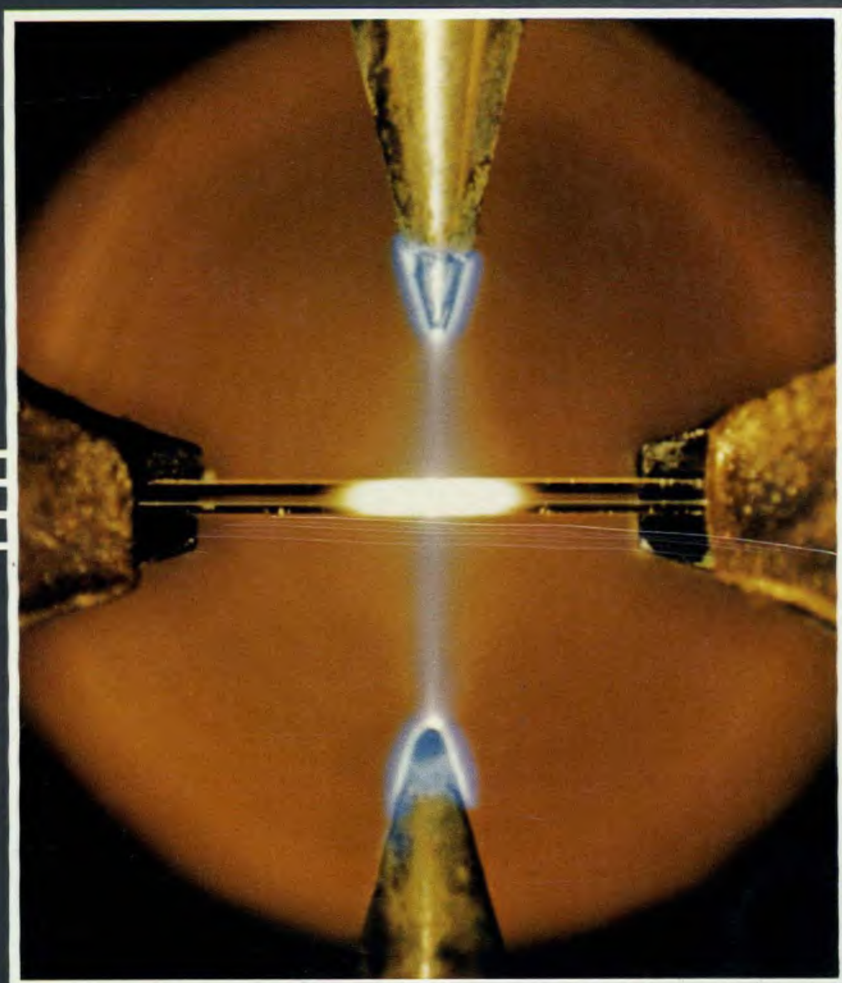
Elie-St. Eustache Fibre Optic Field Trial



PROJECT EVALUATION REPORT

ELIE - ST. EUSTACHE

FIBRE OPTIC FIELD TRIAL

PROJECT EVALUATION REPORT

prepared by

Kenneth B. Harris
Programme Manager
CTCA

George A. Tough
Project Manager
MTS

Metin B. Akgun
Scientific Authority
DOC

for

CTCA/DOC Field Trial Board of Control

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

March 1985

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. This first volume gives all the findings in as much detail as is reasonable and possible. The second volume is an executive summary which provides in a concise manner the highlights and key findings of the trial.

Volume 1 of the report consists of 15 chapters, each addressing a major issue of the project. Chapter 1 gives the historical background which led to the field trial and also describes the administrative and financial arrangements made to manage the project. Chapter 2 describes the services that were offered to the field trial participants. It provides the rationale for the technical choices made in the systems design. Chapters 3 to 9 deal with the various technical aspects of design, installation, maintenance and performance of the system. Chapter 10 deals with the results of the users reactions to the technical and service aspects of the trial which were elicited through four formal surveys. Results are also presented on the actual use of cable- TV and Telidon services. Chapter 11 provides an overview on the public relations effort that was spent and its important contribution towards the trial's success. In Chapter 12, a detailed cost breakdown is provided of hardware, engineering and installation as they were incurred for this one-of-a-kind system. This cost breakdown is presented in order to identify major cost items which will require future research and development effort in order to make integrated services fibre optic distribution systems economically feasible. These costs are therefore not necessarily indicative of what mass produced commercial systems may cost in the future.

At every stage of the project many valuable experiences were gained and they are mentioned in the appropriate chapters. Chapter 13 pulls together all this scattered information in one place. Chapter 14 provides an outlook on what future experiments the trial system could serve and then continues to give an overview of similar activities worldwide. Finally, from the experiences gained and from worldwide trends a likely scenario for the evolution towards fibre optic subscriber access systems is developed. The final chapter, based on the conclusions drawn from this trial, provides separate recommendations for governments and various sectors of the industry with the view that certain sectors can be more influential and effective in their implementation.

An effort was made to write each chapter in such a way that readers who are interested in only certain aspects of the trial may not have to read the whole report. This, however, has necessitated in some instances unavoidable duplications. Even for those who may be interested only in certain chapters, reading of chapters 2 and 3 is recommended, since they respectively provide a general overview of all trial services and the systems technical aspects.

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 Informart 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. Léger of the Department of Communications during their review of the draft have been very valuable. Finally, we would like to thank D. Allard of the Department of Communications for her patience and effort in preparing the final manuscript.

There would have been nothing to report about without the dedicated effort of many people who successfully launched, implemented and operated this unique field trial. The authors wish to express their sincere appreciation to these unmentioned contributors from all the sponsoring organizations.

Kenneth B. Harris

George A. Tough

Metin B. Akgun

CONTENTS

CHAPTER 1 - BACKGROUND

1.1 General

The telecommunications carriers in Canada are continually examining new technology and techniques to improve and upgrade the telephone service to urban and rural subscribers. This has led to a steady improvement in the telephone plant both from a reliability and quality point of view and from quantity of service approach.

Time has seen the gradual replacement of open wire circuits of iron and copper wire by buried and aerial twisted pair cable. Equipment such as long line repeaters, loading coils and amplifiers have been incorporated in the design of the subscriber loop. These changes have improved the reliability of subscriber loops by reducing their susceptibility to storm damage as well as noise problems that have surfaced with massive rural electrification programs. However, a large percentage of subscriber lines still fail to meet noise objectives particularly in rural areas where there are long exposures to power lines.

Areas of the country classified as rural have a population density of at least one person per square kilometre and include small settlements and villages having populations of 2,500 or less. Areas with population density less than one person per square kilometre are designated as remote areas and towns or cities with population greater than 2,500 are classified as urban. Approximately six million people or 25% of the population of Canada live in rural areas as shown in Figure 1.1.

At one time, rural areas were served mainly by multi-party service and, as recently as 1960, 16% of main telephones were multi-party. This has been reduced to 6½% today and there is a need to find means of offering these remaining rural subscribers individual line service at a reasonable rate.

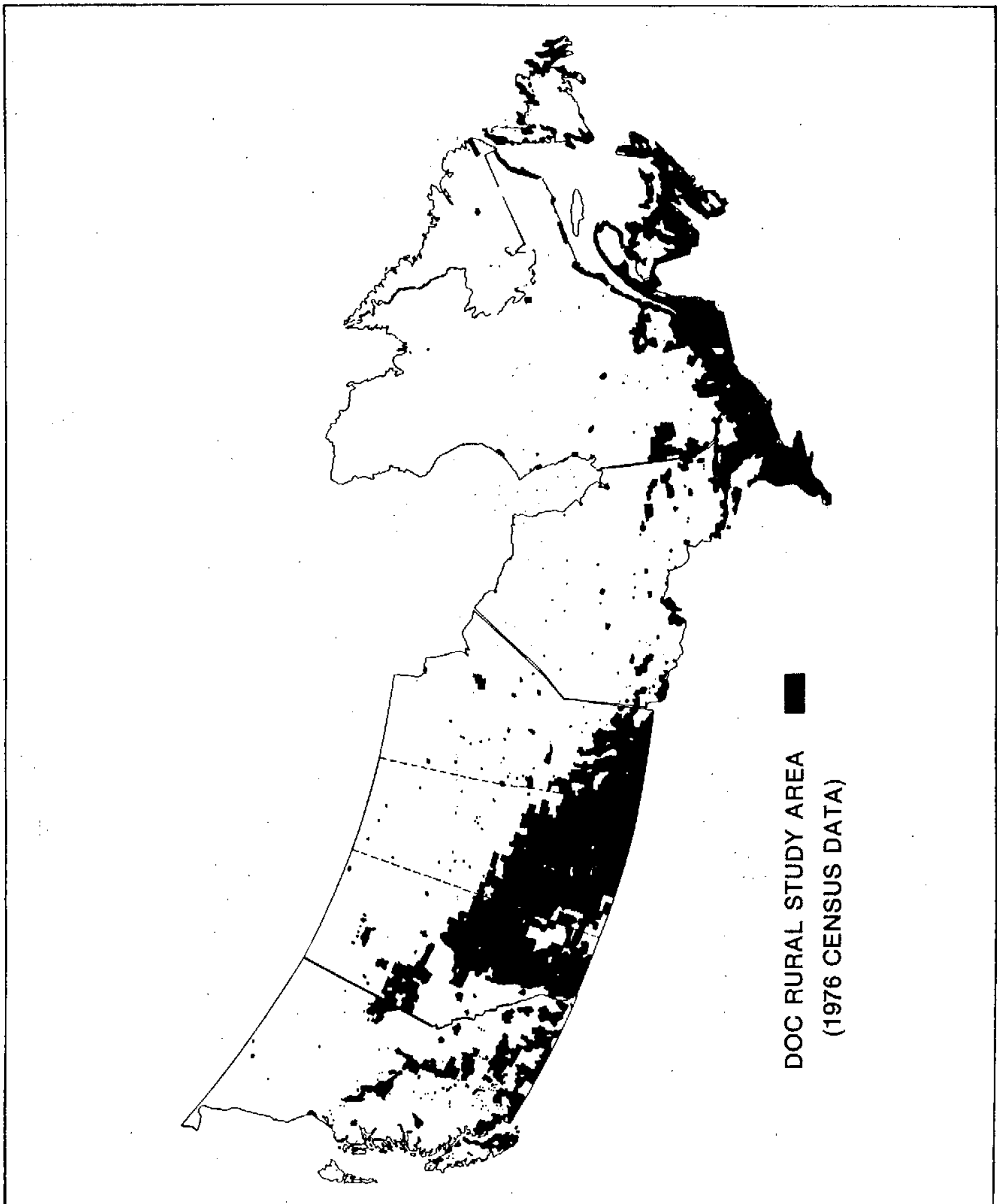


Figure 1.1 Distribution of Rural Areas in Canada

New telecommunications services are usually introduced first in the urban areas and it takes time to find ways to overcome the economic problems associated with less densely populated areas. When television service was first introduced, TV stations served mainly urban areas. In the larger cities subscribers now have access to TV stations in adjacent cities and in many cases additional channels are piped in by cable. As time went on, low power TV transmitters scattered throughout the rural areas and provided at least single channel TV to most Canadians, but the rural viewer was still limited in his choice of channels. The high cost of providing cable television (CATV) service in areas with low population density has prohibited the provision of cable TV in most rural areas.

A case can be made that single-party telephone service and CATV are even more important to rural dwellers than urban dwellers. The physical distances separating subscribers from sources of entertainment, and educational and cultural centres support this belief. In addition, many prairie farm families represent large businesses each with several hundred thousand dollars invested in land and equipment, and therefore have the financial resources to pay, within reason, for improved telecommunications services which they both desire as well as need.

New services are vying for the attention of customers and many of these new services will prove to be of real value to rural subscribers because of their isolation. Some of these services might be: fire, burglar and temperature alarms, medical data, teleshopping, telebanking, television, and Telidon for business, education and entertainment.

As new service demands arise carriers and service providers have to be aware of emerging new technologies and the opportunities they offer to provide such services efficiently and at reasonable costs. Fibre optics and communications satellites are typical examples of technologies which were almost unthinkable only a few years ago, but which are now within the realm of practicability for a number of services, due to their broad bandwidths. These allow the delivery of a variety of services simultaneously on a single carriage system. The service options and delivery system alternatives which such new technologies offer have to be considered when developing network and service evolution plans.

Such planning activity, however, is not only influenced by technological advances, but also by regulations which may be applicable to a number of services as well as carriers, service providers, broadcasters and cable TV system operators. To complicate the matter, regulations may come from both federal as well as provincial agencies which may have jurisdiction over different services and carriers. In addition regulations, based on historical conditions, may not necessarily be conducive for carriers and service providers to take full advantage of emerging new technologies.

Indeed a CRTC regulation which requires that a cable-TV licensee has to own at least some parts of the delivery system, particularly the drop to the subscribers premise and the inside cabling to the TV set is an example which makes it very difficult if not impossible to provide integrated services delivery systems, which for example fibre optics technology is capable to do. Fortunately, in the case of Manitoba, an agreement signed between the governments of Canada and Manitoba in 1976 (The Manitoba-Canada Agreement) permitted The Manitoba Telephone System (MTS) to own the facilities to carry any telecommunications services, with the restriction that MTS was not to provide the content of cable-TV as a service to the end customer. This agreement allowed the concept of an integrated network to be considered. MTS's studies predicted that fibre optic technology would likely result in a reduction of the cost of providing CATV in rural areas in the long term (late 1980's) by a factor of up to 4 times relative to coaxial cable based systems.

1.2 Preceding Studies

1.2.1 MTS "Rural Experimental Trial" Study

An MTS study [1.1], which was issued in 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 of implementation policies. In the latter the fact was taken into consideration that, while an integrated broadband network would cost less to build than separate networks for telephone and cable television, the revenue requirements would still remain very high, particularly for the lower subscriber density areas.

1.2.2 DOC Research Program on Rural Communications

Between 1976 and 1980, the Department of Communications of the Government of Canada also launched a research program on Rural Communications. As part of this program a systems study on the application of fibre optics for broadband communications was contracted to Bell-Northern Research [1.2]. The study again concluded that, in the long term, the integration of services on a fibre optic based broadband network would be economic with respect to capital expenditures compared with other delivery systems and technologies.

1.2.3 MTS Unsolicited Proposal for Rural Distribution Trial

With present technology, it is not financially feasible for cable television companies to provide service in areas with a low subscriber density because the revenue to provide adequate return on investment requires subscription rates which are unacceptably high. MTS developed a much wider ranging approach considering the following:

- An integrated distribution network (likely fibre optics) was the most economical system to deliver telephone and CATV service even though it generated an inadequate return on investment.

- Additional new services would improve the return on investment, though still not to the break-even point.

- The federal and provincial governments separately or together might consider rural CATV a necessity from a social obligation point of view, and subsidize it in some manner.

- The telephone utility was a stable, long term provider of service subject to regulation and best positioned to be the owner of the distribution network.

- Therefore, the telephone utility should be the transporter of all services delivered to the home.

In order to demonstrate the practicability of the above scenario, MTS submitted an unsolicited proposal to the federal Department of Communications. This proposal, based on the MTS January 1977 study mentioned in section 1.2.1, and illustrated in Figure 1.2 was to serve 150 subscribers and estimated to cost $ 6 million.

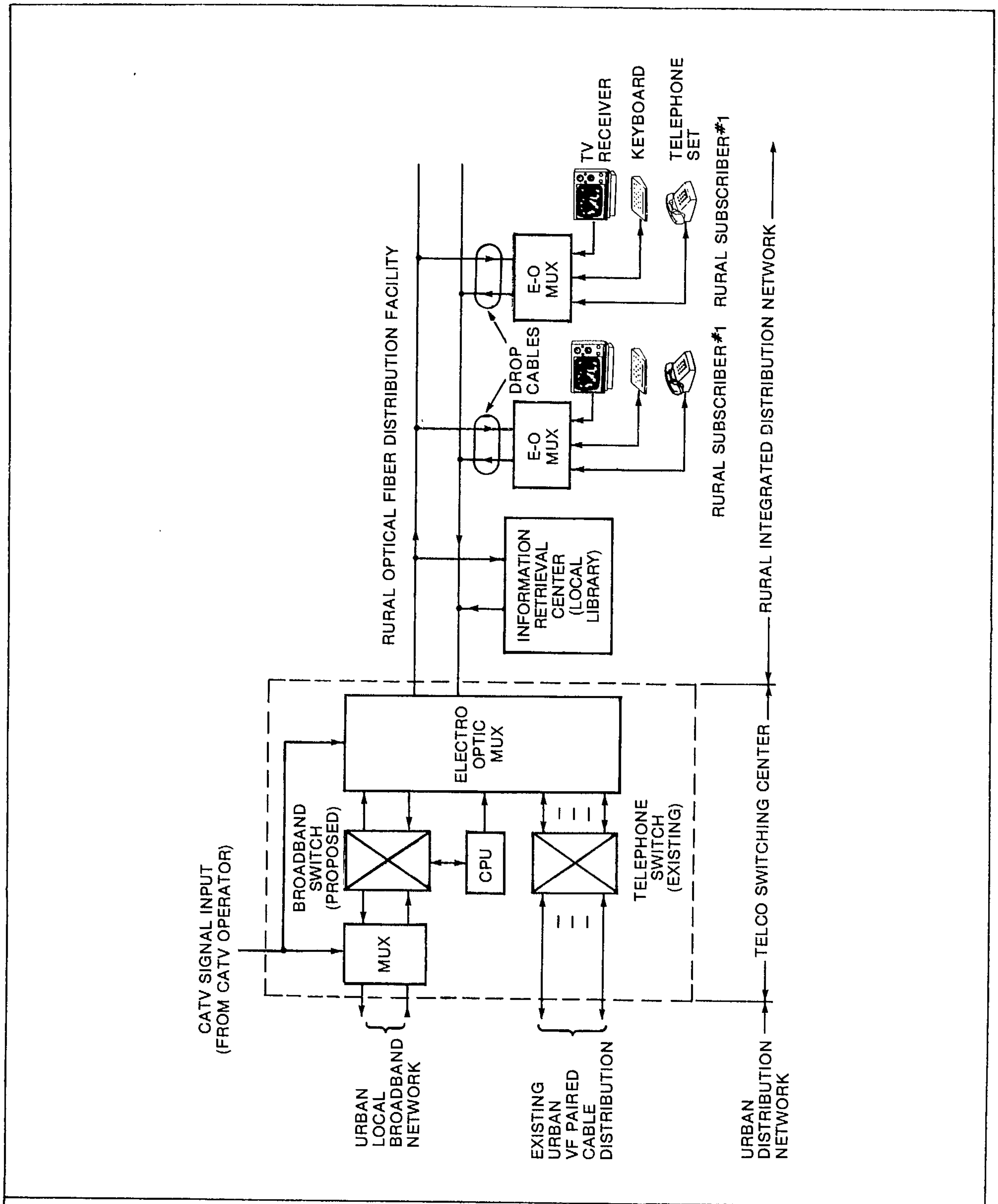


Figure 1.2 Functional plan for an Integrated Broadband Distribution System for Low Density Rural Areas proposed by MTS to DOC

The proposed functional plan provided conventional individual line telephone and data service in the most efficient manner by making use of the channel demand assignment concept now widely used in digital subscriber carrier sytems. Cable television signals were to be obtained from a CATV head-end and to be multiplexed directly onto the distribution facility, bypassing the broadband switch. These channels were to be accessible continuously by any CATV subscriber.

The on-demand switched program video and audio information was to be made available on a channel demand assigned basis through the broadband switch and under the billing and supervisory control of the central processor unit. Video and audio program material ultimately could be originated from almost anywhere, in the local broadband network of an adjacent town or city, or even within the rural area itself.

1.3 Trial Objectives

Since DOC was interested in MTS's proposal to build an experimental trial rural distribution system using fibre optics a set of trial objectives were established reflecting both DOC's and MTS's concerns:

- To assess the technical and economic feasibility of utilizing fibre optic 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 in respect of policies, regulatory requirements and future system choices.

- To assist Canadian industry in developing 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 systems capability in fibre optic technology.

DOC stated its willingness to fund one half of the trial cost, provided that the telecommunications industry in Canada would fund the remainder. MTS then entered into negotiations with the Canadian Telecommunications Carriers Association (CTCA) with a view to obtaining their agreement to assist with the funding.

1.4 Program Definition Studies

It was identified at this time that two Program Definition Studies were required to be undertaken by two major Canadian telecommunications suppliers. Since one of the objectives of the field trial was to encourage the participation of the Canadian industry, Northern Telecom Canada Limited (NTCL) and Canstar Communications Limited (a division of Canada Wire and Cable Company) were contracted to carry out the studies. The objectives of this study were:

- To determine the form that a useful rural field trial of fibre optic communications technology should take and to identify viable options with due consideration of practical rural subscriber densities, the level of service to be provided, the present and near-term status of Canadian fibre-optic technology and the need for the use of this technology to prove its cost-competitiveness in the long run with conventional communications delivery technologies in this application.

- To estimate accurately the total cost of the program and to break this cost down into its natural components such as design, hardware, installation, operation, home terminal, programming and maintenance costs.

- To estimate accurately the total duration of the program by breaking it down into convenient phases and to allocate and coordinate the time required to carry out such functions as design, installation, evaluation and shutdown of the trial. The breakdown into phases was to be guided by the requirement to maintain effective management control of the program throughout its duration.

- To identify and suggest a detailed management and implementation plan for the trial.

- To document the value of the trial and to provide a sound data base for use by the management in their decision making process that was to precede authorization being granted to implement the field trial proper.

- To develop a general business plan outline for the introduction of fibre optic technology into the rural environment for delivery of broadband services and to indicate the manner in which this would fit into the total business plan.

Each Program Definition Study was priced at $100K, and contracts were awarded so that work would start in November 1977. It was agreed that DOC and CTCA would share the cost of the Program Definition Studies.

1.5 Selection of Trial Location

In order for the two suppliers to complete their work, it was necessary to select the site for the possible future trial. MTS along with DOC established certain selection criteria, both desirable (acceptable site) and undesirable (unacceptable site).

Desirable charateristics:

- Good mix of people - commuters, farmers, young, retired
- High average income level
- Dense rural
- High telephone development
- Progressive people - willing to participate in a communications laboratory
- School (for educational services)
- Doctor or hospital (for telemedicine)
- Along MTS's intercity broadband network (for easy delivery of CATV)
- Radio tower (for easy connection of services to Winnipeg)

Undesirable characteristics:

- Too large population
- Town is candidate for CATV license
- Too close to Winnipeg
    - ° Volatility of growth and change
    - ° Urban influence
- Duplicate town name elsewhere

Some of the criteria were more subjective than objective, and cannot be quantified with the facts at hand. Some criteria were also more important than others, but again on a subjective basis.

Three groups in MTS (Planning, Marketing and Engineering) selected nine likely candidate sites for the proposed trial. A matrix taking the criteria into account was used to eliminate all but two sites. Representatives from MTS and DOC visited the two sites, and subsequently met with the councils of the two affected rural municipalities separately. The proposed field trial was explained, along with the obligations of the possible participants. The councillors were asked if they thought the area residents would be interested in assisting in the trial.

From the reactions of the two councils and additional information and impressions collected by the representatives, MTS and DOC decided that the town of Elie and the surrounding area would be the field trial site for the purpose of the Program Definition Studies.

During the preliminary discussions with the two suppliers in preparation for the Program Definition Studies, it became known that a research study funded by DOC was being published by BNR [1.2]. This comprehensive study contained information relating to:

- Methodologies and design considerations
  - Rural, urban models
  - Fibre optics for CATV, switched video, and integrated services
  - Operational considerations
- Costs
- Implementation and operational considerations
  - Local network evolution
  - Fibre compatibility with existing networks

This report was made available to both contractors so that the starting level of information for their studies would be equal.

1.6 Selection of Participants

1.6.1 Initial Selection of Participants

The two contractors also required guidance regarding the location of the trial participants. Budget requirements limited the number of participants to 150. This number was to be made up arbitrarily of 75 participants from the town of Elie, 40 from the village of St. Eustache and 35 from the rural area around and between them.

The exact locations of the participants were not identified at this stage. However, certain criteria were specified to test all possible loop distribution situations. A representative number of

- Short loops
- Maximum length loops
- Aerial loops
- Buried loops
- Loops distributed from the street in front of the home
- Loops distributed from the rear of the home
- Loops crossing under the La Salle river

were to be included.

Maps of the villages and surrounding area showing buildings were provided to the contractors.

1.6.2 Final Selection of Participants

After the trial site was selected, several steps were taken to identify individual households and businesses that would eventually participate in the trial.

On three different nights MTS organized informational meetings which were held at the town hall and to which all residents were invited by letter. At these meetings an overview of the trial was given.

As a second step all residents were visited by MTS representatives in their homes in order to establish personal contact as well as to ensure that nobody was left uninformed.

Finally a questionnaire was mailed to each household with a return envelope. The questionnaire is shown in Appendix 1-1.

The final selection of participants was based mainly on the following three criteria:

i) The resident had returned the questionnaired that was sent, thus indicating a willingness to participate in the trial.

ii) The resident had also shown a keen interest when personal contact was made in the community by an MTS representative.

iii) The residence fell within the prescribed boundaries of the technology trial (i.e., no farther than 5 km from the Field Trial Centre (FTC) or Remote Distribution Centre (RDC)).

During this selection process locations of alternate participants were also identified, should change become necessary. Residents who were to be provided with two independent television channels were identified during this selection process as well.

Finally, Selected Participants were asked to sign a Consent and Waiver form in which they acknoledged that the services being offered were of a trial nature and waived any rights of action against MTS and other participating companies from any claims and demands which may arise from participating in the trial.

1.7 Contending Proposals

The two completed Program Definition Studies received by DOC and CTCA in September 1978, were based on quite different designs as outlined in Appendices 1-2 and 1-3. The criteria for evaluating the Program Definition Studies are given in Appendix 1-4.

A study session was held by CTCA and DOC technical representatives who assessed the designs and the companies capabilities. This group recommended that the NTCL proposal be adopted. Some of the factors that were considered were:

- NTCL system architecture conformed more to the design of the existing network and would result in an easier evolutionary step.

- NTCL being a larger company with more resources and relevant experience could undertake a risk of this size more readily.

This recommendation was accepted by CTCA and DOC.

1.8 Trial System Configuration and Services

The system adopted for the Elie St. Eustache trial consisted of a Field Trial Centre (FTC) serving the residents of Elie and a

Remote Distribution Centre (RDC) serving the residents of St. Eustache. Four services were to be provided:

- Telephone
- 8 Television stations
- 6 FM radio stations
- Telidon

1.9 Contractual Arrangements

The total program was conducted in two phases. In Phase I of the program the basic system was designed, manufactured and installed to provide telephone, cable TV and FM radio services. In Phase II of the program additional facilities as well as data bases were established to provide Telidon services via the full duplex 56 kb/s data channel of the basic system.

1.9.1 CTCA/DOC Memorandum of Agreement

The first formal agreement to be prepared was a Memorandum of Agreement between CTCA and DOC. This set out the relationship between the parties, and established the terms and conditions governing the design, development, construction, establishment, maintenance and operation of a fibre optic field trial at Elie, Manitoba.

1.9.2 Phase I Contracts

Phase I of the contract started with the signing of a contract by DOC and CTCA with NTCL in September 1979 after a lengthy period of examination and negotiation of the NTCL proposal.

With this contract, NTCL was to design, manufacture and install the basic system consisting of a Field Trial Centre(FTC) in Elie, a remote Distribution Centre (RDC) in St. Eustache, a Fibre Optic trunk connecting the two centers, the fibre optic distribution plant connecting the 150 trial participants to the FTC and RDC and certain equipment in the trial participants' premises such as the Subscriber Entrance Unit (SEU), the telephone set and a television set top unit (STU) and its remote controller.

A second contract was signed by DOC and CTCA with MTS. With this contract MTS was to provide cable route engineering, power at the FTC and RDC, a CATV head-end in the CDO, cooperation in the provision of video and FM radio services, the in-house wiring and the operation and maintenance of the system. Furthermore, MTS was also to observe acceptance tests of the system for DOC and CTCA.

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

The original values of the contracts and the contributions by each of the trial sponsors are shown in Table 1.1

Subsequently some revisions to all contracts were made. In the contract between NTCL, DOC and CTCA, funds were provided for the inclusion of a service usage measurement system at an estimated cost of $280,000. However, since during the design and manufacturing phase of the basic system the details of services other than telephony and cable-TV could not be established, it was not possible for NTCL to design an appropriate usage measurement system. It was therefore decided, by mutual agreement of all parties, to transfer this responsibility together with the associated funds into the contract of MTS with DOC and CTCA.

CONTRACT	SPONSOR CONTRIBUTIONS			TOTAL CONTRACT
	DOC	CTCA	NTCL	
DOC/CTCA & NTCL	2,902,000	2,250,000	653,000	5,805,000
DOC/CTCA & MTS	150,000	150,000	--	300,000
DOC & CTCA	100,000	100,000	--	200,000

Table 1.1 Phase I Contracts Original Values

CONTRACT	SPONSOR CONTRIBUTIONS			TOTAL CONTRACT
	DOC	CTCA	NTCL	
DOC/CTCA & NTCL	2,762,000	2,110,000	653,000	5,525,000
DOC/CTCA & MTS	290,000	290,000	--	580,000
DOC & CTCA	130,000	130,000	--	260,000

Table 1.2 Phase I Contracts Revised Values

The original program management contract was to cover activities until end of March 1981. However, as it was necessary to provide program management for the remainder of the project, the contract value was increased by $60,000 and its duration extended until end of August 1983. The revised contract values are shown in Table 1.2

It was also agreed between CTCA and MTS, that MTS would pay 40% of CTCA costs in addition to the regular MTS share of CTCA expenditures.

1.9.3 Phase II Contracts

For the provision of Telidon services two contracts were signed, one between DOC and MTS the other between DOC and Infomart.

Under the contract between DOC and MTS, MTS was to engineer, operate and maintain additional transmission and switching facilities required for the Telidon services as well as to conduct user surveys. The actual facilities valued at $357,000 were purchased by MTS and remained their assets. Similarly DOC purchased Telidon terminal equipment also valued at $357,000 for use by the trial participants. The terminal equipment remained the property of the Government of Canada.

The contract with Infomart provided for the creation of a Telidon data base suitable for and responsive to the needs of people living in rural areas. The data base was to cover agricultural and lifestyle information and transactional services such as messaging, farm and business management programs and electronic games. The original contract was to terminate at the end of March 1983. In order to allow for the testing of some additional interactive Telidon services the contract was extended until end of March 1984 and its value increased by $240,000.

Table 1.3 shows the final values of the contracts and the contributions by each of the trial sponsors.

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 to be successful. Since this could not be clarified, CTCA decided not to participate in Phase II of the program.

CONTRACT	SPONSOR CONTRIBUTIONS			TOTAL CONTRACT
	DOC	MTS	INFOMART	
DOC & MTS	343,000	343,000	--	686,000
DOC & INFOMART	1,020,000	--	1,020,000	2,040,000

Table 1.3 Phase II Contracts Final Values

References

[1.1] MTS; Rural Experimental Trial, Study, January 1977

[1.2] Bell-Northern Research; A System Study of Fiber Optics for Broadband Communications, Technical Report, for Communications Research Centre, Department of Communications, Government of Canada, DSS Contract No: 0ST 76-00054, March 1978

APPENDIX 1 - 1

TRIAL PARTICIPANT SELECTION QUESTIONNAIRE

MANITOBA TELEPHONE SYSTEM BOX 6666. 489 EMPRESS ST., WINNIPEG, MANITOBA R3C 3V6

ELIE/STE. EUSTACHE FIBRE OPTIC TRIAL

This is an experiment to test both the technology and service aspects of telecommunications over an integrated fibre optic network. This means that all communication services to the home, such as cable television and telephone, will be transmitted on a single distribtuion line to the home.

Since this is an experiment we cannot guarantee the availability of services at all times although every effort will be made to provide an acceptable service.

If you decide to become involved and are selected, yours may be one of the homes which will trial one or more of the new services. There is no financial commitment from the homeowner.

To assist us in the selection of the one hundred and fifty homes which will receive the following:

1. Digital Single Party Telephone
2. Access to Cable T.V.
3. FM Radio Channels

we are attaching a household questionnaire. Any information which you provide is voluntary and will be held in confidence.

NAME: ______________________________

ADDRESS: ______________________________

PHONE NUMBER: ______________________________

I am willing to participate in this experiment and I clearly understand that it is an experiment of both technology and telecommunications services.

______________________ ______________________

Date Signature

HOUSEHOLD QUESTIONNAIRE

Head of Household:

Sex: ____________________

Age: ____________________

Marital Status: Single ☐ Divorced ☐

Married ☐ Separated ☐

Widowed ☐ Other ☐

Occupation: ____________________

Type of Business: ____________________

Do you work: On Farm ☐

In Elie ☐

In Ste. Eustache ☐

In Winnipeg ☐

In Portage la Prairie ☐

Other - Specify: ____________________

Education: ____________________

Other Members of Household:

Relationship to Head of Household	Age	Sex	Occupation	Education

Family Income

Under $10,000 ☐

$10,001 - $15,000 ☐

$15,001 - $20,000 ☐

$20,001 - $25,000 ☐

$25,001 - $30,000 ☐

Over $30,000 ☐

Please specify language most commonly spoken in the home:

English ☐ French ☐ Other: ____________

Do you own property? Yes ☐ No ☐

If renting, who owns the property?

Name: ____________________________

Address: ____________________________

Do you own a T.V.? Yes ☐ No ☐

Number of Black & White TV's ____________

Number of colour TV's ____________

APPENDIX 1 - 2

NORTHERN TELECOM CANADA LIMITED PROPOSAL

NORTHERN TELECOM CANADA LIMITED PROPOSAL

The service integrated fibre optics distribution system will be overlaid onto the existing copper based telephone system. Such an approach will minimize disturbance to the existing telephone service as well as provide full service protection against failure of the fibre link without requiring complex protection switching schemes. It also simplifies restoral to the original mode of service upon termination of the Field Trial Program.

The rural distribution field trial architecture is based on a centrally switched star configuration with two distribution centers (Fig. 1.3). The Field Trial Center (FTC) is located in a trailer adjacent to the Community Dial Office (CDO) in Elie and the Remote Distribution Center (RDC) is located 8.5 km North of Elie at the junction of highways 248 and 241. A dedicated fibre optic trunk cable connects the FTC and RDC. Distribution fibre cables connect the distribution centers to a Subscribers Entrance Unit in the subscribers home.

Telephone service is based on the Northern Telecom DMS-1 system with the Control Concentrator Terminal (CCT) located at the FTC and Remote Concentrator Terminals (RCT) at both the FTC and RDC. By utilizing the distributed remote feature of the DMS-1 and locating RCT's at the FTC and RDC, a common Line Interface Unit (LIU) can be used at both locations. This reduces the types of LIU plug-in units required which improves reliability and simplifies maintenance in this key area of the system.

For the standard system, one upstream and one downstream optical fibre, connects each subscriber to the distribution centre. Telephone signals are transmitted to the subscribers

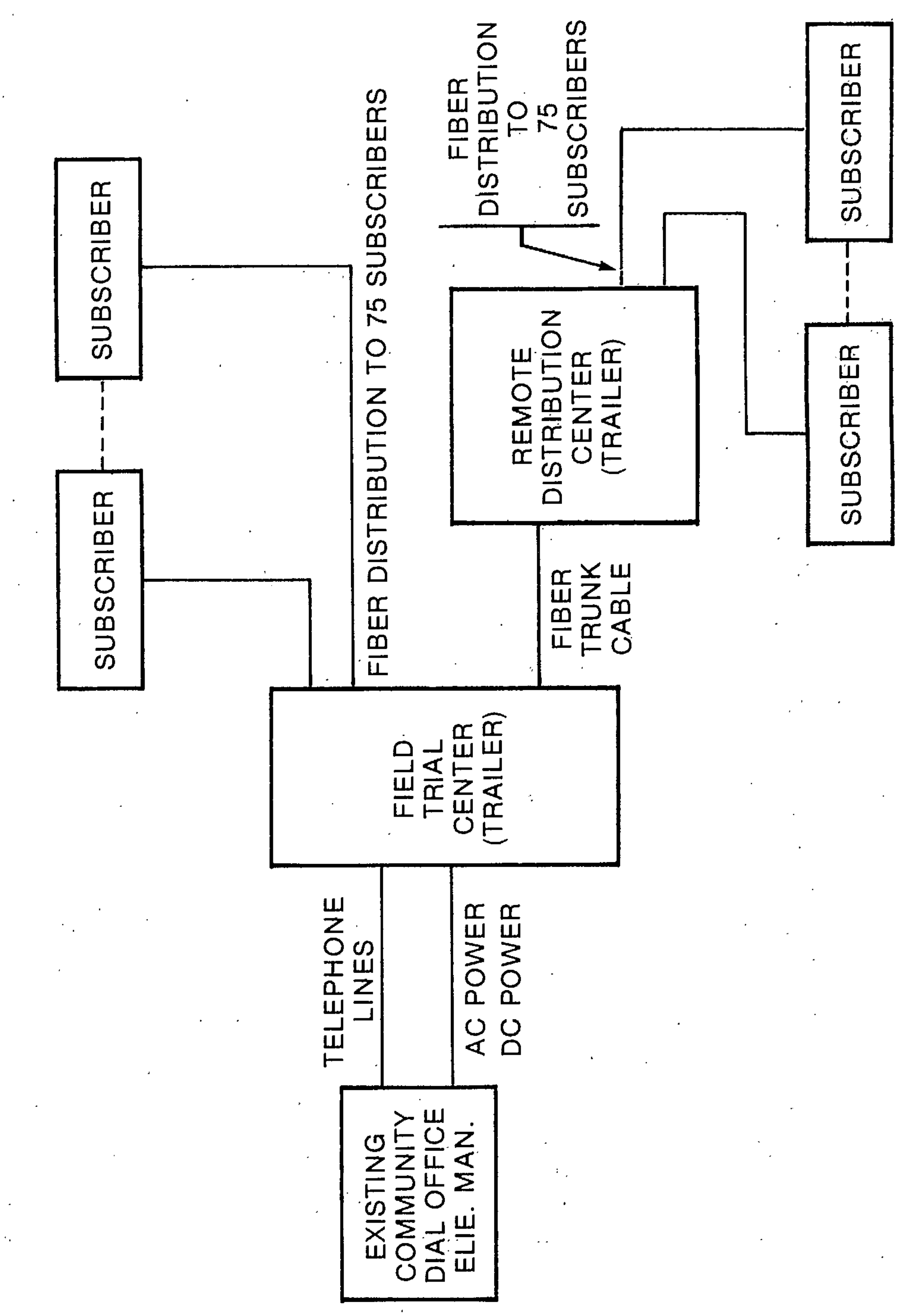


Figure 1.3 Field Trial Network Architecture proposed by Northern Telecom Canada Limited in their program definition study

premises in digital form, time division multiplexed with the data and signaling functions.

In the standard system, one analog video signal at a time is transmitted to each subscriber with access to a larger number of video channels being provided by a frequency domain video switch at the distribution center.

Trunking for telephone and data services is provided on the FD1 and FD2 digital transmission systems. Video trunking is provided in analog format on the Northern Telecom FA-1 transmission system.

APPENDIX 1 - 3

CANSTAR PROPOSAL

CANSTAR PROPOSAL

The proposed system topology is loop/tree for telephony and tree/tree for video. These topologies (for video, and telephony) are compatible with one another, and integration of the services can be done in a straight-forward manner. The transmission format for video is digital differential pulse code modulation (DPCM) on the feeder, and standard vestigial sideband (VSB) on the distribution. For telephony, the format is digital (64kb/s) on the feeder as well as on the distribution. On the feeder 24 digital telephony channels are time division multiplexed to form a digital T1 stream; on the distribution the telephone channels are frequency division multiplexed on independent carrier frequencies. These ideas are illustrated schematically in Figure 1.4.

The distribution control terminal (DCT), at the central office interfaces with existing telephony equipment that is compatible with the DS-1 format, with baseband video signal (conversion from standard VSB is provided by standard equipment external to the DCT), and with FM radio at standard IF. The DCT strips off the fault alarm and monitoring signals and the data channel information to allow a DS-1 signal compatible with D3 channel banks or digital switching to be provided to the central office telephony equipment. A format has yet to be defined for the data channel interface. This definition will depend ultimately on the type of service to be provided.

Remote distribution terminals (RDT's) are located at each of the active nodes. An increase in the number of such RDT's reduces the reliability of the system because of the loop/tree topology which limits the number of RDT's that can be used in the system. The RDT has fault monitoring equipment which monitors the local distribution to subscribers and in the event of a major

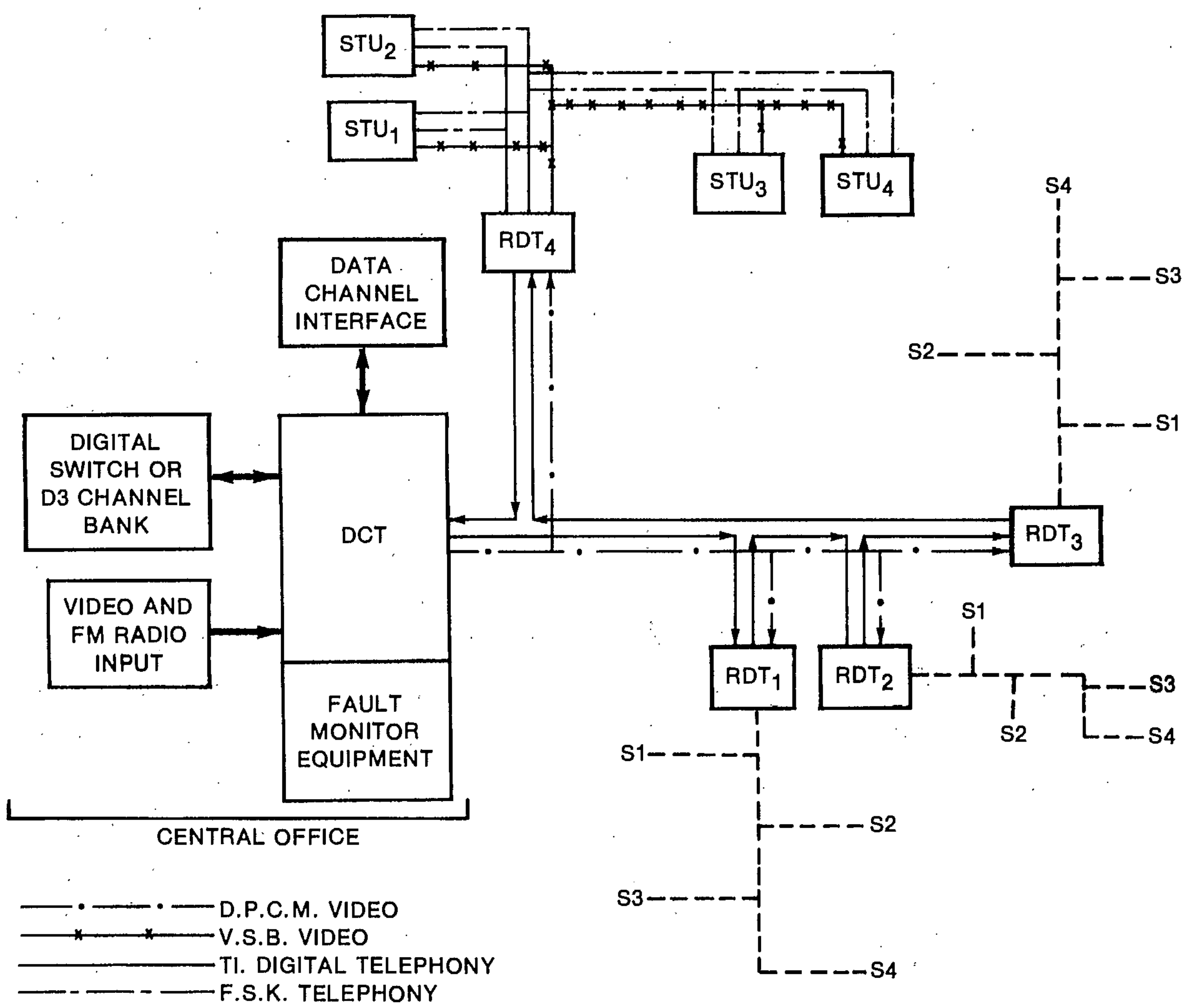


Figure 1.4 Field Trial Network Architecture proposed by Canstar in their program definition study

fault in the local distribution, the RDT offers a by-pass which prevents the fault from propagating through the rest of the network. Each RDT is able to access up to 24 channels in order to service up to 24 subscribers on a dedicated channel assignment. Due to the proposed extensive use of low cost microprocessors in the equipment design, demand assignment could be incorporated into the distribution network. In this mode, each T1 stream shared among any number of RDT's will be capable of serving 128 subscribers or more depending on the required blocking probability.

It is proposed that each feeder route has at least two T1 streams for telephony, so that the probablility of simultaneous failure of both is minimized. The optimum method of transmitting the T1 streams is dependent on whether a decision can be made about the number of video channels that will be engineered into a feeder route. If this number is 12 or more then at least one T1 stream can be multiplexed with each T4 video stream on one fiber. This will be a low cost method of providing a soft failure (i.e. the blocking probability increases as the number of available trunks is reduced from 48 to 24 channels). If the video, telephony and digital data cannot be integrated into one fiber because of economic or operational considerations, separate fibers can be provided for each T1 and T4 group. It may be noted that use of separate fibres does not greatly increase the cost of the system because a separate T1 stream for telephony is relatively simple.

The analog to digital conversion for video, telephony and FM radio is done at the central office for transmission to the RDT nodes. The telephony signal remains in the digital PCM format (64Kb/s) till the subscriber's codec in the subscriber terminal unit (STU). The video and FM radio channels are converted into analog form at the RDT resulting in codecs on a per channel basis rather than on a per subscriber basis.

In the distribution network, separate fibres will be used to transmit video and telephony. FM radio and FSK telephony could be multiplexed on one fibre. Since data services are provided on the overhead bits available in the 64Kb/s telephony stream no separate transmission provision is required for these services. Laser linearity and power currently limits the capacity of VSB channels that can be carried on one fibre. The number of subscriber taps and the distances to be covered will determine the number of repeaters to be introduced in the distribution networks. Ideally, it would be desirable to eliminate the need for repeaters in the distribution.

APPENDIX 1 - 4

EVALUATION CRITERIA FOR PROGRAM DEFINITION STUDY

EVALUATION CRITERIA FOR PROGRAM DEFINITION STUDY

			Points
I.	COMPANY AND STAFF CAPABILITY		40 - TOTAL
	A. Qualifications and Related Experience of Staff: Past Experience of Company (and Subcontractors) in Closely Related Activities		24
	-- cables	8/24	
	-- equipment, electronics and outside plant	8/24	
	-- complete systems	8/24	
	B. Commitment to Program		6
	-- relationship of fibre optic systems to existing corporate activities		
	-- interest in achieving objectives in the project.		
	C. Project Management		10
	-- role of contractor with MTS, DOC, CTCA	4/10	
	-- depth of project management and support demonstrated	3/10	
	-- project management capability	3/10	

	Points
II. TECHNICAL PROPOSAL	60 - TOTAL
A. Proposed Approach and Methodology (Design Concept)	40

- -- utilizes modern system design techniques
- -- provides full service flexibility (as required)
- -- interlocks with business strategy
- -- permits development of new service offerings
- -- provides basic services at reasonable cost
- -- supports existing or planned related activities by utilities
- -- compatible with the evolution of the telecommunication network
- -- analog/digital
- -- technical specifications
- -- physical environment
- -- privacy, security
- -- simultaneity of services

B. Technical Feasibility of Proposed Method (Implementation)	20

- -- uses state of art technology - fits time frame
- -- minimizes MTCE and operational costs
  - ° reliability
  - ° alarms
  - ° order wire
  - ° fault location
  - ° power failures
  - ° mean time, between failures and to repair

	Points
-- considers all field trial parameters	
-- proves validity of technical and business strategy	
-- provides techniques where required for extrapolating Elie trial to other applications	
-- installation methods	
-- line-up, adjustment procedures	
-- test equipment	
-- personnel skill levels	
-- cable - care and safety of installation	
FOLLOWING ARE EXCLUDED FROM TECHNICAL EVALUATION EVALUATION ONLY	
III. TERMS AND CONDITIONS	--
IV. CANADIAN CONTENT	--
	100 - TOTAL

CHAPTER 2 - SERVICES OFFERED

2.1 General

One feature of an integrated distribution system is the capability to deliver a number of different telecommunications services to the customer simultaneously. In the Elie - St. Eustache trial two known and one developing service were provided to the particpants. These were:

- Single party telephone
- A CATV package including TV channels and FM radio stations
- Telidon, the Canadian developed version of videotex

In the initial design of the system it was planned to provide each participant with single party telephone service over the fibre, plus CATV channels and FM radio stations. Additional services were not identified at that time but a 56 kb/s full duplex data channel was provided to each home in the event that other services would be implemented during a second phase of the trial.

A number of services were considered for inclusion in the second phase, but for various reasons were not offered. Both the schedule and budget were part of the constraints. In addition, a slightly earlier trial (IDA) inititated by MTS had given the service providers and MTS both technical and market information about some services. It was therefore considered not to be essential to demonstrate these services again on the Elie trial.

One service that was, however, considered necessary to implement on the Elie - St. Eustache trial was videotex. The

Department of Communications of the Government of Canada had developed a second generation videotex coding scheme, called Telidon, for introduction of videotex services in Canada. The nucleus of a compatible data base already existed in Winnipeg, because Infomart, an electronic publisher, had developed it for IDA and was considering to offer a suitably augmented version of this data base as a commercial service to the farming community in Manitoba.

One major purpose of the further development of this Telidon data base through the Elie - St. Eustache trial was to change it from a simple page retrieval system to a sophisticated interactive system offering services such as computer programs, teleshopping and messsaging. In the initial planning phases of the project, where each service was to be provided independently from each other, such services had not been considered as prime candidates for the trial for various technical, cost and user requirement reasons. The relative ease, however, with which these services could be incorporated into the Telidon service, reversed that decision and eventually these services became part of the Telidon service package.

On the other hand some services that were considered, but could not be offered for reasons given below, included:

- Alarms - fire, burglar and medical. These had been implemented on the IDA trial, and did generate subscriber interest. The Elie - St. Eustache trial participants also expressed some interest but the logistics became a problem. To whom would the alarms be reported? There is no 24 hour alarm centre open in Elie or St. Eustache and no alarm company was prepared to open a report centre for the small number of possible customers. Even if the alarms were reported, what action would be taken? Again, as in many typical rural towns, there was neither a fire department nor a police station that could react immediately to an alarm.

- Utility meter reading - electricity and water (town of Elie only) are metered. The electric utility (Manitoba Hydro) had been involved in the IDA trial, but had found that the economics were not right for remote meter reading at that point in time, and was, therefore, not interested in participating in yet another trial.

- Energy management - a non-issue at that time in Manitoba.

As can be seen, nearly all the services require the participation of a third party - the actual service provider. This could range anywhere from a utility to a small local alarm company. Many of these service providers were at that time either not able to assist or not interested in assisting financially and otherwise the development of new services.

2.2 Telephone

It is the desire of the Canadian telephone companies to be able to offer single party telephone service to all rural subscribers economically. DOC of the Government of Canada encourages this philosophy. The Elie - St. Eustache integrated services system was therefore considered a demonstration of a system capable of providing single party service to rural subscribers in the future. Thus, single party service became the prime trial service offered to all participants in comparison to the multiparty service offered to many of them by way of the conventional plant.

Touch tone was included in the provisioning for a number of reasons:

- A significant number of participants had previously been renting digipulse telephone sets. This is a set in which push buttons are used to generate dial pulsing.

- Touch tone sets (12 button) have the instant capability of providing end to end tone signalling required for some new services. This feature, however, was not used in Elie during the trial.

- MTS took the opportunity to try a method of converting an older crossbar local switching machine to touch tone service.

For the duration of the trial, the participants had their original paired plant telephone still in service as a standby. This telephone service was paid for by the participant, just as before the trial. There was no additional charge for the new phone service over the fibre. Since the trial system is continuing to be operated and is proving to be reliable, MTS is considering to discontinue use of the paired plant service and have the participants pay for the telephone service over the fibre plant.

2.3 Cable Television

2.3.1 Cable channels available

The Elie - St. Eustache area is geographically located close to Winnipeg so that the residents are capable of receiving the Winnipeg broadcast TV channels by means of roof-top antennae. These are shown in Table 2.1

Elie and St. Eustache area residents are not able to receive TV signals from the USA off-air for distance reasons. The trial system now delivers the American network stations to the subscribers in addition to the Winnipeg channels. The available cable TV channels are shown in Table 2.2.

