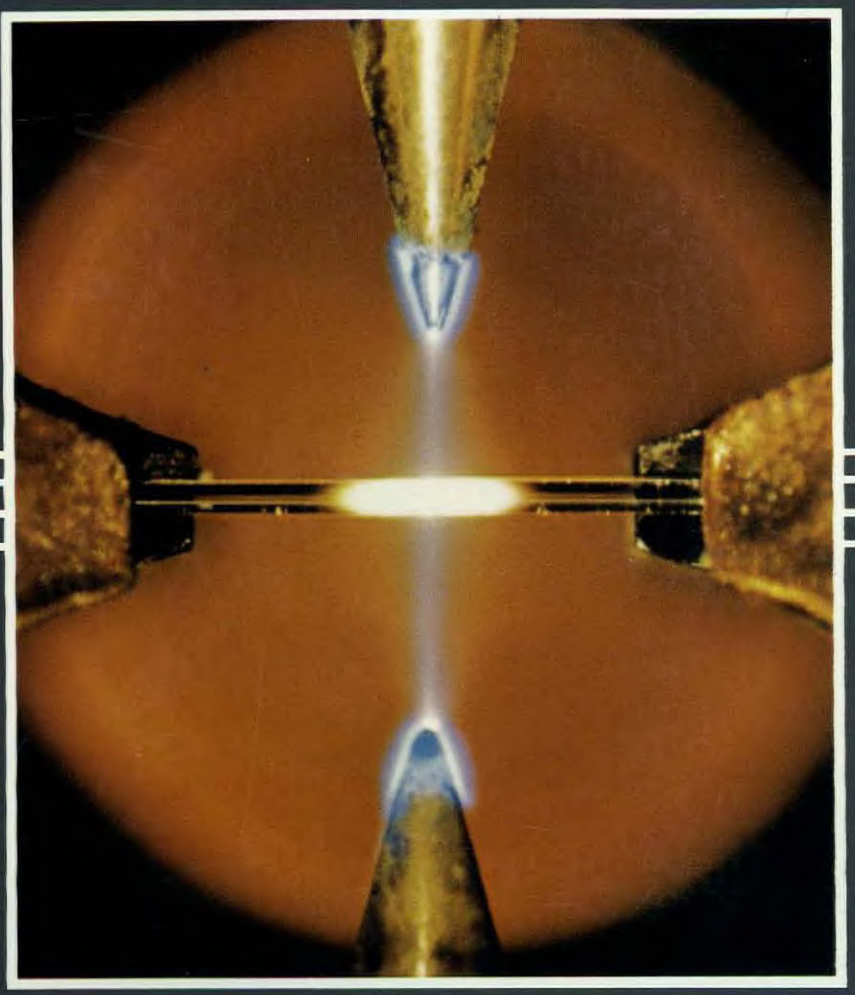
Elie-St. Eustache Fibre Optic Field Trial



PROJECT EVALUATION REPORT

EXECUTIVE SUMMARY

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ELIE - ST. EUSTACHE

FIBRE OPTIC FIELD TRIAL

PROJECT EVALUATION REPORT

EXECUTIVE SUMMARY

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for

CTCA/DOC Field Trial Board of Control

The views expressed, the conclusions reached, and the recommendations made in this report are those of the authors and do not necessarily represent the official views of their respective organizations

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FOREWORD

The Elie - St. Eustache Fibre Optic Field Trial has provided voice, data and video communications through an integrated services access system to 150 residential and small business participants in a rural area. The trial has generated a wealth of information in all stages of the project such as design, implementation and operation. The uniqueness of the system makes it worthwhile to document in detail all the experience gained for use by national and international parties who have an interest in the design, manufacture and operation of similar systems in the future.

The report is presented in two volumes. The first volume gives all the findings in such detail as is reasonable and possible. It provides historical information which was used as background against which the decision was taken to launch this trial. Volume I covers the details of design, implementation, operation and user survey results, makes reasonable predictions concerning the future of fibre optic systems and closes with recommendations for actions which could be taken by industry and governments in the pursuit of an early commercial introduction of fibre optics in subscriber access networks. The second volume is a concise executive summary which gives the highlights and key findings of the trial.

This report could not have been written without the contributions, in particular, of J. Chalmers, J. Scott and D. Kahn of Bell-Northern Research Ltd., of R. Kristjanson and P. MacLaren of Northern Telecom Canada Ltd., L. Sigurdson of Infomart Ltd. and L. Buckels, D. Peacock, R. Prasad and J. C. Rohne of The Manitoba Telephone System. Although the valuable contributions made by these persons are gratefully acknowledged, the responsibility for the contents of this report and the views expressed rest entirely with the authors. The constructive criticisms received from R. Kachulak of The Manitoba Telephone System and F. Leger of the Department of Communications during their review of the draft have been very valuable. Finally we would like to thank E. Schreiber of Bell-Northern Research Ltd. for his contributions in the preparation of the Executive Summary of this report.

No project of this size can ever succeed without the relentless dedication of many people. The authors wish to express their sincere appreciation to these unmentioned contributors from all the sponsoring organizations.

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SUMMARY

General Overview

In the 1970's approximately 6 million people, or 25% of the population of Canada, lived in areas classified as rural. Rural areas (as distinct from urban areas and low-density remote areas) are basically agricultural areas with a lower population density than urban areas.

The population density aspect creates disparities between urban and rural householders in the area of communications. While single-party lines are standard in urban areas, multiple service (or "party-") lines are still quite common in rural areas. Urban dwellers have a larger choice of TV channels than rural dwellers. Many new services (e.g. alarm systems) appeal to both urban and rural dwellers, but are usually more readily obtainable in urban areas.

The main problem with providing urban type communication services in rural areas is the cost per line which increases rapidly as subscriber density decreases. The concept of an integrated telecommunication network (a single facility generating revenue from a number of services) and the introduction and stimulation of a new technology (fibre optics) which promises wide bandwidth and lower cost in the future was the basis for the Elie-St.Eustache trial. The trial objectives were established as follows:

- To assess the technical and economic feasibility of fibre optics for improving communication services in rural areas.
- To test fibre optics under real environmental and operational conditions.
- To provide technical, economic and marketing data.
- To provide Canadian industry with an incentive to develop systems capability and new products in fibre optics.
- To obtain information about service requirements of rural communities through utilization of Telidon technology.

Early in 1977, The Manitoba Telephone System (MTS) proposed the Elie-St.Eustache field trial to the federal Department of Communications (DOC). DOC agreed to participate, provided that the telecommunications industry also shared the cost. This resulted in DOC and the Canadian Telecommunications Carriers Association (CTCA) jointly selecting a Northern Telecom Canada Ltd. (NTCL)

proposed fibre optic system design for the Elie trial. DOC and CTCA contracted with NTCL in 1979 for the implementation of the field trial system. DOC and CTCA also contracted with MTS for the operation and maintenance of the system, plus the provision of the CATV head-end, in-house wiring and cable route engineering. Additional contracts were signed between DOC and MTS for the provision of Telidon facilities and between DOC and Infomart for the creation of a suitable Telidon data base.

The contracts for providing and operating the trial systems were valued at $ 6.4 M while the implementation of Telidon amounted to $ 3.4 M including sponsor expenses not accounted for in the contracts. The total project, therefore totalled $ 9.8 M. Contract and price details can be found in section 1.9 of the detailed Project Evaluation Report.

The schedule of major events to complete the project was as follows:

Jan./77	MTS trial proposal to DOC
Jan./79	Memorandum of Agreement, DOC/CTCA (for system implementation and operation)
Apr./81	Construction start at Elie
Oct./81	Trial Inauguration
Mar./83	Termination of contract period

Since the systems operation and reliability has been excellent, the trial is still continuing.

The project was completed on schedule and within budget. This is noteworthy in light of the number of unknowns and risks, the number of sponsors, contractors and participants involved, and the uniqueness of the project. There was also a strong commitment to succeed among all sponsors and contractors, with a good cooperative spirit in evidence.

System Description

The trial system is a fibre optic distribution system designed, manufactured and installed by NTCL. It serves 150 participants in and around Elie and St.Eustache, Manitoba. This system provides each participant with single party telephone service, a choice of 8 TV channels, 6 FM radio stations and a 56 kb/s data channel. The data channel was used for Telidon, offering service from two separate data bases.

The trial system uses a switched star configuration with two dedicated fibres (transmit/receive) from each participant's home to one of two equipment trailers. One trailer, the Field Trial Centre (FTC) is located adjacent to the Elie telephone switching office and serves 90 participants. The second trailer, the Remote Distribution Centre (RDC) is located near St.Eustache, about 8.5 km north of Elie, and serves the remaining partic-

ipants. The two trailers are connected by an optical fibre trunk cable.

A Subscriber Entrance Unit (SEU) is required in each home to convert optical/electrical signals and modulate/demodulate the various services signals.

