" map ____
"2nd person" map ____
"3rd person" map ____
"4th person" map ____
"5th person" map ____
"6th person" map ____

At the other geographic location - numbered "2" in question 5

"1st person" map ____
"2nd person" map ____
"3rd person" map ____
"4th person" map ____
"5th person" map ____
"6th person" map ____

13. Circle the check mark(s) in question 12 which indicate(s) the map(s) that you personally used.

14. In the test session just completed, - what was the direction of route tracing?

bottom to top ____
top to bottom ____

15. Taking into account all factors, what is your own overall evaluation of the teleconferencing system that was used in the test session just completed?

excellent ____
good ____
fair ____
poor ____
bad ____

16. If you check "fair", "poor" or "bad" in question 15 above, briefly describe the shortcomings of the system as you experienced it in the test session just completed.

17. The following alternatives describe some of the difficulties which may be found in audio circuits. Check any that apply to the test session just completed at the left of the alternative. Further describe the difficulty in the space to the right of any alternative that you checked.

____ noise ____________________

____ loudness ____________________

____ distortion ____________________

____ other voices on the line ____________________

____ echo ____________________

____ fading ____________________

____ other ____________________

18. (If you were the only participant at your geographic location, skip this question and go to question 19).

At times when you had taken over the role of tracing and announcing an attempted route on the map, consider the ease or difficulty of being interrrupted appropriately by road block announcements in the test session just completed. Compare the ease or difficulty of responding to interruptions from persons at the other geographic locations or nodes with responding to those interruptions coming from persons at your own geographic location.

Compared with persons at my own geographic location, in the test session just completed, persons at the other geographic location were able to interrupt me

less easily ____
as easily ____
more easily ____
not sure ____

19. (If there was at least one other participant in addition to yourself at your geographic location, skip this question and go to question 20).

How easy did you find responding to interruptions by road block announcements from other participants in this test session?

difficult ____
neither easy nor difficult ____
easy ____
not sure ____

20. If you checked "less easily" (question 18 above) or "difficult" (question 19 above), how disturbing did you find this in the test session just completed?

very disturbing ____
somewhat disturbing ____
not disturbing ____
not sure ____

21. (If you were the only participant at your geographic location, skip this question and go to question 22).
At times when you interrupted another participant by announcing a road block shown on your map, consider the ease or difficulty of achieving the interruption (i.e. at getting appropriate attention to your interruption attempt) in the test session just completed. Compare the ease or difficulty of interrupting persons at the other geographic locations with interrupting persons at your own geographic location.

Compared with interrupting persons at my own geographic location in the test session just completed, I found that getting the appropriate attention of persons at the other geographic locations to my interruption attempts was

more difficult ____
as easy ____
less difficult ____
not sure ____

22. (If there was at least one other participant in addition to yourself at your geographic location, skip this question and go to question 23).
If you were the only person at your geographic location in the test session just completed, how easy did you find it to interrupt others by your announcements of road blocks in this test session?

difficult ____
neither easy nor difficult ____
easy ____
not sure ____

23. If you checked "more difficult" (question 21) or "difficult" (question 22), how disturbing did you find this in the test session just completed?

very disturbing ____
somewhat disturbing ____
not disturbing ____
not sure ____

24. At times when you were neither tracing and announcing a route nor interrupting others by announcing a road block, how easily were you able to follow the ongoing proceedings on your own map in the test session just completed?

with great difficulty ____
with some difficulty ____
moderately easily ____
very easily ____

25. If you checked "with great difficulty" or "with some difficulty" in question 24, briefly describe the nature of the difficulties.

26. Do you have any further comments you wish to make about the teleconferencing system used in the test session just completed? Your comments need not be restricted to experiences with the map route task.