Off-Air Channel No.	Designation	Affiliation
3	CBWFT	CBC French Network
6	CBWT	CBC English Network
7	CKY	CTV Network
9	CKND	Winnipeg Independent

Table 2.1 Off-Air TV Stations Available in Elie and St. Eustache.

Cable Channel	Designation (Affiliation)	Location of Station
2	CBWT (CBC)	Winnipeg
3	KGFE (PBS)	Grand Forks
4	KXJB (CBS)	Valley City
5	CKY (CTV)	Winnipeg
8	WDAZ (ABC)	Devil's Lake
10	CBWFT (CBC)	Winnipeg
11	KTHI (NBC)	Fargo
12	CKND (independent)	Winnipeg

Table 2.2 Cable TV Stations available in Elie and St. Eustache

The trial system is also designed to carry channel 13 - the community channel-required by CRTC. While the channel is in place in the system, it is not in use. No program origination equipment, such as a studio camera chain or a character generator has been provided. This is further referred to in section 2.3.3.

It was also decided to demonstrate the capability of the trial system to deliver FM stereo radio signals. All Winnipeg FM-broadcast stations were delivered, including also one AM-broadcast station, CKSB, which is the only French-language station in this area:

FM stations

CKWG
CBW
CHMM
CHIQ
CITI
CKSB (French AM)

2.3.2 Signal Delivery to Elie

The Winnipeg TV channels and FM stations are picked up off-the-air at the Elie Community Dial Office. They are processed and combined with the USA TV channels, then fed to the fibre optic trial system and to the coaxial cable local broadband network.

The USA TV channels are picked up off-the-air at Tolstoi, Manitoba. Since the distances of the four TV broadcast stations from Tolstoi are between 130km to 255km, the quality and reliability of the signals vary with time and weather. The signals are carried by MTS microwave radio from Tolstoi to Winnipeg, then carried westward past Elie on the coaxial cable intercity broadband network (ICBN). A breakout of the ICBN was established at Elie to extract the signals for processing and combining with the local channels.

2.3.3 CATV Operator

Initially, it was expected that CATV would be delivered on an experimental basis only to the participants of the fibre optic trial system. Being experimental, there would be no need for a licensed CATV operator, and there would also be no charge.

However, the Canadian Radio-Television and Telecommunications Commission (CRTC) invited applications for CATV service in Elie and St. Eustache in March, 1979. At a public hearing in December, 1980, the CRTC received one application that was subsequently approved in February, 1981. The successful licensee was Communitec, a company formed by a group of citizens of the Elie - St. Eustache community. Some of the significant conditions which were part of the CRTC decision and which did cause some changes to the planning of the trial were:

- 150 households would be served by the fibre trial system.
- The remaining households would be served by conventional coaxial cable.
- Ownership of the head end and inside wiring by the CATV licensee is a standard requirement. This would apply only upon termination of the experimental period.
- License will expire September 30, 1985.
- A charge of $10.00 per month for service payable by the subscribers was approved.
- A community channel was required.

The above conditions forced the following changes to the trial plan and also raised some concerns:

- A local broadband network (LBN) had to be constructed in both Elie and St. Eustache to serve non-trial households. This was an additional cost to MTS, since it was known from cost studies performed earlier, that an LBN serving less than approximately 1000 subscribers generally does not prove to be profitable to either the licensed operator or to MTS when typical urban subscriber subscription charges are made.

- The necessity for the CATV operator, in the long term, to purchase the headend equipment and the inside wiring of the subscriber premises under the condition where no profit can be expected would be a serious financial burden for which a satisfactory solution has yet to be found.

- For cost reasons it was decided that no studio equipment for the community channel was to be purchased. Consequently no programs on the community channel were available.

2.4 Telidon

2.4.1 General

The decision to offer Telidon service on the trial system was made easier because a database operator was already active in Winnipeg. Infomart was providing service for the MTS (IDA) trial. From observation by MTS and from comments by IDA customers, it was recognized that the database needed enhancement - both in quality and quantity. Regular updating of certain pages was also considered as necessary.

A three-way agreement was finally established whereby:

- Infomart would increase the size of the database and enhance its usefulness.
- MTS would provide connecting circuits between the trial participants and the database 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 database.

During the course of the trial, the database was improved significantly, with an emphasis on rural and agricultural content. Based on the fact that these improvements would be continuing, Infomart and MTS jointly introduced Grassroots, a commercial videotex service available anywhere in Manitoba on a dial-up basis.

Meanwhile an opportunity to encourage a second database operator arose, and Cybershare was offered a chance to participate in the Elie - St. Eustache trial. The two databases were judged complementary rather than competitive. Infomart at this time was providing essentially page retrieval of mainly agricultural information. Cybershare on the other hand offered mainly computer aided educational programs, and was much more interactive. A description of the two databases follows in sections 2.4.2 and 2.4.3.

The entire Telidon service was provided free to the participants of the Elie - St. Eustache trial. No charges were made for the Telidon home terminal, the usage of the databases and circuits. This was done partly because of the initial unknown reliability of the fibre system and the Telidon service, and partly in return for the trial households participation in market and usage surveys.

2.4.2 The Infomart Database

2.4.2.1 General

In early 1981, Infomart, which is the largest electronic publisher in Canada, was contemplating the introduction of a commercial Telidon service in Manitoba addressing the business needs of the farmers. The initial target population was the 1,000 largest farm businesses in the province from the total of 30,000 farms. It was expected that this leading edge group of farmers would prove, in a short time, the usefullness and need of a timely and frequently updated database to the remainder of the farming community.

The purpose of the Government of Canada in signing a jointly funded contract with Infomart, was to accelerate the development of a strictly farm business oriented database and to augment it with information categories which would have a broader appeal to people living in rural communities. Such information became eventually to be known as "lifestyle information". In addition, much more interactive Telidon services such as messaging, electronic shopping and banking were encouraged in order to gain experience in their acceptance by users as well as to learn about problems that may be encountered by interfacing computers with the public at large.

The support given through this trial, to develop a Telidon service has achieved its main goal, namely, to make it commercially viable. At the end of March 1983 there were about 700 paying subscribers in Manitoba alone. GRASSROOTS Telidon Service has now been expanded into Saskatchewan, Alberta and Ontario and the growth rate has steadily increased.

2.4.2.2 Content Available

The Infomart database content was available in three major categories with the following total number of pages as of end of March 1983:

Agriculture Information	18,000 pages
Lifestyle Information	12,000 pages
Government Information (CANTEL)	90,000 pages

The overall total number of pages was somewhat less than the sum of the three categories, since some information categories, such as weather, were accessible from both the Agriculture and the Lifestyle section. There were 151 Information Providers (IP) who contributed to the Agricultural Information category and 86 IP's for the Lifestyle Information category. The total number of IP's was again less than the sum of the two figures above, since some IP's contributed to both categories and were, therefore, counted twice.

The Government Information data bank was actually created under a separate program of the Government of Canada and is still available under the name CANTEL throughout Canada.

This latter data bank is fully bilingual and provides to the public information about the services available from the Government of Canada and its agencies. The other information was only partly bilingual. Because about 30% of the trial participants speak French at home the IP's were encouraged to provide their information in both official languages, but the final decision to do so was left to them. Aside from the Government Information section only 10% of the data bank is available also in French, which covered News, Weather, some Children's Stories and some Electronic Games.

In addition to information retrieval, Infomart did also offer highly interactive programs. These were:

- Messaging

- Farm Management Programs
  - ° 4 Livestock
  - ° 7 Crops

- Business Management Program
  - ° 6 Finance

- Electronic Shopping

- Electronic Games (19 games)

- Consumer Information (3 calculators)

Electronic Banking, although technically feasible, could not be implemented during the trial period, due largely to legal and policy concerns by major chartered banks. It appears that some of these concerns have now been resolved, at least to the extent that such a service was added to the data bank on a trial basis, in cooperation with one major chartered bank in late 1983.

The details of the Agriculture and Lifestyle information sections including some of the interactive programs are listed in Tables 2.3 and 2.4 respectively.

News and weather were frequently automatically updated throughout the day. Commodity Market information was automatically updated continuously with a 15 minute delay during the market trading hours.

At the start of the trial there were only about 1,500 pages available. Out of the 30,000 pages available at the end of March 1983 (excluding the CANTEL Government Information section) 13,000 were generated and stored as part of the Elie - St. Eustache

SUBJECT	NO. OF IP'S	NO. OF PAGES
Weather	4	335
Livestock Markets	8	1,295
Crop Markets	10	1,065
Livestock Management Programs	-	4*
Crop Management Programs	-	7*
Financial Management Programs	-	6*
Oilseeds and Special Crops	21	1,950
Newsletters	14	850
News	4	3,440
Insurance/Investments	10	1,890
Chemicals	9	270
Seed and Feed	11	1,020
Equipment	13	830
Government (Excl. CANTEL)	14	1,760
Research and Education	10	1,065
Farm Realty	2	30
Classified Ad's	3	105
Events	5	125
Employment	1	85
Finance	12	2,600
T O T A L	151	18,715

* Indicates number of Programs, not pages. They are not included in the total for pages.

Table 2.3 Agricultural subject content of the Infomart data base as of 31 March 1983

SUBJECT	NO. OF IP'S	NO. OF PAGES
News and Weather	4	3,440
Consumer Information	26	4,875
Calculator Programs	-	3*
Entertainment	12	700
Electronic Games	-	19*
Travel	8	400
Sports	13	1,160
Education	23	1,575
T O T A L	86	12,150

* Indicates number of Programs and Games, not pages. They are not included in the total for pages.

Table 2.4 Lifestyle subject content of the Infomart data base as of 31 March 1983

Field Trial program. The remainder was created by Infomart in conjunction with their commercial GRASSROOTS service. All data bases were equally available to the Elie - St. Eustache Field Trial participants and the commercial GRASSROOTS subscribers.

Access to the Infomart Database was through an account number and password. The account number was also used when sending a message to an other Telidon user. In order to simplify the memorization of account numbers, the numbers were identical to the subscribers 7-digit telephone number. Since all of the Province of Manitoba is within the same area code, each telephone number identified uniquely any Telidon subscriber in the province.

Users of the database had four means of finding the desired information:

- Subject Index
- Keyword Access
- Page Number
- Printed Directory

The printed directory was introduced only about 15 months after the start of the trial in response to a demand by both the Elie - St. Eustache field trial participants and the commercial GRASSROOTS subscribers. With the rapid growth and change of the database, such a printed directory will, however, always lag behind the actual content, even if it were up-dated as frequently as every month.

2.4.3 The Cybershare Database

2.4.3.1 General

Cybershare is first and foremost a data processing utility, specializing in a full range of engineering, scientific and network services. They are also active in an educational computing network connecting a number of schools in Manitoba.

When first approached with the idea of creating a Telidon database with a rural emphasis, Cybershare chose two areas in which they had some experience:

- Interactive computer assisted instruction courses in mathematics, accounting, chemistry, electricity, statistics and probability, and BASIC programming at the high school level.

- Agricultural management services such as a hog operation simulator and a loan analyzer.

It was thought that the educational programs would test the appeal of do-it-yourself education for people of all ages, and could be used in the home or at the schools. The agricultural programs would be intended to assist the large farms in the management of their business.

Two further areas were also identified that would have appeal to the rural areas:

- Topics of interest to the homemaker, such as nutrition and plants.

- A retrieval library created by the users for the exchange of cooking recipes, and an electronic bulletin board of classified ads for the community.

A number of problems or concerns surfaced as work on the above four areas proceeded:

1. The likelihood of sponsors funding educational courses, agricultural program homemaker courses, etc., seemed

small. Sponsors were known to fund individual or small groups of pages only. Since some of these courses take up to seven hours to complete, some form of payment from the user would have to be considered in the future, unless some alternate form of subsidization or funding could be developed.

2. Some parts of the retrieval library would appeal only to a particular district, so that a province-wide database would contain retrieval libraries for many districts, creating extra storage costs.

3. A subscriber created retrieval library raises the need for a review board to examine the material inputted in order to ensure that false, erroneous or derogatory material is eliminated.

This final concern obviously raised the question of censorship and whose responsibility it would be.

2.4.3.2 Content Available

Despite the experimental nature of the Telidon trial, and the unresolved concerns, a database along the above lines was created. It included:

Educational Courses

- Prerequisite mathematics skills - 30 hours. A first semester community college level course.

- Intermediate mathematics courses - 30 hours. A course for intermediate grades.

- Mathpro - 30 hours. A french language mathematics course for intermediate grades.

- Technology mathematics - 40 hours. A first semester community college level course.

- Mathematics of finance - 25 hours. A first semester community college level course.

- Electricity - 50 hours. A first year community college level course.

- BASIC programming - 7 hours. No level was specified for this course.

Business Library

This section contained the agricultural management services, and also some programs of general interest:

- Loan calculator
- Savings calculator
- Annuity calculator
- Retirement calculator
- Sinking fund calculator
- RRSP calculator
- Feed lot operation simulator
- Hog operation simulator
- Calendar generator
- Desk calculator

The above included two agricultural programs. Others that had been written but were not made available to the trial participants included:

- Grain operation simulator
- Ration analyzer
- Least cost feed formulation
- Cow maintenance feed formulation

All the above agricultural programs have extensive documentation and worksheets. Since the output of the programs is most effective in printed form a printer for each trial participant would have been necessary. However, this could not be provided as part of the trial, and therefore, it was decided not to offer these programs. The programs would have permitted the subscriber to input various assumptions and thereby obtain answers to the different alternatives possible.

Homemaker Information

- Plants
- Nutrition
- Demonstration package including games

Retrieval Library

- Cooking recipes
- Bulletin board

This part of the data base was not implemented during the trial partly because of the concerns identified earlier. Its implementation, however, would have been of great interest because of its highly interactive nature.

The Elie - St. Eustache trial system is continuing to operate, and Cybershare has agreed to continue to provide the existing programs, and even to experiment with new ones.

CHAPTER 3 - SYSTEM DESIGN

3.1 System Architecture

3.1.1 Basic Configuration

The integrated services fibre optic distribution system has been overlaid onto the existing copper based system. This approach minimized disturbance to the existing telephone service and provided full service protection against failure of the fibre link without requiring complex protection switching schemes. It also will simplify restoral to the original mode of service upon termination of the Field Trial Program.

The rural distribution field trial architecture is based on a centrally switched star configuration with two distribution centres (Fig. 3.1). The Field Trial Centre (FTC) is located in a trailer adjacent to the Community Dial Office (CDO) in Elie and the Remote Distribution Centre (RDC) is located in a trailer 8.5 km north of Elie at the junction of highways 248 and 241. A dedicated fibre optic trunk cable connects the FTC and RDC. Distribution fibre cables connect the distribution centres to a Subsciber Entrance Unit (SEU) in the subscriber's home.

For most distribution loops one upstream and one downstream optical fibre connects each subscriber to the distribution centre. Telephone signals are transmitted to the subscriber premises in digital form, time division multiplexed with the data and signalling functions. Normally only one analog video signal at a time is transmitted to each subscriber with access to a larger number of video channels being provided by a frequency domain video switch at the distribution centre.

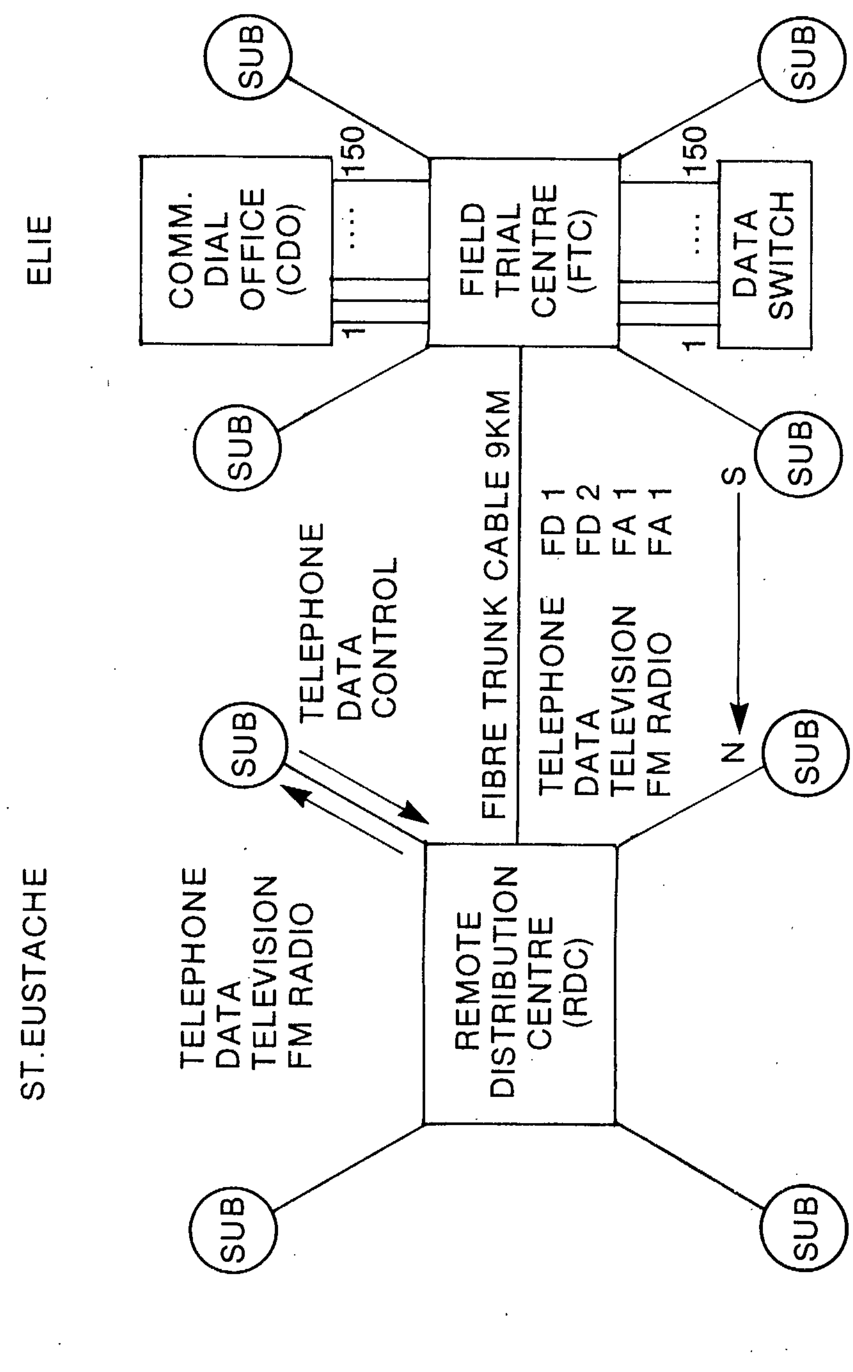


Figure 3.1 Block diagram of the field trial network architecture

In most cases Light Emitting Diodes (LED) were used as optical transmitters in both directions. For more advanced technology trial purposes several special designs were also implemented on a selected number of subscriber loops. For longer loops and for loops where simultaneously two video channels were transmitted to the subscriber, laser diodes were used in the downstream direction. On several loops a single fibre was used for bidirectional transmission of upstream and downstream signals using Wavelength Division Diplexing (WDD).

Trunking for telephone and data services is provided on the Northern Telecom FD1 and FD2 digital transmission systems respectively. Video trunking is provided in analog format on the Northern Telecom FA-1 transmission system.

The main fibre optic distribution system which includes the FTC, the RDC, the trunk between the FTC and RDC, the fibre optic cable distribution plant in Elie and St. Eustache and finally the subscriber premises equipment consisting of the Subscriber Entrance Unit (SEU) and the television Set Top Unit (STU) and its remote controller pad was provided by Northern Telecom Canada, Limited (NTCL) and its subcontractors. It will be referred to as the "Basic System". The cable TV head-end and Telidon data set, switching equipment and transmission facilities between the Elie central office and the data bases in Winnipeg were provided by the Manitoba Telephone System (MTS). The Telidon display unit, decoder and keyboard were loaned by the Department of Communications (DOC) for the duration of the trial.

3.1.2 Technological Choices and Limitations

The existing community dial office serves an area roughly within a radius of 30 km from the switching centre, which is considered to be typical for rural telephone service. One of the objectives of the trial was to find fibre optic based network architectures that could serve such typical rural areas. In 1979, the time when the system design choices had to be made, the only available fibre optic technology was short wave length based multi-mode fibre. To meet the signal quality objectives, in particular for video signals, the maximum unrepeatered reach with this technology was restricted to about 3 km with LED transmitters and 5 km with laser transmitters. Therefore, to reach any subscriber in St. Eustache from the Elie Community Dial Office (CDO) either each loop would have to be repeatered or a remote concentration point would have to be established. Maintenance and repair of widely distributed active equipment in the subscriber access plant is, for economic reasons, highly undesirable.

Furthermore, because of the inherent non-linearties of optical sources and photo diodes, repeated opto-electronic conversion of the multiplexed signal on the subscriber's loop for amplification purposes would have introduced impairments to the video and FM radio signals which would have exceeded the limits of acceptable quality. Therefore, the choice was made to use a remote concentration point in the form of a Remote Distribution Centre (RDC) trailer. This enabled the system to reach subscribers that were up to 14 km away from the CDO.

It should be noted here, that this is similar to the approach taken in urban areas where remote concentrator or multiplexer units of digital switches are placed at the end of a feeder at the Jumper Wire Interface (JWI) point in plant built according to the Serving Area Concept (SAC). The trial, however, has not provided answers with respect to the optimal fibre optic distribution plant architecture to serve widely scattered and remote subscribers economically and without the need of active components such as repeaters and amplifiers being scattered in the outside plant. The answer may lie in the use of long wavelengths and single mode fibres which have the potential to increase the unrepeatered reach by an order of magnitude over what was possible with the available technology at the start of this project. These considerations, however, were beyond the scope of this trial.

3.1.3 Flexibility to Cope with Subscriber Changes

Selection of subscribers for the trial was based both on technological considerations, such as distance from the trailers, the type of service provided by the conventional plant, (individual, two party or multi-party) as well as their desire and willingness to participate in the trial. During the planning and engineering stages it was realized that an unexpected high number of the participants moved within the community. Since the fibre optic distribution plant was to be limited to certain routes and areas in both Elie and St. Eustache, it was decided that participants would be designated by the dwelling or business location rather than by the individual or family. A limited number of spare fibres were incorporated into all feeders and distribution plant to provide flexibility for minor reassignments and for monitoring fibre characteristics with environmental changes.

Since the objective of the trial was to gain experience with the more fundamental aspects of fibre optic technology, flexibility for reassignment was limited also at the trailers. The equipment arrangement in the trailers was configured such that a specific line appearance from the switch entering the trailer was associated with a specific Line Interface Unit (LIU) slot and a specific fibre in a specific outside plant cable. In other words there were no cross connect fields or flexibilities for re-assignment internal to the system. If re-assignment of a subscriber was desired, the VF re-assignment had to be done at the Main Distribution Frame (MDF) in the Community Dial Office and fibres spliced in the outside plant feeder cables as appropriate.

3.1.4 Flexibility to Cope with New Services

At the outset of the trial, it was recognized, that services other than voice telephony and cable-TV would be a requirement in the future. Since most of these services were envisaged to be of a data communication nature it was decided during the pre-contract negotiations to provide a full duplex transparent 56kb/s data channel to each subscriber. It would have been fairly simple to provide at the subscribers premises a number of standard low-speed data interfaces that could be multiplexed for transmission on the 56kb/s data channel. However, since the nature of any new services could not be determined prior to the start of Phase I of the project, it was decided to provide a single 56kb/s RS-422 compatible interface at each subscriber location, and to provide any required multiplexing outside the basic system. This approach is less attractive from an economic point of view, but it provided greater flexibility for providing new services as their requirements were to be defined at a later time. As it turned out, the need for multiplexing several new services did not materialize during the trial, since a number of services could easily be provided through the Telidon system, and other services such as fire and burglar alarms were not practical, since neither of the communities have a local fire department or police station.

3.2. Field Trial and Remote Distribution Centres

3.2.1 General

This section briefly describes the general design of the Field Trial Centre (FTC) and the Remote Distribution Centre (RDC) covering both the mechanical and electrical aspects. Further details are contained in the System Design Report[3.1] which is available to interested readers on request.

3.2.1.1 Functional Block Diagrams

The functional block diagram of the Field Trial Centre (FTC), is shown in Figure 3.2. The FTC, located in a trailer adjacent to the Elie CDO, provides the interfaces with the switched telephone network, the TV and FM Radio sources and the digital data switch for the Telidon services for all trial subscribers whether they are located in Elie or in St. Eustache.

The subscribers' telephone lines from the SA-1 analog switch in the CDO are connected to the line circuit packs on the DMS-1 Control Concentrator Terminal (CCT) where the voice signal is converted into standard 64kb/s PCM format and multiplexed into a DS1 (1.544 Mb/s) signal. Telephone channels associated with subscribers in St. Eustache are transmitted by the FD-1 fibre optic trunk termination equipment over dedicated fibre trunks to the Remote Distribution Center (RDC). Telephone channels associated with subscribers in Elie are demultiplexed in the DMS-1 Remote Concentrator Terminal (RCT) for distribution to each subscriber Line Interface Unit (LIU).

The DMS-1 configuration in Elie is somewhat non-standard. The normal system configuration has a central unit known as a Control Concentrator Terminal (CCT) which is usually located at the local serving office and feeds several remotely located Remote Concentrator Terminals (RCT's). In the configuration in Elie the CCT and RCT are co-located in the central office location with the local RCT providing the digitized voice signals for the subscribers fed from that location. The rationale behind this configuration was to maintain consistency in the LIU design such that all LIU's are fed digitized voice signals from an RCT whether they are used at the central office or the remote site. This means that all LIU's can be used at either site. If the system had not been configured this way, the LIU's at the central office site would have had to interface with the SA-1 switch on

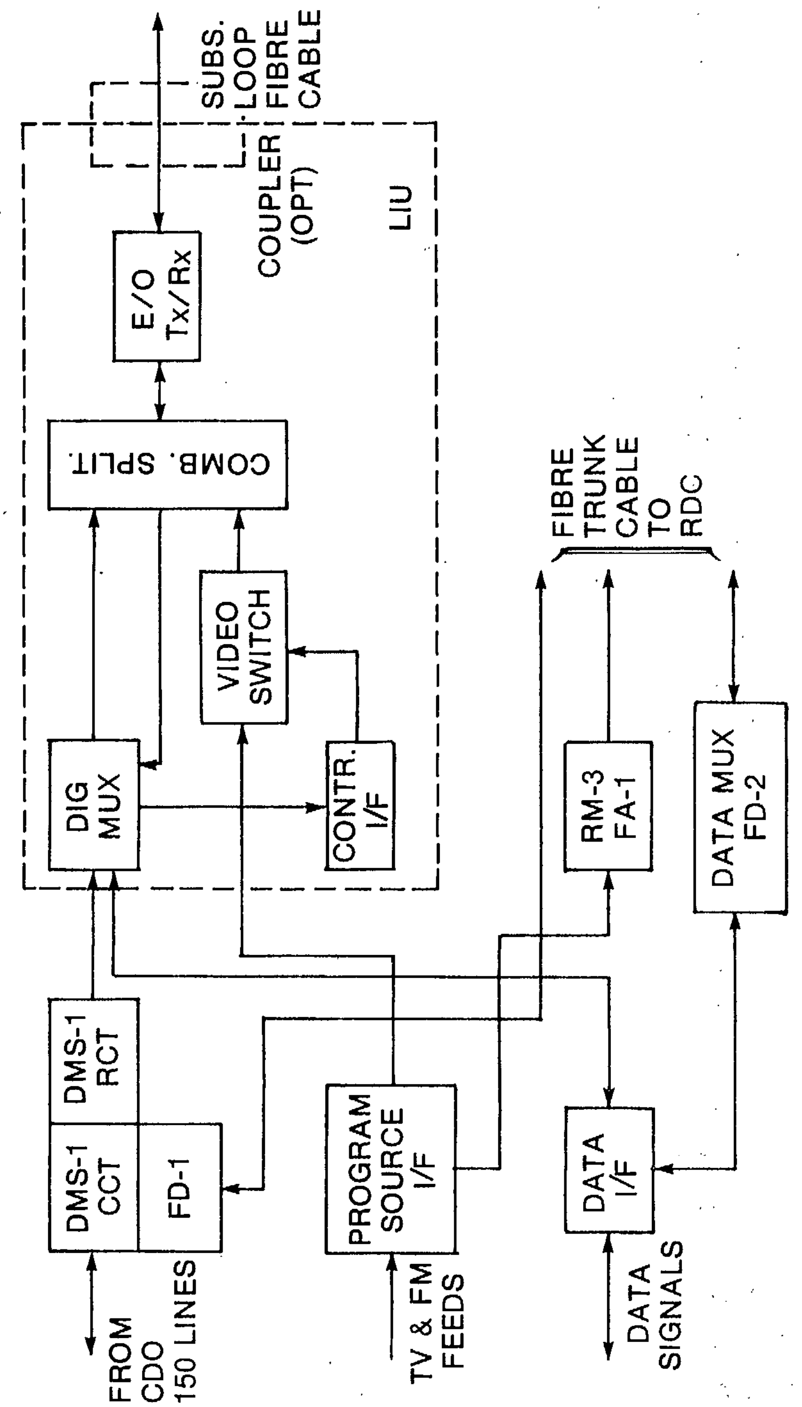


Figure 3.2 Functional block digram of the Field Trial Centre (FTC) in Elie

an analog voice frequency (VF) basis instead of the digital interface with the RCT as well as having to have signalling generation and detection capability.

The functional block diagram of the Remote Distribution Centre (RDC) is shown in Figure 3.3.

The signals for all services fed to each LIU of the subscribers in St. Eustache are derived from the dedicated fibre optic trunks connecting the RDC to the FTC. The digital telephone signals received by the FD-1 terminal are demultiplexed by the DMS-1 Remote Concentrator Terminal. The analog television and FM-Radio signals are received by the FA-1 terminals and demodulated by the RM-3 terminal and then multiplexed and fed to each LIU. Data and control signals are received and demultiplexed by the FD-2 terminal equipment. Power for the trailer is derived from a 48 volt battery which is float charged from 230 volt AC Supply. The battery has a capacity to maintain all required power for 8 hours in case of an AC power failure.

3.2.1.2 Physical Layout

The FTC is housed in a custom designed trailer 3.65m x 12.10m. The trailer is well insulated to provide for easy environmental control of the interior. For the same reasons as well as for security reasons there are no windows. The trailer is divided into three sections, namely:

- Display area
- Subscriber equipment area
- General equipment area

The floor plan of the trailer is shown in Figure 3.4. The display area is primarily used for demonstration purposes and is provided with living room furniture and all the subscriber

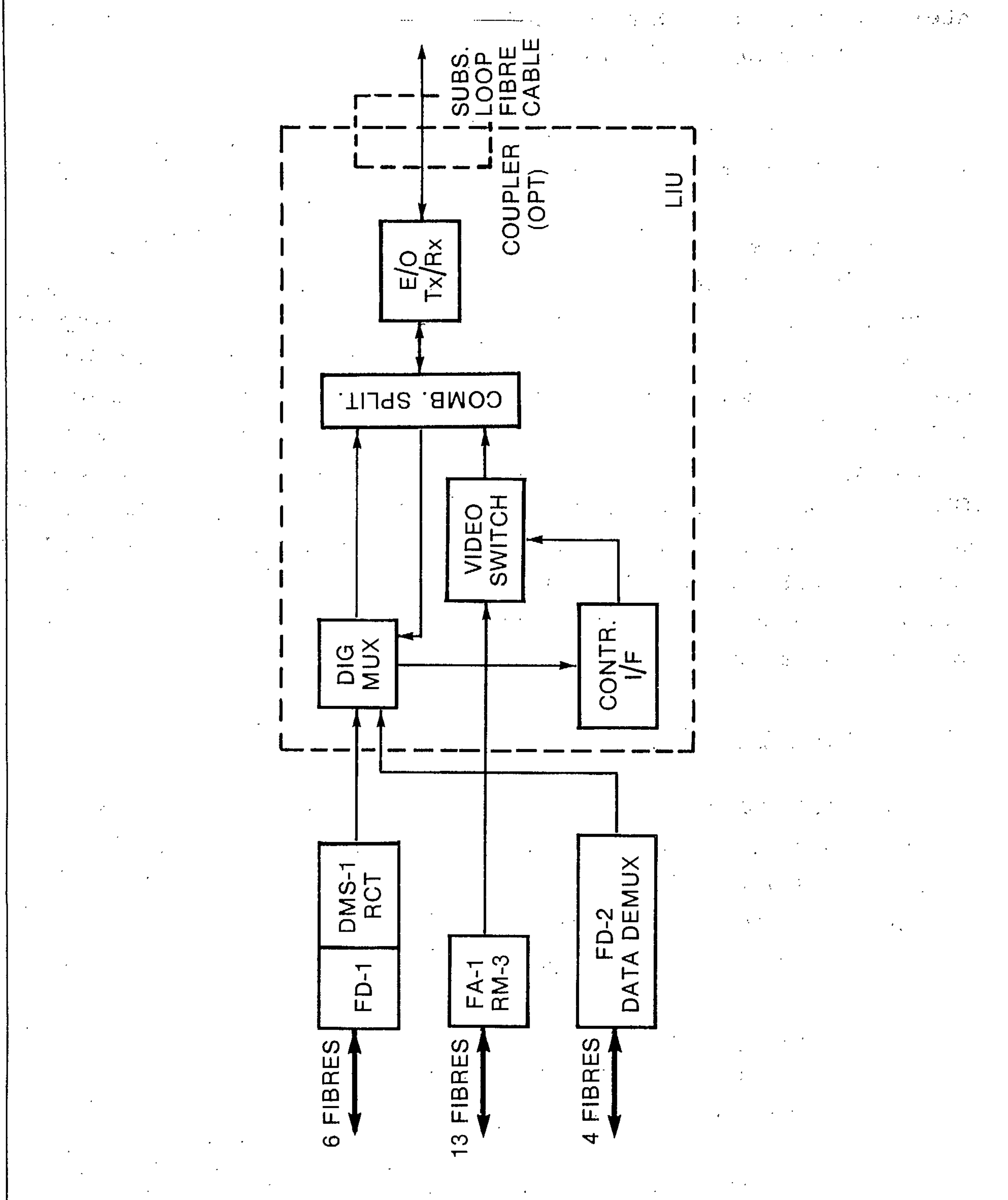


Figure 3.3 Functional block diagram of the Remote Distribution Centre (RDC) in St. Eustache

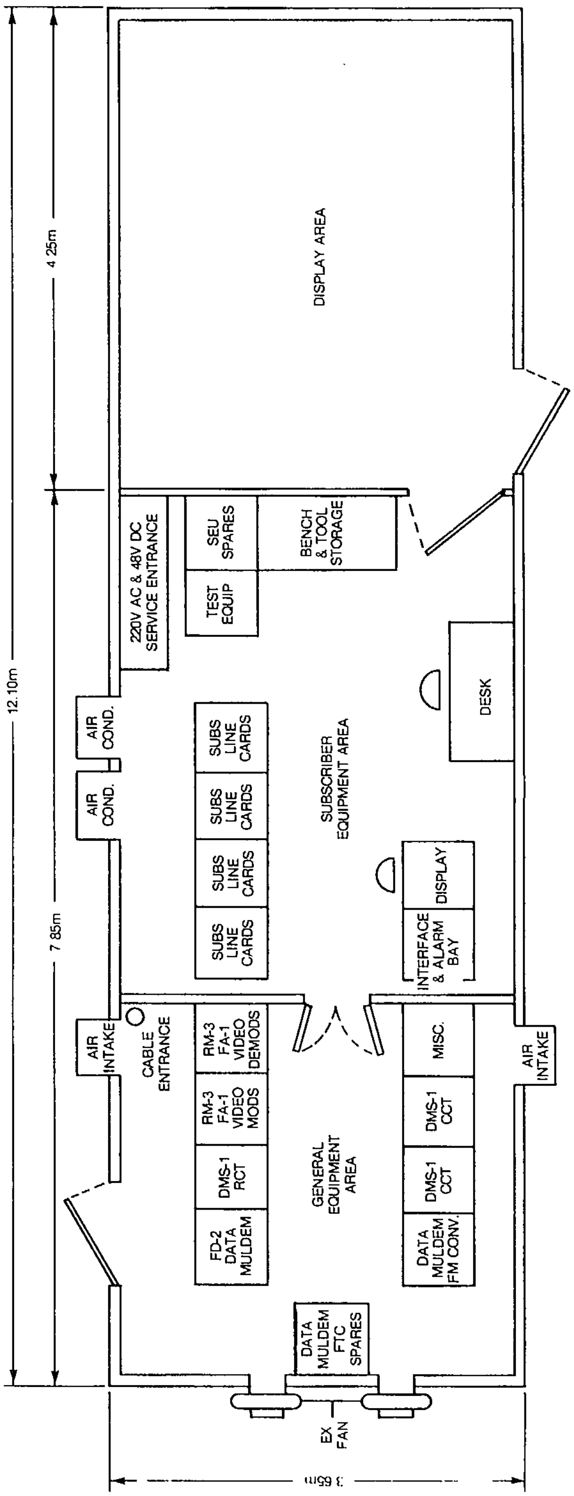


Figure 3.4 Floor plan and equipment arrangements in the FTC trailer

terminal equipment which is normally found in the 150 trial participants residences or businesses.

The subscriber equipment is more sensitive to temperature variations than the other general equipment. For this reason the subscriber equipment area is air conditioned, but the general equipment area is only ventilated by using fans to draw in air from outside.

The RDC is housed in a custom designed trailer 3.00m x 7.20m. This trailer is smaller because there is less equipment and no display area. The construction is similar to that of the FTC. The floor plan of the RDC is shown in Figure 3.5. The subscriber equipment area is air conditioned and the general equipment area is ventilated by air intakes and fans in a manner similar to the FTC. Further details are provided in a technical specification by BNR[3.2].

3.2.1.3 Environmental Control

Full environmental control is provided in both trailers in the subscriber equipment area and the display area of the FTC. Environmental control of the display area of the FTC is provided through a cross ventilation fan between the display area and the subscriber equipment area. The second of the air conditioners in the subscriber equipment area is normally in a standby mode and is only used in case of failure of the first air conditioner.

The general equipment areas in both trailers are equipped with dual fans. The fans maintain the inside temperature rise to 5°C when the outside temperature exceeds 20°C.

The air conditioners in the subscriber equipment areas and the fans in the general equipment areas continue to operate from the battery supply if the primary AC power fails.

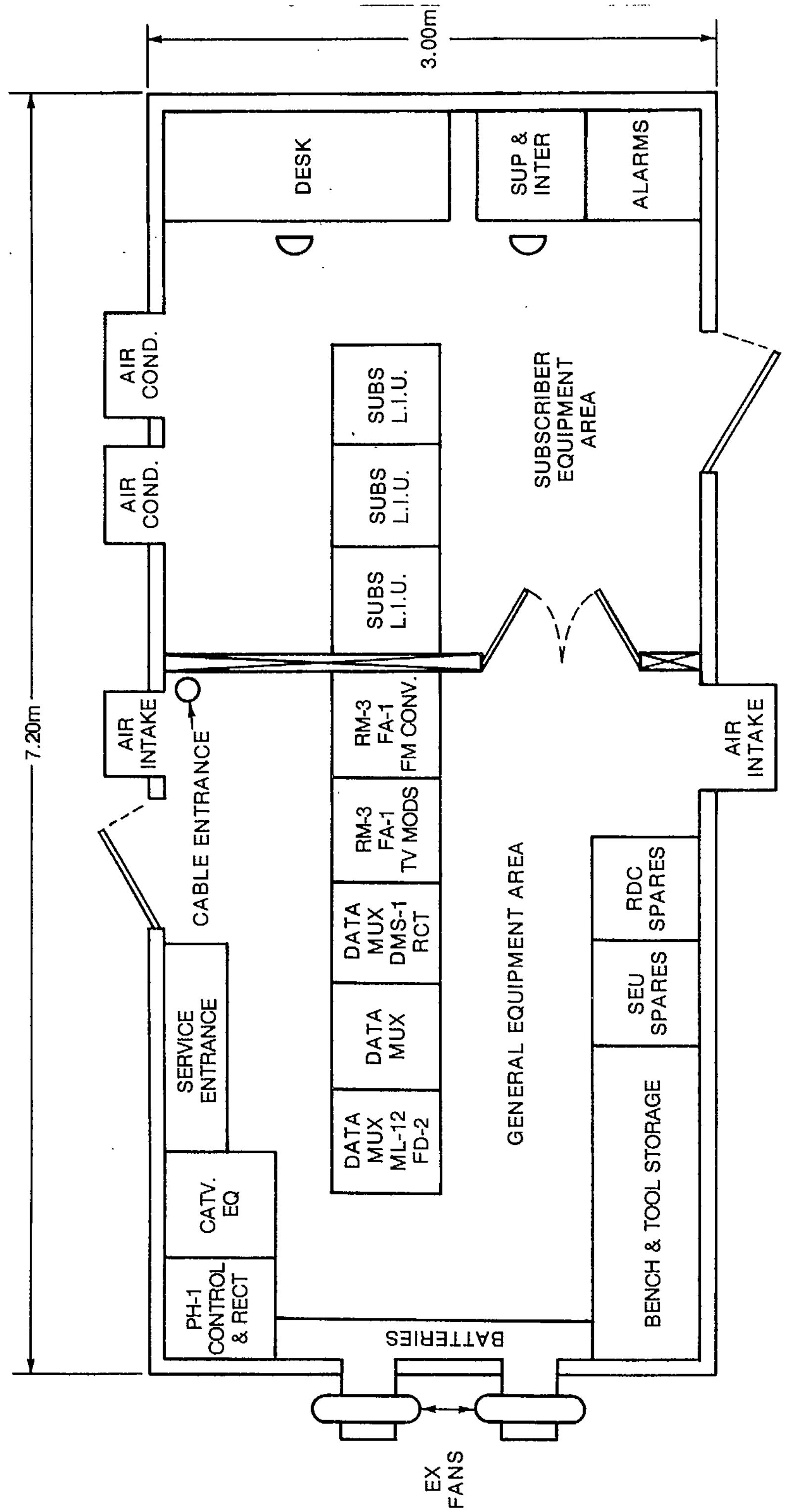


Figure 3.5 Floor plan and equipment arrangements in the RDC trailer

3.2.2 The Line Interface Unit

The Line Interface Unit (LIU) is the key module at the FTC and RDC which provides the multiplexing and demultiplexing of telephone, video, FM Radio, data and control signals from and to the points of origination beyond the trailers and also provides the electro-optical interface to and from the fibre optic distribution plant. The block diagram of the LIU is shown in Figure 3.6. Details of the major functions are described in the following sections.

3.2.2.1 Multiplexing and Modulation

The 64 kb/s digitized telephone signal, control signals, the 56 kb/s data and control signals are multiplexed and demultiplexed in a digital multiplexer respectively for transmission to and reception from the subscriber. For further details of the digital multiplex frame format and allocation of bits for control, alarm and signaling the reader is referred to the System Design Report[3.1].

The digital signal is then further combined with the video and FM Radio signals in the Combiner/Splitter circuit of the LIU before intensity modulating the light source (See Figure 3.6). The loop transmission plan is shown in Figure 3.7. For the basic service, the downstream light source is intensity modulated by a Frequency Division Multiplexed (FDM) signal containing 1 video signal, 7 FM stereo radio signals and a FSK modulated carrier carrying telephony, data and signalling/control in a time division multiplexed format.

Video is transmitted in the standard NTSC VSB-AM format on a visual carrier frequency of 7.6 MHz. Access to up to 9 video channels is provided by a video switch in the FTC or RDC. For some subscribers a second independently selectable video channel is transmitted on VHF channel 2 (visual carrier 55.25 MHz).

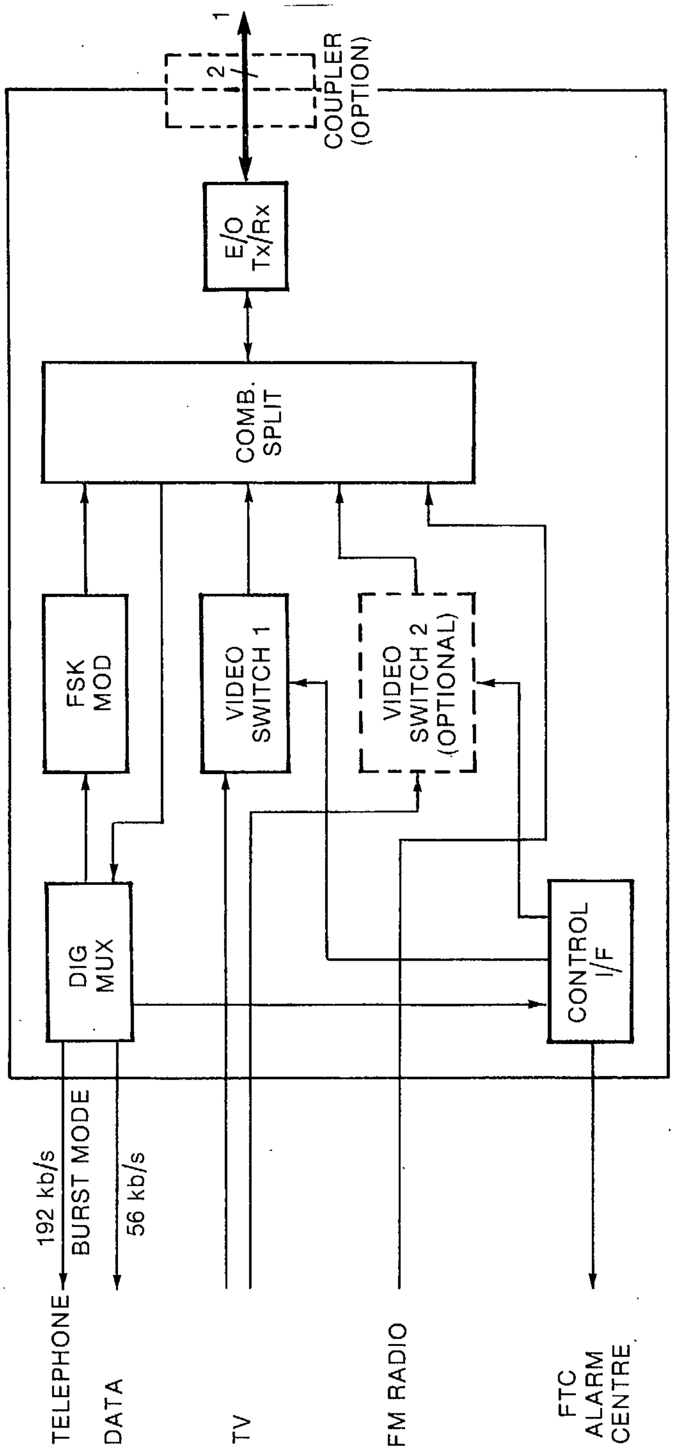


Figure 3.6 Functional block diagram of the subscriber Line Interface Unit (LIU)

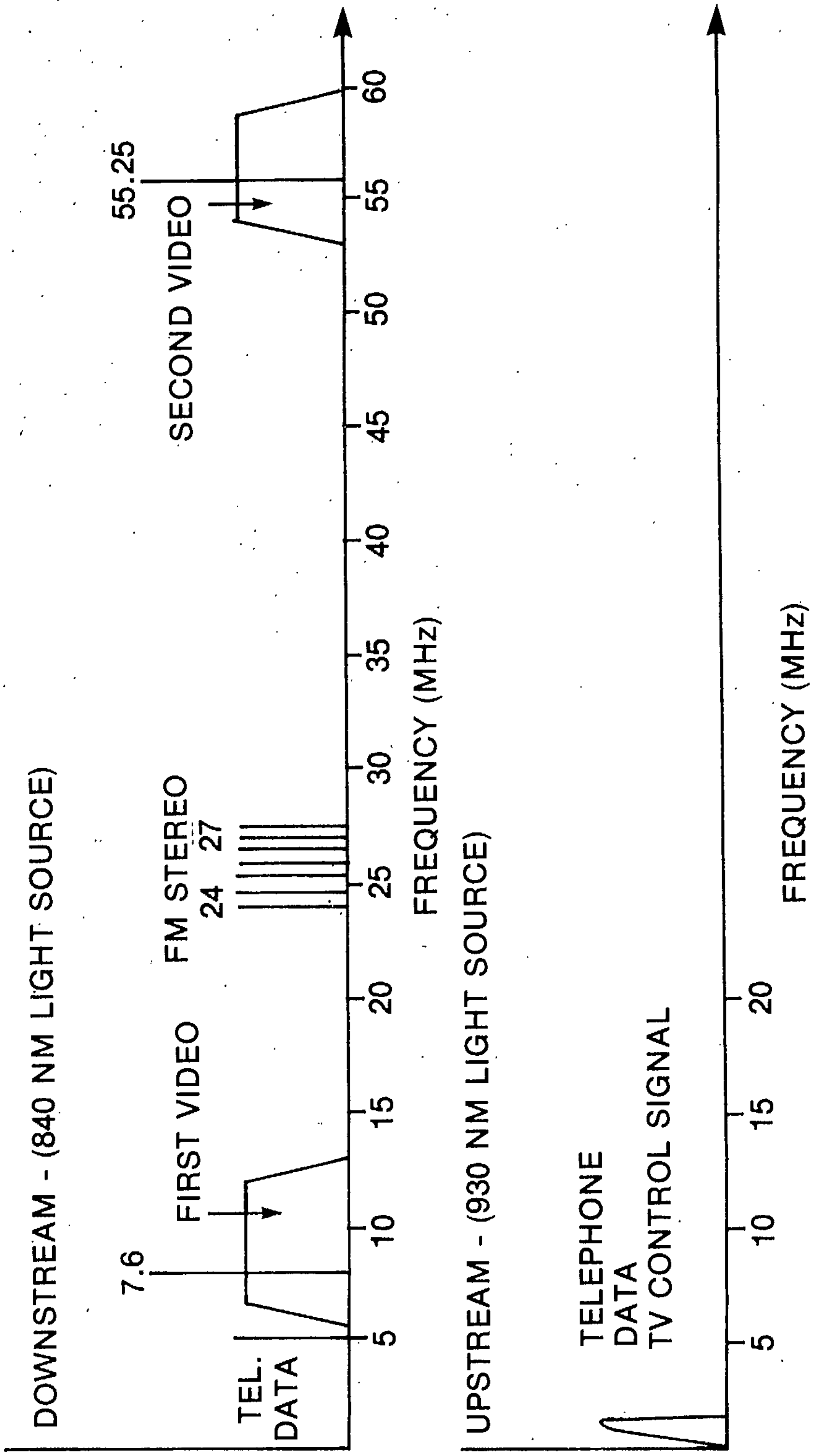


Figure 3.7 The upstream and downstream loop transmission frequency plan

PCM voice and signalling are time divison multiplexed (TDM) with the 56 kb/s synchronous data and other signalling and control functions to form a 192 kb/s signal. This signal is then biphase coded and modulated on a 5 MHz carrier by Frequency Shift Keying. In the upstream direction, PCM voice and signalling are TDM multiplexed with the 56 kb/s synchronous data, the TV control signal and alarms. This signal is biphase coded for baseband digital transmission to the distribution centre.

With the chosen spectrum allocation at the subscriber premises, after converting the optical signal into an electrical signal the first video channel and the FM radio signals can jointly be translated in frequency such that the first channel will appear as a standard channel 5 signal and the FM radio channels will fall into the standard 88 MHz to 108 MHz band. The second channel, which is provided to only a limited number of subscribers, falls into channel 2 and needs no further frequency translation at the subscriber premises.

As optical source and detection devices are non-linear it is essential to choose judiciously the frequencies utilized for the various services to minimize the deterioration of service due to the generation of harmonics and intermodulation products.

Note that, in a multifrequency system, intermodulation products are signals generated at new frequencies as a result of the multifrequency signal being passed through a nonlinearity such as the optical source device. These spurious signals, although of lower amplitude than the original signals, can cause significant interference unless the frequencies are chosen such that the highest level intermodulation product frequencies do not fall in the pass band of a wanted signal. Or if they do, they are chosen to occur where they will cause minimum performance deterioration.

The spectrum design used in the Elie - St. Eustache distribution loops was analyzed using an advanced computerized intermodulation products program to determine the optimum frequencies and signal levels for the services to be carried.