The original design included the use of Light Emitting Diodes (LED) as the optical power source. Two additional devices were developed sufficiently during the design stage for NTCL to incorporate a number of advanced technological demonstrations: the laser and the optical coupler. The demonstrations showed that

- higher power of the laser allowed a longer fibre length to a subscriber,
- higher power of the laser allowed two TV channels to be transmitted simultaneously,
- the coupler allowed two-way transmission over a single fibre.

Experiences Gained

The experiences gained from the trial can be divided into three main areas:

- *Technology*

  The integrated services fibre optic distribution system was shown to be technically feasible. The following observations were made:

  - fibre cables (buried and aerial) and fusion splices withstood all environmental conditions,
  - fibre plant can be installed by regular construction personnel and equipment,
  - fusion splicing can be carried out in the field with relative ease while maintaining consistent quality,
  - electronic equipment located on subscriber premises must be designed to withstand that environment's harsh physical and electrical conditions,
  - bidirectional transmission proved successful and could be utilized in future systems to improve their economics through reduction in the required quantities of fibre,
  - short wavelength and multimode fibre technology limits unrepeatered loop lengths and thus limits its application to the rural market place.

- *Services*

Subscriber services provided through the fibre optic distribution system were shown to be satisfactory. The following observations were made:

- the distribution system must provide at least two simultaneous, independent video channels to each subscriber,
- new services introduced with an entertainment component have a greater probability of success (e.g. games on Telidon)
- subjecting users to new technologies and procedures such as computers, keyboard access, and computer log-on procedures will not be impediments to the introduction and acceptance of new services if adequate guidance is provided.

- *Economics*

- Fibre optic subscriber distribution systems are not economical at today's state-of-the-art optical fibre technology, even when allowance is made for the high R & D costs and the one-of-a-kind equipment low volume manufacturing associated with the trial system. Major cost items are optical fibres, optical transmitters and receivers associated with subscriber entrance units and line cards and, finally, the wide-band video switch.

Major Recommendations

The experience gained from the trial, indicating that fibre optics may not be used in subscriber access systems due to cost at present and in the near future, leads to recommendations for action by industry and governments. These recommended actions are summarized here for the benefit of the various sectors of the industry and governments which could be influential in advancing and improving the competitiveness of fibre optic systems economics.

- *Manufacturers*

The major efforts of the manufacturing sector should be concentrated on the development of techniques and processes to reduce the cost of fibres, optical transmitters and receivers, integrated optics and wideband switches. It is understood that a large scale commitment by common carriers for the use of such systems is required to justify the needed large R & D investment.

- *Common Carriers*

In order to make a major commitment for use of fibre optic technology in the subscriber access plant, competing technologies and new service requirements and their impact must be

assessed. If such assessment should be favourable for fibre optic technology, it is the authors' opinion that carriers would still require the assurance that they will be permitted to carry all services and that no fragmentation in carrying local services will occur.

- *Governments*

  In order to ensure successful commercial implementation of fibre optic integrated services access systems, governments and regulators must address a number of policy and regulatory issues and the public interest. This is to ensure that system design can be driven by practical, technical, operational and economic considerations, rather than by adherence to historical regulatory and institutional schemes which may impose additional and unnecessary costs on all users. Possible financial support or incentive schemes for the industry involved in long term and risky research should also be examined.

A coordinated effort by industry and governments is required if an early application of fibre optics in the subscriber access network sector is to materialize.

ELIE - ST. EUSTACHE FIBRE OPTIC FIELD TRIAL

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1.0 TRIAL PROPOSAL CONSIDERATIONS

1.1 Rationale

The constant aim of telecommunications common carriers in Canada is to improve and upgrade telephone services to urban and rural subscribers. This has always been a difficult task in the rural subscriber networks due to the low population density. Rural areas are classified as having a population density of at least one person per square kilometre. These areas include small settlements and villages with a population of 2,500 or less.

A target of the telecommunications common carriers in Canada has been to replace the multi-party service with individual line service at reasonable rates. In 1960, 16% of main telephones were multi-party. Today this number has been reduced to 6-1/2%.

In more recent times Cable Television (CATV) and the introduction of Pay-TV and Data Transmission present another challenge for rural telecommunication services.

An agreement between the federal and provincial governments signed in 1976 permitted The Manitoba Telephone System (MTS) to own the facilities to carry any telecommunications services, provided MTS is not the seller of cable television service to the end user. This allowed consideration of an integrated network in the trial system studies conducted by MTS. These studies also weighed the well-established coaxial cable technology versus the new fibre optic technology and concluded that the fibre optic technology could result in a reduction in the cost of providing CATV in the rural areas by the late 1980's by a factor of up to 4 in comparison with coaxial cable based systems.

1.2 Preceding Studies

1.2.1 MTS Rural Experimental Trial

An MTS study titled "Rural Experimental Trial" issued January, 1977, developed capital costs for rural CATV on fibre optics as a function of subscriber density, and also estimated monthly revenue requirements as a function of subscriber density and implementation policies. The study showed that, while an integrated broadband network costs less to build than separate networks for telephone and cable television, the revenue requirements are still very high, particularly for the low subscriber density areas.

1.2.2 DOC Research Program

Between 1976 and 1980, the Department of Communication of the Government of Canada launched a research program on rural communications. As part of this program a systems study on the application of fibre optics for broadband networks was commissioned to Bell-Northern Research Ltd. (BNR) in 1976.

1.2.3 BNR Study

The emphasis of the study titled "A Systems Study of Fibre Optics for Broadband Communications" was placed on rural areas. This comprehensive study was completed in March 1978 and comprised ten separate study activity reports and a final report which concluded that an integrated fibre optic network was technically feasible and cost effective in rural areas in the long term.

1.3 Program Realization

1.3.1 MTS Proposal to DOC

Based on the January 1977 study (para. 1.2.1), MTS submitted a proposal to DOC for the building of an experimental trial distribution system, using fibre optics. This system would provide:

1. an integrated fibre optic distribution network to deliver telephone, data and CATV service,

2. an "on demand" program switching capability for video and audio signals under the billing and supervisory control of the central processor unit (CPU) with the video and audio signals originating from anywhere in the local broadband network of an adjacent town or city or within the rural area itself, and

3. a capacity to serve 150 subscribers.

The estimated cost for the proposed system was $ 6 M.

1.3.2 Manufacturer and Carrier Involvement

DOC expressed interest in supporting such a trial, provided the telecommunications industry would participate to an equal extent. Subsequently MTS approached CTCA with the request that they become a funding partner in the trial. Agreement was reached that the trial system would be developed and manufactured by Canadian companies as much as possible.

1.3.3 Project Objectives

The project objectives are directly and indirectly oriented towards obtaining improved rural communications. The trial objectives were:

- to assess the technical and economic feasibility of utilizing fibre optics technology for improving communication services in rural areas,

- to test the application of fibre optic technology under real environmental and operational conditions,

- to provide both government and the industry with technical, economic and marketing data required for possible decisions with respect to policies, regulatory requirements and future system choices,

- to assist Canadian industry in the development of new products and services to meet Canadian and foreign requirements for improved rural and urban communications systems, and to provide Canadian industry with an incentive to develop a domestic system capability in fibre optics technology,

- to assess the socio-economic impact of new services on subscribers living in rural communities,

- to provide a test bed for service providers to obtain knowledge about the kinds of services that are relevant to the rural community.

1.3.4 Selection of Trial Location

MTS together with DOC established certain selection criteria for acceptable trial sites. A matrix taking the criteria into account was used to eliminate all but two sites. After discussions between representatives from MTS, DOC and the councillors of the selected sites, the town of Elie with its surrounding area was finally chosen.

1.3.5 Program Definition Studies

Northern Telecom Canada Limited (NTCL) and Canstar Communications Limited were contracted to carry out studies to establish the form a field trial using fibre optic technology should take. The studies were to consider technology, cost, subscriber densities, level of services, etc. System service and quality specifications were provided by the network owners.

The completed studies received by DOC and CTCA in September 1978 were based on two different design concepts. The NTCL proposal was based on a switched star configuration design with two fibres dedicated to each subscriber and no active or electronic components in the distribution cable plant. The Canstar proposal was based on a loop/tree system for telephony and data, and a tree/tree system for video. Active components were required along the cable routes.

1.3.6 Selection of System

A study session was held by DOC and CTCA technical representatives who assessed the two proposals advanced by NTCL and CANSTAR as to their designs and capabilities. Based on a previously agreed set of criteria, this group recommended that the NTCL proposal be adopted. This recommendation was accepted by DOC and CTCA.

1.3.7 Funding of Field Trial Project

A total of five sponsors agreed to participate in varying amounts in the funding of this project. These sponsors were:

- Department of Communication (DOC)
- Canadian Telecommunications Carrier Association (CTCA) *
- Northern Telecom Canada Limited (NTCL)
- Manitoba Telephone System (MTS)
- Infomart

* Since MTS had originated the proposal and was the host company it was agreed that MTS would pay 40% of CTCA cost in addition to its regular share. This does not include MTS's contribution to the Telidon services part of the project.