Careful thought was also given to the modulation scheme to be used which would meet the performance requirements for all services, video signal quality being the most difficult to meet and at the same time would meet the objective of minimizing the complexity of equipment especially at the subscriber end of the system.

As the system must support 2 video channels, video baseband transmission was rejected. Digital coding of the video signals was also rejected due to the expensive codec hardware required and transmission speed limitations of the LED based loops.

The choice of a modulation scheme was then mostly between the use of AM or FM for video transmission. AM was chosen due to the availability of existing video processing equipment and also because it introduces minimum signal processing in the SEU. Although FM is more tolerant of optical source non-linearities, it was nevertheless decided that there was sufficient margin using the optical devices available for AM transmission. Subsequently at the unit production stage it was found that the yield of lasers, linear enough for 2 channel operation, was fairly low although the single channel operation was well within specification for all devices. This resulted in cross modulation performance being several dB worse than required by the BP-23 specification for some of the 2 channel systems only, although no significant subjective deterioration of picture quality could be observed and no other performance parameters were outside of specification.

3.2.2.2 Video Switching Technique

The video switching requirement for this system can be defined as a need for 175 ports to independently access 12 NTSC colour video channels in any random fashion with 1 channel at a time to each port. There was also to be no restriction on which channels are accessed by which port i.e. all 175 ports could demand access to the same channel at one time. Note, the 25 2-channel subscribers are considered for switching purposes as having 2 independent signals hence the total of 175 instead of 150.

Commercially available video switches are designed mostly for studio use, switch video baseband signals, are extremely expensive, and generally have performance which would be considered overkill for a video distribution system of this nature. Also baseband switching would have to be implemented as a 12 by 175 matrix which introduces some attendant loading problems and level variations.

It was decided that, due to the dimensions of the requirement; the optimum solution for this system would be to implement effectively a 12 by 1 matrix switch on a per port basis. This was realized by using a digitally controlled frequency converter of the type which forms the basis for most cable television frequency converters. The 12 input channels were each frequency converted to different standard VHF broadcast frequencies, and combined together on one coaxial cable such that the same signals are effectively presented at the input to each FDM switch of which there is one for every one of the 175 ports. The channel selection is then made as follows (see also the block diagram of the video switch shown in Figure 3.8):

A single coaxial connection to the LIU connects up to 17 frequency division multiplexed video channels to the input of the switch. The first bandpass filter defines the input band. A

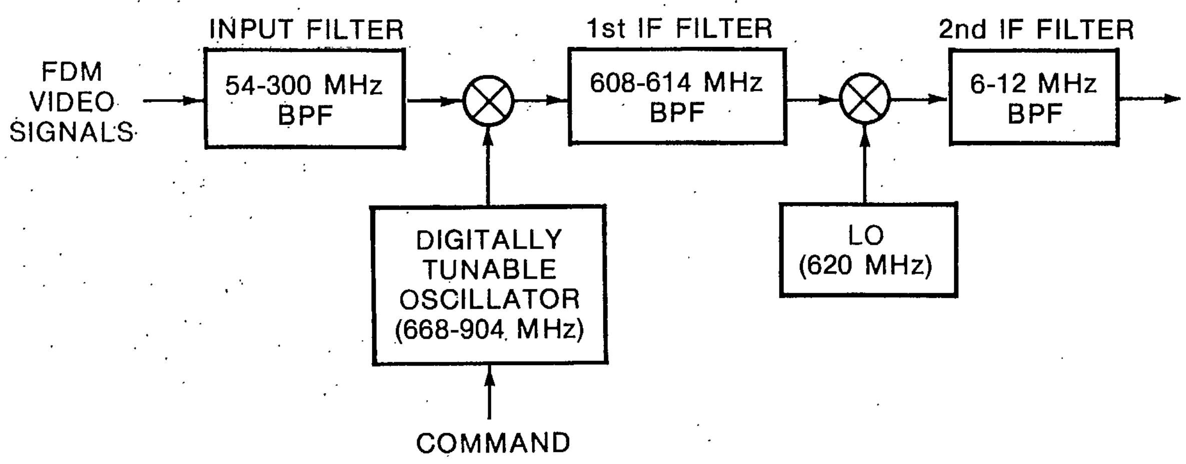


Figure 3.8 Functional block diagram of the centralized video switch

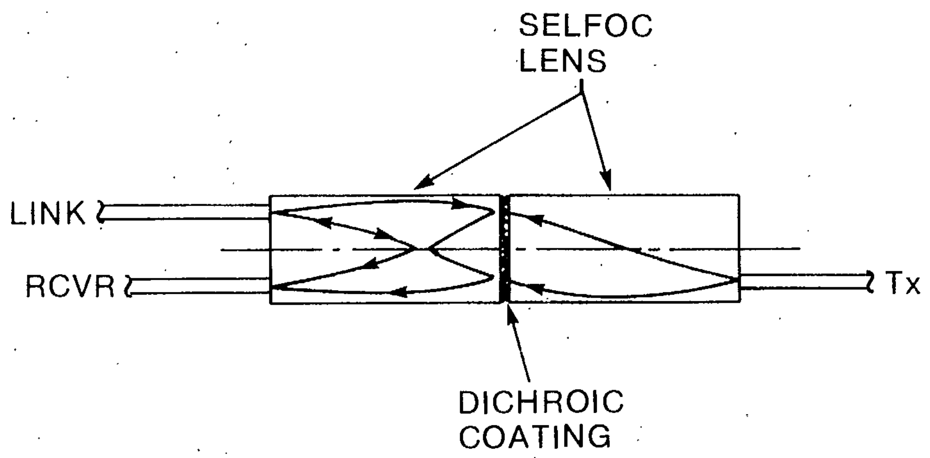


Figure 3.9 Schematic showing the principle of the wavelength selective directional coupler

digitally controlled, tunable local oscillator mixes with the FDM signal and shifts the input up in frequency where one channel, determined by the frequency of the first local oscillator, is accepted by the first IF filter. The selected signal is down converted to the loop transmission frequency by the second local oscillator which has a fixed frequency. Potential image rejection problems with the low output frequency, required for LED transmission, are prevented by using only alternate 6 MHz channels on the input and by choice of an output band of approximately 6-12 MHz.

3.2.2.3 Bidirectional Transmission

As part of the technology demonstration in the project it was required to provide 25 subscriber locations with bi-directional transmission on a single fibre.

Bi-directional transmission is achieved by a bi-directional coupler which separates the upstream and downstream optical signals in the same manner as a hybrid transformer in a telephone system. To avoid creating a different type of LIU with the attendant maintenance difficulties and to avoid loss of isolation caused by reflections in the connector, the bi-directional coupler is located in the fibre connection between the LIU and the outside plant cable.

To achieve the separation necessary between the two directions of transmission it was decided to use a wavelength selective directional coupler based on a dichroic filter as shown in Figure 3.9. The wavelengths used were 830 nm for downstream transmission and 930 nm for upstream. In addition, the electrical content of the upstream and downstream signals were maintained in different frequency bands as shown in Figure 3.7.

The couplers were fabricated in the laboratories of Bell Northern Research, and added losses of typically only 0.8 dB downstream and 1.6 dB upstream per end.

3.2.3 Voice Channel Processing

The subscriber lines from the SA-1 Analog Switch in the Elie Community Dial Office are connected to the Line Circuit Packs on the DMS-1 Control Concentrator Terminal (CCT). Each Line Circuit Pack processes 4 subscriber lines. The received analog signal is companded and converted to a standard u-law PCM code which is then time division multiplexed into a DS1 (1.544 Mb/s) signal for transmission to the Remote Concentrator Terminal (RCT).

The DS1 signal from the RCT is demultiplexed, converted to an analog signal and returned to the SA-1 switch.

The RCT demultiplexes the 1.544 Mb/s signal from the CCT into the 64 Kb/s signals intended for specific subscribers. Each RCT subscriber line card serves four subscribers. Each line from an RCT line card is fed to a subscriber Line Interface Unit (LIU), where its information is combined with the other services for transmission to the subscriber.

The calls received from the CCT at the two RCT's are coded to indicate for which subscriber they are intended. The transmission format between the RCT Line Circuit Pack and LIU is a half duplex burst mode in which each 125 us time slot is shared equally between transmit and receive bit patterns.

3.2.4 Video and FM Radio Distribution

The television channels supplied by MTS are received as AM-VSB modulated carriers in the 50-300 MHz band. The AM-VSB carriers are first demodulated so that all television channels are at baseband at the patch bay. The sound at this point is kept separate.

Two different paths are fed by both sound and video at this point. In one path they are remodulated to the appropriate VHF channel in the television switch input band. In the second path, the sound is diplexed on an FM subcarrier above the video before frequency modulating a 70MHz carrier. This frequency modulation is performed by the Northern Telecom RM-3 FM terminal equipment. This signal is transmitted to the RDC by the Northern Telecom FA-1 optical fibre transmission system.

The FM stereo program channels are received from MTS as modulated carriers in the 88-108 MHz band. These channels are down converted to frequencies between 5.2 and 8.2 MHz, combined and then divided into two equal signals. The first is block converted to the desired band of 24-27 MHz for transmission to the subscribers served from the FTC. The second is used to frequency modulate a 70 MHz carrier by the RM-3 for optical transmission to the RDC by the FA-1 transmission system.

For local distribution, the television and FM program channels are assembled in frequency division multiplex format, the television channels between 154 and 216 MHz and the FM program between 24 and 27 MHz. The distribution to the LIU is accomplished by passive splitters. A four way splitter provides the signal to each bay, this is split three ways to each shelf and a further eight ways to drive each LIU.

3.2.5 Data Channel Interface

Each subscriber has access to a 56 kb/s synchronous, full duplex data signal. The 56 kb/s clock is derived from the DMS-1 master clock. The data interface sends and receives data and clock in the EIA RS422A format with the provision that the optional 100 ohm cable termination is not used. The data channels for subscribers served by the FTC are connected directly to the LIU cards. Those channels for subscribers at the RDC are first synchronously multiplexed into three 1.544 Mb/s data signals, which are then multiplexed to 6.312 Mb/s for transmission to the RDC by the Northern Telecom FD-2 optical transmission equipment. The subscriber-generated data returning from the RDC is processed in a complementary manner.

All data signals from the subscribers in Elie and St. Eustache are routed from the Field Trial Centre to the data switch in the Elie CDO via twisted pair cables.

3.2.6 Trunk Termination and Transmission Equipment

All of the services are remoted to the RDC via a dedicated fibre optic trunk cable. The 9 video channels and 6 FM radio channels are transmitted from the FTC to the RDC by the Northern Telecom FA-1 fibre optic video transmission system. Each video signal is frequency modulated by the Northern Telecom RM-3 FM terminal and converted to an optical signal by the Northern Telecom FA-1 transmitter. One video signal is carried per fibre. The 6 FM radio signals are frequency division multiplexed into a 5.2 to 8.2 MHz baseband signal and transmitted on the 10th FA-1 system. Spare fibres are provided to allow the trunk capacity to be expanded to 12 video channels by adding FA-1/RM-3 terminal equipment.

The DMS-1 CCT and RCT are interconnected by three optical fibres in each direction. Each fibre interfaces with the FD-1 fibre trunk interface which forms part of the DMS-1 system and carries one DS1 signal per fibre. With 3 fibres in each direction, the DMS-1 provides 1 for 2 automatic protection.

Data signals are time division multiplexed to the DS2 rate and transmitted via the Northern Telecom FD-2 fibre optic transmission system. Two fibres in each direction are used to provide a 1 for 1 protected system.

Alarms originating in the RDC are transmitted to the FTC using asynchronous transmission on a copper pair in the fibre optic cable. A second copper pair is provided for order wire.

Further details on the DMS-1 equipment, the FA-1 system, the FD-2 system and the RM-3 FM terminal can be found in Northern Telecom Practices 363-2011-100[3.3], 321-2001-100[3.4], 321-2101-100[3.5], and 420-2301-XXX[3.6] respectively. They are also available in the Elie Project Draft Maintenance Manual[3.7].

3.2.7 Alarm, Maintenance and Diagnostic Facilities

The Monitor and Alarm System (MAS) is designed to monitor the status of all the field trial equipment. It records and reports the current status of all monitored functions as well as a record of the last 20 status changes. These items are stored in a data base which may be queried by maintenance personnel at any time. The information is reported in a form which facilitates the diagnosis of faults.

The system consists of two identical computers, one located in the FTC, the other located in the RDC. They are cooperative and capable of operating autonomously. They communicate with each other over a dedicated fibre optic link. A video display terminal in the FTC is connected to the FTC computer. The terminal provides a means of interrogating the status of the system. It also controls the format of reporting and monitoring of faults. In addition to the terminal, the system has remote dial-up capabilities, achieved through a 300 baud modem and telephone line interface contained in the FTC computer. They allow an off-site operator with a terminal to dial up the FTC computer and thus interact with the MAS. The RDC computer is not supplied with a terminal: one cannot, therefore, communicate with the MAS while in the RDC. Ports are provided on the RDC computer to allow connection of a local console and dial-up modem if desired in the future. An alarm bell sounds when the MAS detects any failure in the field trial equipment. It provides major alarms for trunking or common equipment failures, and minor alarms for failures of individual subscriber loops. A list of alarms is shown in Table 3.1. The status of the system is summarized in the form of 32 alarms which are presented to the MTS alarm remoting system as dry contact closures. A set of lights (LED's) mounted on the front panel of both computers provides a visual indication of the MAS system's status.

It is very likely that such an alarm and maintenance system will be necessary for any future loop developments of this type due to the departure from present day systems by addition of considerable quantities of electronic equipment to each individual subscriber loop. Even for an experimental system, like the one in Elie and St. Eustache, this was considered to be a valuable addition.

3.2.8 Power Plant

The 48 Volt DC and 230 Volt AC supplies to the FTC trailer are provided from the Elie CDO. The FTC requires 87 Amperes average from the 48 Volt DC supply. A separate rectifier and lead-acid battery plant was installed in the CDO to provide the required power for the FTC. The installed capacity of the 230 Volt AC supply is 100 Ampere, which was more than adequate.

The capacity of the rectifier and lead-acid battery plant was based on current drains of various equipment as follows:

SYSTEM	ALARM	EQUIPMENT	LOCATION	ALARM TYPE
ENVIRN.	AC POWER FAILURE		RDC	MINOR
	OPEN DOOR		BOTH	MINOR
	HIGH/LOW TEMP.		BOTH	MINOR
	SMOKE DETECTOR		BOTH	MAJOR
	RECTIFIER FAIL		RDC	MINOR
	BATTERY HI/LO VOLT.		RDC	MINOR
	PRIMARY FUSE		BOTH	MINOR
DMS-1	DIGROUP A FAIL	DMS-1	FTC	MAJOR
	DIGROUP B FAIL	DMS-1	FTC	MAJOR
	BYPASS OPERATE	DMS-1	FTC	MAJOR
	LOOPBACK OPERATE	DMS-1	FTC	MAJOR
	LINE CARD POWER	DMS-1	FTC	MAJOR
	COMMON EQUIP. POWER	DMS-1	FTC	MAJOR
	LINE A FAIL	DMS-1	FTC	MINOR
	LINE B FAIL	DMS-1	FTC	MINOR
	LINE P FAIL	DMS-1	FTC	MINOR
	FUSE	DMS-1	FTC	MINOR
	LOCAL LINK FAIL	DMS-1	FTC	MINOR
TRUNKS	DATA MUX LOSS OF SYNC.	DE-4	BOTH	MAJOR
	PROTECTION SWITCH FAIL	FD-2	BOTH	MAJOR
	LOSS OF DATA OUTPUT	FD-2	BOTH	MAJOR
	LOSS OF OPTICAL OUTPUT	FD-2	BOTH	MINOR
	LOSS OF OPTICAL INPUT	FD-2	BOTH	MINOR
	LOSS OF DATA OUTPUT	FD-2	BOTH	MINOR
	LASER BIAS CURRENT	FD-2	BOTH	MINOR
	LASER COOLER	FD-2	BOTH	MINOR
	OUTPUT SIGNAL FAIL	RM-3	FTC	MINOR
	FREQUENCY OFF	RM-3	FTC	MINOR
	LASER BIAS CURRENT	FA-1	FTC	MINOR
	LASER COOLER	FA-1	FTC	MINOR
	OPTICAL INPUT FAIL	FA-1	RDC	MINOR
	INPUT SIGNAL FAIL	RM-3	RDC	MINOR
LOOPS	DIGITAL LOOP CONTINUITY	LIU	BOTH	MINOR
	LIU OPTICAL OUTPUT FAIL	LIU	BOTH	MINOR
	POWER CONVERTER FAIL	LIU	BOTH	MINOR
	OPTICAL RECEIVE POWER FAIL	LIU	BOTH	MINOR
	SHELF FUSE	LIU	BOTH	MAJOR
	SUBSCRIBER AC FAIL	SEU	BOTH	MINOR
	SEU OPTICAL RECEIVED POWER	SEU	BOTH	MINOR
	SEU SYNC.	SEU	BOTH	MINOR

Table 3.1 Tabe of Alarms

DMS-1	11A
Data Mux	26A*
FD-2, FA-1	4A
LIU bays	6A
Emergency lighting	5A
Exhaust Fans	15A
Air Conditioning	20A

* The initial design had assumed a data multiplexer other than the DE-4. The current drain of DE-4 is less than 26A.

The power budget shows that almost half of the installed emergency power capacity is required for lighting and environmental control. It should also be borne in mind that the custom built equipment was not necessarily designed to be power conservative.

The primary power source for the RDC trailer is 230 Volt AC from Manitoba Hydro.

The 230 volt AC to -48 Volt DC conversion is provided by a standard Northern Telecom PH-1 equipment. These rectifiers float charge a sufficient number of batteries to provide 8 hours operation of the RDC if the primary AC power fails.

The battery storage is made up of twelve volt lead-acid batteries. The batteries are of a sealed, lead-calcium electrode, zero maintenance type.

The batteries are divided into strings, each string having a capability of 50 ampere hours at an end of discharge voltage of 42 volts.

3.3 Subscriber Premises Equipment

3.3.1 General

The equipment located at the subscribers premises terminates the fibre loop and processes the received signals for distribution to the various terminals. Signals coming from sources on the premises include one telephone signal, a 56 kb/s data stream, control signals for the two TV channels and monitor signals. These are coded as required and sent to the LIU in the FTC or RDC via an LED transmitter. The signals received from the LIU are one telephone signal, one or two video channels, 6 FM stereo radio channels, and one 56 kb/s digital data stream. The subscriber premises systems are distributed over five hardware units: the Subscriber Entrance Unit (SEU), the Set Top Unit (STU), the Remote Controller, the Data Set and the Telidon terminal equipment.

A block diagram of the subscriber premises systems and their interconnections are shown in Figure 3.10.

3.3.2 The Subscriber Entrance Unit

The one or two fibres that connect the subscriber's terminals to the LIU are terminated via connectors in the SEU. For bi-directional transmission, the bi-directional coupler is located in the SEU enclosure. The SEU also contains the LED upstream transmitter, the optical receiver, multiplexing and demultiplexing circuits to separate the various signals, interfaces for the telephone, data, audio and video terminals and common equipment, including power supplies with battery backup. The SEU is located near the entrance of the fibres to the subscribers premises.

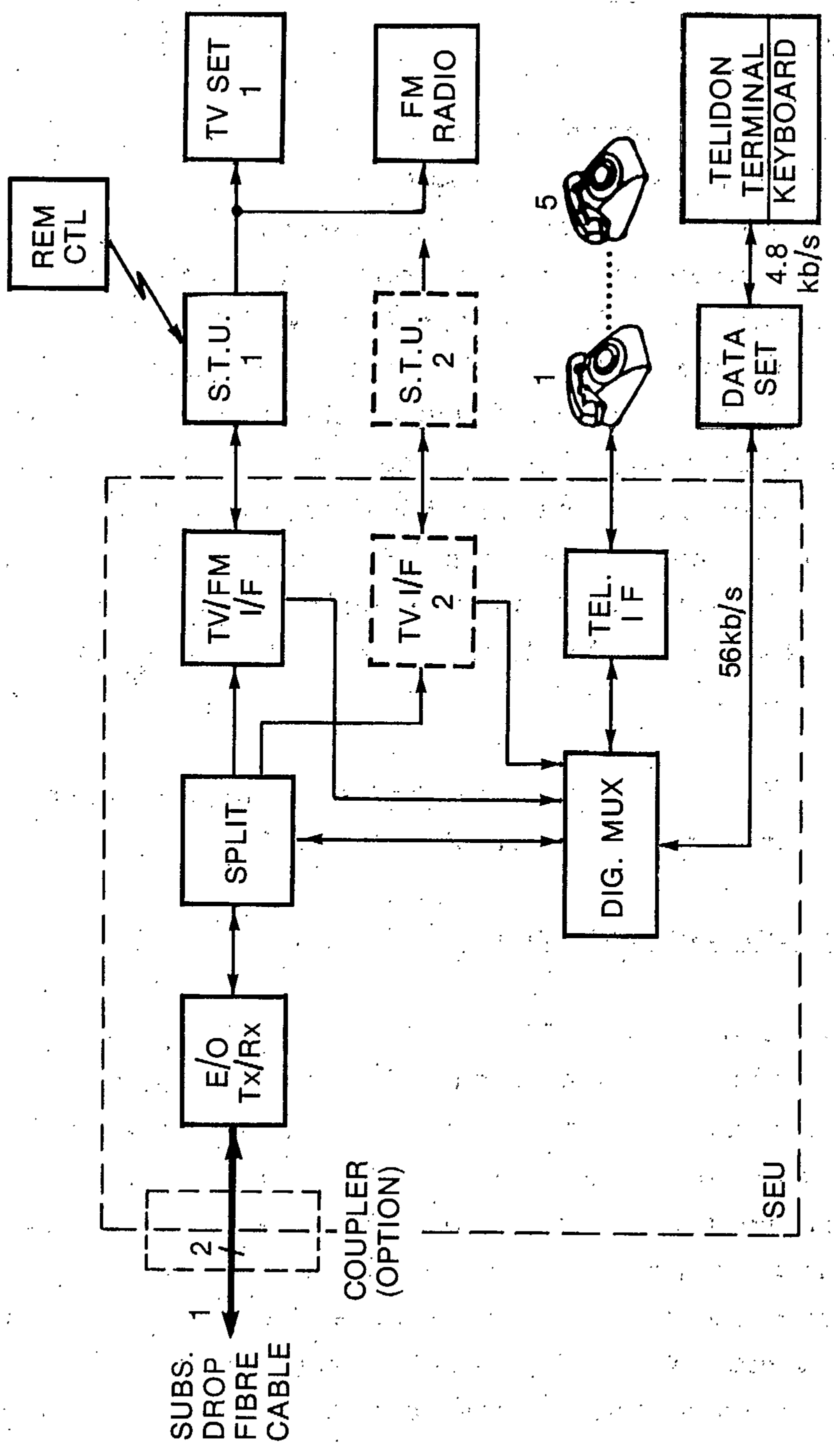


Figure 3.10 Block diagram of the subscriber premises systems and their interconnection

The electrical output of the electro-optical interface is split into 3 signals. One signal is made up of the TV and FM signals, the second is an FSK signal carrying the 192 kb/s digital telephone and data. In 25 cases, the subscriber is supplied with a third signal, which provides a second, independently selectable TV signal.

The first TV and FM interface consists of a frequency converter, which block translates the TV signal to the standard VHF channel 5 frequency band (76-82 MHz) and the FM stereo signals to the FM band (93.7-96.7 MHz). The interface unit also accepts the digital control signal from the STU via the coaxial cable connecting the SEU to the STU. The digital control signal is passed on to the LIU, where the selected TV channel is switched.

The second TV interface does not perform frequency conversion. The second video signal, if provided, is transmitted through the fibre in the standard VHF channel 2 frequency band (54-60 MHz). This interface only separates the second channel from the other signals present and detects the control signals from the STU. The two TV interfaces are mounted on one printed circuit board.

Three type F coaxial output connectors are provided. Two outputs carry the first TV channel on VHF channel 5 plus the FM radio signals. This enables the FM signal to be tapped off at the SEU or, with a hybrid splitter, at the location of the STU for TV set number 1. The second independently selectable TV channel is provided on the third connector on VHF channel 2.

The digital multiplexer/demultiplexer receives the digital signal bit stream together with the required clock signals. It demultiplexes the 192 kb/s TDM bitstream and distributes the demultiplexed digital streams to the various interfaces.

The telephone interface connects the digital MUX and the analog telephone set. A coder-decoder (codec) circuit digitizes the analog signals from the telephone and converts the digital voice signal from the MUX to an analog voltage. A hybrid circuit converts the 4-wire connection for the codec, to a 2-wire connection for the telephone. A hook monitor circuit detects the hook condition of the telephone. The output of the monitor is transmitted upstream as one bit in the MUX output. A relay circuit, controlled by the loopback control, loops back the analog signal with a 4 dB loss. Via this circuit, DMS-1 equipment checks the loop performance. The telephone interface provides also a local ring generator. The ring generator is powered from a DC to DC converter. This converter, which runs at a multiple of 8 KHz, converts the battery voltage to ± 50 V. These voltages power a 20Hz ringing generator. The ringing generator is controlled by one bit in the MUX output. To conserve battery power, the DC to DC converter is energized only when ringing is needed.

The interface can connect up to 5 touch tone telephones with tone ringing.

The Data Interface connects to external equipment via a 4 pair cable terminated in an Amphenol type connector at the SEU end. One pair each is used for downstream data, downstream clock, upstream data and upstream clock.

The electrical interfaces comply with EIA standard RS-422A for balanced voltage, digital interface circuits, with the provision that the optional 100 ohm cable termination is not used (page 4 of the standard). Consequently the "Test Termination Measurement" (page 5 of the standard) is done with 2 kilohm resistors replacing the 50 ohm units.

Primary power for the SEU is taken from an approved control transformer, mounted on the electric fuse panel or on a service box. The SEU contains a 12 V battery pack, a charger circuit and a DC to DC converter, which converts the battery voltage to a stable $\pm$12 VDC and +5 VDC.

The capacity of the battery pack is 2.5 ampere-hours which is adequate for more than 8 hours of telephone and data circuit operation, in the event of an electric power failure. This assumes that, during the 8 hour outage, 8 incoming calls are received which cause 5 ringers to ring 10 times for each call and the telephone is off hook for a total of 4 hours. During electrical power failure the TV-related circuitry is not powered.

The approximate overall dimensions of the SEU are 25 x 20 x 15 cm (10" x 7.9" x 6"). Facilities for wall mounting with four screws are provided. The SEU is considered a replaceable unit.

3.3.3 The Set Top Unit

The functions of the STU are to detect commands from the remote controller, display the selected channel number and provide channel selection and TV on-off information for the service measurement interface.

The STU is equipped with an infra-red receiver that detects the command signals from the handheld remote controller. The received control pulses are decoded and stored for the set top display. The control word is converted to a serial 175 b/s asynchronous start/stop format for transmission via the in-house coaxial distribution cable to the TV interface and, via the digital multiplex, to the video switch in the LIU.

The front panel of the STU shows a two-digit LED display of the selected TV channel. Three pushbuttons are also available to provide direct control instead of using the remote control unit.

The STU is AC powered and must be plugged into a wall outlet. The TV may be plugged into the 115 volt 60 Hz outlet that is on the back of the STU to allow remote on/off control. When the unit is switched off, the infra red receiver circuit stays active, but other circuits, notably the channel display, are unpowered. In this state, no video signal is transmitted from the distribution center.

STU #1 puts out the selected TV channel on the standard VHF channel 5 and 6 FM stereo radio signals. The FM stero signals are also available at the SEU. STU #2 provides the second TV signal only on channel 2.

The approximate dimensions of the STU are 30 x 7.5 x 20 cm (12 x 3 x 8").

3.3.4 The Remote Controller

This is a handheld unit, powered from an internal, replaceable 9 Volt battery. It is similar in appearance to a pocket calculator. It features a keyboard with 13 keys: digits 0 to 9, an "on/off" control, an increment and a decrement button for the channel number. The control signals are transmitted via infra-red LED's.

3.3.5 The Data Set

The Data Set is a Develcon model 9509A unit which essentially performs the RS-232C to RS-422 conversion between the Telidon terminal interface and the SEU data port. The unit is located near the Telidon terminal. It has a standard DB 255 connector at the RS-232C interface and an internal 4-screw barrier strip at the 4-wire RS-422 interface. Only the transmit and receive pairs of the SEU data port are required. For proper operation of the data channel, the receive clock is looped back into the transmit clock port through the connector of the data line of the in-house wiring.

The unit is powered from a 115 volt AC outlet and is normally left in the "ON" mode continously.

3.3.6 Telidon Terminal Equipment

The Telidon equipment consists of three units:

- Decoder
- Display Unit
- Keyboard

The Decoder is a standard Norpak Mark III decoder which, at the time of purchase in 1981, was conforming to the 699 standard. Since this standard was replaced in 1982 by the 709 standard all terminals have been retrofitted to comply with the new standard. The decoder is connected to the display unit by a cable harness consisting of six coaxial cables which are terminated at both ends with standard BNC connectors. Connection to the Data Set is via a standard 25 pin RS-232C compatible connector and cable. The full alpha-numeric keyboard connects to the decoder via a 15 pin connector and cable. A non-switched AC outlet is provided in the back of the decoder for powering the display unit. The unit requires good ventilation and it is not recommended to place it under the display unit unless adequate distance is provided.

The Display Unit is a modified Electrohome colour television set. The modification consists mainly in the provision of direct access to the Red, Green and Blue (R,G,B) guns of the set.

The keyboard connects via a 5 meter cable to the decoder. The length of the cable allows adequate viewing position flexibility in the average living room of a residence. The keyboard is a Norpak TLD-KB5.0 model ASCII keyboard which has an additional numeric keyboard on the right side. The additional top fourth row of keys provides all the special Teldion commands.

For access to most of the database a simple keypad would have sufficed. Providing the users with both a hand-held keypad and a keyboard was considered early in the project. However, because it would have been necessary to unplug the keyboard while using the keypad, which would have been rather cumbersome, it was decided that a keyboard which can provide all system access needs would be preferable and would avoid confusion.

3.3.7 Subscriber Premises Wiring

The subscriber premises wiring is associated with the installation of a junction box, the SEU, the STU and the data set.

Junction Box - a splice box was located on the outside of the home to allow connection between the outside aerial or buried drop cable and the inside fibre cables. This box had to be grounded, and a protective plastic pipe provided through the outside wall into the house for the inside fibres.

Subscriber Entrance Unit - The unit was mounted in an out-of-the-way location in the home, usually near the electric power panel in the basement. The unit is powered from a low voltage transformer mounted at a nearby receptacle. Two one-fibre cables were run in normal house wiring fashion from the SEU to the outside junction box.

Set Top Unit - the STU was mounted on the participant's own TV set and connected with a coaxial cable to the SEU. A small switch was provided to allow the participant to switch back to his own antenna in the event of a TV signal failure over the system.

Data Set - The data set was located adjacent to the Telidon terminal in a room of the participant's choice, close to an AC power receptacle. Normal in-house telephone wiring was used to connect the unit to the data port of the SEU. Loop back of the transmit and receive clocks of the data channel was provided on the connector terminating the data set wires at the SEU.

No special design constraints were specified in the mounting, location or wiring of these units. Normal house wiring practices were followed.

3.4 Subscriber Loop System Optical Design

3.4.1 General

The optical system for subscriber loop transmission was designed as a fully integrated unit to obtain optimum performance from the individual optical components. The components of this system are shown in Figure 3.11 for both LED and laser driven loops. Downstream is defined as transmission from the trailer to the subscriber's premises and upstream from the subscriber to the trailer. Many options and combinations of components were considered in this design but any description of all these would be of too detailed a nature for this report. Therefore, a description is provided of only the final optical system used in the field. Further technical details are available in reference [3.8].

3.4.2 Transmitters

3.4.2.1 Downstream LED Transmitters

The downstream LED, which is an NTCL manufactured high radiance etched well type of device, is provided with a pigtail of step index fibre of the same nominal core diameter and higher

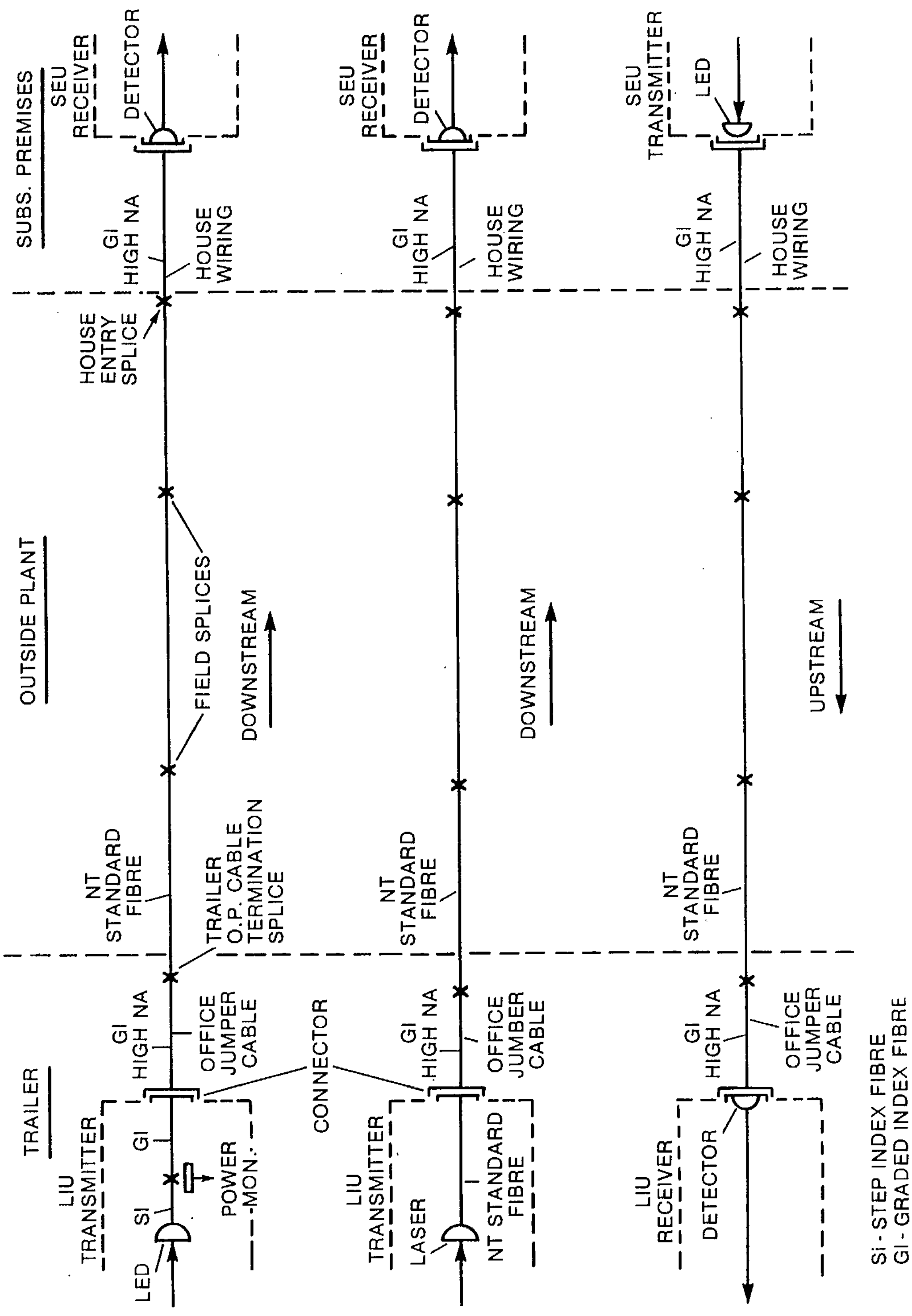


Figure 3.11 Block diagram showing the principle components of the subscriber loop optical transmission system

numeric aperture (NA) than other fibres in the system. Due to the characteristics of step index fibres, considerably more total light power is coupled into the step index fibre pigtail than will eventually be propagated into the cabled fibre in the outside plant. This step fibre is then spliced to a graded index fibre of the same nominal core diameter as the others but with a higher numeric aperture (NA) than the fibre in the outside plant cable. This splice is affixed to a solar cell which is used to detect the light emanating from the splice of two such dissimilar fibres. The higher order transmission modes which are present in the step index fibre cannot all be coupled into the graded index fibre and this non-coupled light is detected by the solar cell. This device is therefore essentially a lossless monitor of the LED output power, as the power which is used to measure the output of the LED would not be transmitted down the cable. A diagram of this device is shown in Fig. 3.12. This optical power monitor is located inside the transmitter module. Connection between the office jumper fibre and the transmitter is made using an NTCL close-tolerance fibre connector. This is the only connector in the loop system which requires precision mechanical alignment dictated by low loss. The use of this connector in this location is governed mostly by the laser loop requirements and the performance required to connect the laser pigtail to the office jumper cable. If there were no laser system requirements then a lower performance connector could have been used and the loss minimised by ensuring the mode volume of the fibre on the device side was greater than the mode volume of the fibre on the office jumper side.

The office jumper cable is a graded index cable of the same nominal core diameter as the other fibres but with a higher NA than the outside plant cabled fibre. This cable has a connector at one end to connect to the transmitter and at the other end it is spliced to a fibre from the outside plant cable. The splices to the outside plant cables are located in splice trays at the

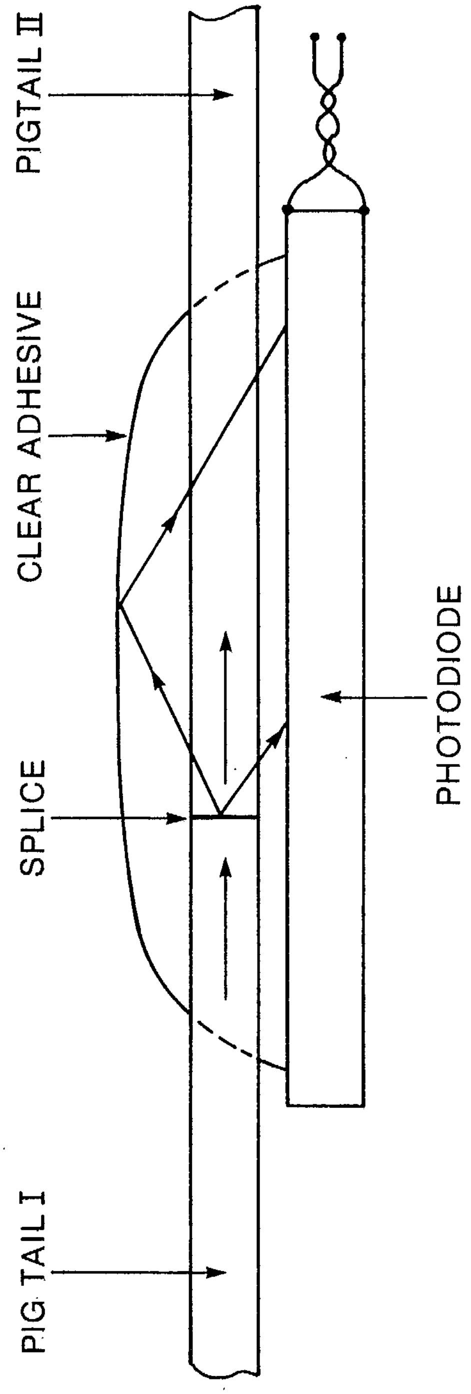


Figure 3.12 Principle of the patented lossless optical power monitor

bottom of the LIU racks on the trailer. It should be noted that there is no fibre equivalent of the MDF in this system. The connections between inside and outside plant are the splices just described. The technique of splicing two fibres of different mode volumes, although causing an apparent loss of total power due to loss of the high order modes, effectively produces lower loss of propagated power than with two identical fibres.

3.4.2.2 Downstream Laser Transmitters

The laser is a GaAlAs stripe geometry device fabricated by Bell-Northern Research. It incorporates an internal photodiode used for power stabilisation, and a monitor of the laser bias current to provide an advance alarm of impending failure. The module is designed for a controlled turn-on and turn-off of bias current to prevent transient damage to the laser through overdriving.

The laser driven downstream system is identical to the LED driven system except the laser is connected directly to the connector on the transmitter module using a fibre pigtail of the same type as the fibre in the outside plant cable. The LED transmitter type of output power monitor could not operate in this case as a laser would not flood a large mode volume fibre in the same manner as an LED. The same information on laser condition, however, is obtainable from the feedback from the laser rear facet PIN photodiode.

3.4.2.3 Upstream LED Transmitters

For the upstream direction the SEU transmitters have a low power LED operating at 930 nm. Since only a relatively narrow band digital signal has to be transmitted, but no analog television signal, this low power is sufficient for all loop lengths.

At the subscribers premises, the connection between inside and outside plant is made by splices located in an entry unit located on the outside wall of the home. The fibre used for in house wiring has the same core diameter as the others but a higher NA than the fibres in the outside plant cable. The LED light is launched into this higher NA fibre. The LED is located in one half of the optical connector on the SEU.

3.4.3 Receivers

3.4.3.1 PIN Photodiode Receivers

At the LIU in the FTC and RDC, PIN photodiodes were used in the receivers. The photodiode is mounted in one half of the connector and is coupled to the outside plant fibre with a fibre of the same diameter but higher NA. Since the area of the photodiode is larger than the fibre core, losses are minimal, even with some misallignment of the connector. This arrangement yields a much better performance compared to coupling the detector to the connector via a pigtail fibre. Since the received signal at the LIU is only a 192 kb/s digital signal, linearity and noise are not very critical. Therefore, although a PIN photodiode requires a higher sensitivity preamplifier, its design was simple because of the non-critical nature of both noise and nonlinearity.

3.4.3.2 Avalanche Photodiode (APD) Receivers

Avalanche Photodiodes (APD) are used in the SEU receivers. The mounting arrangement and the fibre connection to the outside plant fibre is the same as for the photodiodes at the LIU's. APD's provide a higher output and their gain can be controlled by the bias current. Since linearity and noise are important considerations for the reception of the analog video signal, particularly where two channel video is received, the APD's gain control capability and higher output level simplify the design of the pre-amplifier and allow the performance specifications to be met. Noise and linearity were then the main considerations for using APD's in the SEU optical receiver.

Despite the advantages of the APD's, it was still necessary to insert optical attenuators on the short loops which were used for 2 TV channel operation and hence were driven by laser transmitters. This was required to avoid performance degradation due to high receiver APD power dissipation and increase in APD non-linearity at high light levels. Two values of attenuation were used with nominal optical losses of 5 dB and 10 dB. As these were inserted at the transmitter end of the system it was necessary to have an attenuator design with low reflectivity to avoid reflection back into the laser cavity. Reflections would cause an increase in laser noise and non-linearity. To this end the input port reflection loss was maintained greater than 25 dB.

3.4.4 System Power and Loss Budget

Typical optical loss budgets for the upstream and downstream channels are shown in Tables 3.2 to 3.4. The large unallocated margins are a reflection of the improvement in fibre manufacturing processes that occurred between the design and implementation phases of the project. Attenuations of 2.6 dB/km were measured at 820 nm[3.9] and the upstream value was as low as 1.7 dB/km at 930 nm, indicating the almost total removal of the nearby hydroxyl absorption peak previously evident.

The dispersion impairment shown in Table 3.2 relates to the TV channel. The prime impact of the dispersion with the LED source falls upon the FM channels near 25 MHz, and is 2.2 dB.

It should be noted that no WDD coupler loss allowance is shown in the downstream loss budgets. The reason is that the longest loops for which the loss budgets are shown would have

LED average power launched into fibre	-13.0	dBm
Receiver senstitivy(80% mod depth)	-30.0	dBm
Span gain	17.0	dB
Splice repair margin (6 x 0.4)	2.4	dB
LED degradation with age	1.5	dB
Dispersion Impairment (9 ns)	0.2	dB
Fibre attenuation (2.5 km x 3.0)	7.5	dB
Splice losses (3 x 0.4)	1.2	dB
Subtotal	12.8	dB
Unallocated margin	4.2	dB

Table 3.2 Downstream Loss Budget Using LED/APD @ 830 nm.

LED average power launched into fibre	-37.0	dBm
Receiver sensitivity	-64.0	dBm
Span gain	27.0	dB
WDD* coupler losses (2 x 2)	4.0	dB
Splice repair margin (6 x 0.4)	2.4	dB
Dispersion Impairment (18 ns)	0.0	dB
Fibre attenuation (5 km x 2.0)	10.0	dB
Splice losses (5 x 0.4)	2.0	dB
Subtotal	18.4	dB
Unallocated margin	8.6	dB

* Wavelength Division Diplexing (WDD) is used on 25 loops.

Table 3.3 Upstream Loss Budget Using LED/PIN @930 nm

Laser power (av) launched into fibre	-3.0	dBm
Receiver sensitivity (55% mod depth)	-27.1	dBm
Span gain	24.1	dB
Splice repair margin (6 x 0.4)	2.4	dB
Laser excess noise impairment	0.5	dB
Fibre attenuation (5.0km x 3.0)	15.0	dB
Splice losses (5 x 0.4)	2.0	dB
Subtotal	19.9	dB
Unallocated margin	4.2	dB

Table 3.4 Downstream Loss Budget Using Laser/APD @ 830 nm.

left no unallocated margin, which is not considered good engineering practice. For this reason bidirectional transmission on a single fibre was implemented only on loops which were shorter than the design limit.

3.5 CATV Facilities

3.5.1 General

In order to provide television service to the subscribers, it was necessary to obtain approval from the CRTC. A number of residents of the community incorporated a cable TV company which made application to the CRTC to provide service within specified boundaries. The CRTC authorization required that CATV service be offered not only to participants in the trial, but also to anyone located within the specified boundaries. A standard coaxial cable network was implemented to serve the subscribers who were not participating in the trial.

The major facilities installed in Elie and St. Eustache to provide cable television service are the head-end in Elie, the secondary head-end (hub) in St. Eustache to provide service to subscribers connected to the coaxial cable local broadband network (LBN) and the coaxial cable distribution plant in Elie and St. Eustache to serve subscribers who were not participating in the field trial.

3.5.2 Elie CATV Head-End

The Elie CATV head-end has been installed in the Elie C.D.O for ease of maintenance during the field trial period by MTS personnel. A basic block diagram of this head-end is included in Figure 3.13 showing the major components of all CATV facilities.

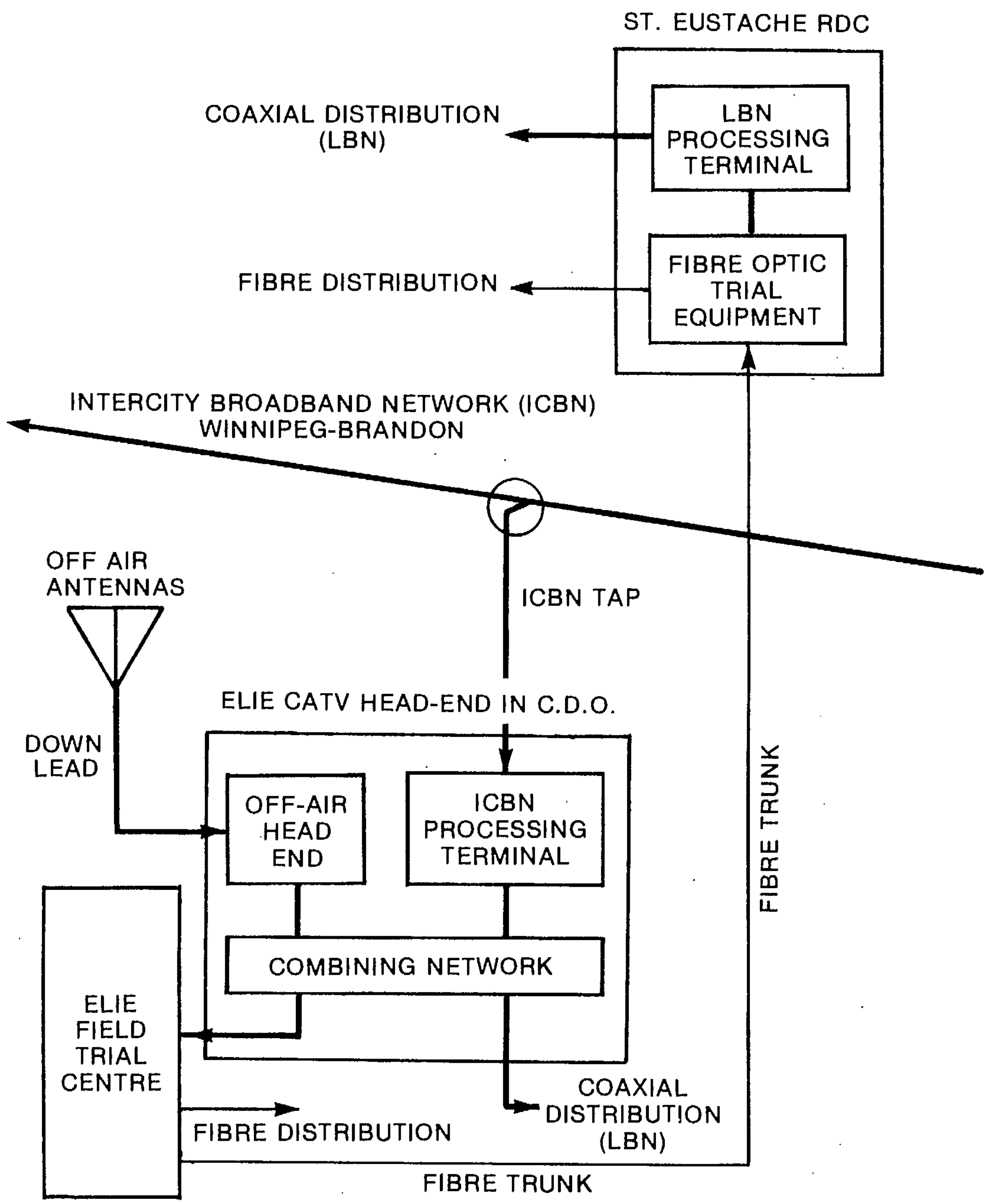


Figure 3.13 Block diagram showing the major components of the CATV facilities in Elie and St. Eustache

3.5.2.1 Signal Reception Facilities

There are 4 local television channels, 4 remote television channels orginating in the U.S.A. and 6 local radio stations.

Local signals are received off air at the Elie Central Office using four separate Yagi antennas mounted as a pole supported mast as shown in Figure 3.14. Antennas are Lindsay, five element Yagis tuned to channels 3,6,7 and 9. Separate downleads bring the signals into the head-end equipment in the C.D.O. building where the off-air channels are processed. The FM radio signals are stripped off the downlead from the channel 6 antenna and processed to meet the requirements of the Department of Communications' Broadcast Procedure 23.

The remote U.S. Network television channels are received at Elie via the Intercity Broadband Network (ICBN) between Winnipeg and Brandon. The signals originate in the U.S.A. and are picked up off air at Tolstoi, Manitoba then brought via microwave into Winnipeg where the signals are inserted into the ICBN. Again the ICBN signals delivered to Elie are processed before combining with the local signals. The processed and combined signals shown in Table 3.5 are fed to the Fibre Optic Trial Centre at Elie and to the coaxial distribution network.

3.5.2.2 Signal Processing Facilities

For processing of the television channels, commercially available model 6150 processors from Scientific Atlanta were used. A Catel model FMR 2000 audio processor was used to process the FM Radio signals.

3.5.3 St. Eustache CATV Hub

All television and FM Radio signals for distribution in St. Eustache either via the fibre optic trial plant or the

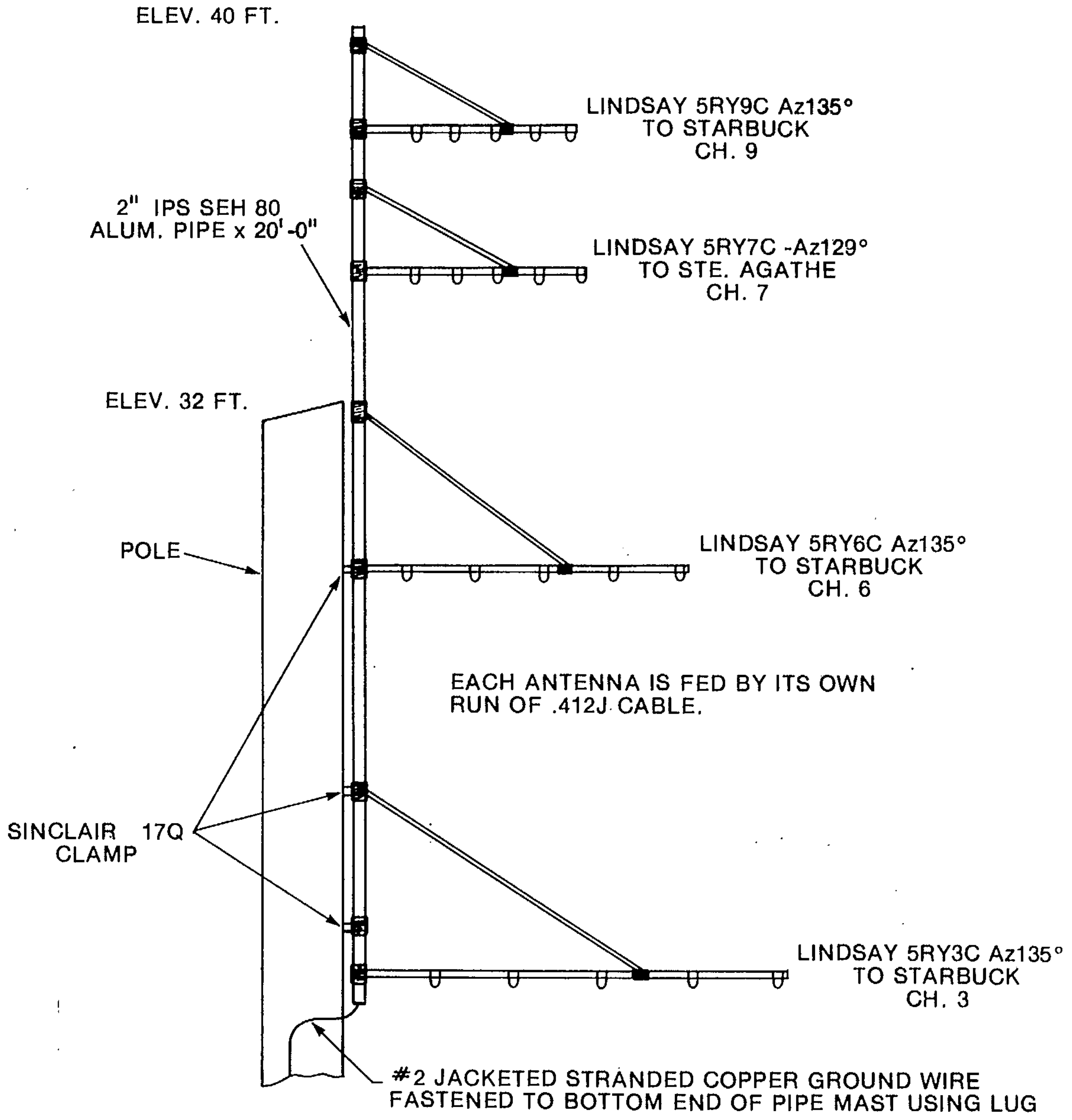


Figure 3.14 Antenna system for reception of off-air TV signals at the Elie CATV head-end

VHF TELEVISION CHANNEL ALLOCATIONS

CHANNEL #	DESCRIPTION	ORIGINATION
2	CBWT (CBC ENGLISH)	OFF AIR (CH 6)
3	KGFE (PBS)	GRAND FORKS (VIA ICBN)
4	KXJB (CBS)	VALLEY CITY (VIA ICBN)
5	CKY (CTV)	OFF AIR (CH 7)
8	WDAZ (ABC)	DEVIL'S LAKE (VIA ICBN)
10	CBWFT (CBC FRENCH)	OFF AIR (CH 3)
11	KTHI (NBC)	FARGO (VIA ICBN)
12	CKND (INDEPENDENT)	OFF AIR (CH 9)
13	LOCAL PROGRAM	

FM RADIO CHANNEL ALLOCATIONS

CHANNEL #	DESCRIPTION	ORIGINATION
285	CKSB* (AM RADIO)	WINNIPEG
288	CKWG	WINNIPEG
291	CBW	WINNIPEG
294	CHMM	WINNIPEG
297	CHIQ	WINNIPEG
300	CITI	WINNIPEG

*This is the only French language radio station in this area.

Table 3.5 Television and FM Radio Channel Allocations coaxial cable local broadband network are received via the fibre optic trunk from the Elie head-end. The signal processing is again accomplished by the same type of processors used in the Elie head-end. Table 3.6 shows the frequency translations for TV and FM Radio signals between the RDC received signals and the signals distributed to the subscribers.

3.5.4 The Coaxial Cable Local Broadband Network

The coaxial cable facility is built for a bandwidth of 220 MHz (20 TV channels plus FM Radio band). The majority of the plant is buried (69%) and the remaining is aerial. The outside amplifiers are Century III Electronics and taps are also Century III Electronics , 3300 series.

The Elie CATV service boundary has a potential of 130 subscribers and St. Eustache has a potential of 104 subscribers including the fibre optic field trial subscribers in both communities.

3.6 Telidon Switching and Trunking Facilities

3.6.1 Switching

In order to provide Telidon services from the two service providers' host computers in Winnipeg the 150 data interfaces at the FTC had to be concentrated through a switching machine to a limited number of dedicated trunks connecting Elie to the host computer ports. Two switching alternatives were considered:

i) Expansion of the existing SA-1 switching machine in the C.D.O. by additional 150 line appearances and trunk interfaces configured in a hunting group.

ii) Use of a separate digital data switch.

TELEVISION CHANNEL TRANSLATIONS		
TELEVISION	RDC RECEIVE CHANNEL	CATV DISTRIBUTION CHANNEL
CBWT	C	2
KGFE	E	3
KXJB	G	4
CKY	I	5
WDAZ	8	8
CBWFT	10	10
KTHI	12	11
CKND	J	12
LOCAL PROGRAM	L	13

FM RADIO CHANNEL TRANSLATIONS		
FM RADIO	RDC RECEIVE FREQUENCY MHz	CATV/FM DISTRIBUTION CHANNEL
CKSB (AM)	25.45	285
CKWG	25.85	288
CBW	26.25	291
CHMM	26.65	294
CHIQ	27.05	297
CITI	27.45	300

Table 3.6 St. Eustache Television and FM Radio Channel Translations

The alternative to expand the existing SA-1 switch was dropped in favour of a digital switch. The SA-1 switch is an electro-mechanical switch which could create impulse noise problems for the transmission of 4800 baud data rates. Furthermore, since very little population growth and consequently very little additional need for new telephones is foreseen, the added 150 lines would have no further use in Elie at the end of the trial. Also, the opportunity for use of that hardware somewhere else in Manitoba was considered low. On the other hand a digital switch would allow transmission of the original digital signal on a digital basis at least up to the trunk interface point. Furthermore with the increase in data services elsewhere in the MTS territory, opportunities for re-use of such a switch after the trial were considered high.

A Dataswitch from Develcon Electronics was chosen. Among many of the useful features, it provided line cards that could interface the subscriber data port lines from the FTC at a 56 kb/s rate and were compatible with the RS-422 standard. The trunk outputs were at 4.8 kb/s and were compatible with the RS-232C interface standard. Its programmability permitted custom design of the user access protocol to the databases, which was required due to the absence of any standard control leads at the RS-422 compatible data interfaces at the SEU's and LIU's. The switch can also collect statistical data with respect to the use of lines, trunks, busy conditions and number of users waiting to get access to a trunk. This data is available at a statistics interface port and has been used for Telidon usage statistics purposes.

3.6.2 Multiplexing

At the time of the switching and trunking network design almost no data on Telidon usage such as holding times, busy hour, etc. was available. Based on such scant data it was decided somewhat arbitrarily to provide for a 10 to 1 concentration ratio of subscriber number to number of trunks to each of the database host computers. Furthermore, to reduce the actual number of trunks from 15 to a smaller number, statistical multiplexers were used. Each statistical multiplexer has an output transmission rate of 9.6 kb/s and is accessed by four 4.8 kb/s output ports of the digital switch. The actual required number of trunks was therefore reduced to four. It should be noted that the effective transmission speed is however in the worst case still twice as fast as the 1.2 kb/s speed, which is used for regular Telidon service over dial-up telephone lines.

Operating experience during the trial period has shown, that the 10 to 1 concentration ratio has not caused any service degradation even during the Christmas-New Year holiday season when the largest number of user accesses were recorded.

3.6.3 Trunk Facilities

The four 9.6 kb/s data streams to each Telidon database host computer are carried over four PCM carrier channels between Elie and the Winnipeg Toll centre. Dedicated, conditioned 4-wire lines are provided between the toll center and the host computers.

A block diagram of the Telidon switching, multiplexing and trunking facilities is shown in Figure 3.15.

3.7 Usage Measurement Facilities

3.7.1 General

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

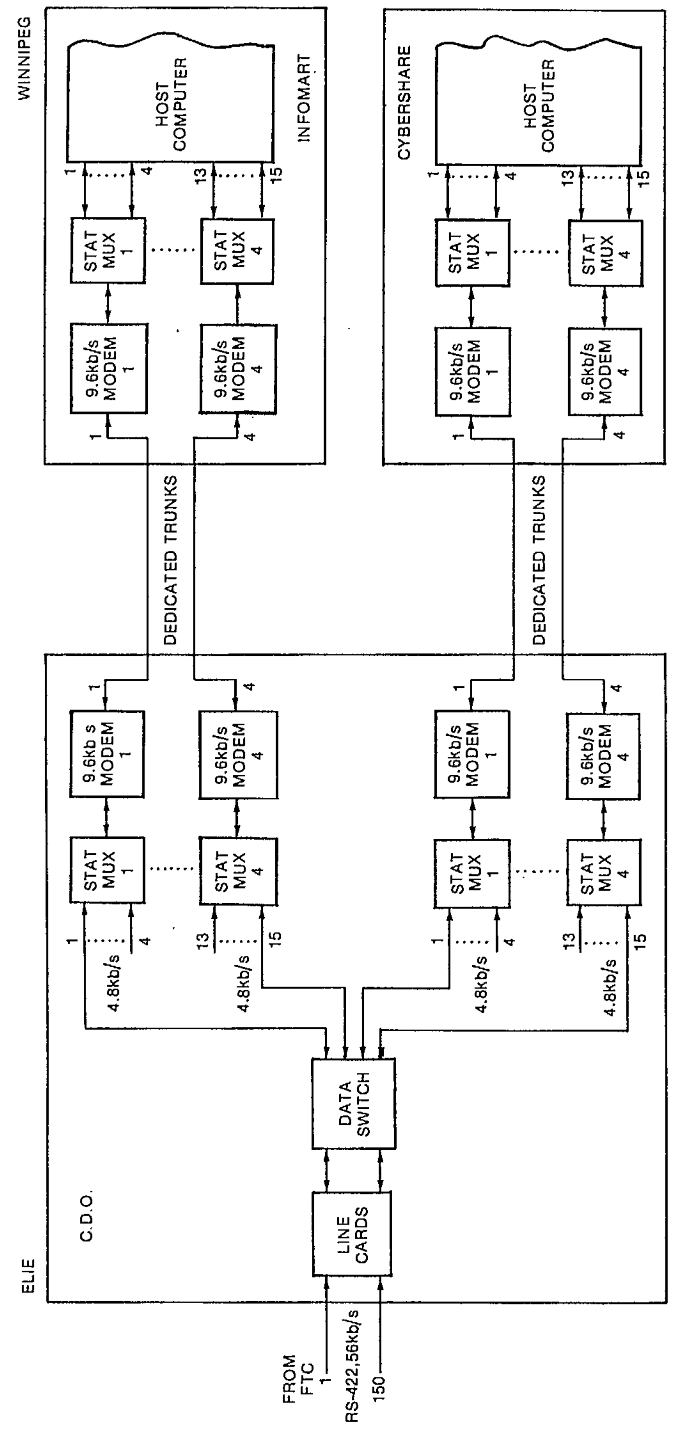


Figure 3.15 Block diagram of the Telidon switching, multiplexing and trunking facilities

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 cable TV services. In the case of cable TV, the ability to collect usage of each channel by each subscriber, would also demonstrate a billing capability for a future pay-TV service.

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

3.7.2 Primary Usage Data Collection Facilities

3.7.2.1 CATV Usage Data Collection Facilities

The source of the CATV usage data is the LIU associated with each trial participant's line. The LIU generates continously "status" data with respect to which channel is selected and whether the STU and consequently the subscriber's TV set is "ON". The status is updated approximately 12.5 times per second. The collection and direct transmission of this huge amount of data for 175 TV sets (this includes the households who have access to two independent TV channels) from two locations, namely the FTC and RDC, was considered to be neither practical nor necessary. It was, therefore, decided to build two special, microprocessor based Line Concentrator Units (LCU) for use at the FTC and the RDC which would provide some preprocessing of the raw data and reduce it to an amount feasible for transmission to a computer for further processing.

The LCU's were custom designed and manufactured by Interdiscom Limited. The data are reduced from 12.5 samples per second per LIU to 1 sample every 2 seconds. Only every fourth reading is stored. Then these readings are examined. Only if

3 consecutive readings are identical they are considered a valid new reading. The approach taken, makes use of the fact, that the users rate of changing channels is much slower than the systems scanning rate. The output from the LCU is available at a standard data interface which is strap selectable for 1200 or 2400 baud transmission rates.

3.7.2.2 Telidon Usage Data Collection Facilities

Telidon usage data collected by MTS originates from the data switch installed in the C.D.O. It utilizes the statistics gathering capability of the switch which is accessible via the standard RS-232C compatible statistics port of the switch. The information available includes identification of the user through identifying the line card, the data base that was accessed by identifying the trunk group and finally the real time when a user logged ON and OFF to and from a database.

Additional usage data was collected and processed by the service providers host computer. The data collected provided in addition to the above data the number of pages accessed and the name or number of the page accessed. Since for more than a year, users could log-ON without individualized account numbers and pass-words identifying them, it was not possible to associate page usage with a user.

3.7.3 Usage Data Processing Facilities

Data collected from the two LCU's and the statistics port of the data switch are transmitted to an IBM Series/1 minicomputer, located at the MTS Vernon local exchange in Winnipeg, for storage and some processing. These preprocessed data are then sent twice a week via a data line to Manitoba Data Services, the Manitoba Government Computer Utility also located in Winnipeg for storage and generation of monthly usage reports. Software for the minicomputer and the Manitoba Data Services mainframe were written by MTS personnel.

The Data collection and processing facilities are shown in block diagram form in figure 3.16.

3.7.4 Data Security and Privacy Protection

The mini-computer was under the control of MTS plant operations and subject to the same security as regular MTS equipment. Standard data processing procedures, such as record counts, were used when the data was transmitted from the mini-computer to the mainframe computer. The data was validated and stored on password protected files. Any request for processing or transmitting the information kept on the mainframe was co-ordinated through and authorized by the MTS project manager or his designate. The actual running of the jobs on the mainframe computer was done through C.I.S. Operations Department.

C.I.S. standards in documentation and control procedure were followed during development, implementation and operation of this system.

To ensure privacy, the users were identified only by a number. Names and addresses were not kept on a computer file, but were stored separately in hardcopy form accessible only by the MTS project manager or his designate. Cross-reference with any profile information was done via the assigned number.

3.8 Outside Plant Design

Outside plant design has been a joint effort between Northern Telecom Canada Limited, Bell-Northern Research and The Manitoba Telephone System. Route selection and engineering was mainly done by MTS and served as an input to the BNR and NTCL detailed design effort.

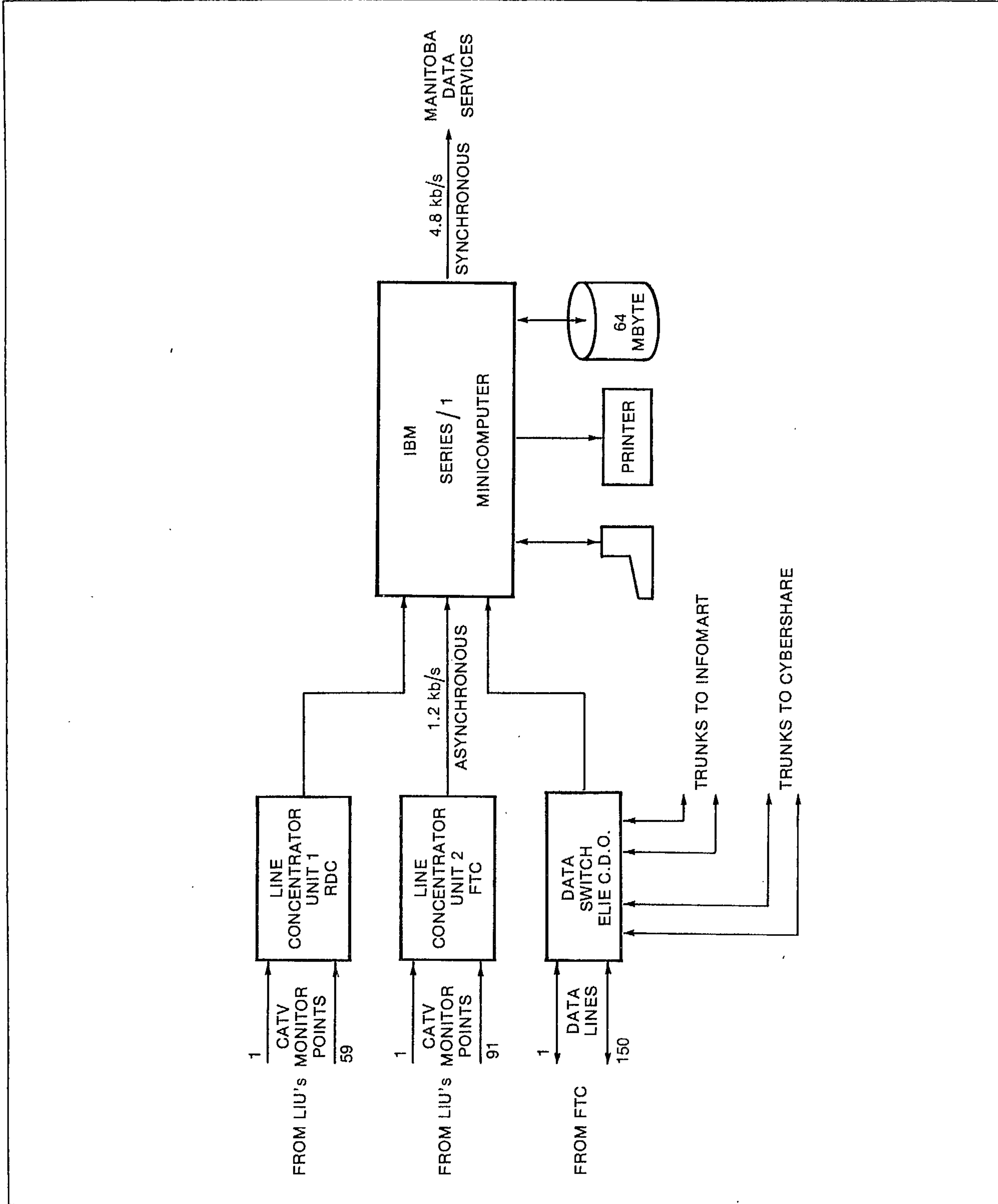


Figure 3.16 Data collection and processing facilities of the usage measurement system

In the selection of routes consideration was given to including aerial, buried and ducted feeder and drop routes in order to gain experience with all types of outside plant construction methods.

The trial system used 75 km of optical fibre cable with a total of 900 km of fibre.

3.8.1 Cable and Fibre Considerations

All the trial cables including drops consist of a slotted plastic core extruded around a steel central strength member. This design is illustrated in Figure 3.17. The fibres are laid into the peripheral slots which are oscillated around the cables central axis. This minimizes any fibre bending stresses. A maximum of 6 individual colour coded fibres or one 22 gauge copper pair can be positioned in each slot. Both the aerial and buried cables are designed for unpressurized application, using a filled core construction. The inner core is enclosed in a Sealpeth (Sealed Alpeth) sheath. This is the standard sheath normally applied on filled core cables. A Sealpeth sheath consists of a coated aluminum tape bonded to an outer black polyethylene jacket. The bonded overlapped aluminum tape prevents moisture, which may have permeated through the jacket, from reaching the cable core.

The trial cables have a diameter of less than 20mm with the minimum cable bending radius being 10 times the outside cable diameter. Permanent distance markers were printed on the outer jacket of all cables to assist in cable placement. In addition, the cable codes were printed on the outer jacket to distinguish the fibre cables from existing MTS cables.

In the initial system proposal and later in the System Design[3.1] it was assumed that since the system was basically LED based for downstream transmission, a downstream fibre

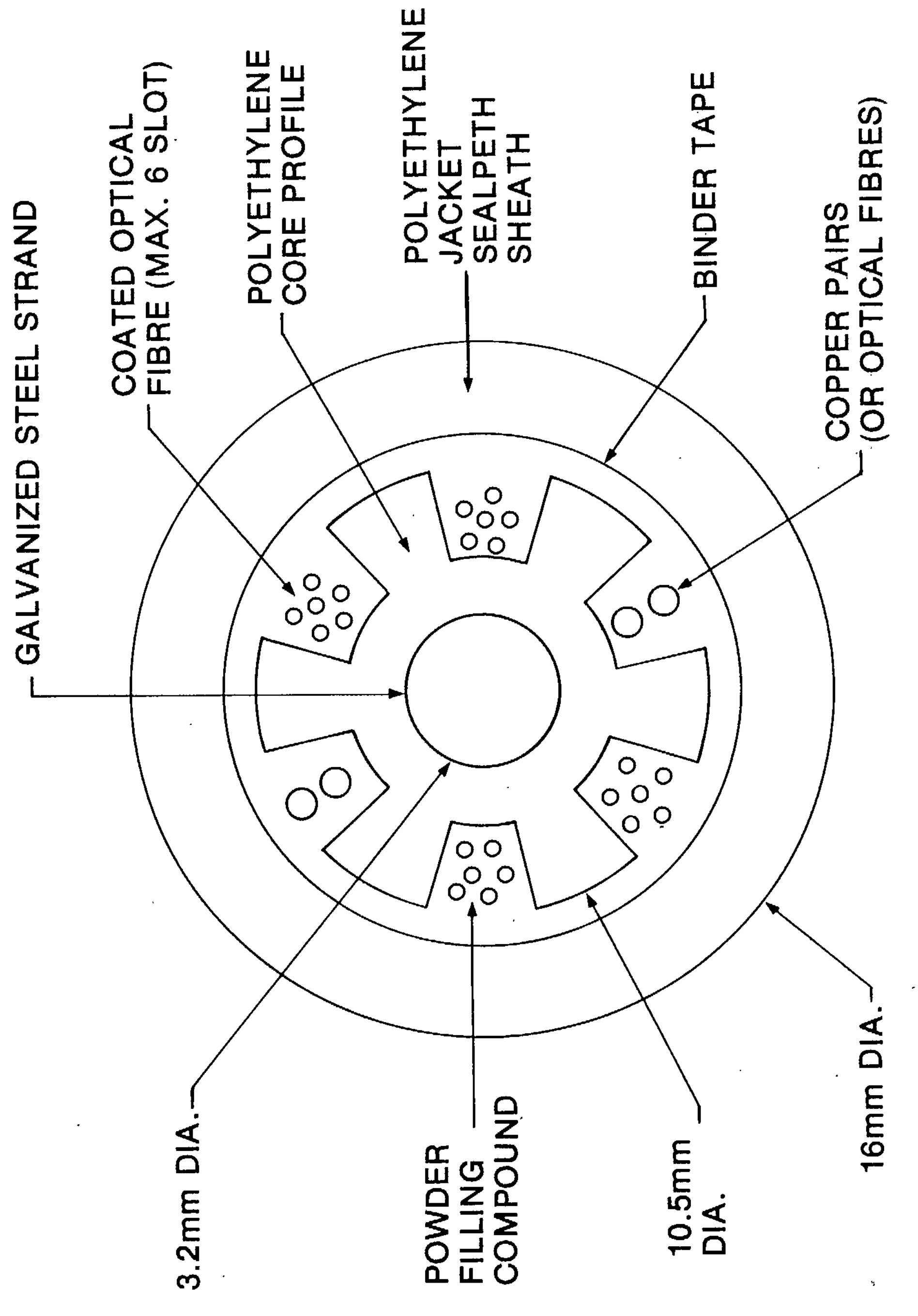


Figure 3.17 Cross section of the optical fibre cable used in the outside plant

compatible with LED's would be most appropriate for the subscriber distribution loops. This would have required the design and manufacture of a fibre with larger core and NA than the existing standard NT fibre. It would also have required low loss and wide enough bandwidth to pass the maximum frequency signal of 27 MHz (for single channel operation) over the maximum length LED based system of 3 km.

It was also assumed in the System Design Report [3.1] that in order to minimize the required bandwidth of the LED compatible fibre, the upstream and downstream fibres in the subscriber loop would be of different types. That is, the fibre for downstream transmission use in a LED based system would be the high mode volume LED type fibre and upstream would use the standard NT fibre. In the laser based systems where the wider bandwidth is required for 2 channel video transmission i.e. 60 MHz system bandwidth, the standard NT fibre would be used for downstream transmission and the LED fibre type for upstream transmission. This approach had the disadvantage of requiring spares for each fibre type, even in the drop cables, and potential administrative difficulties in identifying which fibre type was in use.

To overcome the above described system disadvantages it was decided to use the standard NT fibre (core = 50 um, NA = 0.17) throughout. Due to the reduction in coupled power in the LED loops, it was also necessary to replace the longest LED loops with additional laser transmitters. This design change was adopted in the final system design. Due to the loop length distribution (Fig. 3.18) this increased the number of single channel laser transmitters by only a quantity of 7 from the contractual quantity of 35 and reduced the maximum length of LED loops from 3.0 km to 2.4 km. However this allowed that the drop cables could be reduced from four fibres to three fibres. Also there was no longer any need to differentiate between upstream and downstream fibres as now both were identical thus eliminating the potential administrative difficulties mentioned earlier.

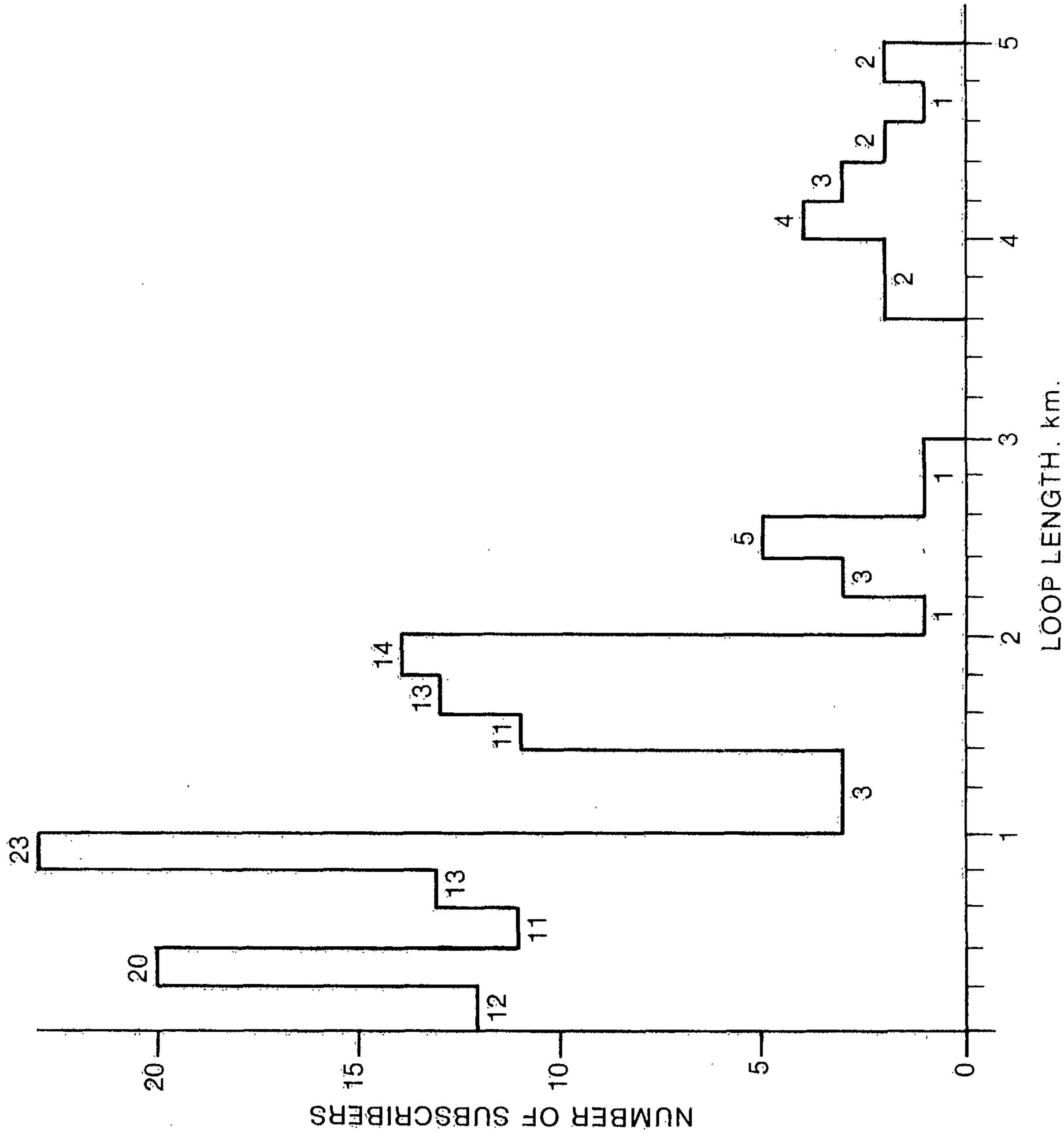


Figure 3.18 Histogram of the loop length distribution of the trial system

The design using NT standard fibre throughout proved to be successful and was reinforced by ongoing reductions in the loss of the standard NT fibre which was generally less than 3 dB per km (at 830 nm) even when cabled.

The characteristics of the standard NT fibre are given in Table 3.7.

FIBRE PARAMETERS	
TYPE	GRADED INDEX
PROCESS	I.V.P
NA	0.17
ATTENUATION	4 dB/km (840 & 930 nm)
3dB-OPT.BDW.	600 MHz
CORE-DIAM.	50 μm
CLADDING-DIAM.	120 μm
COATING-DIAM.	320 μm

Table 3.7 Characteristics of the Standard NT Fibre

3.8.2 Route Engineering

NTCL was responsible for the overall fibre optic system design, with MTS being responsible for the route or field engineering portion. This required that MTS had to produce the construction plans for all outside plant, identifying cable routes and locations, sizes and lengths of cables, splice enclosure and pedestal locations, FTC and RDC trailer locations, etc.

From this information NTCL produced the design and construction practices upon which the design and construction was based. The entire process was evolutionary. The design and construction practices were being developed as the route layout proceeded, and each affected and improved the other. Similarly, materials (eg. choice and size of pedestals) were influenced by construction methods (eg. cable splicing and enclosures) and vice versa. Many iterations occurred as problems were identified and solved on a mutual basis. Considerable communication and cooperation went into the development of the practices leading to the route engineering.

NTCL's basic system design included two parts:

i) The actual cable distribution to 150 homes from two trailers, the FTC and RDC. This involved providing two dedicated fibres to each home from either the FTC or RDC. A constraint was, that the maximum length of the loops was not to exceed 5.0 km.

ii) A fibre optic trunk cable connecting the RDC to the FTC. The RDC is located 8.5 km from the FTC.

The design philosophy was slightly different for the two parts. This was reflected in the route engineering work.

In the case of the trunk, the calculated optical loss of the fibre plus splices was almost equal to the maximum allowable between the opto-electronic transmitters and receivers in the FTC and RDC. Since the sites and the number of fibre splices were fixed, all other possibilities to reduce loss were examined. The cable route, location of splice pedestals, etc., were studied to keep the cable length to a minimum.

The objective of lowest loss was also the goal in the design of the distribution plant. This was translated into a requirement for as few fibre splices as possible. Since the design required fibres to be dropped off at splice points along the cable just as in the usual paired copper design, a procedure whereby through fibres were not cut and respliced was developed. This is described in more detail in section 3.8.5.4.

3.8.3 Cable Routing

NTCL approached the fibre cable design with two requirements. First, it was requested that the entire route of the cables be measured (trunk, distribution and drop) so that optical losses could be calculated. Second, individual cable lengths had to be determined so that cables could be manufactured to length and individually tested.

This caused deviations from the usual route engineering process. The minimum loss constraint required that the location of splice enclosures, both aerial and buried, had to be optimized so that the number of splices on each loop was a minimum. From this requirement emerged the idea of splice locations where only fibres that had to be split off the main feeder were cut and spliced but not through fibres. Such concerns were taken into account during the initial design phase and identification of required cable lengths by considering:

i) The development of a method to obtain fibre slack at splice locations on feeders with through fibres.

ii) The requirement of installing particular lengths past splice locations where the cable sheath would have to be entered during the splicing process.

iii) The requirement that cable lengths might have to be installed from a buried splice location to an aerial location or vice versa.

It was anticipated that the installation of certain cables, because of such special considerations, was going to be a difficult job. Therefore, in a number of cases, MTS consulted with NTCL and received approval to specify additional splice locations where cables would be cut to shorten cable lengths for easier installation.

Once the cable routes and splice locations were established, actual distances were measured, splicing allowances were added and a 1% contingency was included. Because of the anticipated and planned installation sequence (multiple cables to be buried or lashed aerially simultaneously, aerial cables installed before buried cables for weather reasons) an order of priority for cable shipment to Elie was established. However, during the construction phase it was not feasible for NTCL to adhere to the priority because of their own manufacturing constraints. This complicated the installation and caused some delays, however, it did not affect the overall completion date.

The drop cables were also initially planned to be measured and cut to length. During the design, however, it became apparent this would be impractical and could lead to waste since drop cables are regularly subject to on the spot route changes at the time of installation. The reduction in splice locations required the placement of drops up to 1900 metres. It was finally agreed that the drop cables would come in maximum manufactured lengths (2100 metres) to be used at the discretion of the installation forces.

After the system was installed and tested, it became apparent that the need for a minimum number of splices had been over-emphasized. Actual fibre attenuation was less than the estimated value (2.5 db/km vs 4.0 db/km) and splice loss was also less (0.3 db vs 0.4 db). Consequently more splices could have been allowed in shorter subscriber loops with a resultant simplification of the design, engineering and installation work.

3.8.4 Cable Sizings and Multiple Cables

The system design specified two fibres to be dedicated to each participant - one for transmission to the participant, the other for transmission from the participant. The least number of fibres in a cable was to be three - the drop cables were to have two working fibres and one spare.

MTS' Route Engineering Department identified cable requirements ranging from a minimum of three fibres to a maximum of 114 fibres. NTCL's cable design at that time had a configuration of maximum 36 fibres (now 96). In order to simplify manufacturing, the same cable configuration was used for all cables whether 36 or fewer fibres were required. The fibres not required were simply not placed in the core slots during manufacture. Where more than 36 fibres were required, two or more cables were provided.

This led to several locations where a larger number of cables was required (10 leaving the FTC, 8 leaving the RDC, 5 running north from the FTC in Elie, etc.). Therefore, in consultation with NTCL, some adjustments were made from the intial design, such as:

i) Underground duct systems were included in the design at both the FTC and the RDC.

ii) The main cable run north from the FTC (five cables) was changed from aerial to buried.

In all other cases, because of the small size of the cable and its light weight, no design problems were encountered because of multiple cables.

3.8.5 Special Considerations

3.8.5.1 Cable Location

Since the design was new and the practices were under development, the aerial sections of cable were assigned a separate space on the poles to make room for splice enclosures, cable formation, drop takeoffs, etc. This space was above the existing paired cable plant. This forced the replacement of a number of poles with higher ones to maintain ground clearances and to obtain adequate separation between the existing plant and the new.

Similarly, new easements were obtained on the main north-south route between the FTC and the RDC to separate completely the existing and new plant.

3.8.5.2 Cable Burial Depth

Existing paired distribution cable is buried 90 cm (36") below ground. Drop cable on private property is buried 60 cm (24") below ground. In order to give the trial sponsors first hand experience with fibre cables that are subject to the freeze-thaw cycle of prairie soil, a conscious decision was made to maintain these depths for fibre cables as well. This also allowed existing ploughing or trenching equipment to be used.

Only one change from the above was made. In Elie, the five cables running north from the FTC were buried at about 1 m (42") and protected by old crossarms. This was done because the highways department was uncertain regarding possible redesign and construction of this portion of the roadway.

3.8.5.3 Buried Splices

Buried splices have always been a subject of discussion and contention with outside plant engineering forces. To obtain some experience with buried fibre cable splices, the burial of two splice enclosures on the trunk cable between the FTC and RDC was proposed by MTS. The same type of splice enclosure was used that was used elsewhere. The enclosures were then enclosed in rough wooden boxes for physical protection and to mark the splice locations.

3.8.5.4 Splicing Slack for Cables with Through Fibres

Not surprisingly, the method of obtaining slack for splicing fibres at locations involving unspliced through fibres was unique. In the aerial situation, the through cable was attached to the messenger cable and pole with a small amount of slack provided on the opposite side of the pole from the office. A splice enclosure was installed close to the pole on the slack portion of cable. No fibres were cut. The drop or other cables to be spliced into the feeder were brought into the enclosure with a splice tail of fibre provided. To obtain a splice tail for fibres in the feeder, a second sheath cut was made at about 1.2 m away from the splice enclosure in the slack area farther from the pole. The correct fibre was cut at this point and pulled back into the enclosure. A splice could now be performed, and the enclosure closed. A heat shrink bandage was placed over the second sheath cut to seal that opening. For buried cables, a large enough pedestal had to be provided to accommodate a cable loop to include the enclosure and the sheath cut. Details of this method are described in the Outside Plant Handbook[3.10].

Two observations are noteworthy:

i) The dead fibre downstream from the cut is not any longer accessible at this splice and is in effect wasted.

ii) The fibre to be pulled back into the enclosure for splicing is vulnerable to breakage, with no second chance. It is a credit to NTCL's fibre and the skill of the splicers that no difficulties arose.

3.8.5.5 Fibre Expansion Loops

Expansion loops and loops at each splice enclosure location were required. These expansion loops were provided to ensure that the fibre within the cable remains unstressed when the cable is subjected to temperature and loading extremes throughout its life. At splice enclosure locations which were generally located at the end of cable reels, major road crossings, or at cable junction locations, a cable loop (radius = 10 times cable diameter) was provided to ensure additional cable is available for maintenance purposes. This requirement defines the minimum spacing between associated cables on joint use poles and the size of pedestal required for buried applications.

3.8.5.6 Aerial Drop Cables

During the design phase another constraint was addressed. The drop cable was not self supporting and required the support of a messenger cable. A normal #14 suspension strand was used for all feeder cables (single or multiple) while a special 1/8" suspension strand was specified for drop cables. A maximum span length of 30 meters was also specified to prevent stretching of the drop cable.

A re-examination of all aerial drops resulted in some being changed to buried drops rather than placing additional poles.

3.8.5.7 Manitoba Hydro Substation

A small transformer substation was directly in line with the route of the trunk cable between the FTC and the RDC. Initial plans foresaw the installation of the cable immediately adjacent to the substation, but it was soon realized that while the fibres themselves and the signals they carried would be unaffected, the sheath and strength member of the cable would be subject to lightning and ground fault currents. This would be hazardous to maintenance personnel working on the cable.

A study was initiated by NTCL, calculations were performed, and the cable was routed approximately 70 meters from the substation.

References

[3.1] System Design Report, Elie, Manitoba, Rural Fibre Optic Field Trial, Bell-Northern Research, February 1980.

[3.2] BNR; Mobile Equipment Enclosures - Elie, Manitoba, Specifications and Drawings, Guideline, June 1980 (In "Outside Plant Practice and Technical Specification Check List", Section 15)

[3.3] DMS-1 Digital Multiplex Systems, Northern Telecom Practices, Section 363-2011-100, Issued 80, 11, 28.

[3.4] FA-1 Optical Fibre Transmission System, Northern Telecom Practices, Section 321-2001-100, Issued 78, 12, 12.

[3.5] Optical Fibre Digital Transmission Equipment FD-2, Northern Telecom Practices, Section 321-2101-100, Issued 81, 03, 30.

[3.6] RM-3 Type FM Transmitter and Receiver Units, Northern Telecom Practices, Section 420-2301-XXX, Issued ....

[3.7] Elie Project Draft Maintenance Manual, Northern Telecom, Issued August 1981.

[3.8] D.A. Kahn, M.B. Akgun, E.H. Hara, G.A. Tough; Technical and Operational Aspects of the Elie Fibre Optic Field Trial, the First to Offer Fully Integrated Loop Services, IEEE Globecom 83, Conference Record, Vol. 1, pp. 150-158, San Diego, Nov. 28 - Dec. 1, 1983.

[3.9] R. Neumann; Fibre Optic Measurements for the Elie Manitoba Field Trial, IEEE Electrical and Electronic Measurement and Test Instrument Conference, Ottawa, 1981.

[3.10] Elie, Manitoba, Rural Fibre Optic Field Trial, Outside Plant Handbook, Northern Telecom, April 1981.

CHAPTER 4 - OUTSIDE PLANT CONSTRUCTION

4.1 General

The construction phase included all work associated with:

- Installation of all outside plant cable
- Installation of associated messenger strand
- Installation of pedestals and house terminals
- Installation of splice closures
- Splicing of optical fibres
- Some attenuation testing of splices

All the above work was carried out by MTS outside plant construction crews under subcontract from NTCL. The responsibility for the overall construction phase was NTCL's.

All material, unique equipment and tools, practices and procedures and training was provided to MTS by NTCL.

4.2 Specification and Constraints

The objective of the design of the fibre cable and its associated materials (enclosures, etc.) was that the cable would not receive any special treatment or require new installation equipment or training of craftsmen. Thus NTCL was required to come up with a design whereby the cable and associated material was to be capable of being handled by a regular construction crew (experienced with copper paired cable) using the usual construction equipment (eg. ploughs) and using the normal practices and procedures, within reason.

The most obvious deviation was of course the handling and splicing of the glass fibre itself. New procedures had to be developed for it.

Other constraints included:

- The cable had a bending radius of ten times the cable diameter. This is very similar to that for copper paired cable. It is, however, not only a minimum radius to be adhered to in the cable's final installed position, but a condition to be adhered to at any time during installation. It is possible that a permanent fibre impairment could occur if the cable is subjected to bends tighter than the stated minimum.

- The cable has a maximum permissible pulling tension of 750 pounds. This small pulling tension, although alleviated by the cables small diameter and light weight, was nevertheless of some concern particularly when pulling cable through ducts. However, since only two short sections of duct were used in the Elie system, no problems were encountered.

- For expedience and economy, the same configuration and size of cable was used for feeder, distribution and drop cables. Only the number of fibres within the cable differed. Therefore aerial drop cables required a slack messenger to be installed right to the house. Two problems surfaced:

    1) An appropriate structurally sound mounting location at the house for the strand was not always easy to find

    2) The slack strand and drop cable were difficult to lash together

A self-supporting small drop cable, containing only a few fibres, will be required in future installations.

4.3 Fibre Cable and Splicing

4.3.1 Practices and Procedures

A list of 21 practices is shown in Appendix 4-1. These practices were provided by NTCL. Although some are standard, most were guidelines developed for the Elie - St. Eustache system and apply only to that system at this time.

The practices went through an extensive development phase in NTCL with the result that they are now well detailed, complete and easy to follow and include many sketches and photographs.

The practices emphasize the tools that are unique to fibres (cleavers, fibre strippers), the fusion splice set, and various test sets. The practices also include information on new, unique materials relevant to fibre cable such as the splice enclosure and organizer tray.

4.3.2 Training

NTCL provided training to MTS personnel for various purposes relating to the Elie - St. Eustache trial system. Training was provided mainly through three courses, two of which were given in Winnipeg and one in Ottawa:

- Outside plant installation practices and methods - one week in Winnipeg

- Fibre cable testing - in Ottawa

- Loop acceptance testing - in Winnipeg

Courses were attended by outside plant construction personnel which included also foremen and staff personnel.

For the splicing of all fibres in the trial system three crews of two were required. Selection of splicers was based on desire to participate, interest in a new technology and finally also on seniority. A special training course was given in Winnipeg which included classroom and hands-on training.

4.4 Aerial and Buried Cable Experience

4.4.1 Handling Procedures

The practices specify cable expansion loops and loops on cables entering enclosures in the aerial plant. There are loops at pedestals in the buried plant. The bending radius restriction of the cable required special attention, but the cable was easy to handle and no specific problems were encountered as mentioned in section 4.2.

4.4.2 Aerial Drops

The cable used for drops had the same configuration as feeder cables, but was provided with only three fibres. In aerial situations this cable had to be lashed to a slack messenger cable. This was somewhat difficult, as mentioned in section 4.2. This problem could be eliminated if a self-supporting, small, light-weight drop cable were available. NTCL recognized this problem, and indicated, that they would develop and produce such a cable provided there was sufficient demand.

4.4.3 Cable Lengths

As discussed in chapter 3 in section 3.8.2, the emphasis was on a minimum loss budget for the loop design, requiring a minimum number of splices, which could be satisfied by the use of long (unspliced) lengths of cable. Such cable were to be delivered in precut lengths to suit specific locations.

The installation of these long custom lengths created additional work as compared to placing shorter lengths used in a typical copper pair plant installation. An example are the four multiple cables about 1500 m in length between the RDC and St. Eustache. One end of the cables was pulled through 110 m of duct into the RDC. The next 210 m was ploughed north to the road into St. Eustache. The remaining length of the cables were then threaded through 40 m of pipe pushed under the road. The rest of the cables were then ploughed another 1030 m to pedestals. One of the cables did not stop at the pedestal location. It went up a pole and went aerial for 110 m up to a splice point.

It should be noticed that the above example was rather unique and examplifies the length of trouble that was taken to keep splice losses to a minimum in such a first application of fibre optics to the subscriber access plant. With the decreasing fibre and splice losses more conventional outside plant construction methods with more splice locations and sheath cable runs can be anticipated.

4.4.4 Ploughing

NTCL's cable design at the time of the design of the Elie system had a maximum of 36 fibres in a cable sheath. At certain locations in the Elie design, more fibres were required in a cross-section and therefore multiple cables were needed. Similarly, a distribution cable and one or more drop cables could also be in a cross-section.

This resulted that multiple cables had to be ploughed in at certain locations. Although this was time consuming, no difficulties were encountered. It can be expected that multiple cable runs will decrease in the future, when larger diameter cables with more fibres become available.

Another reason for additional time being taken for ploughing fibre cable were start/stop pits. Such pits were used to eliminate the possibility of excessive bending or stress on the cable as the plough share was forced into the ground at the start of a cable run, or as the share was pulled out of the ground at the end of a run. Although this allowed stress-free starts and stops, it was time consuming. Despite the use of start/stop pits, the overall effort for ploughing optical fibre cables was only minimally larger compared to that for a copper plant. The reason for this favourable comparison is that unusual and special outside plant procedures were used, as mentioned in section 4.4.3, in order to keep the number of splices to a minimum which resulted in a smaller number of pedestals compared to the number that would have been required for a traditional copper plant. However, should, as anticipated, in the future more standard outside plant practices be applied to fibre optic cable plant, then such start/stop pits will represent an addtional cost over that for a copper plant.

Burial depths were the same as for standard copper pair cables. This was decided in order to test the effect of frost and earth movement on fibre cables. Feeder, distribution and trunk cables were buried at depths of between 75 to 90 cm. Drop cables on private property were buried at various depths depending on the plough or trencher. Burial depths ranged from 60 cm to as little as 30 cm where the ground surface was unlikely to be disturbed (lawn, driveway, etc.).

Only one situation required a lower depth for the cable. For the first 650m north from the FTC along the main street to the highway, the cables (including the trunk) were buried one metre down, and also protected with planking. This was done to protect the cables in the event the Highways Department decided to rework the road in this section.

4.4.5 Protection

The cable section discussed in 4.4.4 above was the only cable run given any form of protection in the ground.

Other protection that was used was for the buried splices on the trunk cable. In this case a wooden box was constructed to contain the splice enclosure and the cable loops. This was covered in the practices.

4.4.6 Lashing

Regular lashers and standard procedures were adhered to. Only two problems were encountered. One, mentioned earlier, was the difficulty in lashing the drop cable to a slack messenger cable leading to the homes. The second was the need for special equipment to hold the large number of reels required, when lashing multiple cables to the strand.

4.4.7 House Terminals

The house terminal is the junction point between the outside fibre cable and the inside house fibre. Grounding of the outside cable sheath and strength member, and splicing of the inside and outside fibres was done at this terminal.

The location of the terminal on the house was determined in consultation with the home owner. This was particularly true for homes with metal siding or other materials that are difficult to patch.

Since the drop cables often came from the same direction as the a.c. power wires, the terminal was in many cases located adjacent to the power service entrance. Consideration of where in the house the subscriber entrance unit (SEU) was to be mounted and its distance from the terminal was an additional consideration.

To coordinate all locations and distances in the house, an Individual House Plan for each house was drawn. Locations for the subscriber's TV set, telephones, the SEU and the house terminal were all marked along with connecting wire distances. This was found very valuable for the various installation personnel as they arrived at a home to do work, and also for the ordering of cables and other material.

4.4.8 Fibre Splicing and Testing

Since several types of construction were used in the Elie - St. Eustache system, various splicing situations occurred allowing valuable splicing and testing experience to be gained by MTS craftsmen. Much of this experience has been utilized on subsequent fibre projects in Manitoba.

Cable preparation and fibre splicing was performed in many different situations. Multiple cable splicing was done in both aerial and buried locations. Aerial work was performed using the normal platform and tent. The only operation that could not be completed in excessive wind was the optical fibre splicing because of the difficulty of handling the fibres in the fusion splice set. Use of tents for buried or pedestal splices were left to the decision of the splicing crew. No difficulties were identified.

Originally, it had been planned to test each splice as it was made for attenuation or discontinuities. The level of splicing expertise among the splicers, however, rose quickly to the point where testing of each splice was discontinued on the loop plant. The splicers became adept at inspecting their splices visually and determining its quality.

Splice testing, however, continued on the trunk fibres. The loss budget for the trunk was very tight and minimum splice losses were required. Splicers who had gained some experience on the loop plant were assigned to the trunk job, and therefore no difficulties were encountered.

4.5 Outside Plant Construction Equipment

The only additional outside plant construction equipment that was found to be necessary and not available within MTS was a reel carrier capable of handling five reels of cable. This was required for the placement of multicables. MTS borrowed one from its sister utility, Manitoba Hydro.

4.6 Activity Times

Unit times for certain activities were estimated before the job started. Upon completion, these times were checked and found reasonably accurate. As with all unit times, they are averages and may vary from place to place.

4.6.1 Field Splices

The work breakdown was as follows:

- Moving and setting up	1.0 hours
- Arranging cables, 15 min/cable x 4	1.0 "
- Preparing cables, 30 min/cable x 4 (bonding, powder dam)	2.0 "
- Closure preparation (end discs)	1.0 "
- Ring cut, bonding, heat shrink	1.0 "
- Installing organizer (placing tubes)	1.0 "
- Setting up for splicing	0.5 "
- Fibre splicing, 15 min/splice x 10	2.5 "
- Removing, cleanup	1.0 "
T O T A L	11.0 hours

The above assumes 4 cables to be opened at the enclosure, with 10 fibres to be spliced.