1.3.7.1 Contractual Agreements

It was agreed to conduct the program in two phases. In Phase I of the program the basic system was designed, manufactured and installed to provide telephone, cable-TV, FM radio services and a full duplex 56 kb/s data channel. In Phase II of the program additional facilities and data bases were established to provide Telidon services via the full duplex 56 kb/s data channel of the basic system. The purpose of Phase II was to engineer, operate and maintain additional transmission and switching facilities required for Telidon services, and to conduct user surveys and develop Telidon data bases.

1.3.8 Phase I Contracts

The main contract to realize Phase I was signed by DOC and CTCA with NTCL in September 1979. With this contract NTCL was to design, manufacture and install the basic system.

A second contract was signed by DOC and CTCA with MTS to provide services and engineering support at the same time.

A third contract was signed between DOC and CTCA by which CTCA would provide a Program Manager for Phase I of the project.

Sponsor contributions for Phase I contracts as established after final adjustments and revisions are shown in Table 1-A.

1.3.9 Phase II Contracts

For the provision of Telidon services two contracts were signed, one between DOC and MTS, the other between DOC and Infomart. A third contract was signed between MTS and Cybershare as a subcontract to MTS's contract with DOC for provision of a second Telidon data base. The items covered by these contracts are given in 1.3.7.1.

All contracts were to terminate at the end of March 1983. In order to allow for the testing of some additional interactive Telidon services the contract with Infomart was extended until the end of March 1984 and its value was increased by $240,000. Sponsor contributions for Phase II through contracts or own expenses are summarized in Table 1-A.

CTCA was reluctant to participate in Phase II of the trial since at that time regulatory uncertainty existed as to whether the carriers would be permitted to introduce such services commercially, should the trial prove successful. Since this could not be clarified, CTCA decided not to participate in Phase II of the program.

TABLE 1-A
TABULATION OF SPONSOR CONTRIBUTIONS TO THE PROJECT

PROJECT PHASE	SPONSOR	CONTRIBUTIONS IN DOLLARS	TOTALS
I	DOC CTCA NTCL	3,182,000 2,530,000 653,000	6,365,000
II	DOC MTS Infomart	1,720,000 700,000 1,020,000	3,440,000
TOTAL PROJECT COST			9,805,000

2.0 IMPLEMENTATION OF ELIE FIELD TRIAL

2.1 Services Implemented

In the Elie trial one undeveloped and two known services were provided for the participants as follows:

- Telidon (Canadian version of Videotex)
- CATV package including TV channels and FM radio stations
- single party telephone, touch-tone service

Telidon services were implemented over a 56 kb/s full duplex data channel that was provided for each home as a carrier of services other than telephone and cable-TV. Only Telidon service was implemented, however, it included teleshopping, messaging and computer programs in addition to information retrieval. Telebanking was added in late 1983.

2.1.1 Subscriber Participation

The trial system served 150 subscribers, most of them households, but also including 3 schools, the rural municipality offices and a number of small businesses. 90 subscribers (76 located in the town of Elie, the remainder on farms surrounding Elie) were served from the equipment trailer in Elie, while 60 (41 located in St.Eustache, the remainder on surrounding farms) were served from the trailer located near St.Eustache.

2.2 Service Providers Participation

2.2.1 Cable Television Services

The CRTC licensed a local CATV operator, "Communitec," with the proviso that he was to obtain ownership and responsibility of head-end equipment and inside wiring only upon termination of the experimental period. A local broadband network (LBN) had to be constructed in both Elie and St.Eustache to serve non-trial households. A charge of $ 10.00 per month for CATV, payable by all subscribers, whether trial participants or not, was approved.

The cable-TV system provides four Canadian stations (CBC English, CBC French, CTV and one independent), all originating from Winnipeg, and four U.S. stations (one each of the ABC, CBS, NBC and PBS networks), picked up from the Intercity Broadband Network. The system also provides access to five radio stations in the FM band.

2.2.2 Telidon Services

A four-way agreement was established whereby:

- Infomart would increase the size of its data base and enhance its usefulness,
- Cybershare would provide a second data base consisting mainly of computer aided education programs,
- MTS would provide a data switch and connecting circuits between the Elie participants and the two data bases in Winnipeg,
- DOC would provide the subscriber Telidon terminals for the duration of the trial and would also assist in the funding of the work on the data bases and the operation and maintenance of the delivery system.

The Infomart and Cybershare data bases were considered complementary rather than competitive. The entire Telidon service was provided free to the trial participants.

2.2.2.1 Data Bases

Infomart is an electronic publisher with a data base containing about 31,000 pages of information plus a number of games and computer programs. Infomart's data base is divided into two sections as follows:

- Lifestyle, containing news, consumer information, entertainment, games, sports and educational programs,
- Agricultural, oriented toward the rural farming communities and containing weather reports, market information for crops and livestock, futures market, chemicals, equipment, farm news, and educational subjects related to farming.

Cybershare is a computer utility with experience in educational computing networks serving some schools in Manitoba. The Cybershare data base established to serve the Elie field trial contained the following programs:

- Seven interactive computer assisted high school level course instructions totalling 212 hours,
- Computer programs in agricultural management.

2.2.3 Technical Implementation

2.2.3.1 Architecture

The rural distribution field trial architecture was based on a centrally switched star configuration with two distribution centres (Fig. 2-1).

The Field Trial Centre (FTC) was located in a trailer adjacent to the Community Dial Office (CDO) in Elie and the Remote Distribution Centre (RDC) was located in a trailer 8.5 km North of Elie near St.Eustache. A dedicated fibre optic trunk cable connected the distribution centres. One upstream (subscriber to trailer) and one downstream (trailer to subscriber) optical fibre connected each subscriber with the distribution centre. A subscriber entrance unit (SEU) was installed in each participant's home at the end of the fibres to convert optical/electrical signals and to modulate/demodulate the signals for the various services. The FTC provided the interfaces with the switched telephone networks, the TV and FM-radio sources and the digital data switch for the Telidon services for all subscribers.

Video was transmitted on the fibre loops in the standard NTSC VSB-AM format on a visual carrier frequency of 7.6 MHz. Access to up to 9 video channels was provided by an FDM switch associated with each subscriber loop in the FTC or RDC. Control of the switching was by means of signals from a hand-held TV channel selector relayed upstream to the switch.

A TV head end was established at Elie. Four Winnipeg broadcasting channels and the FM radio channels were picked up off-air and were combined with four USA TV network station signals which were tapped off the Winnipeg-Brandon intercity broadband network.

As part of the technology demonstration in the project, NTCL provided 25 subscriber locations with bi-directional transmission over a single fibre. A wavelength selective directional coupler based on a dichroic filter design was used to separate upstream/downstream wavelengths. This coupler was specially developed for this trial.

NTCL provided 35 lasers in the downstream direction of certain loops. About 25 laser driven shorter loops were used to demonstrate the simultaneous transmission of two TV channels. All bi-directional loops were equipped with lasers. All loops over 3.0 km up to 5.0 km (the maximum loop length) in length were laser driven.