4.6.2 House Terminal Splices

The work breakdown was as follows:

- Moving and setting up	0.5 hours
- Cable preparation	0.5 "
- Splicing, 15 min/splice x 2	0.5 "
- Cleanup	0.5 "
T O T A L	2.0 hours

APPENDIX 4 - 1

ELIE, MANITOBA
OUTSIDE PLANT PRACTICE AND
TECHNICAL SPECIFICATION CHECK LIST

(FROM: OUTSIDE PLANT HANDBOOK)

ELIE MANITOBA

OUTSIDE PLANT PRACTICE AND TECHNICAL SPECIFICATION CHECK LIST

PRACTICE NO.	TITLE	STATUS	ISSUE	SECTION
081-4321-100	QKAC1A Fiber Preparation Kit Description.	Guideline	Mar. 81	1
081-4301-200	Optical Fiber Stripper, Miller 101-S. Description and use.	Guideline	Mar. 81	2
081-4301-202	Optical Fiber Cleaver, Fisher 11-347A. Description and use.	Guideline	Apr. 81	3
626-2301-101	Optical Fiber Cable NTF Type F Description.	Standard		4
626-2301-101	Addendum.	Addendum	Mar. 81	
627-3911-200	Aerial Cable. Optical Fiber Cable Placing.	Guideline	Mar. 81	5
627-3911-200	Addendum.	Addendum	Mar. 81	
628-2011-200	Underground Cable. Optical Fiber Cable Placing.	Guideline	Mar. 81	6
629-2311-200	Buried Cable. Optical Fiber Cable Placing.	Guideline	Mar. 81	7
629-2311-200	Addendum.	Addendum	Mar. 81	
462-4011-200	Drop and Block Wiring. Optical Fiber Cable Placing.	Guideline	Mar. 81	8
621-2xxx-xxx	House Terminal - Elie, Manitoba.	Guideline	Mar. 81	9
632-4361-200	Cable Splicing Fusion Splicing Optical Fibers.	Guideline	Mar. 81	10
633-5261-100	Splice Organizer and Closure Description.	Guideline	Mar. 81	11
632-4281-200	Cable Splicing. Lead Sleeve Closure for NTF Powder Filled Cable Installation.	Guideline	Mar. 81	12

PRACTICE NO.	TITLE	STATUS	ISSUE	SECTION
632-xxxx-xxx	Cable Terminal Splicing System for NTF Type F Optical Fiber Cable using the UC6-18 Siemens Closure.	Guideline	Feb. 81	13
631-4511-200	BIX. In-building Cross-connect System. Material, Installation and Servicing Wall-mounted System.	Standard	Mar. 80	14
631-4511-200	Addendum.	Addendum	Mar. 81	
632-xxxx-xxx	NTF Type F. Fiber Cable Terminations. Elie, Manitoba FTC and RDC.	Guideline	Mar. 81	15
Technical Specification	Mobile Equipment Enclosures - Elie, Manitoba Specifications and Drawings.	Guideline	June 80	16
638-3211-200	Electrical Protection - Bonding Optical Fiber Cable. Sheath to Strand Bond.	Guideline	Mar. 81	17
634-4011-500	Cable Testing, Optical Fiber Cable. Fault Locating.	Guideline	Mar. 81	18
107-xxxx-xxx	Attenuation Test Set, Optical Fiber Cable. Description and Use.	Guideline	Mar. 81	19
107-3081-111	Optical Time Domain Reflectometer. Description and Use.	Guideline	Mar. 81	20
634-xxxx-xxx	Acceptance Test Procedures, Optical Fiber Cable. Elie, Manitoba.	Guideline	Mar. 81	21

CHAPTER 5 - EQUIPMENT INSTALLATION

5.1 Introduction

Installation of trial equipment was carried out in three distinct groups. The first group of equipment included those located in the Field Trial Centre (FTC) and the Remote Distribution Centre (RDC). The majority of this equipment was installed by NTCL with some additional equipment installed by MTS. The second group consisted of a number of pieces of equipment and associated wiring installed in the trial participants' homes. The third group of equipment was installed in the Elie Community Dial Office and consisted mainly of Telidon switching and trunking equipment. The installation of the last two groups of equipment was carried out by MTS personnel under contract from NTCL and DOC respectively.

5.2 Equipment Installed in Trailers

5.2.1 NTCL Installed Equipment

The two trailers destined to become the FTC and RDC were built in Montreal and delivered to BNR in Ottawa. Installation of equipment was carried out in Ottawa, including:

- Line interface units
- Optical trunk equipment
- DMS-1
- TV channel conversion equipment
- Data channel multiplex
- Jackfields
- Power plants
- Environmental control of separate rooms
- Display room in FTC
- BIX Cross Connection Terminal
- Monitor and alarm system

Standard installation specifications were prepared for the trailer mounted equipment. Floor mounted equipment was arranged in typical lineups with normal overhead racking and frame grounding. Installation was done by regular central office installation crews. Since this equipment was in trailers, it was possible to do this work at the BNR laboratories under the close supervision of the design engineers. This saved both time and additional engineering effort compared to installing the equipment for the first time in Elie and St. Eustache. This consideration was one of the main reasons in deciding to place the FTC and RDC equipment in trailers. The installation in the trailers is similar to that of many small Community Dial Offices.

The display room in the FTC was designed and installed by an interior decorator.

5.2.2 Usage Measurement Equipment

As part of the usage measurement system that was provided by MTS, a line concentration unit was installed by MTS in each trailer after the trailers were located in their final sites in Elie and St. Eustache. Bay space was allocated by BNR designers for this purpose. In addition, cabling had to be run connecting the line concentration units to each LIU in the trailers. Close coordination between BNR designers and MTS personnel was required so that the cabling could be done correctly, without damage to the LIU, and without interference with NTCL personnel installing other equipment.

5.2.3 CATV Processors at RDC

MTS was required to make available CATV and FM signals to all residents in Elie and St. Eustache. To provide service to those residents in St. Eustache not connected to the trial, a coaxial cable local broadband network (LBN) was constructed. It was decided to utilize the TV and FM signals delivered to the RDC over the fibre trunk cable from the FTC as the source of the head-end signals for the LBN at St. Eustache. TV channel processors had to be installed in the RDC in coordination with BNR designers to derive the appropriate TV channel allocations for the LBN.

5.3 Equipment Installed in the Elie C.D.O.

The participants were able to select videotex service from two different data base operators. To provide both switching and concentration from the participants to the dedicated trunks connecting to the data bases, a data switch and multiplexing equipment was installed.

All equipment was installed in two floor mounted cabinets with an operator console located beside the cabinets. Since all transmission was at voice frequency, no special precautions were taken regarding cabling. Connectorized multiwire cables were used extensively for connections.

5.4 Equipment Installed on Subscribers' Premises

All equipment at the subscribers' premises and the associated wiring is shown in Figure 5.1. Details of installation are given in the following sections.

5.4.1 Subscriber Entrance Unit

The SEU contains the LED upstream transmitter, the optical receiver, multiplexing and demultiplexing circuits to separate the various signals and interfaces for the telephone, data, FM radio and CATV services. It also contains a power supply with battery backup, powered by a small plug-in transformer. This approach was taken for the trial to speed up installation, since without a 110V a.c. power supply built in the SEU no CSA approval was required.

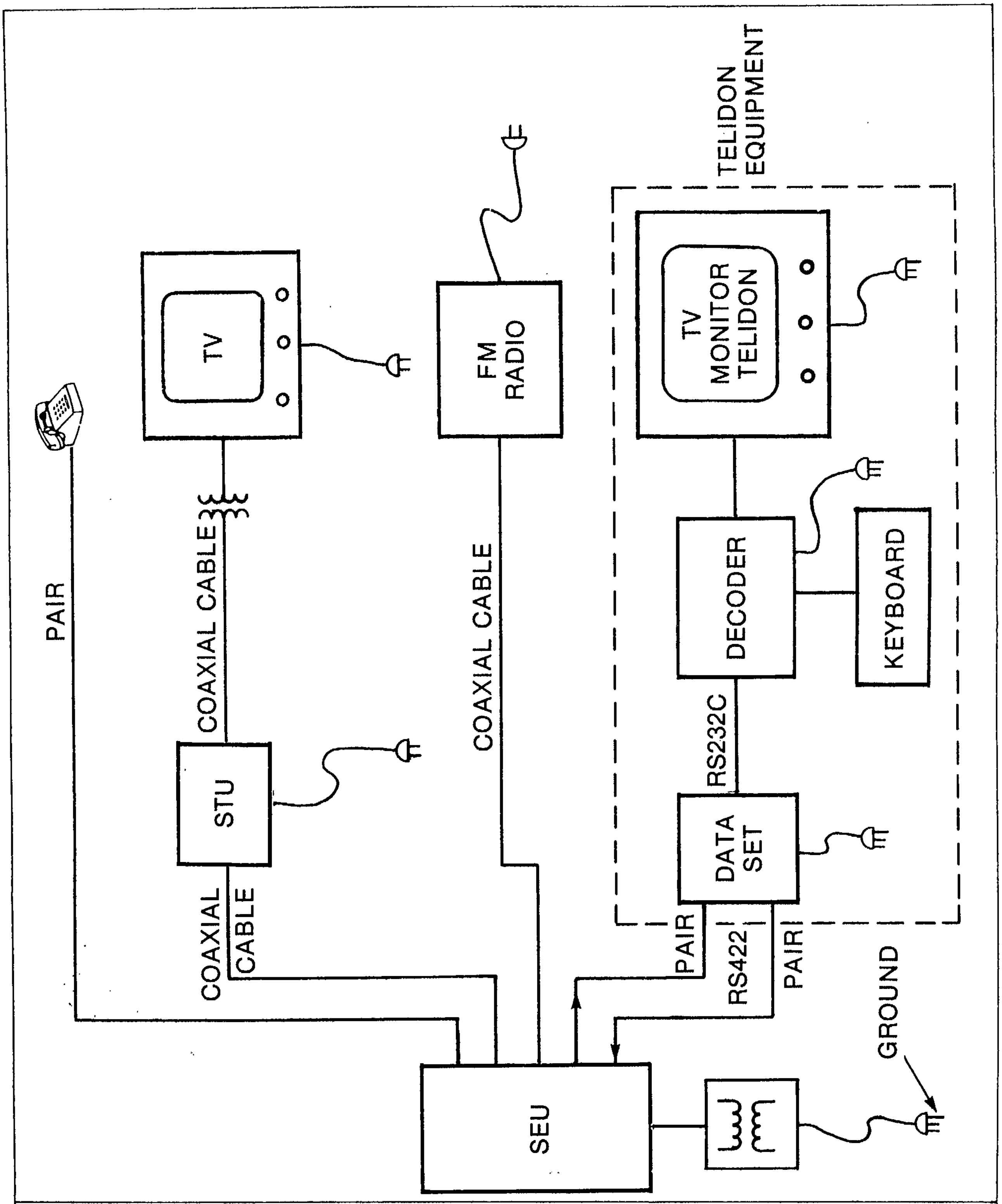


Figure 5.1 Block diagram of subscriber premises equipment and their interconnection

The SEU was designed for wall mounting. It was installed in an out of the way location usually in the basement, and reasonably close to the house terminal mounted on the outside wall. The power transformer was installed at a nearby receptacle. If none was available, a receptacle was installed at trial expense.

The SEU was connected to the exterior house terminal by two single fibre cables. Each cable had a single optical fibre surrounded by Kevlar strength members, all enclosed in an extruded black polyurethane jacket. A plastic conduit was installed from the house terminal through the basement wall for protective purposes. Each cable was 2.5 mm in diameter with a bending radius of 2.5 cm. Normal house cabling procedures were followed, with the bending radius being the only additional constraint.

The SEU was designated a repairable unit, and was therefore intended to be replaced by a working SEU if trouble was reported. The optical-transmitter and receiver, the coaxial cables for FM radio and TV and the data port were connectorized for easy disconnection.

Since the SEU optical transmitter and receiver were connectorized, the inside fibre cable was also equipped with connectors. A house wiring plan was prepared for each house well before the wiring was started. The inside fibre cable length was estimated, and customized lengths were supplied by the manufacturer with connectors already installed. Spare cables of the longest length were stored for use in the event an active cable was damaged.

During the trial, it was determined that a protective circuit had to be installed at the data port. Rather than modifying each SEU at the factory (or even at the trial site) it was decided to mount the circuit in a small connectorized box which could be plugged into the SEU data port. The cabling to the Telidon equipment could then be plugged into the new box.

This allowed the installation of the protective device by only a short visit of a maintenance person to each subscriber.

5.4.2 Telephone Wiring

The existing house wiring and telephones were left untouched as backup to the new trial telephone. The participants were given their choice of colour in a Northern Telecom Contempra touchtone telephone and their homes were wired with jacks in the usual manner.

5.4.3 TV Set-Top Unit

The STU was located near the participant's own television receiver. It provides connectorized access to the video and FM radio signals. It also contains a receiver for control signals from a remote controller, and a display that shows the selected channel number. The remote controller is a hand held unit, similar in appearance as well as function, to existing remote controllers for TV receivers.

The STU was connected by coaxial cable to the SEU, and to a matching transformer and switch that allowed the participant's existing antenna to be used in case of system failure.

A second STU was cabled to the SEU in 18 homes where the participants had two TV receivers in use.

5.4.4 Telidon Terminal

A Telidon terminal was supplied to each participant for videotex service. The terminal consisted of a TV monitor, a Telidon decoder and a full size alpha-numeric keyboard. A data set was also installed to allow the Telidon equipment operating at 4.8 kb/s to be connected to the 56 kb/s data port. Normal two pair copper house cable was used for connections between the Telidon terminal and the SEU.

CHAPTER 6 - TEST & ACCEPTANCE PROCEDURES

6.1 General

It was recognized that NTCL would have to put considerable development and design effort into the fibre optic system. While part of the system was provided using standard equipment or equipment with minor modifications, much of the system contained equipment that was completely new.

In accordance with good contract practice, milestones were identified as points at which work already done was accepted so that further work could proceed. Final acceptance was also a requirement so that the contract could be judged to be complete. This chapter discusses the various test and acceptance procedures as identified in the NTCL contract, and the results obtained.

6.2 Contractual Responsibilities

NTCL's contract with DOC and CTCA contained with respect to acceptance of work essentially the following:

- NTCL was to provide a set of recommended tests including details of the procedures and test equipment to be used in acceptance testing. These acceptance test procedures were to include one for laboratory acceptance testing and another for field acceptance testing.

- NTCL was to carry out acceptance tests in the presence of the Scientific Authority and representatives from CTCA. The successful completion and certification by the Scientific Authority of these tests was to constitute acceptance of work performed to that date by NTCL. The objectives of the acceptance tests were stated as follows:

a) Laboratory Prototype Acceptance Tests (Preliminary Acceptance)

The objective is to verify that the design of the system and laboratory prototype equipment can deliver all the services required of the field trial system. Wherever possible, environmental conditions expected in the field trial system will be simulated. The scope and configuration of the laboratory testing will be in accordance with the agreed laboratory acceptance test procedures.

b) Field Acceptance Tests (Final Acceptance)

The objective is to verify that NTCL has successfully installed the field system and that the service and performance requirements have been met. The scope of the testing will be in accordance with the agreed field acceptance test procedures.

6.3 System Performance

A functional system performance specification was also part of the NTCL contract, and included the following performance requirements for the three services:

Telephone Loop Performance

The telephone service was to be fully capable of interfacing with the existing telephone network through the SA-1 switch. Table 6.1 gives the telephone performance for major transmission parameters when the circuit is terminated in a 500 or 2500 type telephone set.

PARAMETER	SPECIFICATION
Idle Channel Noise	20 dBrnc0 max.
Echo Return Loss	18 dB min. against 900 ohms + 2.16 μF
Singing Point Return Loss	15 dB min. against 900 ohms + 2.16 μF
Frequency Response Loss relative to 1 kHz loss measured with 0 dBm0 input	60 Hz -20 dB min. 300 to 3200 +1 to -3 dB 600 to 2400 +1 dB

Table 6.1 Telephone Loop Performance

Video and FM Services Performance

Video and FM radio services were to meet or exceed the BP-23 Grade I performance objective at the subscriber set.

This performance was dependent on the input signals supplied to NTCL meeting or exceeding the following minimum performance levels:

Video:
- Signal to noise ratio 46 dB
- Cross modulation distortion -52 dB
- Intermodulation distortion -61 dB
- Hum Modulation -35 dB

FM Radio:
- Minimum signal level to be 100 uV (-2dBmV) referred to a 75 ohm impedance.

If the input signals were not to meet their standards the output performance was to be degraded accordingly.

Data Performance

The data channels were not to exceed an error rate of 10^{-6} for 99.9% of the time, exclusive of outage.

6.4 Design Acceptance

The report on Final System Design was issued on schedule by NTCL five months after their contract was signed. The main objective of this document was to describe the system in sufficient detail in both embodiment and performance to assure the funders that the trial objectives would be met. The report was based on the initial contract activities which were concerned mostly with a more detailed technical evolution of the technical proposal associated with the contract. Negotiations of unresolved technical details with CTCA, DOC and MTS also aided the completion of the report.

6.5 Laboratory Prototype Acceptance Tests

The laboratory prototype was assembled and tested in accordance with the draft test procedures and measurement limits prepared by NTCL, and approved by DOC and CTCA.

The actual tests were performed by NTCL with DOC and CTCA/MTS personnel witnessing the tests. The test results showed that the prototype equipment met all design objectives and performance requirements as proposed and tested.

As the newly developed equipment used in the Elie - St. Eustache system was prototype by nature, not all the rigorous evaluation processes common to NTCL standard products were carried out.

6.6 Manufacturing Quality Control

6.6.1 Equipment

All equipment manufactured by NTCL was subjected to NTCL's normal quality control tests, to assure that each unit manufactured met its performance requirement.

Equipment purchased by NTCL from other manufacturers for inclusion in the system were not tested upon receipt by NTCL. Final system acceptance testing was expected to identify units that did not meet system requirements.

6.6.2 Fibre and Cable

The fibre was manufactured and then graded after testing for dispersion (bandwidth) and attenuation. Based on individual requirements, fibres were selected for loops and trunks. After cabling, fibres were again tested for attenuation. Such testing and selection is the normal process in the manufacture of fibre cable. The measurements for both attenuation and bandwidth were made available to the funders.

6.7 Installation Tests

6.7.1 Trailers

A decision was made by NTCL early in the design to install their equipment for the Field Trial Centre and Remote Distribution Centre in two trailers. The trailers were built in Montreal and transported to Ottawa by road. Equipment was installed in the trailers by BNR and tested. Plug-in modules were then removed and the trailers taken by road to Elie where they were mounted on piers.

To ensure that the equipment would arrive in Elie undamaged, the running gear of the trailers was designed to limit shock and vibration on the trailer floor to:

Shock :	20 g	acceleration (max.)
Vibration:	1.25 g	(max.) from 5-500 Hz

Measurements were taken on the Montreal-Ottawa trip using two shock recorders and three accelerometers. Both shock and vibration were well within limits. High levels of shock up to 30 g were recorded only during connection and disconnection to the highway tractor at the beginning and end of the trip. Precautions were taken to prevent recurrence of high levels of shock during connection and disconnection of the trailers during their trip from Ottawa to the trial sites in Elie and St. Eustache, in order to protect the equipment that was installed in the trailers. The highest shock recorded was 15 g.

Further measurements were taken with the loaded trailers between Ottawa and Elie. As a precaution, temporary bracing under some heavy items like power-plant transformers was installed, as was temporary foam pads in some equipment to prevent components from vibrating. Despite a rough road with areas of construction, shock and vibration levels remained well within limits, and no evidence of mechanical damage was found.

6.7.2 Equipment

The subscriber loop equipment, primarily the line interface units and the associated bays and wiring, were tested in Ottawa after the equipment was installed in the two trailers. The intent was to verify that both service and performance requirements could be met when the trailers were installed on site.

Forty LIU's were available at this time, and were moved around so that all equipment positions could be tested. System tests included:

- The operation of the LIU bay power supplies when these bays were fully loaded with 24 LIU's.
- The operation of the video distribution system, specifically to verify that each LIU slot received all the head end channels at the correct level.
- Verification that there was no interaction in any of the services between adjacent LIU's in a fully equipped shelf or between shelves in a bay.

The LIU's themselves were measured for the following parameters:

- NCTA video signal to noise ratio (subjective)
- Intermodulation
- 56 kb/s data error rate
- Video and audio carrier levels of the TV signal
- FM Stereo carrier levels
- FM carrier to noise ratio
- Optical receive signal level

Since only 40 LIU cards were available at the time of testing, the operation of all slots in the LIU bays in both the FTC and RDC were verified by sequentially equipping them with the existing LIU cards. This verified also the operation of each DMS-1 office line card and remote digital access card, the wiring to the BIX entrance panel, the DE-4 data cards, the wiring to the data interface panel and all trunk equipment. The following parameters were measured or observed in the slot tests:

- NCTA video signal to noise ratio (subjective)
- 56 kb/s data error rate
- Telephone VF loss in both directions
- Telephone idle channel noise in both directions.

The two trailers were connected together by a simulated fibre trunk representing an equivalent loss of the actual trunk. The video and FM trunk equipment was measured for:

- Optical receive signal level
- Baseband, CCIR weighted signal to noise ratio
- Differential phase
- Differential gain

The data trunking equipment was measured for:

- Optical receive signal level
- Data error rate

With the trailers still in Ottawa, bench tests were made with the LIU's and the SEU's using a simulated fibre loop representing the maximum loss. Parameters measured were:

- For the LIU

  ° Optical receive signal level
  ° NCTA video signal to noise ratio (subjective)
  ° Intermodulation distortion
  ° Cross-modulation in the case of 2 channel LIU's.

- For the SEU

  ° Idle channel noise in both directions
  ° Loop loss in both directions
  ° Dial pulse distortion

For the move of the trailers to their final sites in Manitoba, all plug-in equipment was removed, packed and shipped separately. Once the trailers were mounted in their final locations, all plug-in equipment was reinstalled and power was connected.

Tests were made to verify that the already tested equipment had survived the trip. The significant differences between these tests and previous tests were that now the voice frequency lines were connected from the DMS-1 CCT to the SA-1 switch, the final video and FM radio sources were used, the full 8.5 km optical fibre trunk cable was utilized for inter-trailer transmission and the powering system was in its final configuration.

6.7.3 Fibre and Splices

The trunk between the FTC and the RDC is composed of five separate cable lengths. Before shipment to Manitoba, each length of cable was spliced in the same sequence as would be used when installed. The attenuation and bandwidth were measured after each section was spliced. The results showed that the trunk fibre cable could be installed with confidence and that the target attenuations and bandwidths could be achieved.

A similar procedure was followed during actual installation. The cumulative loss was measured after each splice.

Initially, a similar procedure, whereby each splice was measured for attenuation, was also specified for the subscriber loop cables. Very early in the splicing of the loop fibres, it became apparent that the measurement of each splice was unnecessary since the splicers could judge the quality of the splices by visual inspection. The test procedures were therefore simplified and reduced to require only two optical attenuation measurements for each completed loop.

The loop optical attenuation was measured in both directions using two Bowmar optical test sets. The first loop attenuation measurements were for the outside plant cable fibre only. The second set of measurements were from connector to connector once the inside fibres were spliced on at both ends (trailer and subscriber premise).

6.8 Subscriber Loop Tests

These tests were designed to measure the overall parameters of the subscriber loop and to test the operation of the services provided. These tests constitued the final acceptance tests. The acceptance of the system was based largely on the results of these tests.

Measurements taken at the SEU were:

- Optical signal levels - downstream-receive
  - upstream-transmit
- Video carrier level
- FM carrier level
- Subjective TV picture assessment
- TV channel change check
- Test telephone call

Measurements taken at the LIU were:

- Optical signal levels - downstream-transmit
  - upstream-receive
- Data error rate with loopback at the SEU.

6.9 System Acceptance

During the final system acceptance process, it was found that while some of the optical test results exceeded the specification limits, overall system performance was satisfactory. Therefore, a debate arose between NTCL/BNR, DOC and CTCA/MTS regarding the significance of these optical tests on system acceptability in view of optical measurement uncertainties. The problem was finally resolved by agreeing that acceptance should be based on overall system performance. Acceptance tests were then completed on that basis.

6.9.1 <u>Equipment</u>

Data was presented from measurements made at BNR in Ottawa and later verified in Elie.

System tests checked the bay and shelf loading and unit interaction in the FTC and the RDC trailers. No problems were identified.

All 175 LIU's were tested. Results for optical transmit power, video signal to noise and FM carrier to noise were all found to be acceptable.

Cross-modulation test results for the 2-channel laser LIU's showed large variations ranging from 10 dB better than specified (-48 dB) to 9 dB worse. This variation was caused by the individual laser characteristics being different from each other and had been revealed in earlier meetings. According to the designers, it was not possible to always meet both the video signal to noise ratio and the cross-modulation requirements simultaneously. Since they found from subjective evaluations of received video signals, that noise was by far more objectionable, they decided to adjust the bias of the laser transmitters such, that this requirement was always met. Since it was subjectively unnoticeable, DOC and CTCA agreed to accept some degradation. Therefore the LIU's were considered acceptable, but assurance from NTCL was requested and subsequently given that 2-channel LIU's sent to NTCL for repair would be returned with a cross-modulation level no worse than what existed at the time of acceptance (-39 dB).

All trunk equipment met specifications for signal to noise, differential phase and differential gain.

All LIU/SEU bench tests met specifications as well.

6.9.2 Fibre and Splices

Table 6.2 shows the fibre cable attenuation including splices for the FTC-RDC trunk. Individual cable attenuation figures are shown in Table 6.3 which amount to an average total fibre loss of 22.77 dB. From these measurements an average fibre loss of 2.7 dB/km and an average splice loss of 0.4 db has been calculated.

Considerable concern and effort had been focussed on the trunk since the distance between the FTC and RDC was 8.5km and the theoretical loss budget was approaching the terminal equipment limits. However, the lower than the specified maximum attenuation values for the fibres and the low splice losses ensured a problem free trunk.

CABLE	AVERAGE LOSS dB/km	LENGTH m	TOTAL LOSS dB
A1	2.92	694	2.03
A2	2.77	2040	5.65
A3	2.65	2040	5.41
A4	2.55	2040	5.20
A5	2.64	1697	4.48
TOTAL	2.73	8511	22.77

Average total splice loss: 1.64 dB
Average loss per splice (4 splices): 0.41 dB

Table 6.3 Individual cable section fibre losses and splice losses of the trunk

Fiber	A1 + S1 + A2		A4 + S4 + A5		A1+S1+A2+S2+A3		A1+S1+A2+S2+A3+S3+A4+S4+A5	
#	target	meas.	target	meas.	target	meas.	target	meas.
1	8.1	7.3	10.1	10.4	13.9	17.1	24.5	25.7
2	8.0	7.3	11.2	11.0	13.4	17.1	25.1	26.1
3	8.0	7.3	10.4	11.0	13.6	18.3	24.5	25.5
4	7.7	7.7	10.8	11.3	13.9	18.0	25.2	25.2
5	7.5	7.7	10.3	10.8	13.5	17.3	24.3	24.8
6	7.5	7.8	10.2	11.2	13.3	17.1	24.0	25.2
7	8.4	8.8	10.4	10.4	14.2	17.3	25.1	25.9
8	8.0	7.3	11.0	10.6	13.8	16.2	25.3	24.5
9	8.5	8.8	10.3	10.6	14.5	17.4	25.3	25.9
10	7.8	8.8	10.0	10.0	13.6	16.3	24.1	24.4
11	7.7	8.1	10.8	10.6	13.5	15.9	24.8	24.5
12	8.2	9.2	10.4	10.2	14.4	16.5	25.3	24.6
13	8.6	7.9	10.0	10.1	14.4	15.6	24.9	23.5
14	8.7	8.5	10.7	10.1	14.7	15.7	25.9	25.3
15	8.5	8.5	10.3	9.9	14.7	16.5	25.5	24.7
16	8.4	8.8	10.4	10.4	14.0	16.3	24.9	24.4
17	7.5	8.3	11.2	11.4	13.9	15.4	25.6	23.9
18	8.1	8.4	10.4	10.4	14.3	15.9	25.2	24.2
19	8.6	8.3	11.3	9.8	14.6	16.2	26.4	24.1
20	8.9	8.5	10.3	10.2	14.9	15.0	25.7	23.7
21	8.5	8.4	10.9	10.6	14.5	15.7	25.9	23.9
22	8.1	7.9	10.3	10.6	13.9	15.7	24.7	24.2
23	8.3	7.8	11.2	10.6	14.1	14.8	25.8	24.2
24	8.9	8.4	10.9	10.6	15.1	16.9	26.5	24.8
25	7.9	8.2	10.4	10.2	13.5	14.3	24.4	22.3
26	7.9	7.6	11.4	11.4	13.7	14.0	25.6	23.5
27	8.3	7.8	10.4	10.7	14.1	13.9	25.0	22.2
28	7.9	7.9	10.8	10.6	13.7	13.7	25.0	22.3

Average total loss of fibre and splices: 24.41 dB
A_n: Indicates the fibre in a cable section
S_n: Indicates the splice between two cable sections

Table 6.2 Trunk cable fibre and splice loss test results

NTCL's factory attenuation measurements of loop fibres varied from 2.3 dB/km to 3.7 dB/km with an average of about 2.9 db/km.

6.9.3 Subscriber Loop Tests

Test results showed that all loops met the system performance requirements.

Some difficulty was encountered in the acceptance of TV signal quality. The acceptance of TV quality was based on BP-24, which is a subjective test. One difficulty was due to unfamiliarity of the acceptance committee members in subjective assessment of picture quality in accordance with the BP-24 picture quality gradings. The other difficulty arose from the fact, that a picture meeting the minimum requirements of grade 1 quality already shows some noticeable degradation, which is below the expectations of a viewer connected to a modern cable TV system. Upgrading the requirements of BP-24 to reflect the capabilities of today's technology appears highly desirable.

Despite those concerns the acceptance committee did however agree that the system met the requirements of BP-24 and was therefore acceptable. As a result of this experience the acceptance committee recommended, that future fibre optic distribution system should aim at a higher TV picture quality. With the advances made in fibre optic technology it appears that higher linearity lasers for analog signal transmission can be expected. Ultimately it would be desirable to distribute TV signals in digital format, for which fibre optic systems are more suitable.

6.9.4 General Comments

Many measurements were taken on individual units and on sections internal to the system. This was done in the interest of learning the significance of various measurements for future system designs. Many measurements probably would not be taken on a "future" system.

As an example, for the LIU, it became clear after discussions that the most important and meaningful test was the receive power level. LIU tests were conducted under the worst case loop length and loss conditions, and in every case the received power was above the required minimum. LIU optical output power tests were done with only very short lengths of fibre involving several connectors and changes in fibre core diameter and Numerical Aperture values, causing several points for transient effects on the modal power distribution resulting in a wide variation of measured apparent output power. These results should, therefore, not be used to draw precise conclusions on the actual power output from the optical transmitters and such tests are therefore not recommended to be part of a system acceptance specification.

Similarly, in the loop tests, the significant test data was again the received power. Fibre loss measurements were not to be taken as precise values, but rather as an order of magnitude value. There were two reasons:

(1) One aim of the field trial was to prove that loop plant can be installed without excessive engineering and testing which would be a requirement for regular use of fibre optics in the distribution plant. Therefore, deliberately, no great effort was made to do precision measurements (i.e. precise alignment of connectors between plant and test set, cleanliness of connector ends, etc.).

(2) Nominal fibre loss values per unit length vary appreciably as factory cable tests indicate. Therefore, it is not unusual to find significant differences in fibre loss for upstream and downstream directions.

One test, which was done for the present system and which should be included in future systems is the end-to-end loop loss measurement. This would allow to ensure that margins are left as calculated in the loop loss (3 dB for design, 3 dB for aging). If such margins were used up by bad splices and similar faults, then the possibility exists that the services could suddenly be interrupted due to a break of the transmission path resulting from such undetected faults. Services would not slowly degrade, but crash. Only after a sufficient confidence level is built up from having measured a very large number of loops such tests may be discontinued.

Having gone through a learning experience in the analysis of the test results, and establishing their relevance the representatives of the funders and NTCL agreed that the system met the overall performance requirements and was therefore to be considered satisfactory and acceptable.

CHAPTER 7 - SYSTEMS OPERATION AND MAINTENANCE

In this chapter, all activities relating to system operation and maintenance are discussed. These include setting up of maintenance practices, procedures, training of personnel for maintenance as well as the activities during the periods of start-up and regular operation. Special problems that were encountered and remedial actions taken are also discussed in this chapter.

7.1 Start-Up Period Activities

Start-up represents the period when the first service was delivered to the first participant's home until the time all services were available to all participants. It also includes the time when the system was undergoing the initial shakedown and when maintenance procedures were being adjusted for efficiency and effectiveness.

Initially the system's maintenance was the responsibility of NTCL, who followed their own routines and repair procedures. As the system approached completion, MTS personnel became more involved with the operation and maintenance of the system. A formal date was set on which MTS took over the operation and maintenance of the system. At this point MTS maintenance procedures and interfaces with other companies became operational.

There are no records or information available regarding the start-up experience of NTCL. The following represents the organizational and other work which only MTS was involved in during the start-up period.

7.1.1 Maintenance Personnel

Since MTS was under contract to maintain the fibre optic system, it was MTS's responsibility to select the required maintenance personnel.

As with most modern telecommunications systems, the on-site maintenance became a procedure of locating failed plug-in equipment and replacing them with good, working spares. Faulty units were then returned to a central location (in this case, NTCL or BNR, the manufacturer) for repair. After repair units were returned to the field.

In the case of Elie - St. Eustache, a sophisticated alarm system existed to assist in identifying faulty units. Consequently the required skill level was fairly routine. No highly skilled technical people were required, or special knowledge of fibre optics was necessary. It was considered that any of the current MTS maintenance personnel who were willing to undergo some extra training would make suitable candidates as maintenance personnel for the Elie - St. Eustache system.

One requirement that was considered to be necessary, was that the maintenance personnel should have a knowledge of the district, and preferably of the subscribers, in order to be able to provide necessary feedback to MTS and the other sponsors of the participants reaction to the trial, through their daily contact with the community. MTS was fortunate that one of the leading candidates had lived in Elie and knew the district and residents very well. This knowledge proved to be invaluable, not only from a maintenance point of view, but as a communication link between the participants and MTS.

A further decision had to be made by MTS in dividing the fibre system maintenance responsibility between the various existing maintenance groups. Traditionally, two groups exist:

- <u>Trunks and Switching</u> - This group is responsible for maintenance of all trunks (toll and otherwise) between switching offices, and all switching machines (both toll and local). This group is considered to be more technically oriented since they provide maintenance of radio systems, multiplex equipment, mechanical and electronic switching machines, etc. However, they are normally not in contact with subscribers.

- Service/Construction - This group is responsible for service to the subscriber, which includes provision of telephone sets, outside plant cable to the home and repair of cables. This group is considered to be less technically, but very much more customer oriented.

MTS decided to use these two established groups to maintain the Elie - St. Eustache system, and, through discussions with them, established the following clear division of responsibilities:

- Trunks and Switching - Responsible for everything inside the FTC and the RDC, all equipment installed inside the Elie dial office, and all circuits to Winnipeg carrying trial-related data or TV.

- Service/Construction - Responsible for everything outside the FTC and RDC, i.e. all fibre cables and associated material and all equipment installed in the participant's home (telephone, Telidon, CATV set top unit and SEU).

This division of responsibilities has worked well, and was clear enough to prevent misunderstandings. The managers of the two groups maintained a good working relationship and established "local" rules to provide for efficiency and economy. For example, since there were nearly always Service/Contruction persons in the district, they would be asked by the Trunks and Switching group to clear a simple trunk trouble if practicable rather than dispatch a Trunks and Switching person to drive the 40 km to Elie.

MTS was guided by NTCL in determining the number of maintenance people to be trained and assigned to the Elie - St. Eustache system. From Trunks and Switching, two people were trained with the expectation that one person would be required during start-up and then less than one person would perform the on-going maintenance. From Service/Construction, three people were trained so that two would perform maintenance during start-up, reducing to one for on-going maintenance. This did not include the cable splicers trained by NTCL, who were available for work on the Elie system. It was expected that other personnel would be trained on-the-job to replace, if needed, originally assigned personnel as the trial progressed.

This latter training, however, did not become necessary. The Elie - St. Eustache system had a high profile in the line departments of MTS, and every effort was made to keep the original maintenance people available for the trial system throughout the trial period. A five day training course was prepared and presented by NTCL in June, 1981. The maintenance manual which was prepared for the system was used in the course.

7.1.2 Practices and Procedures

Two manuals were prepared by NTCL to be used in the maintenance of the Elie - St. Eustache trial system. One was the Outside Plant Handbook. Initially used in the installation phase of the outside plant for the system, it was equally necessary for the on-going maintenance and repair of the outside plant. An index of the contents of this handbook is provided in Appendix 7-1.

The second, is the Elie Maintenance Manual. An index of the contents of this manual is shown in Appendix 7-2. The manual contains information relating to system operation, trouble diagnosis and maintenance.

Much of the information included in the manuals is contained in standard practices prepared by the manufacturer at the time equipment was standardized for quantity manufacture for sale to customers. Equipment unique to the Elie system, and most of the outside plant were addressed in guidelines or preliminary practices.

In all cases, the practices were well written, clear, accurate and well illustrated. Their clarity prevented any confusions or errors in their use.

7.1.3 Inventory

The practice followed in all modern systems of providing spare equipment units or modules to allow rapid replacement of failed units in order to keep the system in service while failed units are repaired, was also applied to the Elie - St. Eustache trial system. Since no history of failure rates for this unique system was available, determining the required quantities of spares was particularly important.

In order to ensure prompt service restoration (Mean time to repair not to exceed 4 hours) NTCL was made responsible contractually to always maintain a sufficient supply of spare units in the field.

In the contract with NTCL, actual spare quantities of plug-in units were specified based on past experience with similar complex systems. The quantities ranged from 3% spares for the standard telephone sets to 10% spares for some trunk units. The requirement to be able to restore service promptly was overriding.

In order to keep track of all plug-in equipment, all units were serialized, and an inventory established. A record was kept both by NTCL and MTS as to working units, good spares, bad spares in transit to NTCL, spares under repair, and good spares returning to MTS.

7.1.4 Replace and Repair Routines

In the contractual arrangements, NTCL was identified as having the overall responsibility for maintenance of the Field Trial System, while MTS was to perform routine maintenance tasks such as adjustments and repairs which did not require assistance from NTCL.

In order to facilitate carrying out both NTCL and MTS responsibilities, the following steps were taken:

- NTCL trained MTS craftsmen to provide the routine maintenance.

- NTCL provided sufficient functional documentation and maintenance procedures for the MTS craftsmen.

- NTCL provided adequate alarms at the FTC to facilitate regular maintenance of the system by MTS.

- NTCL provided an Emergency Assistance group which was available for consultation and other forms of assistance, including field visits when necessary, in the event MTS could not diagnose or repair a problem.

- NTCL provided test equipment to maintain or repair the system, with the exception of standard video test equipment and standard telephony test sets which were supplied by MTS.

- NTCL undertook to diagnose, repair or exchange all plug-in units replaced because of suspected trouble. A sufficient supply of spare units to ensure prompt restoration of service was always to be available in the field.

MTS established Repair and Replacement Procedures complete with documentation and transmittal forms in order to facilitate NTCL's responsibility of repairing plug-in units on their premises.

Basically, the procedures covered the following:

- Sufficient good spare equipment units were stored at Elie to ensure prompt service restoration (Mean Time to Repair: 4 hours maximum).

- Replaced plug-in units with suspected trouble were sent to NTCL within one day. A control contact in NTCL indicated the address to which the unit was to be sent (NTCL or BNR).

- NTCL repaired the units in a time interval short enough to maintain sufficient good spares.

- Repaired and tested spare units were returned to Elie to be reused as necessary.

Packaging requirements of the units for transport to or from NTCL were specified by NTCL. Bubble wrap, foam chips and cardboard cartons were used. No known damage occurred to any units while in transit. Some units were designed using CMOS semiconductor technology. These units were shipped using an additional anti-static wrap.

These procedures worked well with only a few instances of service outages due to insufficient spares. The biggest problem was the excessive failure rate of the Subscriber Entrance Units during the early months of the trial. (This is further discussed in section 7.1.7.2.). This large failure rate created occasional shortages of good spares in Elie because of long transit times from Elie to Ottawa and back and a long repair time in Ottawa. Through monitoring of transit times, reducing repair time agreed to by NTCL and giving SEU's priority treatment, shortages were brought under control until the cause of excessive failure rates was identified and eliminated.

7.1.5 Infant Mortality

Infant mortality can be defined as that phenomenon whereby equipment failures occur unexpectedly early in the equipment life and more frequently than the predicted rate. These failures represent a "system shakedown" and include items such as:

- Early failure of electrical components.
- Early failure of circuit boards, wiring, solder joints and connections.
- Mechanical failures.
- Failures brought on by maintenance errors, lack of experience or knowledge.

Infant mortality in the field can be reduced by the manufacturer through "burning in" equipment units in the factory before shipment to the field. NTCL followed this practice by holding units at the factory under full power for a period of time. Some equipment was subjected to a further period of field operation during start up of the system before MTS assumed responsibility for the system in October, 1981. Unfortunately, no records of failures exist for the period before October, 1981.

Statistics available from trouble reports after October, 1981 do indicate a significant higher rate of failures during November, 1981 decreasing in December, 1981 and then remaining fairly constant for nearly a year. Analysis of these failures showed that they were of random nature, very typical of infant mortality.

7.1.6 Subscriber Trouble Reporting Procedures

Since the Elie - St. Eustache system is the first operational integrated services subscriber access system, carrying telephone, CATV, FM radio and Telidon signals, it was desired to collect a record of all troubles of the system. This required that the service providers and system operators establish a unique trouble reporting system.

7.1.6.1 Past

Traditionally, the user or customer is usually the first person to know that a fault or breakdown in his service has occurred. Each service used to be clearly separate form all other services so that it was easy for the user to report troubles to the correct service supplier.

Since the services were and still are usually on different and totally separate facilities, the service supplier was also the person responsible for the repair of the facilities and restoration of service.

7.1.6.2 Present

An integrated services system, like the fibre optic trial system in Elie and St. Eustache, can carry a number of different services which are not on separate facilities. A fault on a common section of the system will cause one or another or all services to breakdown. This commonality blurs the clues to the user as to what or where the trouble is. It was realized early that the subscriber would be faced with a problem in deciding which service provider to report a failure to. Since an integrated services system is transparent to the subscriber, it is not possible for the user to identify the source of any problem. It was essential to develop a simple reporting procedure for the subscriber. Therefore, a single trouble reporting centre was established. This also allowed a complete record of the operating characteristics of the system to be collected.

7.1.6.3 <u>Trouble Reporting Procedures in Elie and St. Eustache</u>

In order to simplify the action to be taken by the subscriber in the case of trouble, the four affected service companies, MTS for telephone, Communitec for CATV, Infomart and Cybershare for Telidon, met in a series of meetings to outline trouble reporting and clearing routines. As a result, the following procedures were established:

- A single trouble reporting centre was established for the customer. All troubles of any nature were to be referred to this center. Since MTS was most involved in the maintenance of the integrated system and was already set up for trouble reporting, customer trouble reporting centre responsibility was assigned to MTS.

- The repair or service responsiblities of each company were listed so that trouble referrals could be made quickly and accurately. The responsibilities assigned to the four companies were as follows:

MTS : Telephone, CATV (on behalf of Communitec) and the integrated services carriage system

Communitec : CATV (MTS was to perform the maintenance for Communitec, but they were to be informed of service outages)

Infomart : Telidon database

Cybershare : Telidon database

- Routines were established to log troubles reported, to record referrals and to log clearing actions. Data recorded included:

  ° Time trouble was received
  ° Nature of trouble
  ° Responsible group
  ° Clearing action
  ° Time trouble was cleared

Follow up procedures were also established so that no trouble report was left unresolved.

The trial participants were informed of the trouble reporting procedures, and were encouraged to report all problems relating to telephone, CATV, FM radio and Telidon services. It took some time before the participants began to use the reporting routine consistently. The participants, however, never did reach the point of reporting all problems. They did not appreciate the importance of, nor could they be bothered to report everything.

An example of this was the fact that a number of subscribers experienced an occasional, random telephone bell tinkling. When the phone was answered, no caller was there. This was reported as a problem by no one. Only during a personal survey of each participant to obtain their reaction to the trial did this problem get revealed as a system characteristic (see also section 7.2.3.).

7.1.6.4 Future

The trouble reporting procedures developed for the Elie-St. Eustache integrated services system emphasize the need for increasing coordination and cooperation between companies offering services over such networks. This will reduce customer confusion, and help speed the time of repair.

In the case of Elie and St. Eustache, all equipment in the subscriber's home relating to the carriage system and the services (telephone, TV (excluding the TV set) Telidon) were maintained by personnel of one company rather than by personnel from several different companies. Although this approach is much more efficient, it could, in the future, lead into questions such as the legal responsiblities of the various companies; i.e. who would be responsible if an alarm service is provided and no alarm is received, because the alarm sensor unit in the home was incorrectly adjusted and failed to go off.

7.1.7 Unique Experiences and Special Problems

During the period of start-up, MTS maintenance people were becoming familiar with the operation of the trial system. Trouble reports were processed, usage data was collected, and trial participants began to use the services. It became possible to identify specific patterns leading to repetitive problems. Some of the problems discovered are discussed in the following subsections.

7.1.7.1 Set-Top Unit

This unit is located adjacent to the trial participant's television receiver. It provides connectorized access to the video and FM radio signals. It is also the receiver of control signals from the remote controller and has a display that shows the selected channel number. The unit is powered from the 110 volt AC house service, as is the television receiver.

A pattern of idiosyncratic behaviour evolved when power failures occurred (the most prevalent were interruptions caused by lightning storms). Upon power restoral, the unit would often not resume operation. It was found that if the unit was unplugged from the power source, then plugged in again, it would start working.

The problem was referred to NTCL, who replied that during lab testing, they too had observed the same characteristics. They were told by the supplier of this purchased unit that the problem was inherent in the design of the CPU within the STU and was a function of the way the power was restored after disconnection. If the restoration was "soft" or gradual, the CPU would not operate, whereas a "hard" or fast restoration would cause it to start immediately. The only way to eliminate the problem was the replacement of all STU's in service.

In view of the time and expense of such a replacement, and since the electric power distribution in the trial area is normally reliable, the trial managers decided to leave the existing STU's in place. Instructions on how to restart the STU was distributed to all trial participants, all maintenance personnel and all trouble reporting personnel. Trouble visits were virtually eliminated except where a real fault existed.

7.1.7.2 Subscriber Entrance Unit

It became apparent from the analysis of trouble reports that the SEU had an excessive failure rate. During the period November 1, 1981 to January 31, 1982, 64 SEU's were repaired, whereas the predicted failure rate was from 5 to 13 units. NTCL (actually BNR, who had manufactured the SEU and were now repairing them) analyzed the failures as follows:

Data channel driver IC chip	44 units

Capacitors in the voltage multiplier	15 units
Random	5 units

The design of the voltage multiplier circuit, which was part of the power supply for the photodetector, was reviewed by NTCL, and it was found that the voltage rating of the failing capacitors was very marginal. NTCL undertook to determine a replacement component involving higher rated capacitors, and proceeded to routinely replace these capacitors on all SEU's returned for repair.

Regarding the data channel IC chip failures, NTCL and BNR performed lab tests on the SEU and the data equipment connected to it. (See figure 7.1). The following observations were made and conclusions were drawn:

- The SEU is connected to the STU via a coaxial cable. The SEU and STU grounds are joined together via the coaxial cable sheath. The SEU ground terminal is not connected to the AC power service ground.

- The STU is powered via an isolated transformer and a 2-pin polarized plug. The neutral of the 2-pin plug is connected to the STU case by a 4.7 megohm resistor to avoid static build up if the case is not grounded.

- It is possible that the floating SEU ground could be subject to 60 Hz leakage from the TV set, the FM receiver, the STU or its own power supply which could cause the SEU ground potential to rise relative to power service ground due to the high source and load impedances involved.

- On the data port the SEU is connected by a 4-wire cable to the data set. No direct ground connection exists.

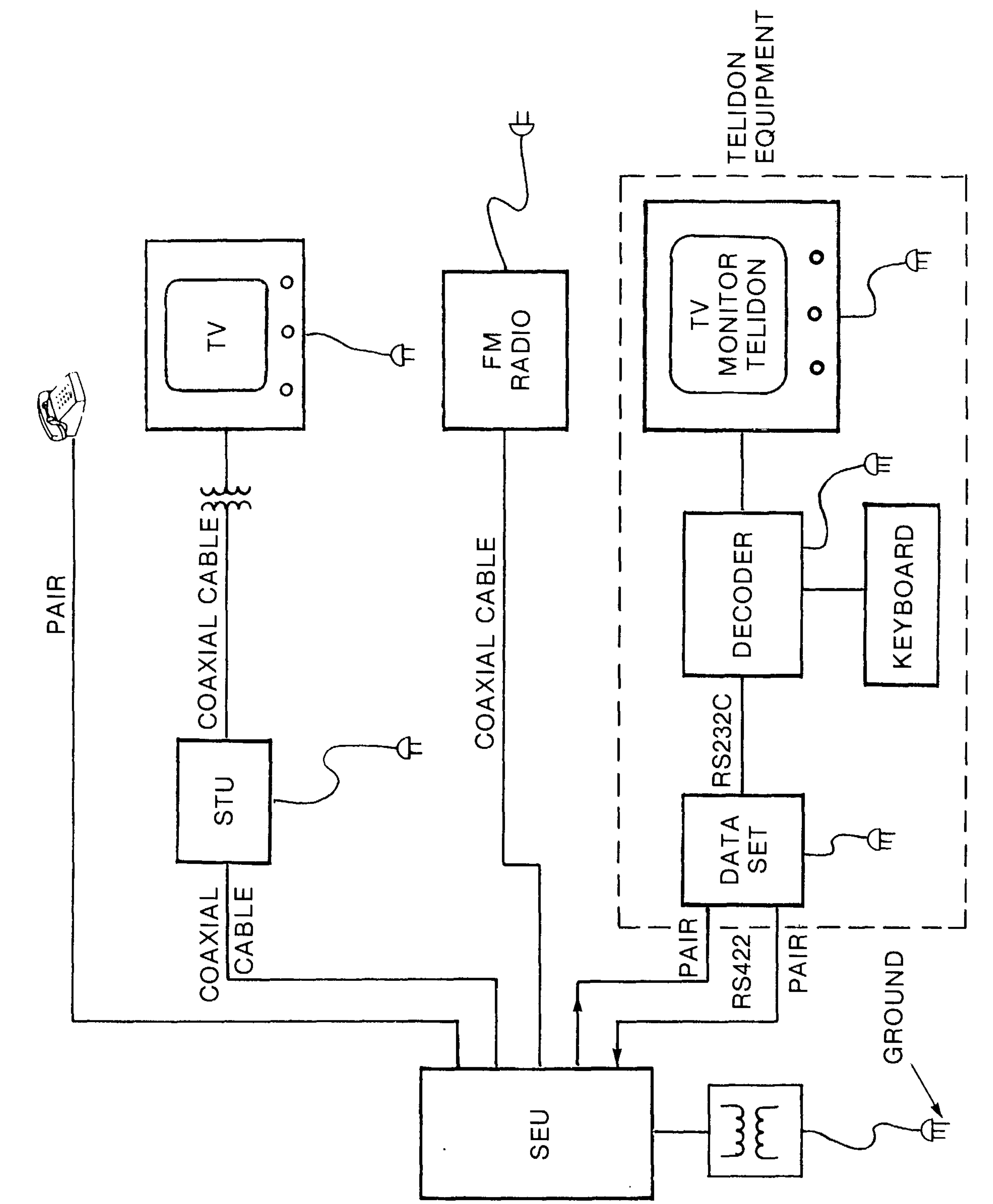


Figure 7.1 Block diagram of powering, grounding and interconnection arrangements of subscriber premises equipment

- The data set has a protective ground connected to the 3 pin power plug. The signal ground can be optionally connected directly to the protective ground or via a 100 ohm resistor.

- If the data set is grounded through the 3 pin plug, then connection of the floating SEU to the data set can set up a voltage difference between the grounds of the two units which could cause either noisy or intermittent transmission performance or potentially IC chip failures.

- Based on the above observations, NTCL then recommended that the SEU be grounded to the electric service ground using the GND terminal on the SEU and also that the common mode potential be eliminated by addition of a ground wire between the SEU data connector and the data set signal ground.

On the basis of the above, MTS began a program to ground the SEU. A ground wire was to be connected between the SEU and the data set only if the common mode voltage exceeded 7 volts, the maximum allowed in the RS-422 EIA specification for the interface between the SEU and data set. Further discussion of this problem follows in section 7.2.1.

7.1.7.3 Monitor and Alarm System

The trial system provided by NTCL was equipped with a sophisticated monitor and alarm system. It was designed to monitor the status of all the field trial equipment. It recorded and reported the current status of all monitored functions, and stored the last 20 status changes in a data base which could be queried by maintenance personnel at any time. The information was reported in a form which facilitated the diagnosis of faults.

The status of the system was summarized in the form of 32 alarms which were presented to the MTS alarm remoting system for transmission to the Provincial Service Control Centre (PSCC) in Winnipeg. Since Elie is an unattended office, maintenance people are called out by the PSCC only in case of trouble and depending on established priorities.

The System Status and Loop Status displays worked well and were effective. The History Display, however, gave a continuously active display showing literally thousands of status changes each day. The display would show a particular alarm point as FAIL, only to be followed in six seconds with a CLEAR. The alarm points seemed to be displayed almost at random.

These status changes were also reported to the PSCC and were presented on status printouts. This represented thousands of lines of print each day, rendering the value of the alarm status to almost zero, since in reality no failures were occurring at the rate the History Display would imply.

MTS referred this problem to NTCL, and also asked for agreement that delay relays could be installed in the alarm leads as an interim measure. This prevented the short six second changes in alarm status from reaching the PSCC. However, these status changes were still shown on the internal History Display.

Further investigation by NTCL suggested that this problem may be caused by noise sensitivity of the high impedance input circuits of the alarm system. As apparent faults may be due to power supply noise or poor grounding, RC noise suppressors on the input circuits and better power and ground decoupling may be required. No further action, however, was taken to remedy this problem.

7.1.7.4 Telidon Usage Statistics

When Telidon was implemented using the 56 Kb/s data channel available to each participant, a data switch was installed in Elie to supervise the connection of the participant's Telidon terminal to either data base in Winnipeg, and to concentrate the 150 subscriber data channels down to 15 data trunks to each data base.

The data switch was also equipped with a statistics port which allowed usage data to be collected, such as:

- Which subscriber is requesting service.
- The time that the subscriber requested service.
- The data base which was requested.
- The time the connection was established.
- The time the call was disconnected.

This raw data was then processed to generate an assortment of statistical reports relating to Telidon usage.

As the operation of the trial began, it quickly became apparent that there were an unexpectedly large number of connect/disconnects recorded by the switch which were many times larger than that recorded by the service providers. Many of the thus recorded sessions were extremely short indicating that they were unlikely actual user initiated connect and disconnect requests. Therefore, MTS rewrote some of the usage statistics processing software to reject such very short sessions from the usage reports. This brought the number of sessions very close to those recorded by the service providers.

Some studies done by NTCL suggest that such false connect/ disconnect signals may be caused by erroneous signals generated by the SEU's. Since the protocol used in the Field Trial to request Telidon service was rather simple, essentially based on detection of any data activity of the terminal by the data switch, the system could respond to simple bit errors and noise signals. The addition of noise suppression circuits and other modifications to the SEU could minimize this problem. However, no further action was taken on this problem either.

7.2 On-Going Maintenance

The transition of the maintenance operation from start-up to on-going is not an easily defined nor clearly identified point in time. It supposedly is the time when problems which were discovered during start-up are solved, and the maintenance of the system becomes routine and well understood.

The Elie trial system maintenance never really reached that point. There were still unsolved problems on the system at the end of the official trial period. Fortunately, these problems were mostly transparent to the participants so that there was no negative reaction to the operation of the system.

The problem that caused the most concern was that of excessive SEU failures which continued despite the remedial actions taken as described in section 7.1.7.2 above. This caused a higher than anticipated maintenance effort for both MTS and NTCL. It also delayed the problem solving effort on other persistent problems such as excessive alarm status changes, large numbers of usage connect/disconnects for Telidon, and participant telephone bell tinkling. It was initially considered that all these problems might have a common solution, or be related in some manner. Therefore work was concentrated on the SEU failure problem with the idea that once that was solved, the other problems would also be cleared, or at least their solution would become more obvious.

7.2.1 Subscriber Entrance Unit

MTS completed its grounding program for the SEU in July, 1982 but the failure rate did not change. SEU failures continued to be the major component of trouble reports. Field measurements and lab tests were performed by all interested parties, DOC, CTCA, MTS and NTCL collectively and separately to try to pinpoint the source of the excessive high voltage that was damaging and destroying the data port IC chip. Finally NTCL discovered a short duration (2.4 microseconds) transient voltage that occurred when the Telidon decoders were switched ON (Figure 7.1). This appeared at the data port of the SEU. Repetitive transients were shown to cause the CMOS driver IC to fail. It was, however, also demonstrated, that such transient voltage spikes could be caused by turning ON any other electrical equipment, not necessarily part of the field trial equipment.

After lengthy discussions between all parties concerned, it was decided that, providing additional protection for the SEU data port driver IC against high voltage transients would be more effective, since controlling the sources of such transients would be rather difficult. As a result, NTCL designed and build an outboard protection circuit that could be plugged into the data port connector on the SEU. After MTS maintenance personnel installed the protective device in all homes between December 1982 and March 1983, failure rates of SEU's dropped significantly.

7.2.2 Outside Plant

The operation of the fibre cables and the ancillary splice enclosures, etc. is the major success story of the trial system. The cables have not been affected at all by the thaw and frost cycles of two summers and two winters in the ground. The cable characteristics have remained unchanged over the two years.

The cables were cut and damaged three times by contractors or other third parties. All three instances were on drop cables so that service was interrupted to only one home each time. A short length of new cable had to be spliced in to replace the damaged section, but the repair and splicing was completed quickly.

On the first repair, the cable splicers had difficulty removing the plastic coating from the fibres in preparation for splicing. In subsequent discussion with NTCL, it was revealed that earlier plastic formulations did dry out and harden with time. Later formulations do not. It was also explained by NTCL that the splicing practices referred to this situation and that a chemical softener was included in the splice preparation kit for this reason. MTS splicers had not read this particular situation in the practice and therefore had not used the softener. Subsequent repairs were performed without problem.

One other difficulty was encountered during the preparation of some spare fibres for attenuation measurements on a regular basis during the trial period. For this purpose, connectors with fibre pigtails had to be spliced to the cable fibres. The cable fibres were of course of NTCL manufacture while the pigtail fibres were Japanese. Although, the diameter of the fibre including cladding was the same, the diameter of the plastic coating was not. This caused difficulty in clamping or holding the fibres during the splicing operation. An NTCL splice set kept breaking the Japanese (thicker) fibre, while an Orionics splice set left the NTCL fibre loose in the holder. It was a clear indication for the need for standardization of fibres and coating sizes in the future or the availability of more universal splicing sets.

7.2.3 Bell Tinkling

As mentioned previously in subsection 7.1.6, it was discovered that participants' telephone bells were occasionally tinkling on a seemingly random basis. This was referred to NTCL who indicated that this problem could occur in early models of DMS-1 systems during switching for either Protection or Processor Restart. The problem could be alleviated by first updating the DMS-1 to the latest model (S/W and H/W units) and then verifying the digital line circuits for timing faults in the line signal. Subsequent to the official trial period, MTS in cooperation with Digital Transmission Division of NTCL was able to identify the source of this problem in the DMS-1 equipment. After correcting the faulty equipment, the bell tinking problem disappeared.

7.2.4 Lasers

During the design stage for the trial system, NTCL decided that they would equip a number of loops with lasers instead of LED's. The higher power would allow the maximum repeaterless loop length to be longer, and furthermore it would allow two TV channel transmission over the loop.

The laser circuitry included a self-regulating bias current to maintain a constant laser optical power output. If the bias current was to exceed a pre-set level an alarm was initiated which indicated that either the temperature of the laser had increased or the laser efficiency had dropped because of reaching end of life. During the course of the trial, a number of lasers were replaced because of such alarm conditions. It was subsequently observed that the ambient temperature in the FTC or RDC had an effect on the bias current as expected and that therefore a laser could create alarm on a day with high ambient temperature but restore to normal when the temperature dropped. When NTCL was consulted on this matter, they indicated, that all laser diodes had been burned-in prior to use and that therefore changes in bias current causing alarm conditions were indeed due to ambient temperature changes. Furthermore, the alarm threshold was also subject to ambient temperature variations. In order to prevent unnecessary alarm conditions, the only simple remedy would be to set the alarm threshold higher for these experimental laser diodes. Since these laser diodes had an estimated lifetime of 20 years, it was unlikely that an alarm would indicate a real failure of a laser in the short term. NTCL also indicated, that, in order to keep the immediate ambient temperature of laser diodes constant, the design of newer production versions included an integral cooler. However, the present design and layout of the LIU printed circuit boards would not permit the replacement of the original laser diodes with the new versions very easily.

No further action was taken during the trial period. With the systems operation continuing, however, the need to establish a new threshold level or another means of determining imminent laser failures is essential and MTS will pursue a solution to this problem with NTCL.

7.3 Outstanding Problems

Two problems that were identified during the trial period still exist. These are:

- Excessive changes of status alarms within the alarm system.

- Large number of Telidon connect/disconnect indications.

These problems have been discussed in preceding subsections. As mentioned in those sections, these problems were referred to NTCL who performed field tests and in July 1983 submitted an analysis of those problems. Since the operation of the system is continuing beyond the original trial termination date, it is becoming rather essential to determine the cause of those problems and to identify a possible solution. These problems have been under investigation by BNR as well, and additional information regarding causes and solutions is expected.

APPENDIX 7 - 1

CONTENTS OF THE OUTSIDE PLANT HANDBOOK

ELIE MANITOBA

OUTSIDE PLANT PRACTICE AND TECHNICAL SPECIFICATION CHECK LIST

PRACTICE NO.	TITLE	STATUS	ISSUE	SECTION
081-4321-100	QKAC1A Fiber Preparation Kit Description.	Guideline	Mar. 81	1
081-4301-200	Optical Fiber Stripper, Miller 101-S. Description and use.	Guideline	Mar. 81	2
081-4301-202	Optical Fiber Cleaver, Fisher 11-347A. Description and use.	Guideline	Apr. 81	3
626-2301-101	Optical Fiber Cable NTF Type F Description.	Standard		4
626-2301-101	Addendum.	Addendum	Mar. 81	
627-3911-200	Aerial Cable. Optical Fiber Cable Placing.	Guideline	Mar. 81	5
627-3911-200	Addendum.	Addendum	Mar. 81	
628-2011-200	Underground Cable. Optical Fiber Cable Placing.	Guideline	Mar. 81	6
629-2311-200	Buried Cable. Optical Fiber Cable Placing.	Guideline	Mar. 81	7
629-2311-200	Addendum.	Addendum	Mar. 81	
462-4011-200	Drop and Block Wiring. Optical Fiber Cable Placing.	Guideline	Mar. 81	8
621-2xxx-xxx	House Terminal - Elie, Manitoba.	Guideline	Mar. 81	9
632-4361-200	Cable Splicing Fusion Splicing Optical Fibers.	Guideline	Mar. 81	10
633-5261-100	Splice Organizer and Closure Description.	Guideline	Mar. 81	11
632-4281-200	Cable Splicing. Lead Sleeve Closure for NTF Powder Filled Cable Installation.	Guideline	Mar. 81	12

PRACTICE NO.	TITLE	STATUS	ISSUE	SECTION
632-xxxx-xxx	Cable Terminal Splicing System for NTF Type F Optical Fiber Cable using the UC6-18 Siemens Closure.	Guideline	Feb. 81	13
631-4511-200	BIX. In-building Cross-connect System. Material, Installation and Servicing Wall-mounted System.	Standard	Mar. 80	14
631-4511-200	Addendum.	Addendum	Mar. 81	
632-xxxx-xxx	NTF Type F. Fiber Cable Terminations. Elie, Manitoba FTC and RDC.	Guideline	Mar. 81	15
Technical Specification	Mobile Equipment Enclosures - Elie, Manitoba Specifications and Drawings.	Guideline	June 80	16
638-3211-200	Electrical Protection - Bonding Optical Fiber Cable. Sheath to Strand Bond.	Guideline	Mar. 81	17
634-4011-500	Cable Testing, Optical Fiber Cable. Fault Locating.	Guideline	Mar. 81	18
107-xxxx-xxx	Attenuation Test Set, Optical Fiber Cable. Description and Use.	Guideline	Mar. 81	19
107-3081-111	Optical Time Domain Reflectometer. Description and Use.	Guideline	Mar. 81	20
634-xxxx-xxx	Acceptance Test Procedures, Optical Fiber Cable. Elie, Manitoba.	Guideline	Mar. 81	21

APPENDIX 7 - 2

CONTENTS OF THE ELIE MAINTENANCE MANUAL

ELIE MAINTENANCE MANUAL TABLE OF CONTENTS

CHAPTER 8 - SYSTEMS PERFORMANCE

In this chapter the systems performance will be reviewed and analyzed in terms of the failures that occurred. These will be compared to the predicted failure rates as were estimated by the designers. Where possible and available, a comparison with failure rate objectives, considered acceptable by the telecommunications industry for conventional delivery systems, will also be provided.

8.1 Classification of Failures for Analysis

Analysis of the system performance and the quality of service will be considered for each of the three services (telephone, television and FM radio, and Telidon) separately with respect to:

1. Troubles found in the basic system provided by NTCL.
2. Total troubles reported by the subscriber.

Under category 1 above, the performance will be related to the objectives specified by the designers for the basic system provided by NTCL. It includes only troubles found in the basic NTCL system as a result of subscriber reports and excludes all subscriber premises equipment on the drop side of the SEU, troubles found in the data switch, the Telidon service providers' data base systems, and troubles classified as "subscriber action" and "found O.K". If a trouble had impaired all three services, such a trouble is counted for each service. If several units were replaced (e.g. the SEU, the Telidon decoder and the keyboard to restore Telidon service) this is counted only as one trouble.

Under category 2, all troubles reported by the subscriber are counted. This also includes troubles due to equipment owned by subscribers such as their television set and troubles rated "found O.K.". Troubles located by MTS personnel as a result of alarms are not included. If one trouble report relates to all three services, a trouble is counted for each service.

Although the official trial period extended only over eighteen months, results have been included for two additional months after the end of the trial in order to provide more data on the systems performance after the high failure rate of the SEU's was reduced. The system performance after January, 1983, at which time the SEU failure rate had dropped, shows the true performance capability of such an integrated services fibre optic distribution system.

8.2 Telephone Service

8.2.1 Telephone Troubles Found in the Basic NTCL System

Table 8.1 indicates that the average number of troubles per month of 6.0 in the basic NTCL system over the total period was better than the objective of 8.4 set by the designers. It is seen also that 60% of the troubles were caused by SEU failures. It is interesting to note that there was a sharp reduction of SEU failures after protective devices were connected to the SEU's in mid December, 1982 and at the same time there was also a drop in the number of troubles in other NTCL equipment. The monthly failure rate dropped significantly below the objective set by the designers.

Figure 8.1, presenting the monthly trend of "found" troubles, indicates that the objective was met for 16 of the 20 months shown, and that there has been a decided drop in the number of troubles since the start of 1983.

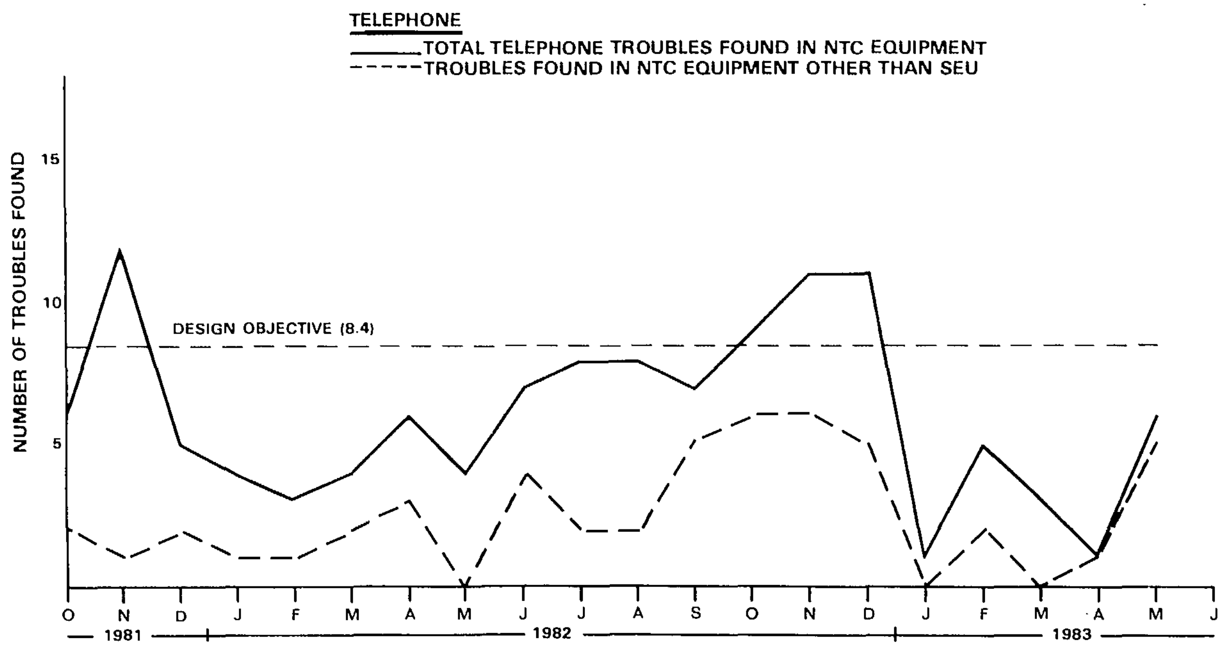


Figure 8.1 Monthly trend of telephone troubles found in the basic trial system

	Total Period		Oct./81 - Dec./82		Jan.1-May 31/83		Design Objective
	No. of Troubles	Troubles per month	No. of Troubles	Troubles per month	No. of Troubles	Troubles per month	Troubles per Month
SEU	71	3.5	63	4.2	8	1.6	-
Other NTCL Equip.	50	2.5	42	2.8	8	1.6	-
Total	121	6.0	105	7.0	16	3.2	8.4

Table 8.1 Telephone Troubles Found in the Basic NTCL System

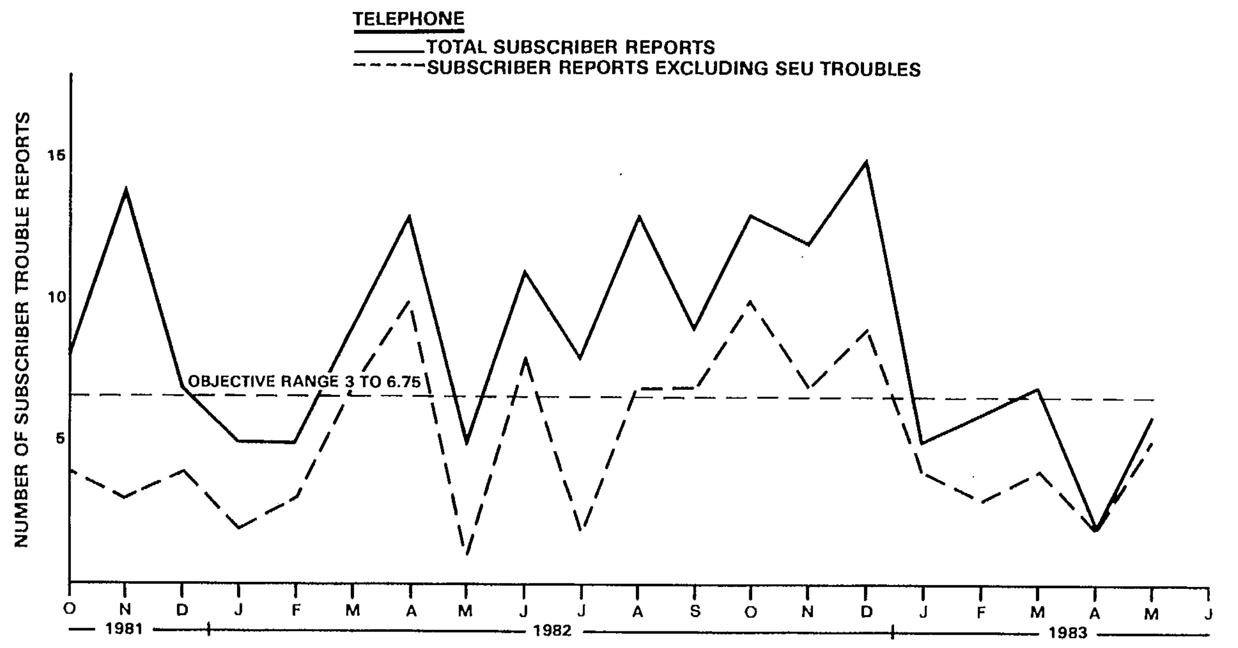


Figure 8.2 Monthly trend of total telephone troubles reported by the subscribers

	Total Period		Oct./81-Dec./82		Jan.1-May 31/83		Current Telco Objective
	Trouble Reports	Reports per month	Trouble Reports	Reports per month	Trouble Reports	Reports per month	Reports per month
SEU	71	3.6	63	4.2	8	1.6	-
Other NTCL	45	2.2	42	2.8	3	0.6	-
Station	43	2.1	31	2.1	12	2.4	-
Subs. Respon. & F.O.K.	14	0.7	11	0.7	3	0.6	-
Total	173	8.6	147	9.8	26	5.2	3 to 6.75

Table 8.2 Total Telephone Troubles Reported by the Subscriber

8.2.2 Total Subscriber Reports of Telephone Troubles

In addition to the troubles found in the basic system provided by NTCL and listed in the previous paragraph, other subscriber trouble reports were classified as: Station, subscriber equipment or subscriber caused, or found O.K. (F.O.K.). Table 8.2 provides the total subscriber trouble reports including these latter categories in addition to those of Table 8.1.

Table 8.2 shows that the average trouble report rate was 9.8 per month for the first 15 months and that it then dropped to 5.2 reports per month. The current acceptable range of trouble reports for telephone service is 2 to 4.5 per hundred stations per month. For 150 stations this amounts to 3 to 6.75 reports per month. If the trouble report rate continues at the current level it will be well within the objective range.

Figure 8.2 also shows, in graphic format, that the subscriber trouble report rate dropped to a satisfactory level after the protective devices were connected to the SEU's in December 1982.

8.3 Television and FM Radio Service

8.3.1 TV and FM Radio Troubles Found in the Basic NTCL System

As shown in Table 8.3 the monthly average of troubles found in the basic NTCL system that affected TV and FM radio is 7.5 which is better than the design objective of 11.7 troubles per month. The TV Set Top Unit (STU), a commercial product modified by NTCLfor use together with the hand held remote control unit as a channel selection device, accounted for about one third of the TV troubles.

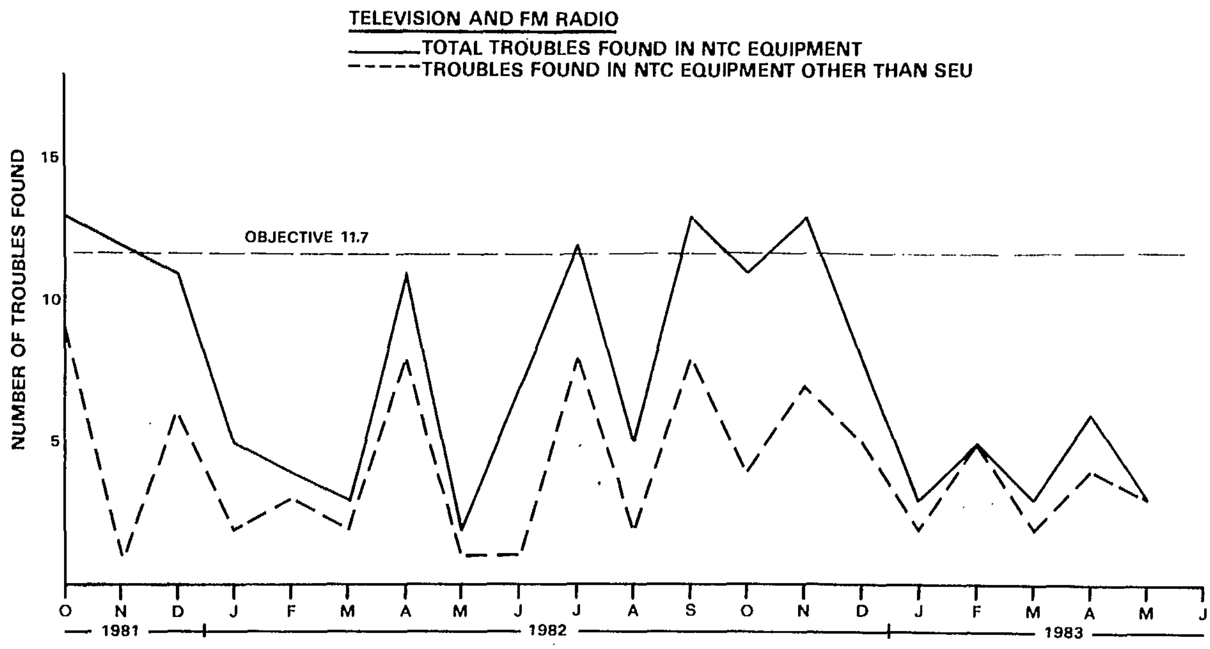


Figure 8.3 Monthly trend of TV and FM Radio troubles found in the basic trial system

	Total Period		Oct./81-Dec./82		Jan.1-May 31/83		Design Objective
	No. of Troubles	Troubles per month	No. of Troubles	Troubles per month	No. of Troubles	Troubles per month	Trouble per month
SEU	67	3.4	63	4.2	4	0.8	-
STU & Remote	50	2.5	39	2.6	11	2.2	-
Other NTCL	33	1.6	28	1.9	5	1.0	-
Total	150	7.5	130	8.7	20	4.0	11.7

Table 8.3 TV and FM Radio Troubles Found in the Basic NTCL System

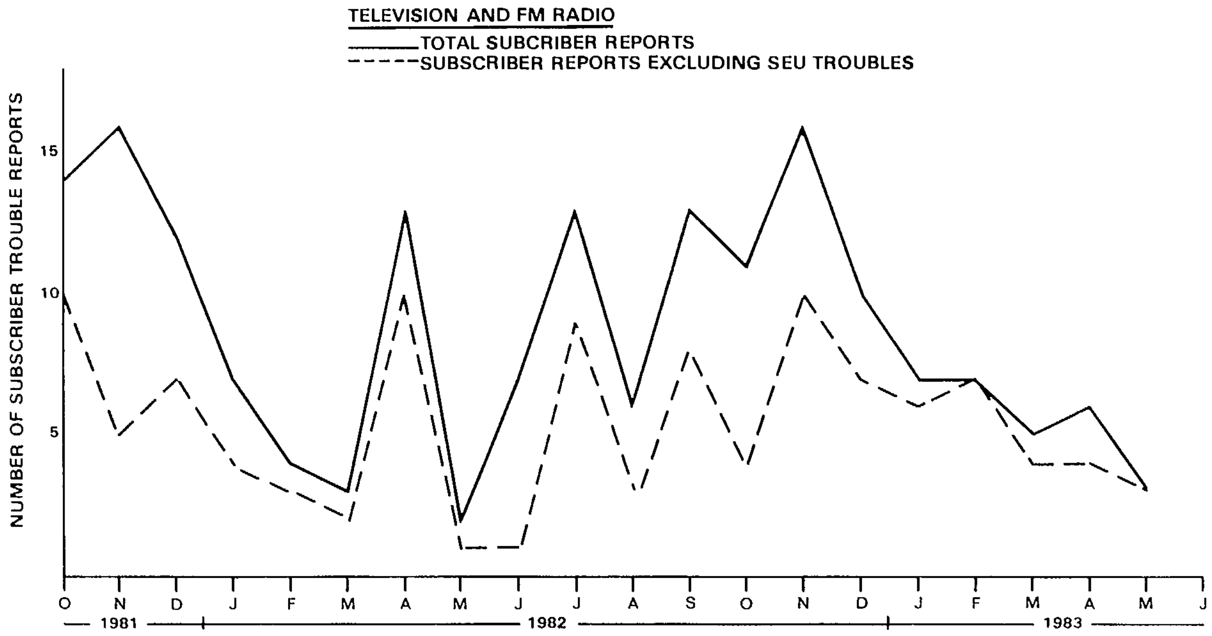


Figure 8.4 Monthly trend of total TV and FM Radio troubles reported by the subscribers

	Total Period		Oct./81-Dec./82		Jan.1-May 31/83	
	Trouble Reports	Reports per month	Trouble Reports	Reports per month	Trouble Reports	Reports per month
SEU	67	3.4	63	4.2	4	0.8
STU & Remote	50	2.5	39	2.6	11	2.2
Other NTCL	33	1.6	28	1.9	5	1.0
Subs. Respon. & F.O.K.	25	1.2	17	1.1	8	1.6
Total	175	8.7	147	9.8	28	5.6

Table 8.4 Total TV and FM Radio Troubles Reported by the Subscriber

Figure 8.3 showing the montly trend of troubles found in the basic NTCL system, indicates that the objective was met most months and that there has been a decided improvement in the number of troubles found since the protective devices were connected in December, 1982.

8.3.2 Total Subscriber Reports of TV and FM Radio Troubles

As shown in Table 8.4, even the monthly average of total subscriber reports of 8.7 for TV and FM radio service for the total period is better than the objective of 11.7 for troubles in the basic system alone, although it includes other equipment and encompasses the period with high SEU failures. Again the improvement in the failure rate after January, 1983 is significant.

Figure 8.4 shows the monthly trend of subscriber trouble reports. The reduction of trouble reports after January, 1983 is entirely due to the reduction of failures of the SEU.

8.4 Telidon Service

8.4.1 Telidon Troubles Found in the Basic NTCL System

During the first 15 months the monthly average of troubles of 11.9 found in the basic NTCL system was almost double the objective of 6.2. 88% of these troubles were caused by the SEU mainly by the failure of the CMOS IC in the driver circuit.

As can be seen in Table 8.5, the number of troubles in the NTCL equipment dropped to a very low value after the protective devices were connected to the SEU's at the end of 1982. Figure 8.5 shows the monthly trend in the failure rate of the basic NTCL system for the Telidon service.

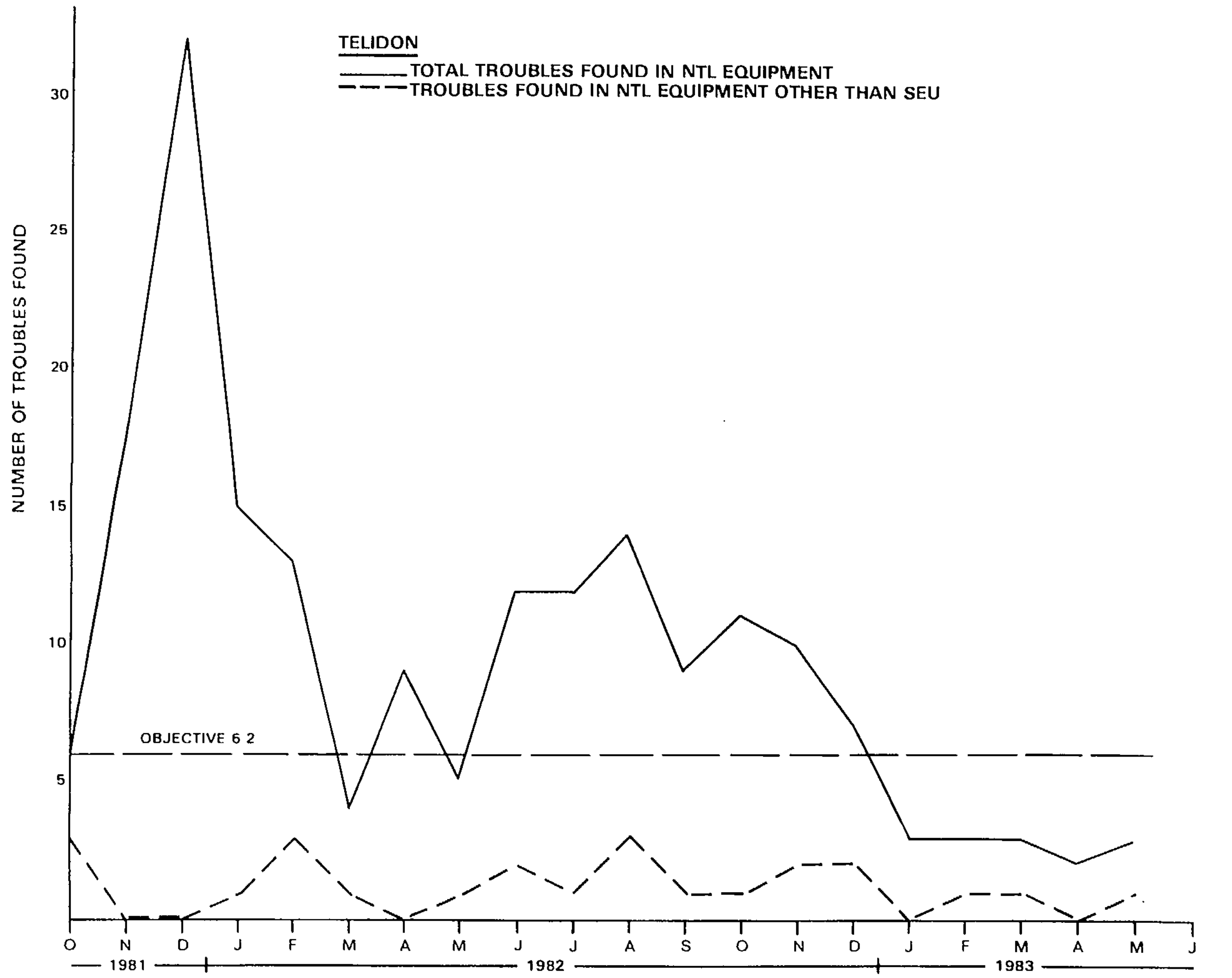


Figure 8.5 Monthly trend of Telidon troubles found in the basic trial system

	Total Period		Oct./81-Dec./82		Jan.1-May 31/83		Design Objective
	No. of Troubles	Troubles per month	No. of Troubles	Troubles per month	No. of Troubles	Troubles per month	Trouble per month
SEU	168	8.4	157	10.5	11	2.2	-
Other NTCL	24	1.2	21	1.4	3	0.6	-
Total	192	9.6	178	11.9	14	2.8	6.2

Table 8.5 Telidon Troubles Found in the Basic NTCL System

8.4.2 Total Subscriber Reports of Telidon Troubles

Table 8.6 shows that the subscriber trouble report rate had initially been quite high due mainly to the excessive failure rate of the SEU's. With the addition of a protection circuit to the SEU data port during December, 1982 the monthly trouble report rate dropped significantly starting with January, 1983 indicating that the excessive failure rate problem of the SEU's appeared to have been solved. The recorded failure rate for the Telidon service during 1983 could be rated as excellent considering the complexity of the equipment involved. The troubles appear to be split approximately equally between the NTCL basic system, the Telidon keyboard and all the other remaining Telidon equipment. Figure 8.6 shows the monthly trend of subscriber trouble reports.

	Total Period		Oct./81-Dec./82		Jan.1-May 31/83	
	Trouble Reports	Reports per month	Trouble Reports	Reports per month	Trouble Reports	Reports per month
SEU	168	8.4	157	10.4	11	2.2
Other NTCL	24	1.2	21	1.4	3	0.6
Switch	12	0.6	12	0.8	-	0.0
Key-Board	46	2.3	37	2.5	9	1.8
Other	44	2.2	36	2.4	8	1.6
Subs. Respon. & F.O.K.	23	1.1	22	1.5	1	0.2
Total	317	15.8	285	19.0	32	6.4

Table 8.6 Total Telidon Troubles Reported by the Subscriber

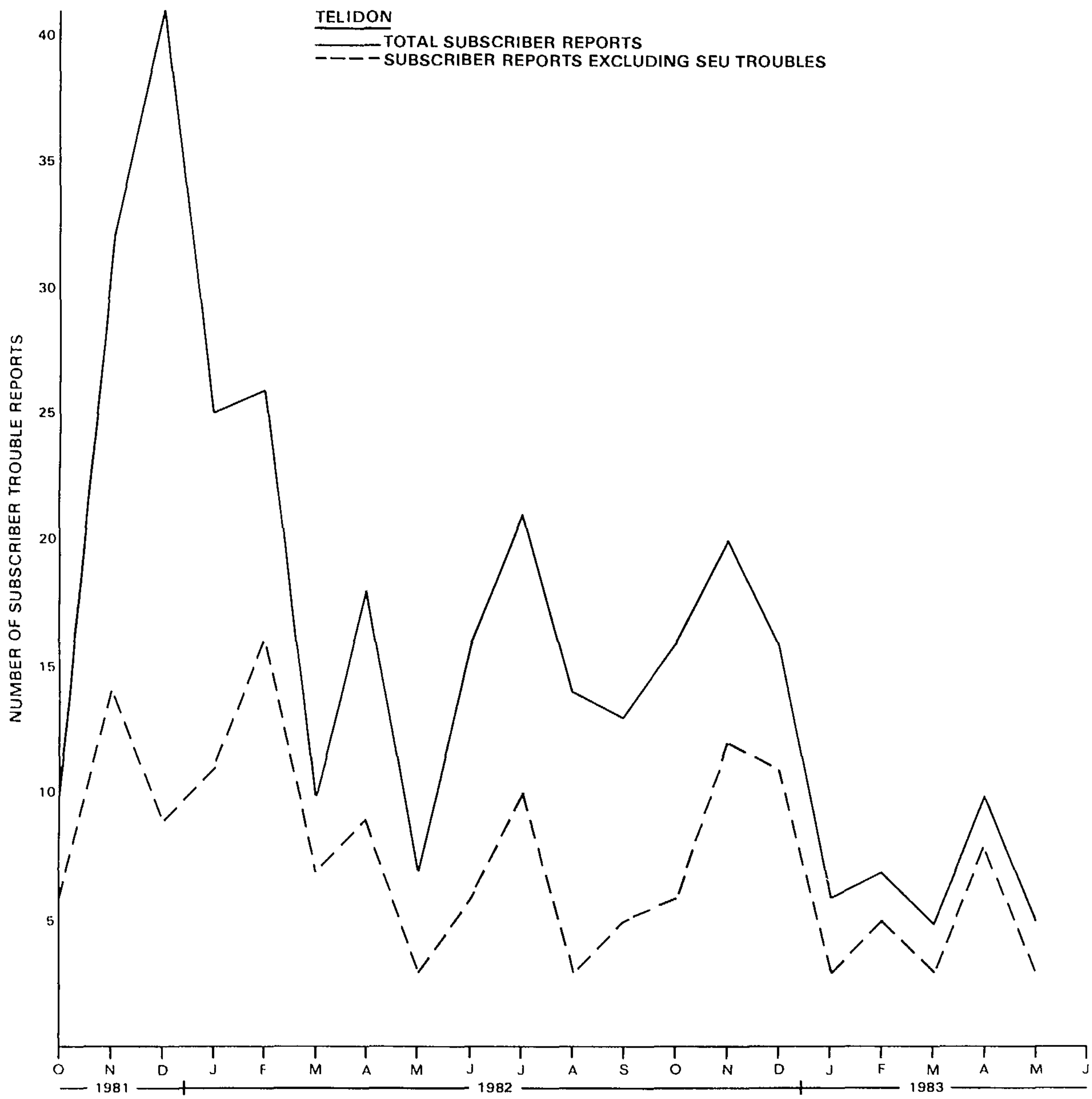


Figure 8.6 Monthly trend of total Telidon troubles reported by the subscribers

8.5 Analysis of Causes of Failures

As described in earlier sections, units, sub-assemblies or printed circuit boards of the basic system that had failed or were suspected of having failed were shipped by MTS for repair to either BNR or NTCL. Repairs of the Telidon terminal equipment, the data set and the data switch were performed by Norpak, Electrohome and Develcon as appropriate. In the latter category of equipment, analysis revealed that failures were of a random nature as one normally would expect of commercially produced equipment.

In the equipment of the basic system, that was specifically developed for this trial, NTCL repair shops or BNR, who did a significant amount of such repairs, found the following problems:

LIU -	11	Units where lasers were replaced
	10	Units with lasers had Tx alarm readjusted
	0	Units had actual LED failures
	5	Units with LED's had Tx alarm readjusted
	8	Units had PCB's replaced
	25	Units had misc. components replaced
	21	Units had various misc. adjustments
	8	Units no fault found
SEU -	147	Units where U8 was replaced
	62	Units where C1-C7 capacitors were replaced
	12	Units required adjustment/calibration
	17	Units had regulator replaced
	15	Units had U30 phase lock loop replaced
	3	Units had LED replaced
	40	Units had other misc. failures

Digital Access Card - 11 units had misc. failures.

Set Top Units - 20 were replaced entirely

TV Remote Control Units - Several were replaced entirely.

The replaced U8 component in the SEU is the previously discussed data port CMOS driver IC. The C1-C7 capacitors in the SEU's are the capacitors which are part of the voltage multiplier circuit. All failures, other than for these two components, were of a random nature.

CHAPTER 9. FIBRE OPTIC CABLE PERFORMANCE

9.1 Purpose of Assessment

Since the fibre optic outside plant consists of a mixture of aerial, buried and ducted cables which were subject to a variety of changing environmental factors such as temperature, humidity, wind and heaving of the ground due to the yearly frost and thaw cycles, it was considered to be an essential part of the field trial to assess the effect of such changes on the fibre parameters, and compare the results of these real life measurements to those of controlled laboratory measurements.

9.2 Test Parameters and Methods

The main parameters of a fibre optic cable plant are the loss and bandwidth of the fibres and the loss of splices. Ideally, it was desirable to measure both parameters for:

- Temperature variations
- Earth movements caused by freezing and thawing
- Possible moisture ingression on buried cables
- Dancing of aerial cable
- Aging.

Since bandwidth measurements require quite elaborate set-ups, it was considered impractical to execute them in the field with plant maintenance staff even after some training. Therefore, all measurements were confined to loss tests.

One of the basic requirements for the test method was its ability to conduct all measurements from the FTC or RDC without the need to have access to the remote end of the fibre, particularly for the fibres in the subscriber distribution plant. Therefore, the test method chosen was based on optical time domain reflectometry. The Optical Time Domain Reflectometer (OTDR) that was chosen for these tests was an Ando type AQ 1902 Optical Fibre Analyzer. At that time (1981) this instrument was one of the few that had the sufficient precision required to perform the desired tests.

During the actual measurement period, which was from September 1982 to April 1983, a Tektronix type OF150 OTDR became available for a limited time and was used to cross-check results obtained with the Ando OTDR and to make a comparison with respect to ease of use and accuracy.

The Ando OTDR provided reliable measurements for fibre cables up to 3 km. Readings were accurate and splice losses were easy to measure. However, for cables longer than 3 km the trace became increasingly scattered making splice loss and fibre end loss measurements rather difficult. The Tektronix ODTR provided reliable measurements at least up to 8.5 km, the longest fibre lengths measured and overall was rated as a better test instrument.

Both test sets had certain features and shortcomings which made their use as a field test instrument somewhat difficult. The major problem was with providing connection between the test set and the fibre under test. Incompatibility between connectors of the test set and the connectors used in the system, difficulty of splicing of test fibres to the test set due to differences in fibre jacket diameters between the cable of the test instrument and the trial fibre were the major sources of test personnel complaints. They indicate towards the need of better standards for fibre optic system components.

Test data was collected from September 1982 to April 1983. Initially, it was decided that test data was to be taken regularly twice a week. However, during the actual data collection, it very quickly became evident that, unless significant environmental changes did occur, such as large changes in wind velocity and humidity, and in particular in temperature, no changes in the measured data would be observed. Therefore it was then decided in order to reduce the cost of taking data, measurements were to be taken only when significant environmental changes occurred. As a result only 16 sets of data were taken.

In order to obtain data for all seasonal extremes and also to detect any aging effects, should there be such, collection of test data has continued into 1984.

9.3 Selection of Test Fibres and Test Set-Up

Fibres were selected from spares in the FTC to RDC trunk and in the distribution plant in Elie and St. Eustache originating from the FTC and RDC respectively. Samples included long and short fibres with one or more splices. They were selected from buried, aerial and combined aerial/buried cable routes. The fibre samples and the pertinent information is given in Table 9.1. For the last three sample fibres which are in the trunk between the FTC and RDC only the first three splices have been shown, since the Ando OTDR was not capable of showing any splices beyond the first three.

The test set-up and the typical picture that is seen on the OTDR is shown in Figure 9.1. The initial test set-up and procedures were established by MTS transmission engineering department with the assistance of experienced plant personnel. Each fibre was tested and appropriate settings on the Ando OTDR were established. The criteria for the settings were based on fibre length and the best trace obtainable on the scope. Figures 9.2 and 9.3 show actual traces of a short and a long fibre

SAMPLE NO.	FIBRE	# OF SPLICES /LENGTH M.	TRUNK OR DISTRIBUTION	BURIED, AERIAL COMBINATION OF BOTH	LOCATION	SPLICE #1/ DISTANCE M.*	SPLICE #2/ DISTANCE M.*	SPLICE #3/ DISTANCE M.*
1	8	1 / 344	DIST	AERIAL	FTC	–	–	–
2	18	1 / 844	DIST	AERIAL	FTC	AERIAL/615	–	–
3	34	1 / 1737	DIST	BURIED	FTC	AERIAL/620	–	–
4	24	3 / 3420	DIST	BURIED	FTC	AERIAL/470	AERIAL/551	AERIAL/1230
5	8	1 / 1815	DIST	COMBINATION	RDC	AERIAL/1600	–	–
6	15	1 / 2364	DIST	COMBINATION	RDC	AERIAL/2210	–	–
7	8	0 / 572	DIST	COMBINATION	RDC	–	–	–
8	5	3 / 4444	DIST	COMBINATION	RDC	AERIAL/1260	AERIAL/2680	AERIAL/3580
9	27	3 / 8300	TRUNK	BURIED	FTC-RDC	BURIED/1600	BURIED/3600	AERIAL/5600
10	1	3 / 8300	TRUNK	BURIED	FTC-RDC	BURIED/1600	BURIED/3600	AERIAL/5600
11	28	3 / 8300	TRUNK	BURIED	FTC-RDC	BURIED/1600	BURIED/3600	AERIAL/5600

*Trunk Splice distances are measured from the RDC

Table 9.1 Selected Sample of Test Fibres and Their Characteristics

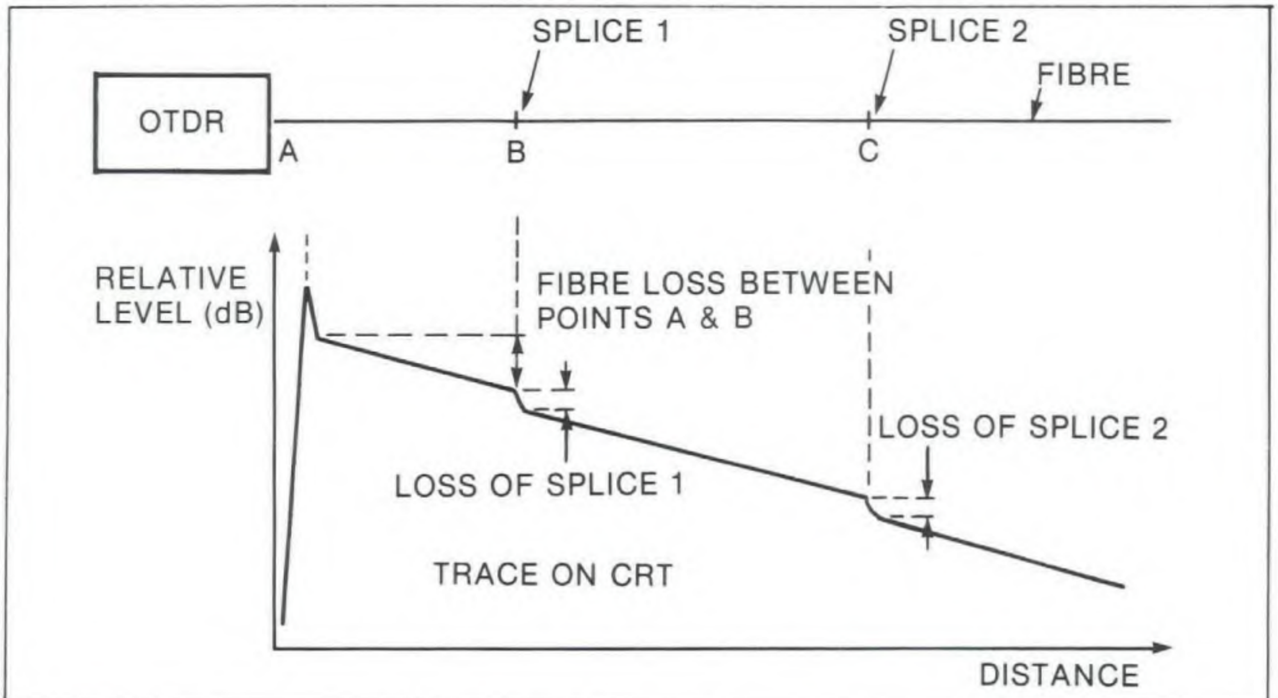


Figure 9.1 Fibre and Splice loss test set up and typical trace to be observed on the screen of an Optical Time Domain Reflectometer (OTDR)

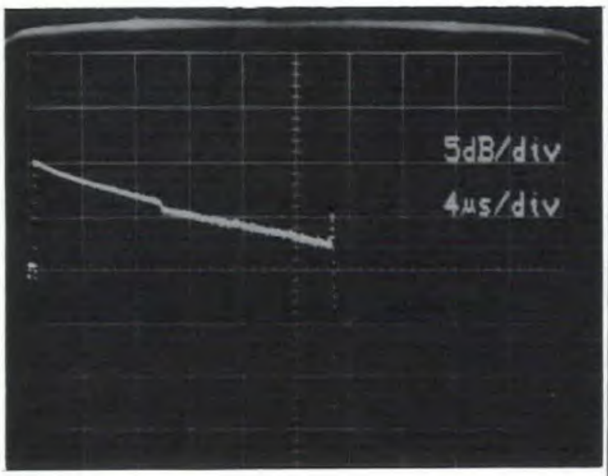


Figure 9.2 Actual OTDR trace for a 844 m fibre with one splice (Sample No. 2)

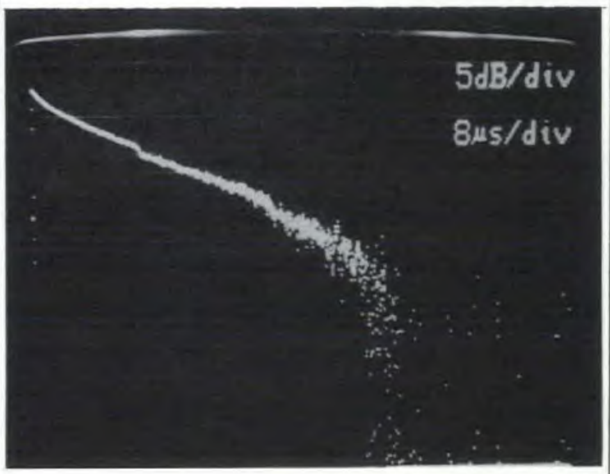


Figure 9.3 Actual OTDR trace for a trunk fibre with three splices. Only the first two splices are discernible.

respectively. The former is 844 m long according to plant records with a splice at 615 m. The OTDR trace indicates a measured total length of 748 m for this fibre. On the long fibre, only the first two splices can be determined with some accuracy which are at 1600 m and 3600 m from the RDC. As can be seen from Figure 9.3 scattering of the trace starts after the first splice and is quite severe after the second. The total measured length up to the third splice is 5.492 km for which the records indicate 5.6 km.

9.4 Test Results

The 16 sets of test data taken from September 1982 until the end of April 1983 were divided into three distinct groups:

i) Aerial
ii) Buried
iii) Buried/aerial combination

Each of these test data groups were further subdivided into:

i) Total loss (fibre and splices)
ii) Individual splice loss

The average loss versus temperature graphs were plotted for each group and subgroup. These graphs are shown in Appendix 9.1 They include all measurements made during the period from September 1982 to April 1983 for all sample cables used in the group for which the particular graph is given. In all cases a 99.99% upper and lower confidence limit is shown. This confidence limit indicates that the probability of a reading being within the upper and lower limits for the temperature range of -25°C to +25°C is 99.99%. A summary of these test results is given in Table 9.2. The table illustrates that the total loss/km varies significantly between the three cable types listed,

	BURIED CABLE				BURIED, AERIAL COMBINATION CABLE				AERIAL CABLE	
	TOTAL LOSS (FIBRE&SPLICE) PER KM	SPLICE #1 LOSS	SPLICE #2 LOSS	SPLICE #3 LOSS	TOTAL LOSS (FIBRE&SPLICE) PER KM	SPLICE #1 LOSS	SPLICE #2 LOSS	SPLICE #3 LOSS	TOTAL LOSS (FIBRE&SPLICE) PER KM	SPLICE #1 LOSS
MEAN [dB]	3.66	0.30	0.50	0.45	3.33	0.25	0.23	0.54	5.14	0.65
STANDARD DEVIATION [dB]	0.39	0.12	0.13	0.11	0.29	0.09	0.12	0.39	0.69	0.31
UPPER LIMIT [dB]	4.88	0.66	0.91	0.80	3.85	0.40	0.46	1.61	6.24	1.15
LOWER LIMIT [dB]	2.44	-0.05	0.09	0.09	2.82	0.09	-0.01	-0.52	4.03	0.16

Table 9.2 Summary of Fibre and Splice Loss Measurements

although only one type of fibre had been used throughout the system. The reason for this discrepancy is that, in the case of aerial cables, the distances were short and therefore the relative contribution of splice losses to the overall per kilometre loss became more dominant. However, this fact does not adversely affect the purpose of these measurements, which was to detect any changes in loss caused by the variation of various environmental parameters, rather than to make absolute measurements.