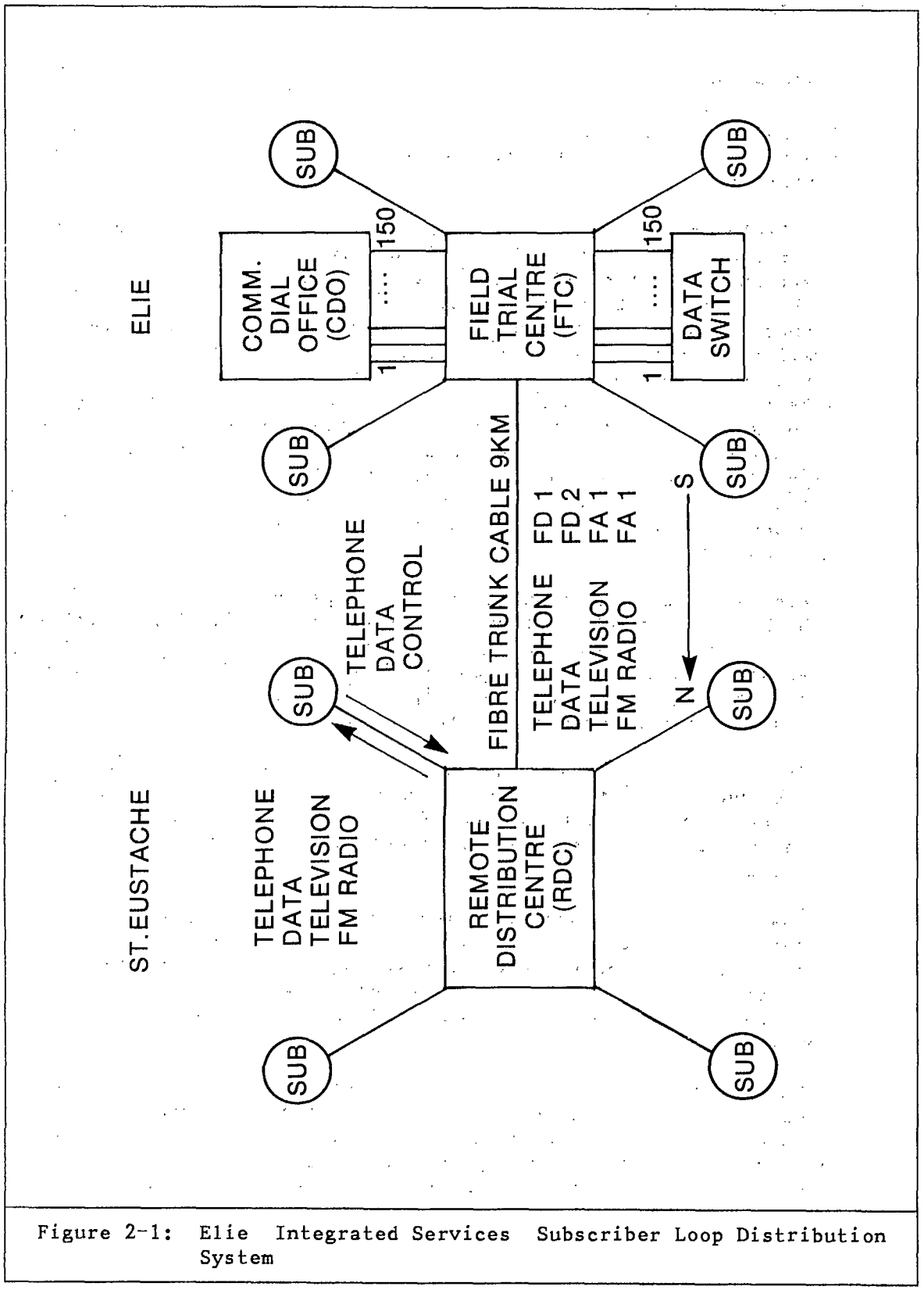

Figure 2-1: Elie Integrated Services Subscriber Loop Distribution System

The Telidon service operated at 4.8 kb/s and used the 56 kb/s data channel between the data switch in the CDO at Elie and the subscriber's location. The switch allowed the subscriber to choose the desired data base to access. It also reduced the dedicated circuits connected to the data bases in Winnipeg. For each data base fifteen 4.8 kb/s data circuits were processed through statistical multiplexers to allow four 9.6 kb/s channels to be used over PCM carriers to Winnipeg.

2.2.3.2 Outside Plant Construction

MTS construction crews carried out the outside plant work under subcontract from NTCL. Responsibility for the overall construction phase rested with NTCL. The following items were associated with this:

- Installation of
  - all outside plant cable
  - associated messenger cable
  - pedestals and house terminals
  - splice closures
- Splicing of
  - optical fibres
- Testing
  - attenuation of all loops end to end

Objectives of the outside plant portion of the field trial were as follows:

- Observe design of the fibre cable and its associated materials (closures, etc.) for performance under regular cable treatment procedures (i.e. any special treatment or new installation equipment or special training of craftsmen required? etc.)

- Observe complexity, training requirements and performance of optical fibre splicing procedures. Observe quality of completed splices.

- Observe need for individual splice testing and splice quality obtained by trained outside plant personnel under normal working conditions, i.e. usually expected weather conditions and work stations.

- Observe fibre cable behavior and performance due to temperature variations, wind forces and mechanical stress as a result of seasonal frost and thaw cycles.

Highlights throughout the construction period were reported as follows:

Aerial and buried cable required special attention only for maintenance of the minimum permissible bending radius, however, the cable was easy to handle and no specific problems were encountered. For aerial drops the development of a special small, lightweight self supporting drop cable would be advanta-

geous. The requirements for continuous lengths of fibre optic cable (in one case 1500 metres) in order to minimize splice losses caused some special work planning and worry with ploughing, ducting and aerial support requirements. The job was, however, accomplished without serious trouble. To eliminate the possibility of having excessive bending or stress on the fibre cable as the plough share was forced into the ground at the start of a cable run, pits were dug to allow stress-free starts and stops. This took extra time but presented no problems. No unusual burial depth was necessary to protect optical fibre cable. The usual outside plant personnel and regular machinery (ploughs, winches, etc.) were employed for this job. The only additional construction equipment that was found to be necessary and not available within MTS was a reel carrier capable of handling five reels of cable for placement of multicables.

Fibre splicing and testing: MTS crews gained valuable splicing and testing experience. It was originally planned to test each splice for attenuation or discontinuities, however, the level of splicing expertise rose quickly to the point where splicers became adept at inspecting their splices visually and were able to determine the quality of the splice so that the testing of each splice on the loop plant could be discontinued. End to end optical loop attenuation measurements were continued, however. MTS crews required only minimal training which was given by NTCL.

2.2.3.3 Equipment Installation

Installation of trial equipment was essentially in three distinct groups. The first group of equipment included equipment installed by NTCL in the FTC and RDC trailers at BNR in Ottawa. Some additional equipment was later installed by MTS in the trailers at the trial site.

The second group consisted of a number of pieces of equipment and associated wiring on the subscriber's premises. This was somewhat unusual for the industry, since normally no electronic equipment is installed in residential subscribers' premises. However, no problems were encountered with trial subscribers due to that arrangement. A block diagram of this equipment is shown in Fig. 2-2.

The third group of equipment was installed in the Elie CDO and consisted mainly of Telidon switching and trunking equipment and the TV head end. The installation of the last two groups of equipment was carried out by MTS personnel under contract from NTCL and DOC respectively.

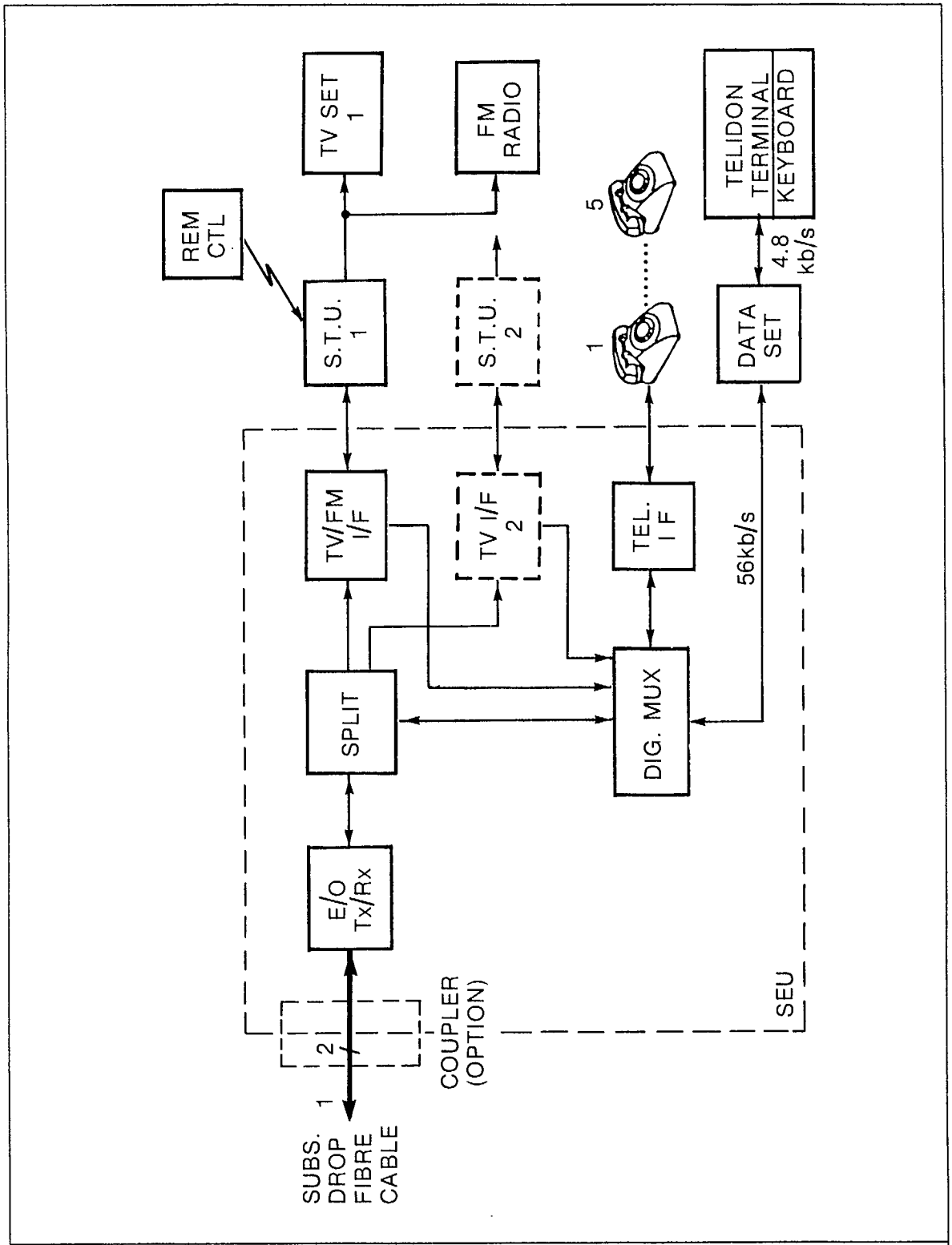

Figure 2-2: Block Diagram of Equipment Installed on Subscriber Premises

2.2.3.4 Usage Measurement System

One of the purposes of this field trial was also to determine the information and entertainment needs of people living in rural areas in Canada. It was considered to be important to obtain information about usage patterns of new services in particular for provisioning of future network facilities and for marketing assessment. Therefore, in the design of the system, consideration was given to collecting usage data automatically for Telidon and CATV services. In the case of CATV, the ability to collect data on usage of each channel by a subscriber would also demonstrate a billing capability for a future Pay-TV service.