9.5 Analysis of Results

The measurements taken between September 1982 and April 1983 indicate that no changes in loss of the 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 thereby confirm for fibre optic cables in an operational environment the findings of controlled environmental laboratory tests. Since tests were conducted only for eight months, a relatively short time period, it is not possible to draw any conclusions with respect to any fibre aging phenomena, should there be such.

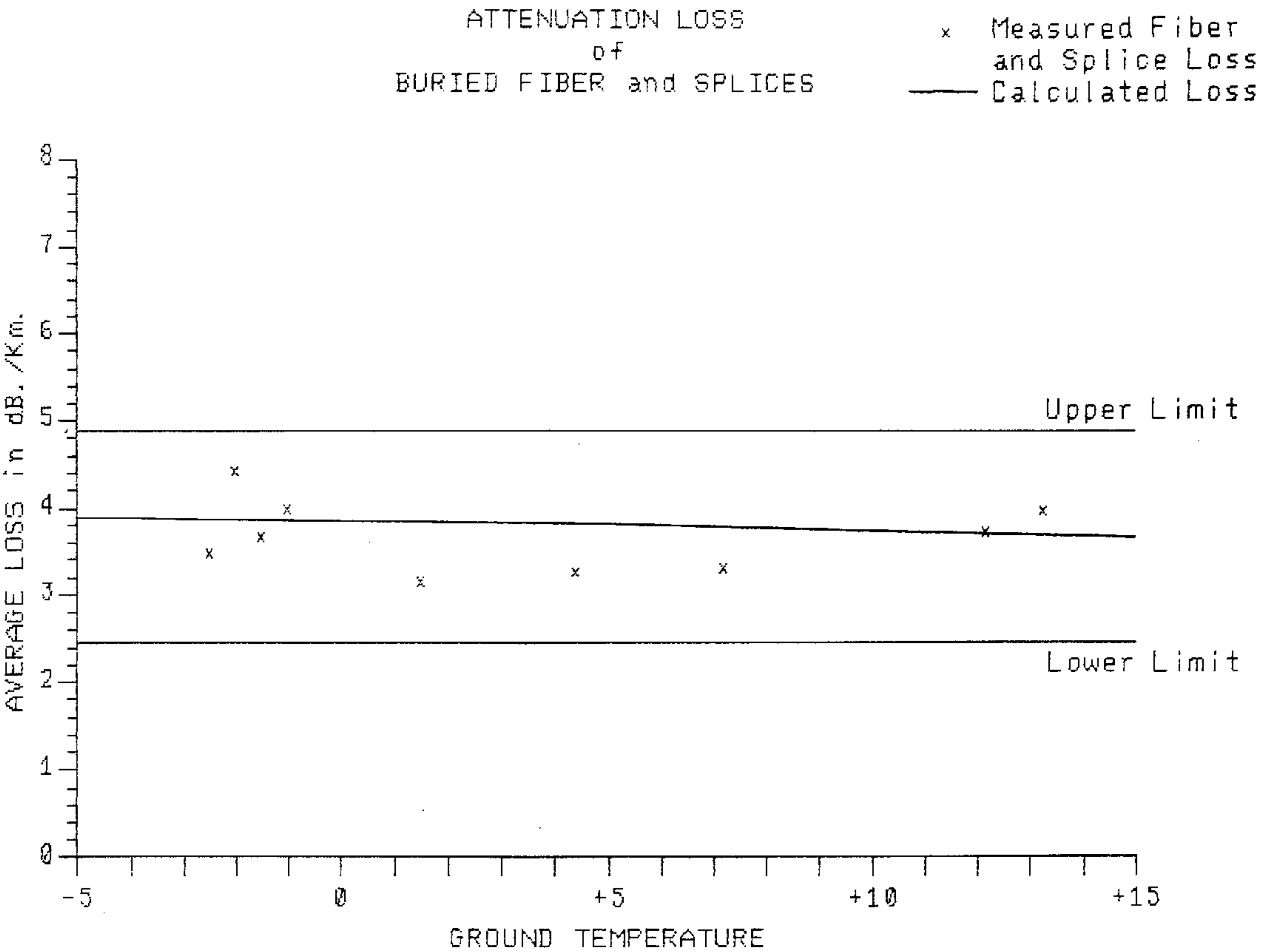
Controlled environmental laboratory tests done in the past indicate, similar to fibre loss test, that there are no loss variations observable for fusion splices for varying environmental parameters. Field test results on the other hand do indicate a slight decrease in splice loss with increasing temperature. Although no systematic investigation into the reason for this change has been made, it is thought, that it may be due to temperature change induced fibre deformation in the splice organizer box. A recent study done by researchers in Japan [9.1] on thermal characteristics of jacketed optical fibres indicates that, variation in mechanical strain due to temperature changes can cause fibre loss to vary.

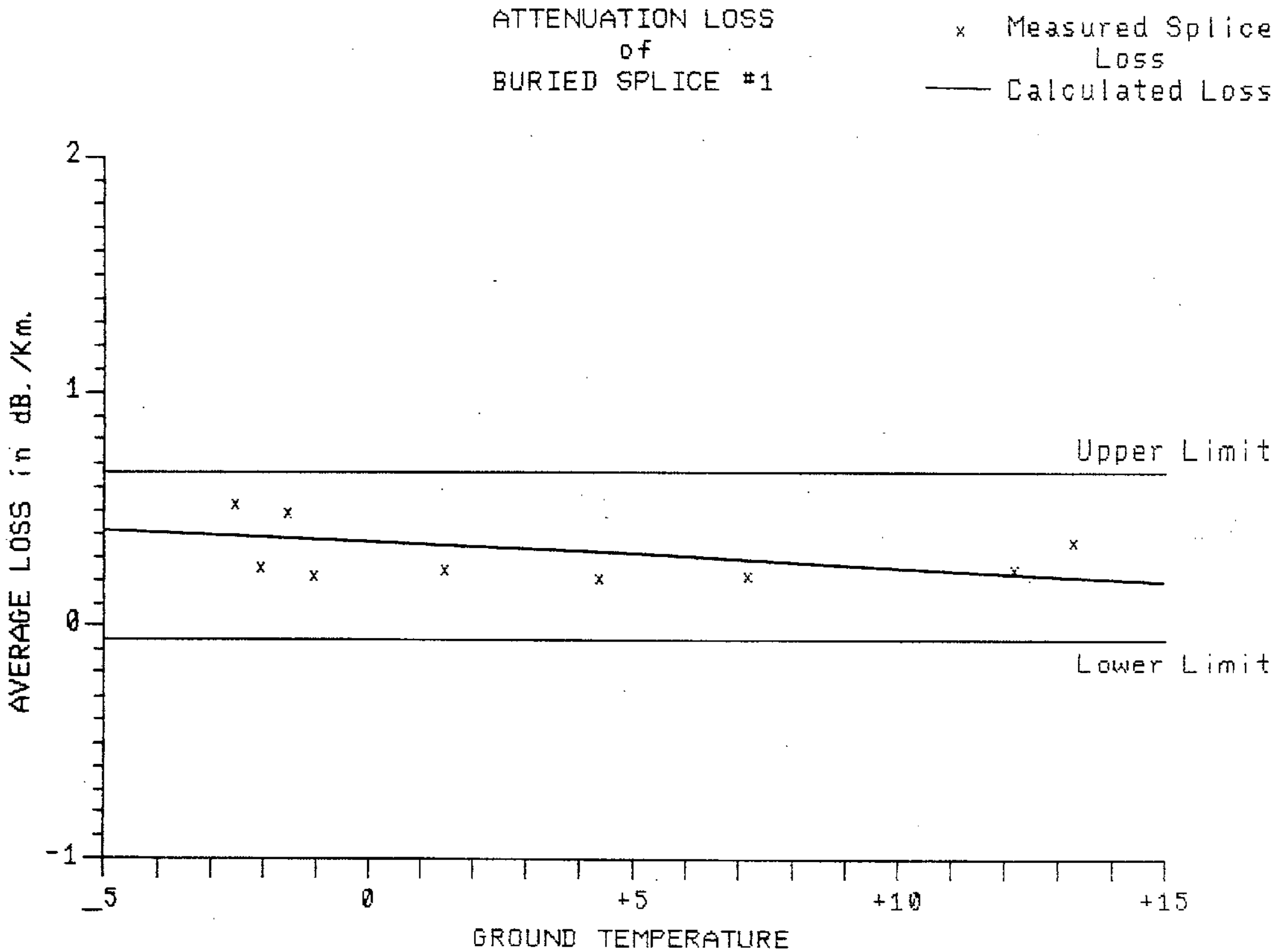
Reference

[9.1] Y. Mitsunaga, Y. Katsuyama, Y. Ishida; Thermal Characteristics of Jacketed Optical Fibres with Initial Imperfection; IEEE Journal of Lightwave Technology, Vol. LT-2, No. 1, February 1984, pp. 18-24.

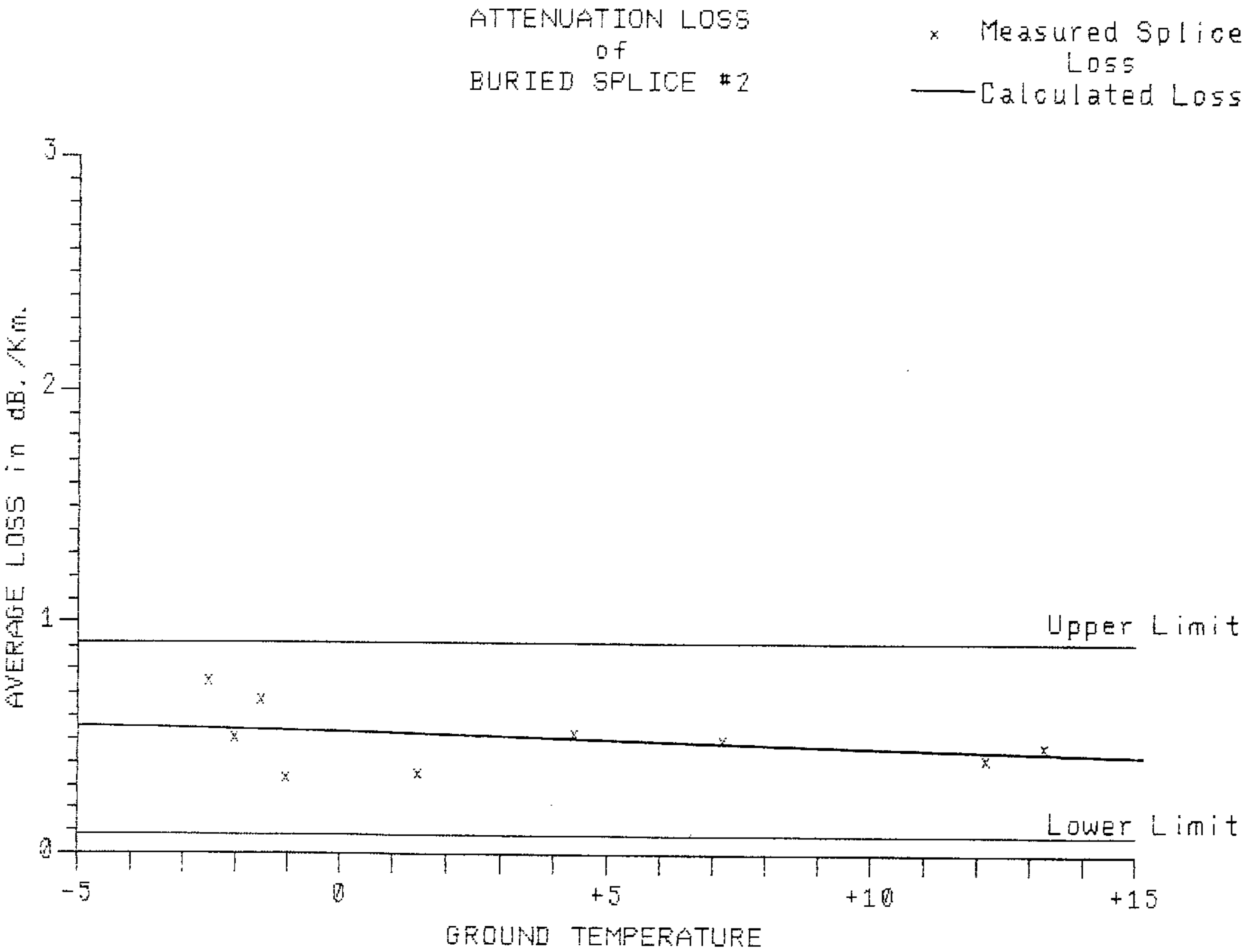
APPENDIX 9 - 1

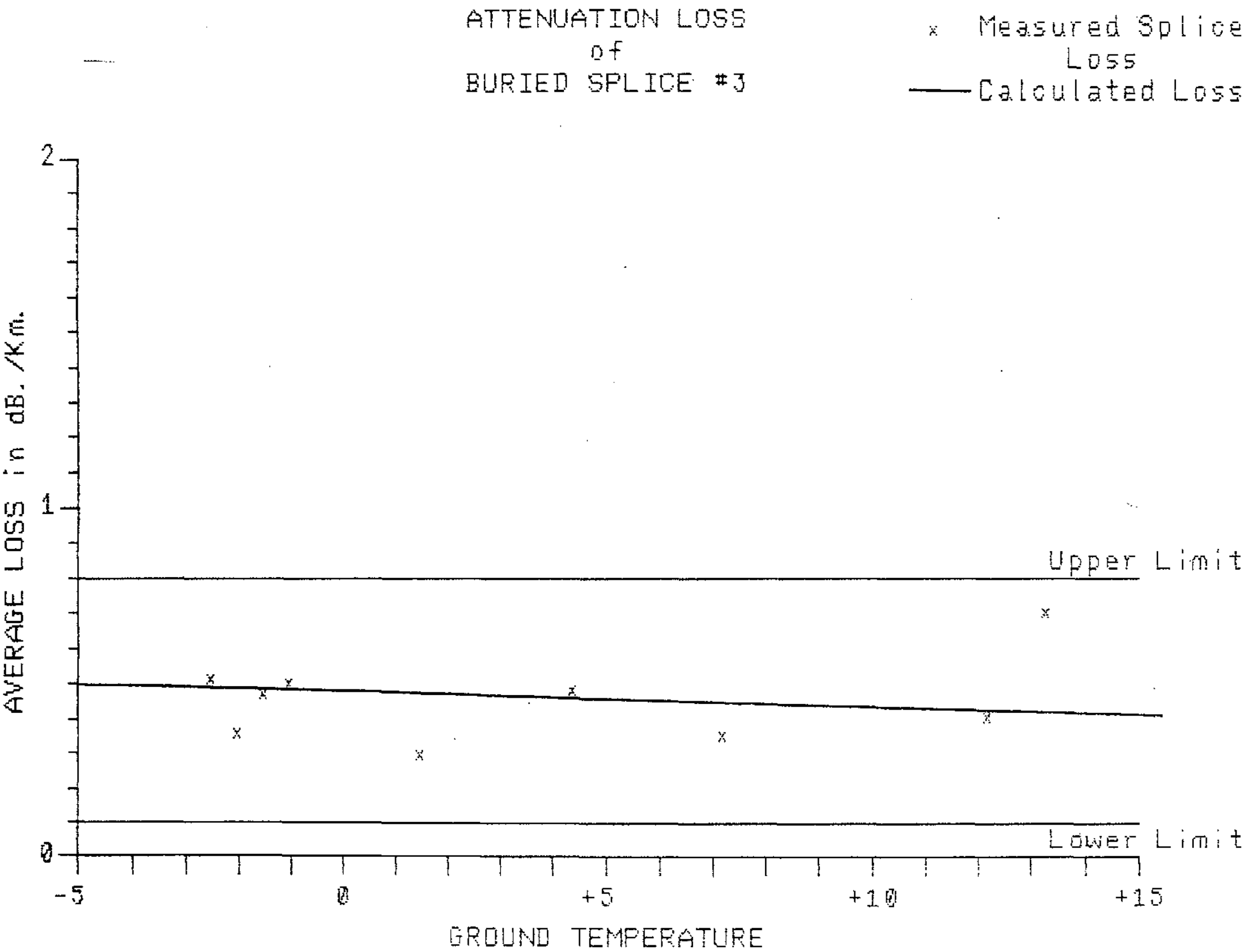
FIBRE AND SPLICE LOSS TEST RESULTS


ATTENUATION LOSS
of
BURIED FIBER and SPLICES
x Measured Fiber and Splice Loss
Calculated Loss
Upper Limit
Lower Limit
AVERAGE LOSS in dB. /Km.
0
1
2
3
4
5
6
7
8
-5
0
+5
+10
+15
GROUND TEMPERATURE

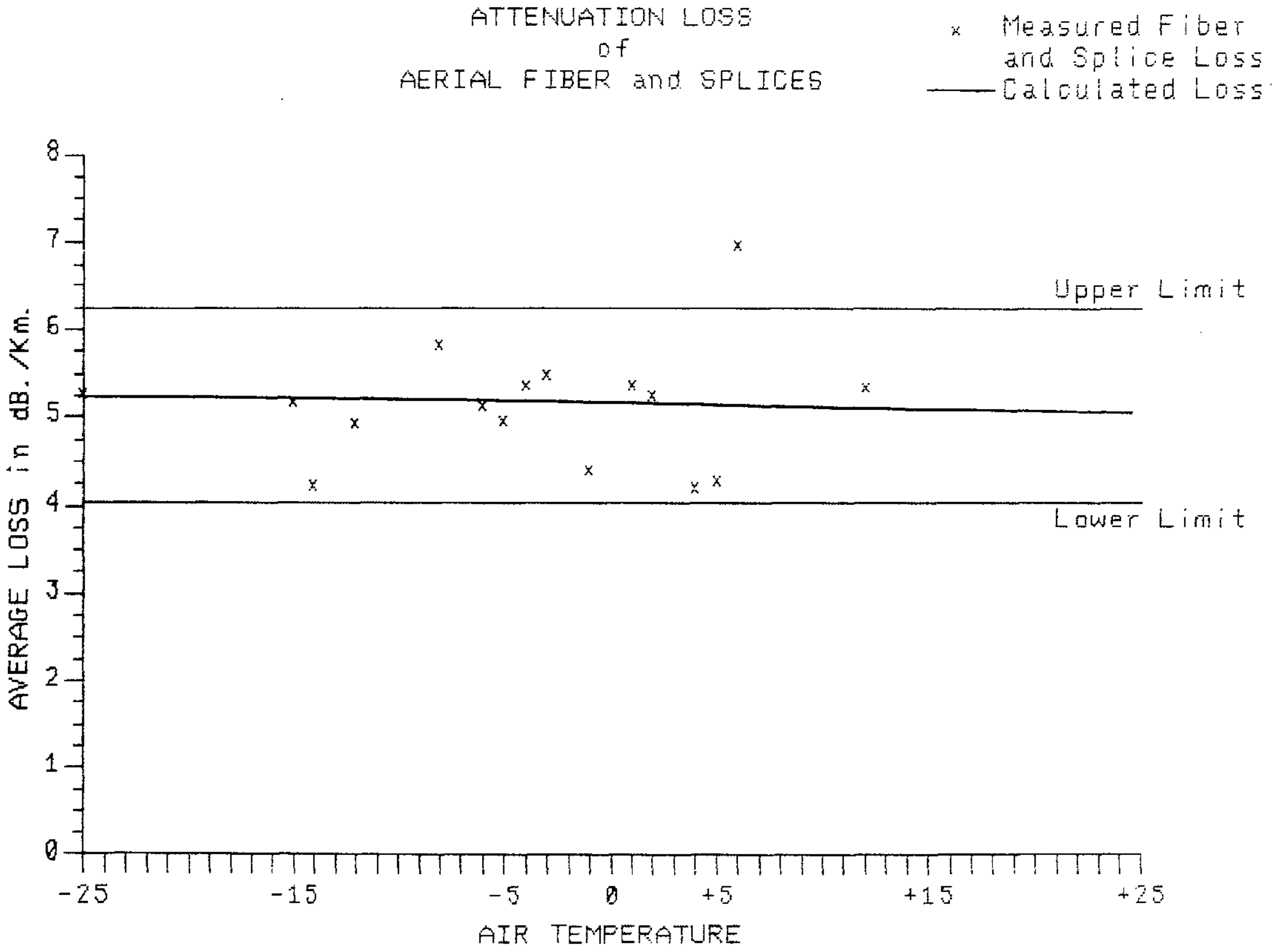


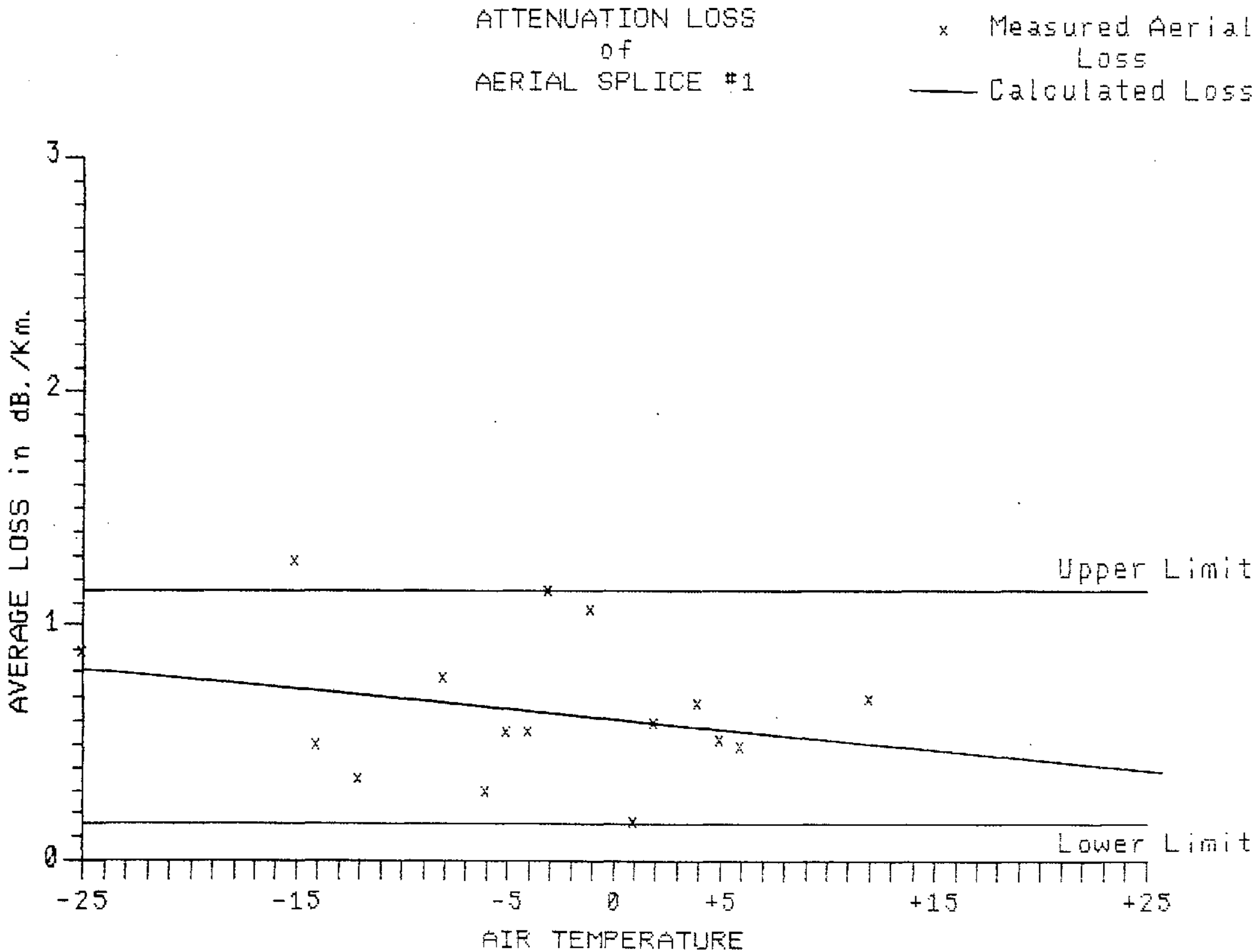
ATTENUATION LOSS
of
BURIED SPLICE #1
x Measured Splice Loss
Calculated Loss
Upper Limit
Lower Limit
AVERAGE LOSS in dB./Km.
2
1
0
-1
-5
0
+5
+10
+15
GROUND TEMPERATURE

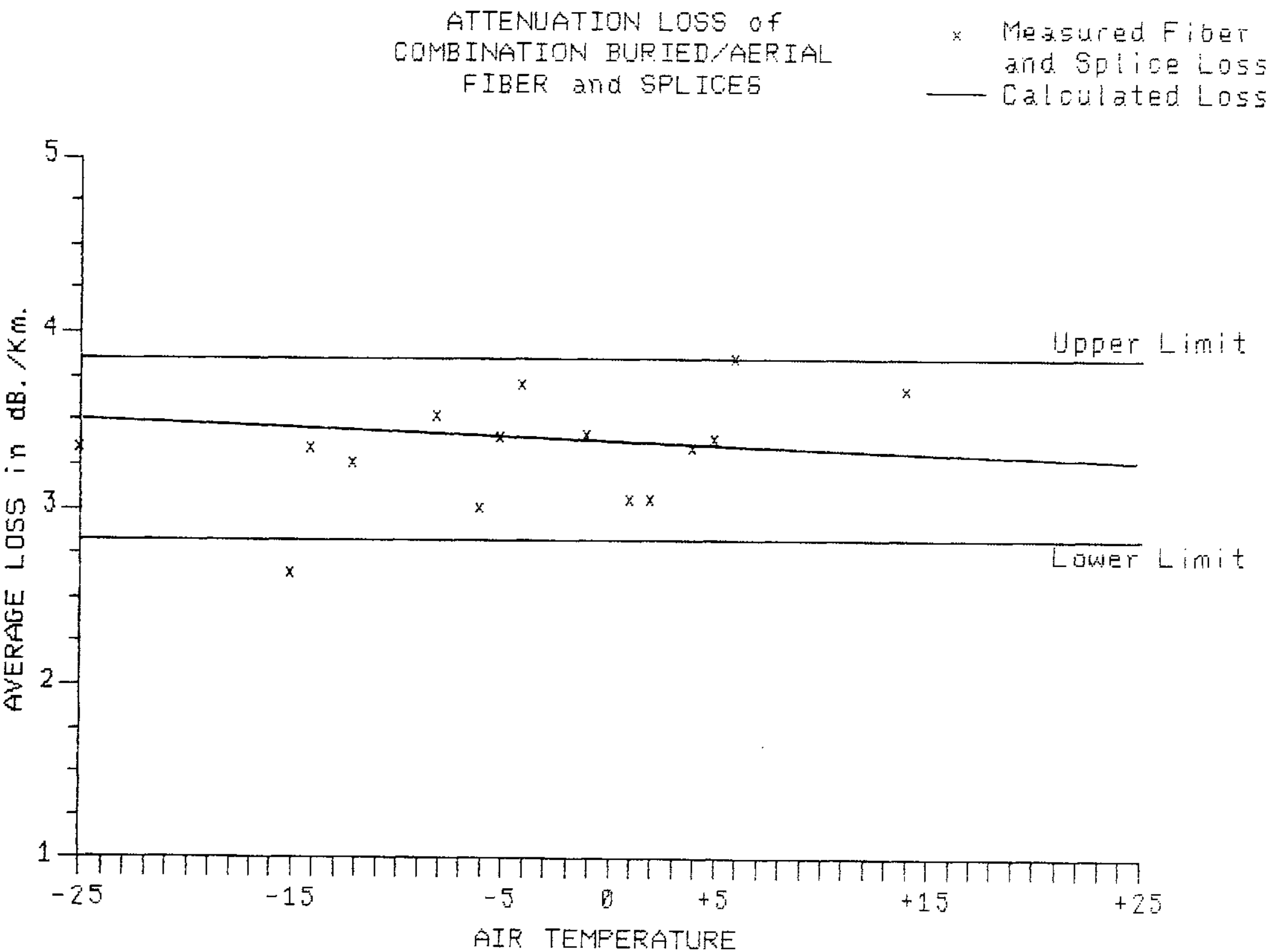

ATTENUATION LOSS
of
BURIED SPLICE #2
x Measured Splice Loss
Calculated Loss
AVERAGE LOSS in dB./Km.
3
2
1
0
Upper Limit
Lower Limit
-5
0
+5
+10
+15
GROUND TEMPERATURE

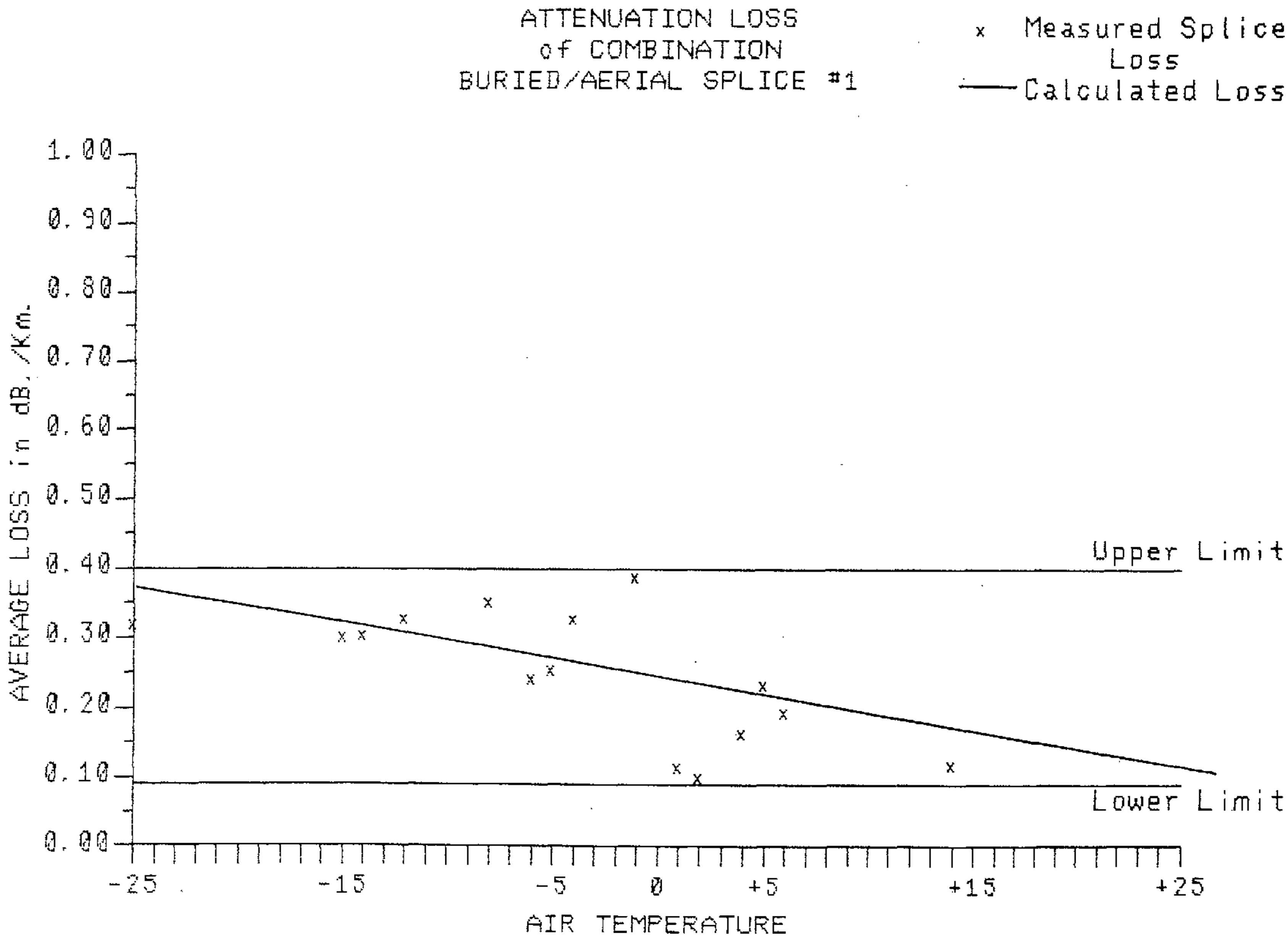


ATTENUATION LOSS
of
BURIED SPLICE #3
x Measured Splice Loss
Calculated Loss
AVERAGE LOSS in dB./Km.
2
1
0
Upper Limit
Lower Limit
-5
0
+5
+10
+15
GROUND TEMPERATURE


ATTENUATION LOSS
of
AERIAL FIBER and SPLICES
x Measured Fiber and Splice Loss
Calculated Loss
Upper Limit
Lower Limit
AVERAGE LOSS in dB. /Km.
0
1
2
3
4
5
6
7
8
-25
-15
-5
0
+5
+15
+25
AIR TEMPERATURE

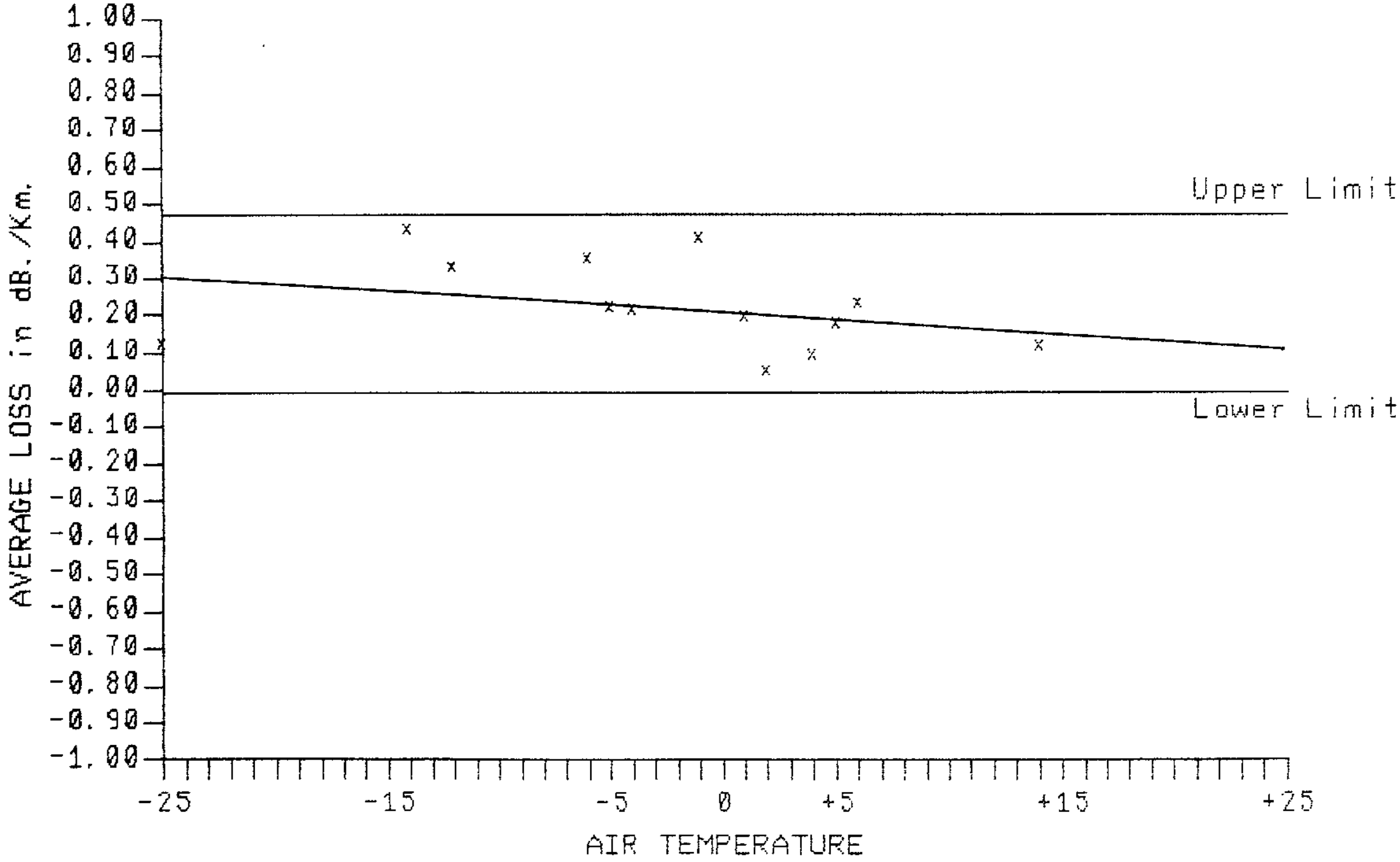

ATTENUATION LOSS
of
AERIAL SPLICE #1
x Measured Aerial Loss
Calculated Loss
AVERAGE LOSS in dB./Km.
3
2
1
0
Upper Limit
Lower Limit
-25
-15
-5
0
+5
+15
+25
AIR TEMPERATURE

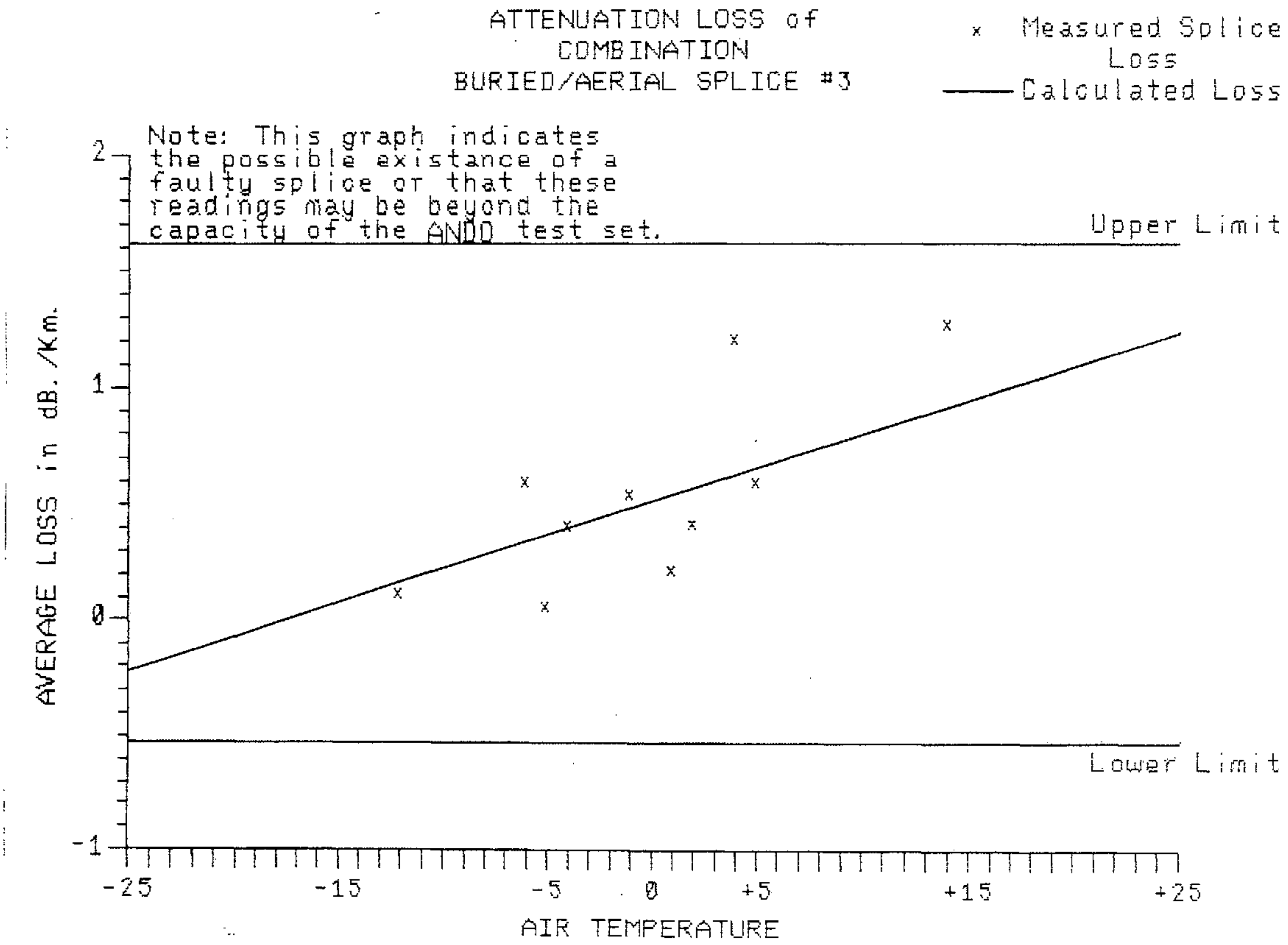

ATTENUATION LOSS of
COMBINATION BURIED/AERIAL
FIBER and SPLICES
x Measured Fiber and Splice Loss
—— Calculated Loss
Upper Limit
Lower Limit
AVERAGE LOSS in dB./Km.
1
2
3
4
5
-25
-15
-5
0
+5
+15
+25
AIR TEMPERATURE


ATTENUATION LOSS
of COMBINATION
BURIED/AERIAL SPLICE #1
x Measured Splice Loss
Calculated Loss
AVERAGE LOSS in dB./Km.
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Upper Limit
Lower Limit
-25
-15
-5
0
+5
+15
+25
AIR TEMPERATURE

ATTENUATION LOSS of
COMBINATION
BURIED/AERIAL SPLICE #2

x Measured Splice Loss
—— Calculated Loss




ATTENUATION LOSS of
COMBINATION
BURIED/AERIAL SPLICE #3
x Measured Splice Loss
Calculated Loss
Note: This graph indicates the possible existance of a faulty splice or that these readings may be beyond the capacity of the ANDO test set.
Upper Limit
Lower Limit
AVERAGE LOSS in dB. /Km.
2
1
0
-1
-25
-15
-5
0
+5
+15
+25
AIR TEMPERATURE

CHAPTER 10 - SERVICE USAGE AND SUBSCRIBER REACTION

10.1 General

The primary objective of Phase I of the trial was technical. The only consideration given to non-technical issues in this phase was the inclusion in the trial of capabilities of monitoring usage of the services. In Phase II of the trial, which was concerned with the introduction of new services, the need for assessment of the quality of the system as perceived by the end-user was recognized and therefore four user surveys were planned. In addition effort was spent to analyze the usage data collected.

This chapter will summarize the work carried out to assess the success of the trial from the end users' point of view, and to present any conclusions reached through this evaluation process.

10.2 Background

10.2.1 The Communities

Elie and St. Eustache where this trial has taken place are very diverse in their general character and business activities. Whereas Elie is experiencing growth through business and industrial expansion and the construction of new homes, St. Eustache is essentially in a no-growth pattern at this time.

There are many thriving businesses in Elie such as car and implement dealers, fertilizer dealers, grain dryer sales agencies, etc., but only a few small businesses in St. Eustache. The business community is generally affluent and aggressive. A listing of all business establishments in the area is given in Appendix 10-1. There are also five foreign owned large farm operations in the area. The owners of these farms are from France.

There is an elementary school in each town with the collegiate located in Elie. There is a Catholic church, rectory and convent in each town. However there is no Protestant church, no pharmacy, no food or clothing stores, and only limited medical service and a small grocery store which also doubles as a liquor outlet. The area has also five Hutterite colonies, of which the Rosedale Colony is the first that was established in Manitoba.

Although the residents support the local businesses, most families rely on Winnipeg, which is only about 40 km away, for food, clothing, furniture shopping, entertainment and medical services.

10.2.2 The Residents

The trial area is basically an affluent community with the majority of families in the middle income range. The majority of families own their homes and approximately 10% who do not, mainly rent dwellings from relatives. Those with low incomes are elderly and retired or the Metis families on fixed income.

Most are married households, but there are also some widowed, 2 separated, and several single households. Family sizes range from 1 to over 8 with the average being approximately 4 per household.

Heads of households range from 20 to over 80 years of age, with the majority being between 31 and 55. Most of the women, who range in age from 19 to 80, with the majority being between 20 and 55, work in the home. Approximately 25% work outside the home in paid occupations. Children living at home range from infants to 25 years of age, with the majority being between 11 to 19.

Education level of heads of households is generally grade 11 or less. Most of them are owners of farms or business, which are generally successful operations or they are in managerial or supervisory occupations. Very few have university education.

Most of the residents work in the area, but, approximately 25% commute, mainly to Winnipeg, some to Portage la Prairie, and a few travel around the area and surrounding towns.

Most of the residents have a French Canadian background and are bilingual. There are some Metis families in the area, most of whom live in St. Eustache. Most of the business in the community is conducted in English, but approximately 30% speak only French at home. German is spoken in several homes and is the main language of the Hutterite community.

Further details on the demographic make-up of the community and the residents shown in Appendix 10-2 reflects the status at the beginning of the trial.

10.3 User Surveys

The purpose of the four surveys was primarily to determine any user perceived problems and degree of user satisfaction with the services provided over a distribution plant using a new technology. The second purpose was to determine their lifestyle, sources of information before and after the trial in order to understand the needs of people living in rural areas and how the new services and technologies could be employed to answer such needs. Of particular interest was the desire to determine the socio-economic effects of the Telidon service, for which very little data is available in general and for rural residents in particular.

The first survey was done in September 1981 just before the actual trial period which lasted from October 1981 to March 1983. The second survey was conducted in February 1982, the third in early November 1982 and the fourth and final survey in April 1983. For contractual reasons the first survey was conducted through a subcontract to the contract between DOC and Infomart, whereas the remaining surveys were conducted through subcontracts to the contract between DOC and MTS for Phase II of the trial. However, 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. In the following sections 10.3.1 to 10.3.4 details of each survey is presented.

10.3.1 September 1981 Survey

The purpose of this survey was to collect and provide quantitative data prior to commencement of the field trial and in particular to aid in determining a Telidon content plan that would be appropriate to the needs of the trial participants. There were essentially three objectives:

i) Determine the kind of information that the Telidon content plan for the service should encompass, and what priorities should be given for the development of each information category.

ii) Establish a baseline or benchmark measurement of the existing behaviour and information retrieval patterns so that over time the impact of in-home Telidon placement and usage could be evaluated.

iii) Determine the interest in a variety of enhanced services on the part of the Telidon trial participants.

Since two new services were introduced with this trial, that is cable television and Telidon, it was necessary to survey two control groups, so that the effects of each of the new services could be separated.

The actual trial participants were to receive both cable television and Telidon services. The first control group included households in Elie and St. Eustache that were not trial participants, but would receive cable television service over the conventional coaxial cable distribution system which was built to comply with the licencing conditions by CRTC. The group did not receive Telidon service. The second control group was randomly selected from the Ste. Anne/Niverville area. The reason for selecting control households from the Ste. Anne/Niverville area was its similarity to the Elie and St. Eustache area. Ste Anne/Niverville is comparable with respect to its proximity to Winnipeg, its proximity to major highways, ethnic background, agricultural orientation and off-air radio and television broadcast services. The community was not expected to receive cable television service during the time the fibre optic field trial was conducted.

The survey sample sizes were as follows:

Field trial participants	137
Non-participants in Elie/St. Eustache	82
Control sample in Ste. Anne/Niverville	153

The survey was conducted in one-to-one personal interviews either in English or in French, depending on the respondents' preference. Prior to administering the questionnaire, it was reviewed by all trial sponsors in order to ensure that it would contain all relevant questions that were of interest to each sponsor.

In order to meet the objectives of this survey the questionnaire that was developed investigated the following subject areas:

Recent time usage in specific areas
Television usage habits
Radio usage habits
Newspaper usage habits
Information sources relied on for specific subjects
Interest in specific information topics
Lifestyle habits
Reaction to Telidon (among trial participants only)

Details of this survey and copies of the questionnaires for all three groups are contained in the subcontractor's report [10.1] of which copies are available on request from DOC, Infomart or MTS. The most important findings are summarized below. Although the survey provides results for all groups, only those for the actual participants are shown here, since this is of greatest interest for this trial. The results of the survey for the other two groups are generally very similar to those of the participants. Furthermore, where the questionnaire provided for a large selection of choices to be made or items of interest to be identified, only the most important ones are shown here.

Time spent on different activities was as follows:

Activity	Hours/week
Watching TV	17.1
Listening to AM Radio	13.9
Listening to FM Radio	12.9
Entertaining Company at Home	8.3
Reading Books	7.0
Visiting Friends at Home	6.7
Hobbies, Crafts	6.5
Participating in Sports	5.0

For all other activities the time spent was less than 5 hours/week.

Frequency of doing different activities regularly was as follows:

Activity	% of Respondents
Follow Weather Reports	82.0
Listen to Radio News	64.0
Watch the Late Evening News on TV	58.0
Watch the Early Evening/6 O'Clock News on TV	53.0
Read a Newspaper	49.0

All other activities were done regularly by less than 49% of the respondents.

Preferred or enjoyed television programs are shown below:

Type of Program	% of Respondents
News	78.0
Movies	71.0
Comedies	66.0
Sports	57.0
Specials	44.0
Educational	42.0

Participants were allowed multiple responses. All other programs attracted lesser per cent of the respondents' interest.

Similarly, the most preferred radio programs are shown below. Again participants were allowed multiple responses:

Type of Program	% of Respondents
Music	78.0
Local News	73.0
National News	64.0
World News	61.0
Sports	37.0
Farm News	34.0

With respect to printed media, 69% were subscribing to a newspaper. The most subscribed to newspapers are shown below:

Newspaper	% of Subscribers
Winnipeg Free Press	88.0
Manitoba Co-operator	18.0
La Liberté	15.0
Portage Leader	6.0

From a list of 80 magazines the following were read or subscribed to most:

Magazine	% of Subscribers
Reader's Digest	29.0
Country Guide	24.0
National Geographic	21.0
Chatelaine (English)	15.0
TV Guide	15.0
Time	14.0
Macleans	11.0
Farm Light and Power	10.0
Good Housekeeping	10.0

All other magazines were mentioned by less than 10% of the respondents.

Since one of the objective of the survey was to provide input to the content plan of the Telidon library, questions were asked for the source (i.e. radio, TV, printed media, neighbours, etc.) of a large number of information categories. In the survey report [10.1] all mentioned sources are shown as well as the second most relied on sources. Below, a list is given which shows only the source most mentioned for a particular information category:

Radio
Weather Stock Market (Equal with Winnipeg Newspaper) Agricultural Commodity Markets Livestock, Cattle for Sale (Equal with Farming Newspaper) Livestock Market Selling Prices Information on Grain Contracts (Equal with Farming Newspaper)

Television
News Stories of the Day Sports Scores Local News Stories Economic Trends Consumer Assistance, Advice Acquiring Information to Increase Knowledge of Specific Subject Matter (Equal with Winnipeg Newspaper) News on Disease Outbreaks in the Area World Trends in Agriculture Production Information on Disease Control

Winnipeg Newspaper
What's on Television
News on Sales in Local Stores
Stock Market (Equal with Radio)
Travel News and Information
Financial Information Required for Business
Available Government Services
Acquiring Information to Increase Knowledge of Specific Subject Matter (Equal with Television)
Information on Entertainment and Fun
Used Machinery for Sale
Automobiles for Sale
Machinery Parts for Sale
Labour for Hire
News on Major Grain Sales
New Agricultural Techniques

Farming Newspaper
Feed Hay for Sale
Livestock, Cattle for Sale (Equal with Radio)
Price and Availability of Fertilizers
Price and Availability of Insecticides and Sprays
New Crops

For a few subjects of very local nature Friends, Neighbours, and Church, Club or Local Store bulletin boards were also mentioned.

The survey also asked the participants and the control groups about the importance of 100 different information categories, which were then indexed on a scale from 1 to 100, with 100 indicating the most important. Below a list of the most important 20 information categories and their "Index of Importance" is given:

Information Category	Index of Importance
Local Weather Information	89
Temperature Forecasts	87
Short Range Weather Forecasts	86
Local News Information	84
Major News Stories of the Day	83
Precipitation Forecasts	81
National News Information	80
World News Information	77
Road Reports for Local Area and Province	71
Long Range Weather Forecasts	70
Medical, Health Care, Nutrition Information Advice	64
Western Canada Weather Information	63
National Weather Information	62
Tax Advice, Information	62
Information on How to Calculate Interest Payments, Charges	62
What's On Television	60
Listings for Merchandise Available, Price Comparisons, Best Buys at Local Stores	60
Tips, Instruction on Do-it-Yourself Projects (i.e. Carpentry, Home Improvement, Decorating, Auto Repairs, etc.)	59
Information on How to Calculate Mortgage Rates	59
Grocery Specials Information	59

In addition to these subjects, the questionnaire also solicited information on activity habits, such as where they did their shopping, banking, where they went for entertainment, etc. Also included in this survey were questions regarding demographics and socio-economic background. Results are again available in the contractors report [10.1].