For Telidon, usage data were collected both by MTS at the data switch and by Infomart, one of the Telidon service providers. TV usage data were collected by MTS only.

CATV Usage Data Collection Facilities: The source of the CATV usage data is the Line Interface Unit (LIU) associated with each trial participant's line. The LIU continuously generates "status" data with respect to which channel is selected and whether the Set Top Unit (STU) and, consequently, the subscriber's TV set is "on." Two microprocessor based Line Concentrator Units (LCU) were installed at the FTC and the RDC. The units preprocess the raw data from the LIU and reduce them to an amount feasible for transmisson to a computer for further processing.

Telidon Usage Data Collection Facilities: Data collected by MTS originated from the data switch installed in the CDO. It utilized the statistics gathering capability of the switch which is accessible via the statistics port of the switch. The data collected included information showing from which subscriber's premise the call originated, which data base was accessed and the time when these activities were taking place. Additional usage data (primarily which pages or programs were accessed and for how long) were collected and processed by the service provider's host computer.

Data collected from the two LCU units and the statistics port of the data switch were transmitted to an IBM Series/1 minicomputer located at the MTS Vernon local exchange in Winnipeg for storage and some processing. This data was sent twice a week via a data line to Manitoba Data Services, the Manitoba Government Computer Utility located in Winnipeg, for storage and generation of monthly usage reports.

3.0 TRIAL SYSTEM OPERATION

3.1 System Performance

The analysis of the quality of service considers each of the three services (telephone, CATV, Telidon) separately in relation to:

1. Troubles found in the basic system provided by NTCL,

2. Total troubles reported by the subscriber.

It was generally found that the trial system maintained the technical specifications very well. Although the trial extended over eighteen months, results have been included for two months after the end of the trial. It was found that 60% of troubles were attributable to SEU failures. As soon as protective devices were connected to the data port of the SEU, the troubles subsided, including troubles in other NTCL equipment.

Table 3-A lists all troubles found in the basic NTCL system. Significant are the rather low trouble rates after December 1982, at which time the protection circuitry was added to the SEU. These figures have to be considered typical for the integrated services fibre optic distribution plant. In all cases they are significantly smaller than the design objectives.

Table 3-B lists all troubles reported by the trial system subscribers. They include station equipment troubles for telephone service, terminal equipment and data switch troubles for Telidon service and all service troubles associated with equipment owned by the customer (e.g. Television sets). They also include troubles rated by the maintenance personnel as "found OK."

A further breakdown and analysis of system troubles is available in chapter 8 of the detailed report.

TABLE 3-A
TROUBLES FOUND IN THE BASIC NTCL SYSTEM

	TROUBLES PER MONTH			
SERVICE	TOTAL PERIOD	OCT.81 to DEC. 82	JAN.83 to MAY 83	DESIGN OBJECTIVE
Telephone	6.0	7.0	3.2	8.4
Cable-TV	7.5	8.7	4.0	11.7
Telidon	9.6	11.9	2.8	6.2

TABLE 3-B
ALL TROUBLES REPORTED BY SUBSCRIBERS

	TROUBLES PER MONTH			
SERVICE	TOTAL PERIOD	OCT.81 to DEC. 82	JAN.83 to MAY 83	CURRENT TELCO OBJECTIVE
Telephone	8.6	9.8	5.2	3 to 6.75
Cable-TV	8.7	9.8	5.6	–
Telidon	15.8	19.0	6.4	–

3.2 Fibre Cable Performance

The measurements taken between September 1982 and April 1983 indicate that no changes in loss of fibre itself were caused by:

- air temperature variations,
- ground temperature variations,
- moisture and humidity variations,
- mechanical stresses caused by wind,
- freezing and thawing of the ground.

The measurements largely confirm the findings of controlled environmental laboratory tests conducted on fibre optic cables. No conclusions can be drawn, however, on the effects of aging as the period of eight months during which measurements were taken is too short a time for sufficient observations. Fibre loss tests and controlled environmental laboratory tests performed in the past indicate that there are no observable loss variations in fusion splices under varying environmental conditions. A slight loss variation was, however, observed in the tests performed in the field.

3.3 Operation and Maintenance

3.3.1 Training and Practices

MTS was under contract to maintain the fibre system and to select the required personnel.

The Elie-St.Eustache field trial employed a sophisticated monitor and alarm system which assisted the operating staff in identifying faulty units. This allowed the use of average skill-level personnel, with no special knowledge of fibre optics, to perform the jobs effectively. In order to maintain good public relations and obtain trial participants comments, the maintenance staff's knowledge of the area and its people was also taken into consideration when personnel was selected. For trunks and switching (defined as everything inside the FTC and RDC, all equipment installed in the Elie dial office and all circuitry to Winnipeg) two people were trained in the expectation that one person would be required during start-up and less than one person would perform the ongoing maintenance. For service and construction (defined as everything outside the FTC and the RDC, including the subscribers' homes) three persons were trained. Two would perform maintenance during start-up and only one would be required for ongoing maintenance. This arrangement worked very well.

Two manuals, prepared by NTCL, were used by the operating and maintenance crews:

- Outside Plant Handbook,
- Elie Maintenance Manual.

Appendices 7-1 and 7-2 of the main report give the contents of these manuals.

3.3.2 Alarm System and Trouble Reporting Procedures

The Elie-St.Eustache trial consisted of an integrated system, carrying telephone, CATV, FM radio, and Telidon, which permitted NTCL to provide a sophisticated monitor and alarm system. This system was designed to record and report the current status of all monitored functions and to store at least 20 status changes in a data base which could be queried by the maintenance personnel at any time. The information was reported in a fault-diagnosis facilitating format. The status of the system was also summarized by 32 alarms which were presented to the MTS alarm remoting system for transmission to the Provincial Service Control Centre (PSCC) in Winnipeg, permitting the dispatch of maintenance personnel to normally unattended offices such as Elie. This system worked well and was effective.

For the purpose of the Elie-St.Eustache field trial it was desirable to collect a record of all troubles during the trial which prompted the service providers and operators to establish a unique trouble reporting system.

In order to avoid confusion for the subscriber as to what service provider to report a trouble to (e.g. CATV, Telidon or telephone), MTS acted as the receiver for all trouble reports from the trial participants. MTS then analyzed the troubles and referred them to the appropriate service providers. A feedback loop was established through which trouble clearances had to be reported back to the central trouble bureau for control and record purposes.

The single trouble reporting system established for all services for the Elie-St. Eustache field trial proved beneficial for both subscribers and service providers.

3.4 Public Relations

Participant understanding, interest and satisfaction had to be secured throughout the trial in order to maintain good will. Furthermore, there was also the need to provide a focal point for disseminating information regarding the trial to national and international industries, the news media and the technical and scientific press. To this end a Public Relations Program was developed with the following objectives:

- Create and maintain the understanding and support of the trial subscribers and other residents of the district so that the trial can be implemented successfully.
- Show an example of the innovativeness of Canada's telephone industry and, in particular of MTS.
- Show that Canada is at the leading edge of telecommunications including research and development, manufacturing, applications and provision of services.

- Serve as an example for the general public of what can be achieved through industry-government cooperation.

- Serve as an example of government-industry concern for the telecommunications needs of the rural subscriber.

3.4.1 Activities

In June 1981 an initial meeting was held with sponsors, participants and other local residents to discuss the progress of the trial and restate its purpose prior to the actual operational period. Additional events included:

- Oct. 23, 1981: High profile trial opening ceremony involving senior representatives from sponsors, the media, trial participants and MTS.

- October 1981: Telidon demonstration and training for participants.

- Nov. 18, 1981: PR coordinator and project managers for MTS and Infomart attended high school "in service" day to explain possible benefits of trial to school and students.

- March 23,1982: Follow-up meeting between sponsors and participants.

- April 3, 1982: "Open Trailer." Viewing of FTC trailer by participants and others.

- May 1982: Infomart visited each home to demonstrate new features in data base.

- Oct. 26, 1982: "Birthday" party; another follow-up meeting.

- Dec. 4, 1982: Christmas party for participants to express appreciation for ongoing cooperation.

- Apr. 12, 1983: "Thank you" dinner to mark end of original trial and end of participation by CTCA, NTCL and DOC.

3.4.2 Publications

A newspaper titled "Dialogue" was distributed to the trial participants before the start of the trial as a means of introducing the residents to the technology they would be using. Newsletters and individualized letters were sent to participants throughout the trial period. Newsletters included updates on

trial activities, enhancements or instructions about trial services, general outline of technical status, review of visitors to trial site and reminders of who to contact in case of problems. Newsletters were sent out bi-monthly or when required. Messages were also sent via the Telidon messaging service.

Good coverage of the trial was provided internationally by articles in newspapers, technical periodicals and newscasts. Also, papers were presented and articles printed in the proceedings of fourteen technical conferences in six countries around the globe.

3.4.3 Subscriber Assessment of System and Services

3.4.3.1 User Surveys

Four surveys were performed to determine any user perceived problems and the degree of user satisfaction with services provided. All survey findings were made available to all sponsors of the trial and, in addition, a copy of each survey report was placed in the municipal offices of Elie for viewing by the participants and other residents of the two communities involved.

The first (September 1981) and last (April 1983) surveys were done primarily to determine the effects of the new services introduced on the participants' lifestyles, their leisure activities and their use of available information sources. The first survey was also used to establish a basis for the contents of the Telidon data bases. The second survey, conducted in February 1982, concentrated on determining the overall satisfaction with the trial as perceived by the participants. Since Telidon was a new service of which very little was known anywhere in the world, the third survey, conducted in November 1982, concentrated in detail on the reaction of the participants to this service.

The results of these surveys provided useful information for the trial sponsors and contractors with regard to any deficiencies or shortcomings of the system and enabled them to take corrective action.

September 1981 and April 1983 Surveys: An analysis and a comparison of the results of the first and last surveys indicate that no major changes in lifestyle, leisure time use and in program preferences on radio and television did occur. At the end of the trial, time spent for watching TV increased by about 15%, whereas time spent on all other activities decreased. With regard to the printed media, the Winnipeg Free Press and Readers Digest remained the most read newspaper and magazine repectively.

The changing perception of Telidon by users after they had an opportunity for "hands-on" experience in this trial is of interest. Generally, the pre-trial expectations did diminish at the end of the trial which may be attributable to the unduly high expectations prior to the trial. Key results are given in Table 3-C. In each case a few percent of those interviewed did not offer any comments.

TABLE 3-C
USER REACTION TO TELIDON SERVICE

		% OF RESPONDENTS	
PERCEPTIONS OF TELIDON SERVICE		PRE-TRIAL	POST-TRIAL
GENERAL	Positive Experience	91.0	70.6
	Negative Experience	2.0	3.4
	Neither Negative nor Positive Experience	5.0	24.3
USAGE	Every Day / Almost Every Day	70.0	28.6
	Several Times per Week	23.0	21.9
	Once or Less per Week	5.0	47.8
INFO. SOURCE	Big Improvement over Other	64.0	22.7
	Some Improvement over Other	30.0	36.1
	Little/No Improvement over Other	5.0	37.0

Despite the decrease of importance of Telidon as an information source as expressed by the users, the surveys nevertheless indicate that Telidon became the primary source for the following information categories:

- Agricultural Commodity Markets,
- Travel News and Information,
- Livestock Market Selling Price,
- Information on Grain Contracts.

February 1982 and November 1982 Surveys: The two surveys were similar in their objectives in that they sought the user reaction to the trial and services. The results from both these surveys are summarized in Table 3-D. The February 1982 survey elicited the trial participants' reaction to all services, whereas the November 1982 survey dealt with the Telidon service only.

The overall reaction to the trial, and to the service and help offered by the service providers in resolving any problems was very positive.

TABLE 3-D
GENERAL REACTION TO THE TRIAL

PARTICIPANTS' QUALIFICATIONS		% OF RESPONDENTS
GENERAL	Like	85.2
	Dislike	3.9
	Neither Like nor Dislike	10.9
SERVICE BY SPONSORS	Satisfactory	96.1
	Less than satisfactory	3.9

The technical quality of the signals for telephony and cable-TV in comparison with signal quality before the trial was also satisfactory as given in Table 3-E.

TABLE 3-E
SIGNAL QUALITY FOR TELEPHONE AND CABLE-TV

	% OF RESPONDENTS	
PARTICIPANTS' QUALIFICATIONS	TELEPHONE	CABLE-TV
Better	15.6	48.2
Same	59.4	37.7
Worse	10.2	10.5
Other	14.8	3.5

The overall reaction to the Telidon service was very positive. That slightly over half of the users had problems with their service at one time or another did not impact on their overall satisfaction. 72% of the problems were associated with access followed by 23% associated with terminal equipment.

Several features of the system on which participants' opinions were solicited were found to have a high degree of acceptance during both surveys (Table 3-F).

TABLE 3-F
USER COMMENTS ON TELIDON FEATURES

FEATURE	PARTICIPANTS' QUALIFICATION	% OF RESPONDENTS FEB. 1982	NOV. 1982
Access Method	Easy	75.6	61.0
Use of Index	Easy	84.0	76.4
Keyboard	Satisfactory	87.4	80.0
Screen Size	Satisfactory	95.0	N/A
Display Print Size	Satisfactory	91.6	83.8
Display Pictures	Satisfactory	82.4	61.0
Access Time	Could be Improved	58.8	45.5

In Table 3-F only the predominant qualifications are shown. The only area where dissatisfaction has been indicated is "Access Time." The reasons for this unsatisfactory response were investigated by MTS and the Telidon service providers. Subsequent actions taken reduced the participants' complaints to an acceptable level by the end of the trial.

The most frequent users of Telidon were children. This fact did not change throughout the two surveys as indicated in Table 3-G.

TABLE 3-G
TELIDON USERS

USER CATEGORY	% OF USERS FEB. 1982	NOV. 1982
Children	52.8	43.4
Adult Males	19.5	30.3
Adult Females	10.6	23.7
All about the same	13.8	2.6
No response	3.3	0.0

During the trial, seven broad categories of Telidon services were offered. Electronic Games were the most popular subjects followed by Community Information. Table 3-H indicates the seven categories and the percentages of usage by the trial participants.

TABLE 3-H
USAGE OF TELIDON SERVICES

TELIDON SERVICE	% OF RESPONDENTS
Agricultural Information	28.2
Community Information	79.7
Consumer Information	42.3
Teleshopping (viewed only)	58.5
School Courses	26.0
Electronic Games	93.5
Messaging	50.4

3.4.4 Usage Measurements

As part of the need and desire to find out the trial participants' actual usage of the two new services (CATV and Telidon), statistics were collected. No usage data for telephone was collected since this was already a well established service on

which sufficient information is available throughout the industry.

CATV Usage: The data collected show the use of each channel (station) and the time of day when it was accessed by individual households. From these data it appears that no significant differences in viewing patterns have emerged for the rural households when compared to urban areas. There is also a reasonable match between these collected data und the information obtained from surveys. Any variance in the two sets of data, in particular with respect to station preference, is probably due to the fact that the measured data represent average figures collected over an extended time period, while survey data represent the respondents' most recent impression and, consequently, are affected by a much shorter time span.

Telidon Usage: Telidon usage data was collected both by MTS and Infomart, but not by Cybershare. MTS's data was collected at the data switch and includes usage data for both Infomart and Cybershare. Infomart's data was collected at their data base host computer in Winnipeg. The usage data collected by Infomart provides, on a daily basis, the number of sessions, the number of page retrievals and the total time of daily sessions by all users, without identifying any individuals.

Fig. 3-1 gives the histogram of total number of sessions per week for the duration of the trial during which the Infomart data base was used. As can be seen, there is a seasonal variation of usage of Telidon with a marked increase during December and January. Page retrievals show a similar pattern. In Fig. 3-2 the hourly variations of the number of sessions during one day averaged over one month (March, 1983) are shown. Peak usage occurs at noon and in the evenings. A shift of the evening peak towards later hours during the summer months was noticed (see Chapter 10 of the detailed report), indicating, again, a seasonal traffic pattern. Finally, Fig. 3-3 shows the distribution of session durations for March 1983. It is of interest to note that more than half of the sessions lasted less than two minutes.

In analyzing the Telidon usage data it should be considered that this service was provided free of charge to the trial participants. The possibility of a usage pattern modification in connection with price levels and, perhaps, graduated fee scales according to usage hours (peak and off-peak periods) can therefore not be excluded.

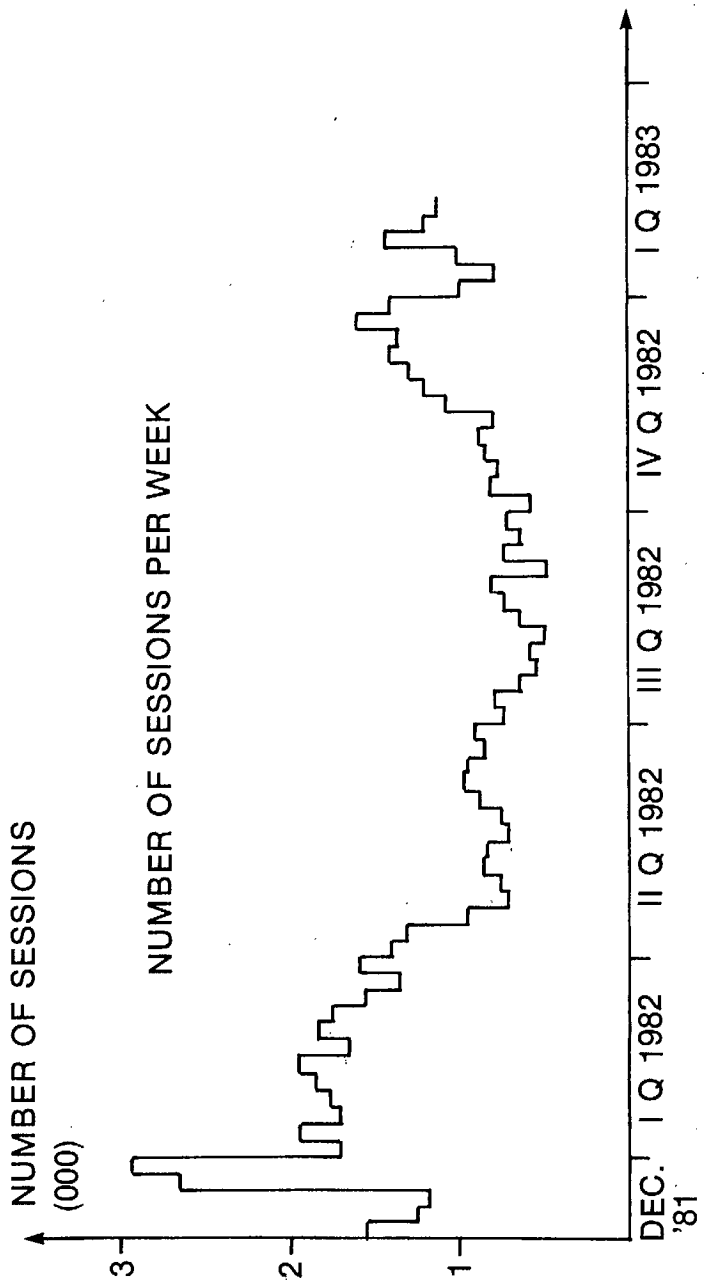

Figure 3-1: Histogram of the Total Number of Telidon Sessions per Week

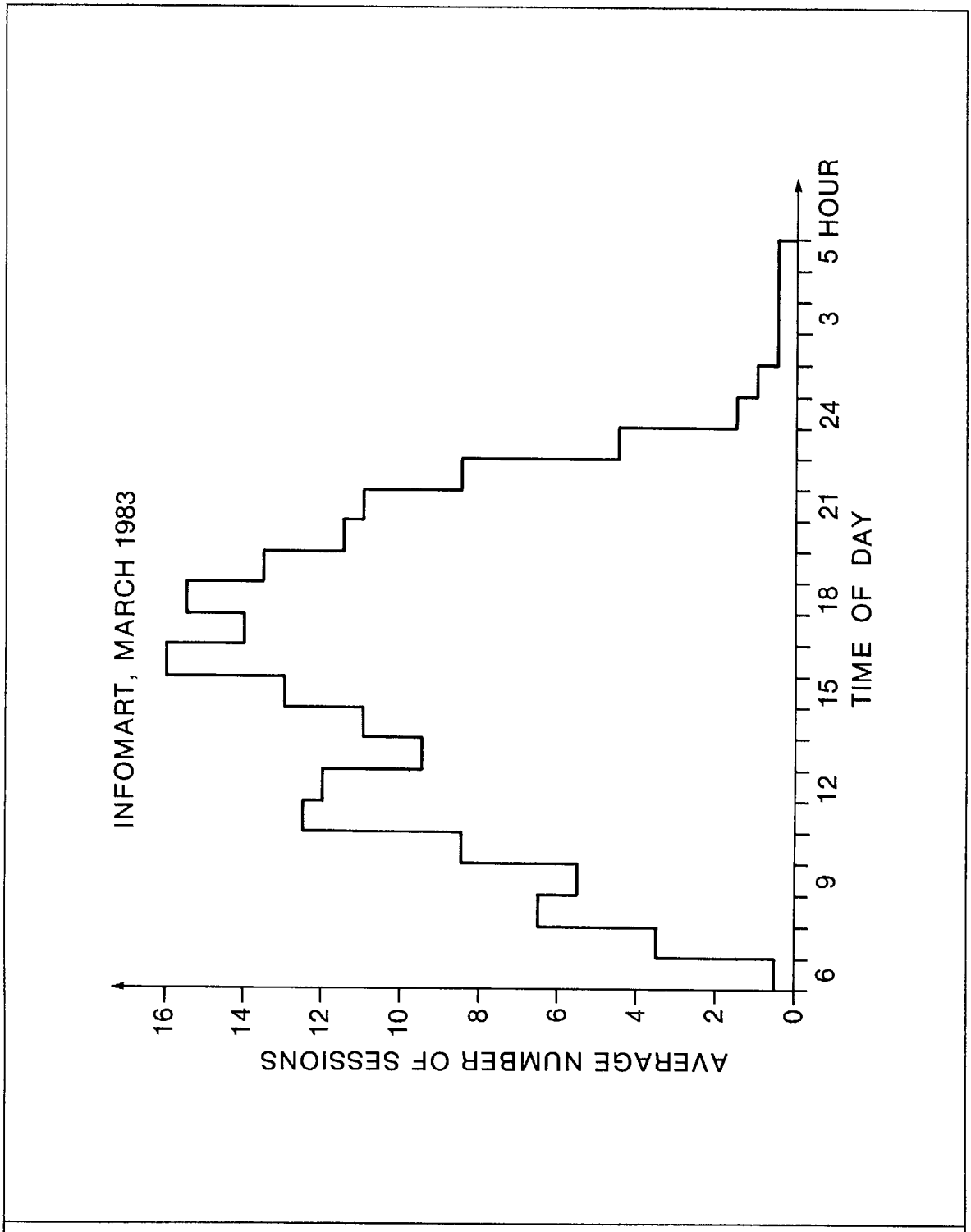

Figure 3-2: Hourly Variation of Number of Sessions per Day Averaged over One Month

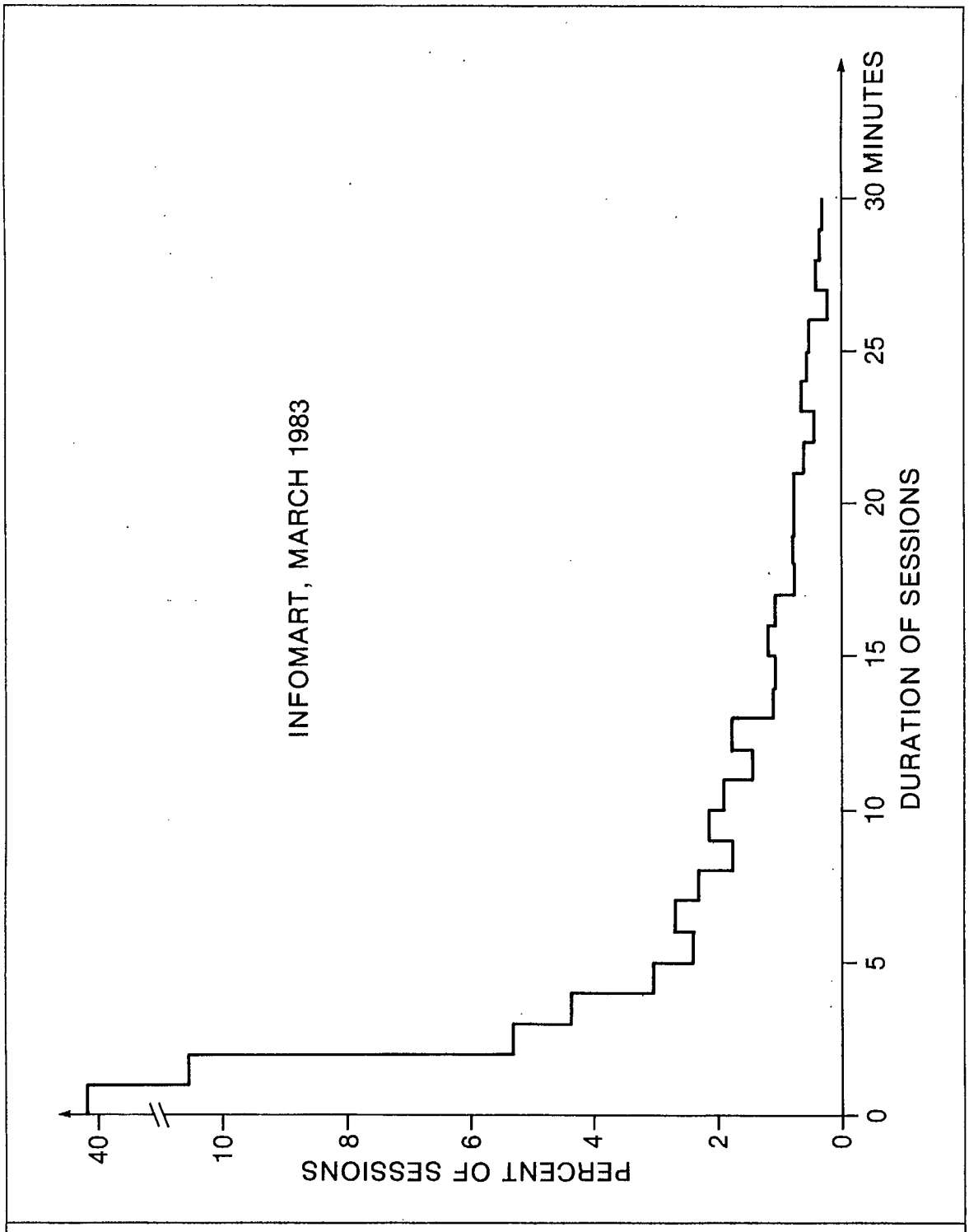

Figure 3-3: Distribution of Telidon Session Durations for One Month

4.0 RESULTS OF ELIE FIELD TRIAL

The final chapter of this report is intended to summarize the experience that has been gained from this trial directly or through observing activities in research and development in fibre optic technology and in systems relating to this project. This chapter also shows to what extent the objectives set for this trial were achieved and what future activities are required to further the development, manufacture and operation of commercially viable integrated services fibre optic subscriber access systems.

4.1 Technical Feasibility

The trial demonstrated successfully that the delivery of telephony, television, FM radio and Telidon services on an integrated services fibre optic subscriber access system to 150 subscribers in a rural environment is technically feasible. The project also provided detailed system and component costs and identified major cost centres that will require future attention. A summary of strengths and weaknesses found as a result of the Elie trial is given as follows:

A. Strengths:

- The concept of the "switched star" configuration proved technically successful.
- Simultaneous transmission of digital and analog signals on subscriber loops was successful.
- Bi-directional transmission of optical signals over one fibre is feasible.
- The capability of optical fibre cable to provide trouble-free operation in the rural outside plant has been proven.
- The fusion splicing method for optical fibres produced consistent low loss splices for both buried and aerial installations.
- No special tools and methods are required for construction crews. Burial depth, lashing and plowing equipment are standard.
- Lossless optical power monitors for LED transmitters are advantageous.

B. Weaknesses:

- Multimode short wavelength fibre optics technology restricts

repeaterless looplengths to 5 km which is too short for rural systems.

- The vintage 1979/80 lasers without an integral cooler resulted in too large bias current changes, with temperature variations causing unnecessary alarms based on bias current monitoring.

- Although not originally required for the trial, the lack of an optical equivalent of a distributing frame made plant rearrangement difficult and time consuming. There is a need for an optical distributing frame for future applications.

- Lashing drop cable to required slack strand is difficult. Drop cable should be self-supporting.

- Different loop designs for different lengths (e.g. LED, Laser with or without attenuator) would be an operational burden for the operating companies in the future.

4.2 Operational Conclusions

The trial has very clearly provided evidence that fibre optic subscriber access plant can be operated and maintained without undue difficulties by regular operations personnel. The following list is a summary of experiences gathered through operation of the trial system:

- A single trouble report centre is desirable for integrated services. This relieves the subscriber of the need to analyze symptons of trouble to determine where to report it and results in economies for all organizations involved.

- The automatic and remotely accessible alarm and maintenance facility provided early warning of potential trouble and enhanced preventive maintenance.

- The system performance and the subscriber trouble rates for all services are compatible with those of traditional systems.

4.3 Service Opportunities

The trial has provided strong indications that there exist several service opportunities that could be exploited in the future. These are summarized here as follows:

- The trial has proven that rural residents have a need for a greater variety of TV programming which CATV can provide. User surveys were conducted throughout the trial and showed wide acceptance of the system.

- The high usage of Telidon for electronic games indicates a

need for additional entertainment and therefore an opportunity for service providers.

- Survey questionnaires indicate a major public interest in the provision of alarm systems over existing data channels.

4.4 Economic Conclusions

The Elie-St.Eustache trial system was built as a one-of-a-kind system which not necessarily optimized the design of terminating optical and electronic circuits and subsystems for mass production. Any conclusions with respect to economic feasibility are, therefore, preliminary. No economic conclusions should be drawn regarding hardware cost.

The Elie trial was a small and unique project and the equipment and outside plant construction cost is, consequently, not representative and cannot be compared properly with construction cost for a larger and routinely established project.

Although the opto-electronic equipment is not economical at today's technological level, improvements and innovations are predicted which can make the installation and operation of fibre optic systems in rural areas economically feasible, provided there is a demand that can stimulate the required research and development.

4.5 General Benefits of the Trial

Essentially, all data collected through the trial will contribute toward decisions to be made by industry and government with respect to the future of fibre optics, its application in integrated services networks and the development of new services. Information was generated by this trial to the benefit of everyone concerned.

In summary, the Elie trial

- promoted the use of fibre optics,
- helped industry gain experience with a new technology,
- generated information regarding new service opportunities
- accelerated development of Telidon services (i.e. "Grassroots" in Canada and U.S.A.),
- promoted Canada's image as a leading country in telecommunications (various publications contributed to spread this message).

The foregoing justifies calling the Elie field trial an unqualified success.

4.6 Major Recommendations

The trial has convincingly demonstrated, in principle, the technical suitability of the application of fibre optic technology to an integrated services subscriber access system in a rural environment. However, it has also become apparent that there still exist major economic barriers for this technology's wide scale application to subscriber access systems.

The following paragraphs recommend actions for the various sectors of the telecommunications industry and governments in areas where they could be most influential in accelerating the practical application and economic feasibility of fibre optic subscriber access systems.

4.6.1 Manufacturers

The major effort should concentrate on the development of technologies and manufacturing processes that will reduce costs of the following items significantly:

- Glass fibres.
- Optical transmitters and receivers.
- Integrated optical devices.
- Wideband video switching devices and systems.
- Wavelength division multiplex (WDM) devices.

Such effort will require large amounts of R & D funds which will only be made available with positive, large service needs and, in particular, through a commitment by common carriers to the large scale utilization of fibre optics technology in the subscriber access network. A close cooperation between common carriers, manufacturers and governments as exemplified by this trial is necessary to secure the R & D funding required for the development of an economic fibre optic subscriber network.

4.6.2 Common Carriers

Around 1976, numerous studies were made by common carriers investigating the possible ways in which improvements to telecommunication services for rural subscribers could be effected. The Elie-St.Eustache trial was one result of those studies. Now, at a time of rapid technological advances, new service requirements and competitive forces, the common carriers, in

order to make a commitment for the large scale implementation of fibre optics technology in the subscriber access network, must again

- determine the role which competing technologies such as direct broadcast satellites (DBS) and cellular radio will play and what impact they will have on the applicability and cost effectiveness of fibre optics,

- study, on a continuing basis, new service requirements and their potential revenues and, therefore, their impact on delivery plant cost,

- determine the effects of integrated services carrier systems on owners, service providers and users with respect to economic, legal and operational aspects in order to eliminate any potential deterrents.

Furthermore, provided that all above conditions are favourable and that technical and economic objectives can be met,

- launch another fibre optic integrated services trial to confirm the appropriateness of new technologies from a carrier point of view.

In order to launch such actions and, eventually, make a commitment in favour of large-scale implementation of fibre optic technology in the subscriber access plant, the authors believe assurances are needed that,

- carriers will be permitted to carry all services without restriction,

- unnecessary fragmentation in carrying local services, which could adversely affect the revenue potential and thus the economics of an integrated services fibre optic distribution plant, will not occur.

4.6.3 Governments

The following items suggest actions which the various governments could initiate in order to accelerate the introduction of fibre optic subscriber networks:

- Examine the impact and appropriateness of present communications policies and regulations that affect integrated service networks and make changes where necessary and desirable,

- promote and develop standards related to integrated services networks,

- analyze and make recommendations concerning possible finan-

cial support or incentive schemes for industry for long-term and high-risk research and development in order to maintain Canada's leadership in fibre optic communications technology and systems.

It is quite evident, that no isolated action by industry or government can create the necessary conditions for fibre optic technology to become feasible for application in subscriber access systems. In fact, the recommendations represent intertwined sets of conditions which require the concerted action of industry and governments.