Knowledge on facts related to videotex and telidon showed that a large percentage had heard about the name "Telidon" but not much about other related nomenclature or involved companies:

Read, Heard, Seen about	% of Respondents
Telidon	72.0
Grassroots	21.0
Videotex	20.0
Infomart	16.0
No Opinion	26.0

The total exceeds 100%, since multiple responses were allowed.

91% of the participants expected that the use of Telidon would be a positive experience and 70% indicated that they would use it almost every day. 64% of respondents felt, that Telidon would be a "Big Improvement" over their current information services.

10.3.2 February 1982 Survey

The objective of the second survey was to:

"Assess the expectations, experiences, perceptions and opinions of the trial participants with respect to services which could be provided using the fibre optics technology."

Since this information was to help the trial sponsors to determine positive and negative aspects of the services, the technology, the operation and maintenance of a fibre optic technology based integrated services subscriber access network, there was no need to include the two control groups from the first survey in this survey as well.

At the time of the survey there were 144 actual field trial participants. The survey was again conducted in one-to-one personal interviews either in English or in French, depending on the respondent's preference. Only 128 interviews could be completed which represents an 89% response rate. The questionnaire which was administered in this survey was again reviewed by all organizations sponsoring the trial, before its finalization.

In order to achieve the objectives of the survey the questionnaire included areas investigating general reactions to the trial and specific reactions to the telephone, cable television, FM radio and Telidon services. There were also questions that solicited opinions on other new services that could be provided over an integrated distribution system but were not offered during the trial.

Overall, the trial participants expressed a high degree of satisfaction with all aspects of the system, the services and their dealings with the trial sponsors, notably MTS which was in most instances their direct interface. Below, the more important statistical results of the survey are listed. The complete results and associated details are contained in the survey report [10.2] which is available on request from DOC or MTS.

10.3.2.1 General Reactions to the Trial

General Like or Dislike of Services	% of Respondents
Like	85.2
Dislike	3.9
Neither like nor dislike	10.9

Only about 24% of the respondents made specific comments on this matter and 60% of these were favourable.

Service Provided by Trial Sponsors	% of Respondents
Service satisfactory	96.1
Service less than satisfactory	3.9

In this case, only 33% of the respondents made specific comments on this subject. 64% of these comments were favourable.

10.3.2.2 Reaction to the Telephone Service

Before the trial only 81% of the participants had single-party telephone service, the remainder had two or four-party service and one person had no telephone service at all. With the trial system, the participants were provided with single-party service and they had a choice of a regular or contempra style telephone. Their old existing telephone had been left as a back-up, but participants were asked to use their trial telephone. The survey revealed following usage pattern:

Use of Trial System Telephone	% of Respondents
All of the time	12.5
Most of the time	45.3
Very little	31.3
Not at all	5.5
Other	5.5

The main reasons for using the new telephone were "location in the house", "touch tone dial" and "single-party service". Reasonsfor not using were mainly said to be "inconvenient location" and to a much lesser extent having plainly forgotten about it.

On the quality of the connections in comparison to their pre-trial service the following was found.

Quality of Connection	% of Respondents
Better	15.6
Same	59.4
Not as good	10.2
Other	14.8

Among "other", different sound, weak, slow, etc. type comments were made.

Almost 44% of the participants said that they had had at least one or more failures in their telephone service. 70% of those had no more than 2 failures. However 23% indicated that they had had more than 5 failures up to that time. (Later in the trial the major source of troubles was identified to be the SEU which ultimately was corrected as has been indicated in other chapters of this report. It also was identified later on that about a dozen locations were causing most of the troubles. The SEU's at those locations were first equipped with protective devices in December 1982 which reduced the number of failures for all three services significantly.)

10.3.2.3 <u>Reaction to the Cable Television and FM Radio Services</u>

Of the 128 trial participants which responded to the survey, 114 had connection to the cable TV service. The 14 respondents who did not subscribe to this service were locations that did not have television sets, which includes almost all business subscribers. 78% of the trial participants using this service had one or two TV sets. In 14% of these locations participants had simultaneous access to two channels.

The participants weekly viewing time was reported as follows:

Weekly Viewing Time (Hours)	% of Respondents
None	1.0
1 to 10	6.1
11 to 20	7.0
21 to 30	15.8
31 to 40	17.5
41 to 50	19.3
Over 50	33.3

The preference of TV stations was as follows:

Station Designator and Affiliation	% of Respondents
CKND (Independent, Winnipeg, Canada)	17.9
CKY (CTV, Winnipeg, Canada)	17.2
KXJB (CBS, Valley City, U.S.A.)	13.6
WDAZ (ABC, Devil's Lake, U.S.A.)	12.9
KTHI (NBC, Fargo, U.S.A.)	11.8
CBWT (CBC - English, Winnipeg, Canada)	10.0
CBWFT (CBC - French, Winnipeg, Canada)	4.3
KGFE (PBS, Grand Forks, U.S.A.)	2.5
All Channels equal	9.7

Prior to the trial the participants could receive only the Canadian television stations.

A large majority of the participants felt that the quality of TV reception for the Canadian stations was equal to or better than before the trial:

Quality of Reception	% of Respondents
Better	48.2
Same	37.7
Worse	10.5
No Response	3.5

43% of the respondents indicated that they had experienced troubles with the reception. 57% had had no problems. Most of the problems were described as "Snowy Picture" (42.7%) and "Audio Problems" (23.2%). There was also an indication that most of the troubles were associated with the stations KXJB (45.7%) and KTHI (20.3), both U.S.A. channels which were made available through the Inter-City Broadband Network (ICBN). It is likely that these troubles were due to transmission difficulties at the off the air pick-up point because of its distance from the T.V. transmitters.

Only a few of the participants were actually using the FM-Radio service (23.4%). 92% of the users felt that the quality of their reception was equal or better, compared to the quality before the trial. The reasons for this favourable reaction were given as "less-interference" and "less drifting of signal".

10.3.2.4 <u>Reaction to the Telidon Service</u>

The reaction to this new service was generally very positive. The service was being used regularly. Most of the participants did not have any difficulty in learning how to access and use the system. Most of the terminal and data base features were found to be satisfactory. In the following the more important reactions will be discussed in some detail.

88% of the respondents used the service between 1 to 20 hours per week:

Weekly Hours of Use	% of Respondents
None	3.3
1 to 10	68.2
11 to 20	19.5
21 to 30	4.9
31 to 40	3.3
Over 40	0.8

Most frequent usage of Telidon by household members showed following distribution:

Most frequent Usage by	% of Respondents
Children	52.8
Adult Males	19.5
Adult Females	10.6
All household members the same	13.8
No response	3.3

The most frequently used information categories were reported as follows:

Information Category	% of Respondents
Games	32.8
Community Information (weather, news, etc)	25.2
Entertainment/Lifestyle Information	16.1
Agricultural Information	10.0
Educational Information (Cybershare)	9.1
All Others	6.8

Comments made with respect to the ease of learning to use Telidon indicate that respondents found it generally easy to learn (70.6%), with only some (20%) indicating that it required some effort. 3.4% of the respondents found Telidon difficult to learn and 5.9% did not learn to use it at all for various reasons. The preferred methods for learning were said to be an "Instruction Manual" (36.0%) followed by "Demonstration" (29.0%).

Detailed comments were solicited on some of the features of the Telidon hardware and software. Details of these responses are contained in the survey report.[10.2] A summary of these findings is given below:

Feature	Qualification	% of Respondents
Access into the Data Base	Easy	75.6
Use of Index System	Easy	84.0
Screen Size	No improvement needed	95.0
Use of Keyboard	Easy	87.4
Display Print Size and Clarity	No improvement needed	91.6
Display Pictures	No improvement needed	82.4
Length of Time to Reach Data Base	No improvement needed Could be improved	36.1 58.8
Type of Information Available	No improvement needed Could be improved	46.2 48.7

The only feature that received a clearly unfavourable reaction was the time required to reach the data base. Comments with respect to information that was available was not unexpected, since the variety and depth of the information available at that time was still relatively small compared with the size it did reach by the end of the trial.

Without stating any price level, respondents were also asked whether they would be willing to pay for the Telidon service if it were not free. Only 5% indicated that they would definitely pay and another 36.1% said that "maybe" they would pay.

10.3.2.5 Reaction to Possible Services not included in the Trial

Since this delivery network and similar future integrated services networks have the capability of delivering additional services simultaneously to the subscribers, for future service planning purposes, participants were asked to indicate, from a list of possible service offerings, the ones in which they would be interested. Respondents were allowed to make multiple choices. The five most desirable services are shown below:

Service	% of Respondents
Fire Alarm	80.5
Burglar Alarm	71.1
Print-out from Telidon	57.8
Pay-TV	55.5
Messaging	52.3

A number of other services also received relatively high interest (in the mid 40% range), but, obviously the greatest interest was for alarm services.

10.3.3 November 1982 Survey

The objective of the third survey was to probe in detail the level of satisfaction with the Telidon service. In particular the following areas were investigated:

i) Identify general satisfaction with the level of Telidon service.

ii) Identify any current or potential Telidon system problems.

iii) Verify previous responses to Telidon system software and hardware questions.

iv) Determine reactions to Telidon system data bases in some detail.

v) Determine participants' opinions regarding the desirable evolution of the Telidon system.

vi) Determine participants' perceptions of whether/how Telidon has affected their lifestyles.

Since, again this information was to help the trial sponsors to determine positive and negative aspects of the Telidon service, there was no need to include any control groups in the survey.

The survey was conducted over the telphone between November 1st and 6th, 1982, by administering a questionnaire by the telephone interview technique.

At the time of the survey there were 144 actual field trial participants. Only 123 interviews were completed. 5 questionnaires were only partially completed and were therefore discarded. The remaining 16 participants could not be interviewed for various reasons. The response rate amounted to 85%. The questionnaire which was administered in this survey was reviewed by all organizations sponsoring the trial, before its finalization.

An attempt was also made to categorize participants with respect to the amount of their use of the Telidon service in order to find out whether their opinion to the various aspects of the service would be distinctly different. The different usage categories were distributed over the total of users as follows:

Usage Category	% of Respondents
Light	35.0
Medium	31.7
Heavy	33.3

As it turned out in most cases no distinguishing differences appeared between the different users of the Telidon service. In instances were differences did appear, these will be pointed out.

Overall the survey respondents showed a high degree of satisfaction with the Telidon service and its various aspects. In the following the more important statistical results of the survey are listed. The complete results and associated details are contained in the survey report [10.3] which is available on request from DOC or MTS.

10.3.3.1 General Reactions to the Telidon Service

Most of the respondents indicated a general satisfaction with the service:

General Like or Dislike	% of Respondents
Yes (Like)	85.4
No (Dislike)	8.1
No Opinion	4.9
Not Applicable	1.6

Only 22.5% of the respondents commented on their general likes and dislikes. Dislikes were mostly associated with system and hardware problems or difficulty of understanding how to use the system.

Several questions were also asked in order to determine the trial participants degree of satisfaction with the two different Telidon services and data bases. Generally a significant higher satisfaction was felt with the service provided by Infomart.

General Satisfaction	% of Respondents	
	Infomart	Cybershare
Yes	96.7	63.4
No	3.3	11.4
No Opinion	0.0	18.7
Not Applicable	0.0	6.5

The response with respect to the reliability and usefulness of each of the data bases showed a similar pattern compared to the response on general satisfaction.

Respondents were also asked to describe the two services along several dimensions, with multiple responses being allowed. Both data bases received percentage wise almost identical descriptions:

Description	% of Total Responses	
	for Infomart	for Cybershare
Captivating	10.3	11.6
Informative	26.4	24.5
Useful	27.0	26.4
Entertaining	27.3	28.2
Distrupting	1.0	1.4
Addicting	7.0	7.4
None of the Above	1.0	0.5

10.3.3.2 Problems with the Telidon Service

Slightly more than half of the respondents indicated that they were encountering some problems with at least one aspect of the service. It is interesting to note that the heavy users indicated relatively more problems with the system than medium users and medium users more problems than light users, 63%, 54% and 49% respectively. The overall results are as follows:

Have System Problems	% of Respondents
Yes	57.7
No	37.4
No Opinion	4.9

The problems that respondents encountered, were in the categories as shown in the table below:

Type of Problem	% of Respondents with Problems
Access	72.1
Equipment	23.5
Information	0.0
Servicing	2.9
Not Applicable	1.5

Access appeared to be the biggest cause of problems with the service. Difficulty to get on the data base, rejection of pass words, access difficulties at certain times in the week were some of the comments made by the respondents.

10.3.3.3 System Features

The survey included questions on several features of the hardware and software of the system. These had also been asked during the second survey in February 1982. For easy comparison purposes the results of the third survey are presented side-by-side with those of the second survey:

Feature	% of Respondents		Comments
	2nd Survey	3rd Survey	
Access Method	75.6	61.0	Easy
Index Use	84.0	76.4/55.3*	Easy
Keyboard	87.4	80.0	Satisfactory
Screen Size	95.0	----	Satisfactory
Display Print Size	91.6	83.8	Satisfactory
Display Pictures	82.4	61.0	Satisfactory
Access Time	58.8	45.5	Could be improved

* The higher figure corresponds to the Infomart data base and the lower figure to the Cybershare data base.

Most of the features received also in this survey a high degree of positive comments, although they were all lower as compared to the second survey. Satisfaction with access time was still marginal in the third survey, although it received less negative comments compared to the third survey. Similarly when asked about suggestions for improvement with respect to displayed pictures 80% of the respondents mentioned speed of picture build-up. It is interesting to note, that speed still appeared to rank as a major problem with the users, despite the fact, that data transmission for this trial was at 4.8 kb/s, which is four times the speed that is provided to regular Telidon users connected through the telephone network via twisted copper pair lines. The speed problem is obviously not due to transmission capacity but rather due to the speed of processing by the decoder. More recent decoders have greatly alleviated this problem.

At the start of the trial all trial participants had received a standard "QWERTY" keyboard. Prior to the third survey 15 Telidon users received a significantly smaller experimental "A to Z" keyboard. Of the 15 trial participants who had a new keyboard, 4 did not use it and 2 were not available for comments. Comments by all users on several features of the standard and new keyboard are listed below:

Keyboard Feature	% of Respondents		Comments
	Overall	New Keyboard	
Size	74.8	56.6	About Right
Weight	78.9	100.0	About Right
Labelling of Keys	57.7	44.4	Very Clear
Labelling Problems	80.5	77.7	No Problems

33.3% of the new keyboard users found that the size was too small. Such a comment may not be too much of a surprise considering that 72.4% of all users knew how to type before they used Telidon, and might, therefore, have expressed indirectly a preference for a standard keyboard. With respect to labeling an additional 30% found the labelling of keys "All Right" which leaves only a relatively small number of users unsatisfied with the labelling.

10.3.3.4 Usage of Telidon Services

In this section the results of the survey with respect to amount of use, the age and gender of the users and the use made of the various Telidon service categories will be summarized. Where appropriate the results of the third survey will be shown side-by-side with the results of the second survey for easy comparison.

Amount of use experienced some changes overtime as shown below:

Weekly hours of Use	% of Respondents	
	2nd Survey	3rd Survey
None	3.3	1.6
1 to 10	68.3	82.1
11 to 20	19.5	11.4
21 to 30	4.9	4.1
31 to 40	3.3	0.8
Over 40	0.8	0.0

Although the general distribution remained essentially the same, a much higher concentration occured in the 1 to 10 hour category.

There was also a change in the most frequent usage pattern by household members:

Most Frequent Usage by	% of Respondents	
	2nd Survey	3rd Survey
Children	52.8	43.4
Adult Males	19.5	30.3
Adult Females	10.6	23.7
All household members the same	13.8	2.6
No response	3.3	0.0

Although children were still ranking as the most frequent users, there was a significant increase in the adult male and female user categories.

The available services on the two data banks were grouped into seven categories:

Agriculture Information
Community Information
Consumer Information
Teleshopping
School Courses
Electronic Games
Messaging

Community Information encompased news, weather, sports, entertainment information, restaurant guide and travel information.

Consumer Information inculded the sub-categories of consumer information, consumer agencies, money matters, health and nutrition, home improvement and classified ads.

The various categories of Telidon services were used as follows:

Telidon Service	% of Respondents
Agriculture Information	28.2
Community Information	79.7
Consumer Information	42.3
Teleshopping	58.5*
School Courses	26.0
Electronic Games	93.5
Messaging	50.4

* This represents the percentage of respondents who had viewed this service. Actually only two respondents had made any purchase representing 2.8% of those who had viewed this service.

The most used community information categories were weather, news, entertainment information and sports which were used by 79.6%, 52.8%, 46.5% and 45.5 % of all the respondents respectively.

The most used consumer information categories were Health and Nutrition, and Classified Ads which were used equally by 48.1% of all respondents.

Various Telidon service categories were used more often by different user groups. The predominate user group for each service category is listed below:

Telidon Service	Predominate User Group	
Agriculture Information	Adult Male	82.9%
Community Information	Adults	63.3%
Consumer Information	Adults	73.2%
Teleshopping	Adult Female	34.7%
School Courses	Children	53.1%
Electronic Games	All about equal	
Messaging	Male Children	21.0%*

* The predominance was rather weak. Male and Female Adults and Female Children were mentioned 12 - 14% of the time as well as all residents.

In the actual survey, the "Adult" and "Children" groups were further subdivided into the "Male", "Female" and "All" subgroups. However, in the above table, when neither subgroup was predominate, but the group as a whole was, the subgroup percentages were totaled under "Adults" or "Children" groups as appropriate.

For most of the services (Agriculture, Community and Consumer information, Teleshopping and School Courses) there were also the questions asked whether additions were desired or some of the information could be eliminated, whether the graphic images were useful to compliment the information and whether the information was current and accurate. Usually no comments were made with respect to any additions, but most of the respondents felt that nothing should be eliminated. "Useful" or "Nice, but not necessary" was the answer by most of the respondents with respect to the usefullness of graphic images. Most of the respondents were also satisfied that the information presented was current and accurate.

74.5% of the respondents who had used the Agriculture Information rated it from "Somewhat useful" to "Very useful". Similarly 70.3% of the respondents who had used the School Courses rated them as useful. Messaging was also rated by 83.9% of those who had used it as useful. Messaging was not heavily used. Close to 70% of those who had used messaging indicated that their use was only "Seldom" to "Sometimes".

Both Infomart and Cybershare offered School Courses and Electronic Games. Infomart's offered courses and games were prefered over those offered by Cyhershare. School Courses of Infomart and Cybershare were used by 84.4% and 59.4% of the participants respectively. Similarly Electronic Games of Infomart and Cybershare were used by 93.5% and 75.6% of the participants respectively. Most users wanted to see new games introduced at a regular basis. The suggested rate of introduction of new games was monthly.

10.3.3.5 Effect of Telidon on Lifestyle

A majority of the respondents indicated that the introduction of Telidon service had very little effect on their lifestyle:

Effected Area	Response	% of Respondents
Daily Routine	No	84.5
Watching TV	Same	75.6
Reading	Same	90.2
Listening Music	Same	88.6
Going Out/Socializing	Same	91.6

Most of the respondents also indicated that they did not rely very much on Telidon as a source of information.

10.3.3.6 Evaluation of the Telidon System

Respondents to the survey also provided answers and opinions on the importance of Telidon in the future as well as the degree of importance of the services offered through the system. 93.5% of the respondents felt that Telidon would be an important part of the future.

The future importance of the seven services offered were indicated as follows:

Service	Importance Level by % of Respondents			
	Very Important	Important	Not Important	No Answer
Agriculture Info.	56.1	30.9	8.1	4.9
Community Info.	22.8	53.6	17.9	5.7
Consumer Info.	23.6	54.5	16.2	5.7
Education Info.	58.5	29.3	8.1	4.1
Teleshopping	13.8	29.3	51.2	5.7
Games	22.8	46.3	26.8	4.1
Messaging	23.6	43.1	26.8	6.5

The most important service was felt to be education followed by agriculture.

Almost 40% of the participants felt that some improvements were needed for the commercial success of Telidon. However a large percentage (60%) either had no opinion or felt that no improvements were required.

10.3.3.7 Pricing of the Telidon Service

Based on what people were receiving from the Telidon service they were asked whether they were willing to pay for this service. Only 15.4% responded affirmative, whereas 43.9% indicated that they would not and 40.7% were undecided.

Participants were also asked what price they would consider to pay for hardware and usage. For hardware a range between $300 to $1200 was given and for usage a monthly charge from $1 to above $50. The lowest price ranges were indicated most often.

For hardware 54.4% and 22.8% chose the ranges $300-$500 and $500-$800 respectively. For monthly usage charges 39.9% and 26% indicated the ranges $1 - $9 and $10 - 19 respectively.

Several features were presented to the participants to elicit their view on which of these would increase the value of Telidon most. "Printout Capability" and "More Ability to Input Info. into the Telidon" were equally often mentioned by 53.7% of all Respondents as being the most important features to increase the value of Telidon. Next mentioned, were "Expanded Info. Base" (48.7%) and "Electronic Banking" (43.1%).

10.3.4 <u>April 1983 Survey</u>

The objectives of this survey were:

i) Establish a "time-budget" for households at the end of the trial for trial participants, non-trial participants in the Elie - St. Eustache area and of a control group located at St. Anne/Niverville.

ii) Compare with the data available from the first survey in September 1981, or with data from any other source.

iii) Verify that problems indicated in previous surveys have been eliminated.

In order to make an accurate comparison between the conditions before and after the trial, ideally the same questionnaire that was used in the September 1981 survey should have been administered in this survey. However, since the first survey was done by an other company, for copyright reasons exactly the same questionnaire could not be used. Furthermore the same households and persons that were interviewed in the first trial should have been interviewed. Unfortunately this was not possible either for the two control groups in the Elie - St. Eustache and St. Anne/Niverville area. However, it is believed that inferences can be drawn between the two surveys, since the information sought in both surveys is similar and the control groups were selected randomly.

Since in the first survey questions were directed to individuals, rather than households, in order to allow for comparison, the same approach was also taken in this survey.

The survey sample sizes were as follows:

Field Trial Participants	119
Non-Participants in Elie - St. Eustache	59
Control Sample in St. Anne/Niverville	136

The sample sizes indicate the number of interviews that could be completed. The low number of completed interviews with non-participants in Elie - St. Eustache was due to significant resistance to being interviewed by this group.

The full details of this survey [10.4] are available from DOC or MTS on request. Only the most important findings are summarized here. Although results are available for all three groups, again as was done for the first survey, only the results for the actual trial participants are shown here, since this is of greatest interest for this trial.

10.3.4.1 Pre- and Post-Trial Activity Comparison

One of the questions asked was to determine the amount of time spent on various activities. The results are shown side by side with those from the survey of September 1981:

Activity	Hours/Week	
	Sept. 1981	Apr. 1983
Watching TV	17.1	20.4
Listening to AM Radio	13.9	13.2
Listening to FM Radio	12.9	7.3
Entertaining Company at Home	8.3	4.7
Reading Books	7.0	3.5
Visiting Friends at Home	6.7	5.1
Hobbies, Crafts	6.5	3.6
Participating in Sports	5.0	2.1

The only activity where there was an increase in time spent, was watching TV. This was also observed for the two control groups. The time spent on all other activites decreased.

The frequency of doing certain activities regularly is shown below:

Activity Regularly Done	% of Respondents	
	Sept. 1981	Apr. 1983
Follow Weather Reports	82.0	85.7
Listen to Radio News	64.0	54.6
Watch the Late Evening News on TV	58.0	53.8
Watch the Early Evening/6 o'clock News on TV	53.0	55.5
Read a Newspaper	49.0	64.7

Only two major changes occured and these were with respect to listening to radio news and reading a newspaper.

The most preferred or enjoyed TV programs were:

Type of Program	% of Respondents	
	Sept. 1981	Apr. 1983
News	78.0	69.0
Movies	71.0	62.2
Comedies	66.0	46.2
Sports	57.7	39.5
Specials	44.0	31.1
Educational	42.0	29.4

The rank ordering did not change in both surveys, but the preferences for all types of programs dropped. Furthermore preference for drama which was only 28% in Septemer 1981 and therefore ranking quiet low was preferred by 37.0% of respondents, which puts it in 5th place in the rank ordering.

According to the two surveys, the preferred TV stations were ranked as follows:

Station Identifier/Affiliation	% of Respondents	
	Sept. 1981	Apr. 1983
CKY/CTV, Winnipeg	29.0	12.6
CKND/Independent, Winnipeg	27.0	26.9
CBWT/CBC-English, Winnipeg	21.4	18.5
CBWFT/CBC-French, Winnipeg	10.9	2.5
WDAZ/ABC, Devil's Lake	4.0	4.2
CKX/CTV, Brandon	3.2	16.0
KTHI/NBC, Fargo	2.4	7.5
KXJB/CBS, Valley City	1.6	5.9
No Response/Opinion	0.5	5.9

Station CKX was included in the survey, although it was not provided over the cable TV system, but was available only Off-Air. On the other hand station KGFE of PBS, which was provided on the cable-TV system, was not included in the survey.

The surveys indicate that there was a shift in station preference over the 18 month period. In the April 1983 survey, station CKND moved to first place replacing CKY which was in first place in the September 1981 survey. In subsequent sections these preferences will be compared to those obtained from actual usage data collected over the trial period.

The respondents indicated also their most preferred or enjoyed radio programs:

Type of Program	% of Respondents	
	Sept. 1981	Apr. 1983
Music	78.0	70.6
Local News	73.0	----
National News	64.0	52.9
World News	61.0	70.6
Sports	37.0	12.6
Farm News	34.0	17.6

Most preferred or enjoyed programs on radio remained music followed by news, although there was a decrease in the degree of preferences.

To complete the comparison, again questions were asked with respect to subscription to printed media. The subscription rate to newspapers rose from 69.0% in September 1981 to 81.5% in April 1983 for the trial participants. Increases were also observed for the control groups.

The most subscribed to newspapers were:

Newspaper	% of Subscribers	
	Sept. 1981	Apr. 1983
Winnipeg Free Press	88.0	72.3
Manitoba Co-operator	18.0	4.2
La Liberté	15.0	5.0
Portage Leader	6.0	----

Although more people did subscribe to a newspaper the subscription rate for each newspaper dropped. A similar observation was also made for the control groups.

63% of the trial participants were subscribing to one or more magazines in April 1983. The most popular magazines were:

Magazine	% of Subscribers	
	Sept. 1981	Apr. 1983
Reader's Digest	29.0	22.0
Country Guide	24.0	7.8
National Geographic	21.0	2.6
Chatelaine (English)	15.0	18.2
T.V. Guide	15.0	1.3
Time	14.0	1.3
Macleans	11.0	1.3
Farm Light and Power	10.0	—
Good Housekeeping	10.0	—

Reader's Digest remained the most popular magazine. One note of caution is required in this comparison. In the 1981 survey the question asked whether the people read or subscribed to any of the mentioned magazines, whereas the 1983 survey asked only whether they subscribed to any of these magazines. The drop in the percentage rate may therefore be due to the difference in the asked question.

In this survey again the question was asked, which the primary and secondary sources were for a variety of information. Only the major primary sources are shown here. Details are included in the survey report [10.4]. A comparison with the September 1981 survey allows the identification of whether a change in these sources did occur due to the introduction of cable-TV and particularly Telidon.

Television	
September 1981	April 1983
News Stories of the day	News Stories of the day
Sports Scores	Sports Scores
Local News Stories	- - - - - - -
Economic Trends	Economic Trends
Consumer Assistance, Advice	Consumer Assistance Advice
Acquiring Information to Increase Knowledge of Specific Subject Matter (Equal with Winnipeg Newspaper)	- - - - - - -
News and Disease Outbreaks in the Area	- - - - - - -
World Trends in Agriculture Production	- - - - - - -
Information on Disease Control	- - - - - - -
____________	World News Information
____________	Weather (National)
____________	National News Information
____________	Agricultural News Bulletins (Equal with Radio)

Radio	
September 1981	April 1983
Weather	Weather (Local)
Stock Market (Equal with Winnipeg Newspaper)	- - - - - -
Agricultural Commodity Markets	- - - - - -
Livestock, Cattle for Sales (Equal with Farming Newspaper)	- - - - - -
Livestock Market Selling Prices	- - - - - -
Information on Grain Contracts (Equal with Farming Newspaper)	- - - - - -
- - - - - -	Local News Stories
____________	Agricultural News Bulletins (Equal with Television)

Winnipeg Newspaper	
September 1981	April 1983
What's on Television	What's on Television
News on Sales in Local Stores	- - - - - - -
Stock Market (Equal with Radio)	Stock Market
Travel News and Information	- - - - - - -
Financial Information Required for Business	Financial Information Required for Business
Available Government Services	- - - - - - -
Acquiring Information to Increase Knowledge of Specific Subject Matter (Equal with Television)	- - - - - - -
Information on Entertainment and Fun	Information on Entertainment and Fun
Used Machinery for Sale	- - - - - - -
Automobiles for Sale	Automobiles for Sale
Machinery Parts for Sale	- - - - - - -
Labour for Hire	- - - - - - -
News on Major Grain Sales	- - - - - - -
New Agricultural Techniques	- - - - - - -
Local Entertainment/Social Activites/Events	- - - - - - -

Farming Newspaper	
September 1981	April 1983
Feed/Hay for Sale	Feed/Hay for Sales
Livestock, Cattle for Sale (Equal with Radio)	Livestock, Cattle for Sale
Price and Availability of Fertilizers	Price and Availability of Fertilizers
Price and Availability of Insecticides and Sprays	- - - - - -
New Crops	New Crops
- - - - - -	Used Machinery for Sale
- - - - - -	World Trends in Agricultural Production

Telidon	
April 1983	Previous Source in September 1981
Agricultural Commodity Markets	Radio
Travel News and Information	Winnipeg Newspaper
Livestock Market Selling Prices	Radio
Information and Grain Contracts	Radio/Farming Newspaper

The list indicates, that some changes did occur for some of the information categories with respect to their primary sources. Dashed bars in the survey columns indicate that the corresponding item mentioned in one survey had a different primary source in the other survey. In some instances the mentioned source is other than the four sources listed here. These additional sources are listed in both the September 1981 as well as in the April 1983 Survey [10.1, 10.4]. A horizontal continuous bar in each of the columns indicates that the information category mentioned in one of the surveys was not included in the questionnaire of the other.

As the April 1983 survey shows, the primary source for some information categories became Telidon. In the second column of that table the primary source that was mentioned in the September 1981 survey is shown.

For some information categories, although not mentioned most often as the primary source, Telidon still appeared as the second and third most often mentioned source. Such information categories were:

Weather
Financial Information Required for Business
Information on Entertainment and Fun
Labour for Hire
Information on Disease Control
World Trends in Agriculture Production
New Crops
Agricultural News Bulletins

As was to be expected knowledge about videotex and Telidon did increase as a result of the trial:

Read, Heard, Seen About	% of Respondents	
	Sept. 1981	Apr. 1983
Telidon	72.0	--
Grassroots	21.0	94.1
Videotex	20.0	31.9
Infomart	16.0	--
No Opinion	26.0	--

At the end of the trial some perceptions on Telidon and general reactions to it did change with respect to the pre-trial September 1981 survey.

Reaction to Trial	% of Respondents	
	Sept. 1981 (Expected)	Apr. 1983 (Actual)
Positive Experience	91.0	70.6
Negative Experience	2.0	3.4
Neither Positive nor Negative	5.0	24.3
No Response/Opinion	2.0	1.7

The actual frequency of use of Telidon did drop significantly from the orignial expectations:

Frequency of Using Teldion	% of Respondents	
	Sept. 1981 (Expected)	Apr. 1983 (Actual)
Every Day	70.0	12.6
Almost Every Day	--	16.0
Several Times/Week	23.0	21.9
Once per Week	5.0	20.1
Less than Once/Week	--	27.7
No Response/Opinion	2.0	1.7

Similarly it appears that the trial participants expectations with respect to Telidon being an improvement over other information sources also dropped significantly:

Perception of Telidon Information	% of Respondents	
	Sept. 1981 (Expected)	Apr. 1983 (Actual)
A Big Improvement Over Other Information Sources	64.0	22.7
Some Improvement Over Other Information Sources	30.0	36.1
A Little Improvement Over Other Information Sources	4.0	16.0
No Improvement Over Other Information Sources	1.0	21.0
No Response/Opinion	1.0	4.2

10.3.4.2 Effect of Telidon on Lifestyle

Once again, as in the November 1982 survey, trial participants were asked what effect, if any, the Telidon service had on their lifestyle. The question was asked somewhat differently than in the November 1982 survey. The purpose was more to find out some qualitative perceptions, rather than quantitative statements such as the amount of time spent on other activities.

Effect of Telidon on Lifestyle (Comments)	% of Respondents
No Effect on Lifestyle	25.2
Children Enjoyed Services/Trial Good For Children	9.9
Do Not Use	4.4
Like the Cable Television and Private Telephone	3.3
Good Information Source	9.9
Interesting	2.2
Trial was Good/Improvement/Advantageous	15.4
Increased Interest in Computers	2.2
Difficult/Hard to Say	6.6
Effect on Business	4.4
Needs Improvement/Expansion of Data Base	4.4
Other	4.4
No Comment	7.7

Except that 25% of the respondents felt Telidon did not have an effect on their lifestyle, no other comments indicate to any common strong opinion.

10.3.4.3 <u>Evaluation of the Telidon System</u>

Trial participants were, as in the November 1982 survey, again asked to comment on the importance of several possible future enhancements to the Telidon system and services. As in the February 1982 survey, also opinions were solicited with respect to the importance of several services not provided in the trial. The combined results are shown below:

Service or Enhancement	Importance Level by % of Respondents			
	Very Important	Important	Not Important	No Answer
Printout Capability	26.1	36.1	35.3	2.5
Electronic Mail/ Messaging	16.0	40.3	41.2	2.5
Electronic Banking	15.1	30.3	52.9	1.7
Fire Alarm	66.4	21.9	10.1	1.7
Burglar Alarm	68.1	21.0	9.2	1.7
Pay TV	9.2	22.7	66.4	1.7
Expanded Info. Base	31.9	38.7	26.9	2.5
Expanded Teleshopping	8.4	19.3	70.6	1.7
More Ability to Input into Telidon	33.6	31.9	32.8	1.7

It is interesting to note that again, as in the November 1982 survey, the same three Telidon enhancements, namely "More Ability to Input into Telidon", "Expanded Info. Base" and

"Printout Capability" were regarded as the most important. In terms of new services, that were not provided in the trial, again "Fire Alarm" and "Burglar Alarm" were indicated as being the most important by a large percentage of the respondents. As a matter of fact these two services outranked by a large margin all other enhancements and services.

10.3.4.4 Problems with Trial Services

The main purpose of asking the trial participants about the problems they had with the services, was to find out whether problems had been resolved during the trial period. Therefore one of the questions they were asked was whether at the time of this survey they had any problems, and the second was whether they had had any problems in the past:

Have Problems with the Services	% of Respondents	
	Apr. 1983	In the Past
Yes	33.6	66.4
No	63.0	31.9
No Response/Opinion	3.4	1.7

Whereas most of the respondents had had problems in the past, only one third still had some problems at the end of the trial.

Problems encountered in the past as well as at the time of this survey were very similar. One third of those who had problems were encountering access difficulties to the Telidon service and one third had malfunctioning equipment. The remainder cited problems such as "noisy connections", "blurred pictures", "inability to use equipment", "keys/keyboards" and also "incorrect billings", a problem which is unrelated to the trial.

Generally the trial participants expressed satisfaction with the resolution of their problems by the trial sponsors:

Satisfactory Resolution of Problems	% of Respondents
Yes	60.5
No	12.6
No Response/Opinion	26.9

10.4 Usage Statistics

As part of the need and desire to find out the trial participants actual usage of the two new services, namely cable-TV and Telidon, usage statistics were collected through facilities described in section 3.7. No usage data for telephone was collected since this was already a well established service on which sufficient usage data is available throughout the industry.

10.4.1 Cable - TV Usage

10.4.1.1 Collected Cable - TV Usage Data

The data collection system had the capability to monitor the use of each cable-TV channel by each user continuously. From such raw data, either for marketing or sociological research purposes many secondary statistics can be derived. During the trial period the following data was printed out:

1 - Channel usage by all subscribers for each half hour interval for each day

2 - Channel usage by all subscribers for each day

3 - Percent of total number of subscribers that were viewing television for each half hour interval for each day

4 - Percent of total number of subscribers that were viewing television each day

5 - For each subscriber viewing time and duration of each channel for each month.

In the latter data, subscribers are only identified by a code number in order to protect their privacy. This data could be used directly for billing purposes if any of the channels was to be used as a pay-per-view pay-TV channel. Also by associating this data with the program content of each channel at the time of viewing and the demographic data about that household, which is available from the pre trial user survey of Septemer 1981, a variety of sociological analysis is possible. No such detailed analysis has been done as of the time of writing this report, since this was outside the scope of this project. However the data, both in printed as well as in machine readable form, can be made available to interested researchers.

10.4.1.2 Analysis of Cable-TV Usage Data

From the available data a preliminary analysis was made to determine the preferred channels and compare this actual data with the users perception as indicated in the September 1981 and April 1983 surveys (see section 10.3.4.1). For this purpose three months were selected randomly (October 1982, December 1982, and March 1983). The most prefered channels are ranked from 1 to 8, with 1 indicating the most preferred channel. The results are shown together with the survey results below. The percentage figures in the surveys have also been replaced by rank order numbers, by replacing the highest pecentage with 1 and the lowest percentage with 8.

Station Identifier/ Affiliation	Survey Ranking		Usage Data Ranking
	Sept. 1981	Apr. 1983	
CKY/CTV, Winnipeg	1	4	2
CKND/Independent, Winnipeg	2	1	1
CBWT/CBC-English, Winnipeg	3	2	5
CBWFT/CBC-French, Winnipeg	4	8	8
WDAZ/ABC, Devil's Lake	5	7	6
CKX/CTV, Brandon	6	3	N/A
KTHI/NBC, Fargo	7	5	4
KXJB/CBS, Valley City	8	6	3
KGFE/PBS, Grand Forks	N/A	N/A	7

In the surveys the PBS station was not included and in the collected data the CKX station was not included since it was not provided on the cable system.

As can be seen there is not much consistency between the three sets of data. At best what can be deduced is, that the CTV network and independent station of Winnipeg appear to remain the most preferred stations throughout this period. One factor for this inconsistency can be attributed to the fact, that during the September 1981 survey only few subscribers had already been connected to the cable-TV system, with the majority therefore being unable to receive the four American TV network stations and thus obviously leaving those stations far less often mentioned.

The usage data allows also other observations to be made. The most preferred channels were usually viewed by 40% -50% of the viewing audience. During winter months more than 60% of all subscribers would be watching television during the evening hours. Peak viewing time was from about 18h to 23h in the evening. Although the recorded daily viewing audience built up was rather gradual, the drop-off after 23h was quite sharp. Overall it appears that no significant differences in viewing patterns have emerged from the collected data for these rural households compared to urban users.

10.4.2 Telidon Usage

10.4.2.1 Collected Telidon Usage Data

Telidon usage data was collected both by MTS and Infomart, but not by Cybershare. MTS's data was colleceted 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 MTS collected data provides a continuous record of each subscribers activities to access the data bases. The raw data provides information with respect to the users identity in coded form, which data base the user accesed, whether the access request was completed and thereby constituted a successful session as far as the data switch is concerned, whether the call was blocked because of unavailability of a trunk, and finally the real time a session started and ended.

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. For most of the trial period users were not required to use an individual account number or password to access the Infomart data base. Therefore from the Infomart data it is not possible to identify the user. The Infomart data could in principle have provided data about the most used information categories and pages by the trial participants. However since such data was collected for all users of the Infomart data base which included a continually increasing number of users of the commerical Grassroots service, it could not be used to gage the trial participants interests and consequently this data was not provided to the trial sponsors.

As has been described in subsection 7.1.7.4 there was a very high number of Telidon service connects and disconnects recorded by MTS. Many of these service requests were noticed also during midnight and 6h in the morning, a clear indication that a majority of these connects and disconnects were false. The discrepancy between the MTS and Infomart data was very high, varying by many factors. Since usually such false sessions were very short, in the final analysis, through software means, such sessions were eliminated from the statistics. After this correction there still remains a small discrepancy between the two sets of data, MTS' data generally yielding a higher number of sessions. It was expected that, even without any errors, the MTS data would yield a higher number of "sessions". The reason for this is, that what is considered to be a successful connection by the data switch does not guarantee that the user was indeed using the data base. Although the user may have been connected to a port of the data base host computer, if the user had not been able to actually "log on" it would not be recorded by the data base computer as a session. With these consideration it is therefore believed that the cleaned-up usage data is accurate enough to make meaningful interpretations.

Since Telidon service was a new service on which very little usage information was available, the raw data was, compared to the cable-TV data, much more extensively sorted and manipulated to print out information that could be used for future network and service planning purposes. From the Infomart data, the following statistics were printed out on a weekly basis:

1 - Daily total number of sessions
2 - Daily total number of page retrievals
3 - Daily total usage time

From the MTS data, the following primary statistics and data were printed out on a monthly basis:

1 - Number of sessions offered, connected and blocked or not completed for each data base for each half hour interval for each day
2 - For each subscriber, date, beginning time, ending time, and duration of each session, and name of database accessed.

In order to provide information which would be more meaningful for network traffic and systems planners additional aggregate statistics were generated and printed out.

The information which was generated separately for each of the two data bases is as follows:

From November 1981 to July 1983 for each month

1 - Histogram of the distribution of session lengths as a percentage of all sessions during the month.
2 - Histogram of the total number of sessions per day.
3 - The total number of sessions, the average daily number of sessions and their standard deviation.
4 - Histogram of the daily average session length and the monthly averge of session lengths.
5 - Histogram of the average number of sessions per hour.

Histograms for the period January 1982 to July 1983 of

6 - Average number of daily sessions for each week.
7 - Average session length for each week.
8 - Standard deviation from average number of daily sessions for each week.

There are minor and major gaps in the available data, due to occasional problems in collecting the primary data which effected parts of days or entire days.

10.4.2.2 Analysis of Telidon Usage Data

From the Infomart data, histograms of weekly number of sessions and weekly total number of page retrievals were drawn as shown in Figures 10.1 and 10.2 respectively. From these histograms it can be seen, that there appears to be an increase in usage during the winter months, in particular November to January. The December 1981 and January 1982 peak is larger than the peak for December 1982 and January 1983, which can probably be attributed to what is called "novelty effect". By comparing the two histograms in figures 10.1 and 10.2 it will be noticed that they show essentially a similar shape, which indicates, that

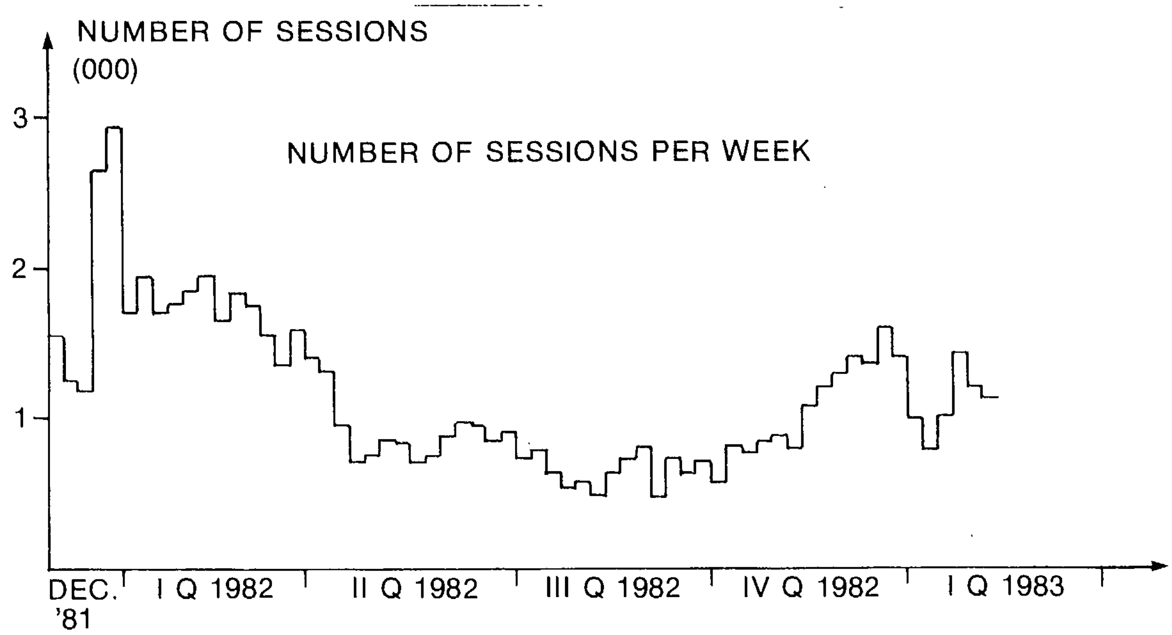


Figure 10.1 Histogram of the weekly number of sessions for the Infomart Telidon data base

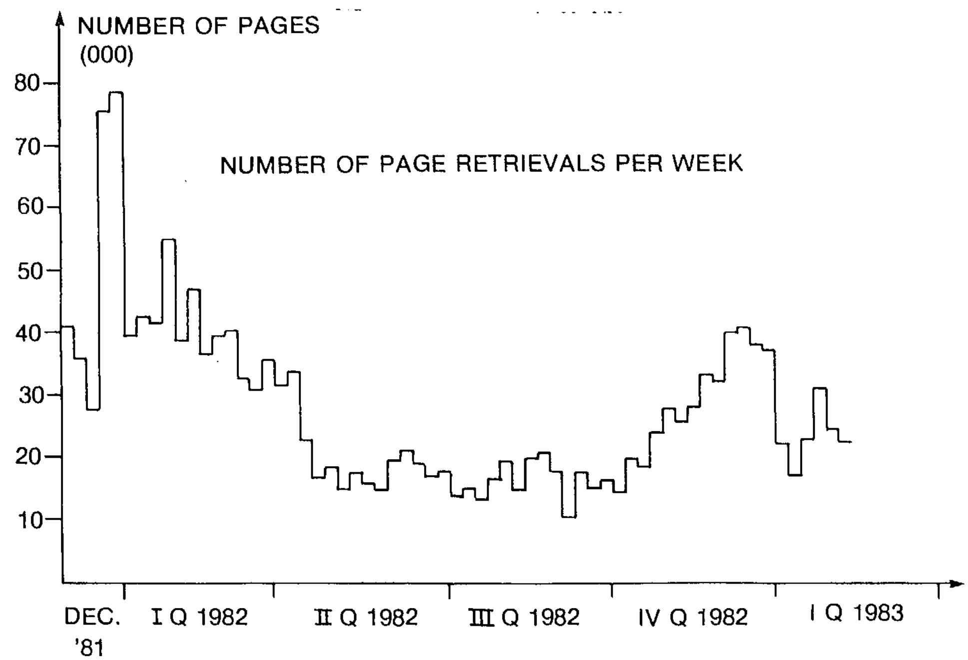


Figure 10.2 Histogram of the total number of page retrievals for the Infomart Telidon data base

the average number of pages retrieved per session was fairly constant. The average number of pages retrieved per session lies generally between 20 to 30 pages.

From the MTS collected data, histograms were drawn of the average number of sessions per day for each week of the usage of both the Infomart and the Cybershare data bases as shown in Figures 10.3 and 10.4 respecively. These histograms are very similar to the histogram in figure 10.1 and indeed show the same basic pattern of higher use in winter and less use in summer. As was mentioned before for some days or weeks data could not be collected and these appear as gaps in the histograms. From comparison of figures 10.3 and 10.4 it will also be noticed that the use of the Cybershare data base was only about 1/5 of that of Infomart. The low use of this data base and hence the much smaller usage data sample makes it more difficult to draw statistically accurate conclusions.

From the remainder of the MTS collected usage data, a variety of monthly usage statistics are presented. Here statistics for only two months will be presented to give an idea of the nature of these statistics. For this purpose August 1982 and March 1983 were selected. The criteria for selecting these two months were that one was a summer month and the other a winter month. Furthermore the data collection appeared to be most complete for these two months, thereby eliminating to a large extent the possibility of wrong conclusions due to gaps in the data. The data of other months have also been examined and no significant differences were observed.

Figure 10.5 shows the histograms of the daily number of sessions for the Infomart data base for the months of August 1982 and March 1983. The average number of daily sessions for the two months was 140 and 147 respectively. Figure 10.6 shows similar histograms for the Cybershare data base. The average number of daily sessions for August 1982 and March 1983 were 24 and 12

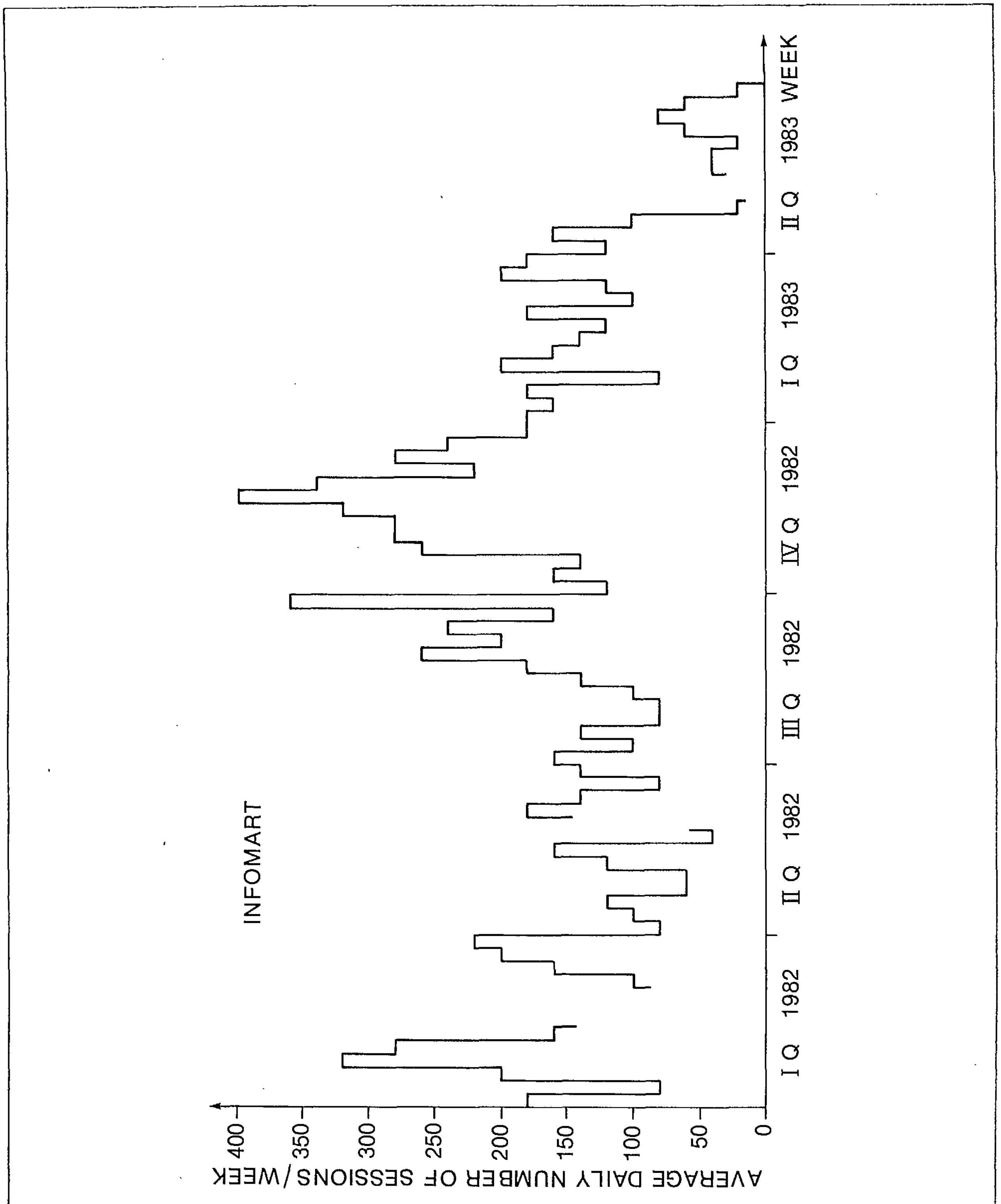


Figure 10.3 Histogram of the average number of sessions per day for each week for the Infomart Telidon data base

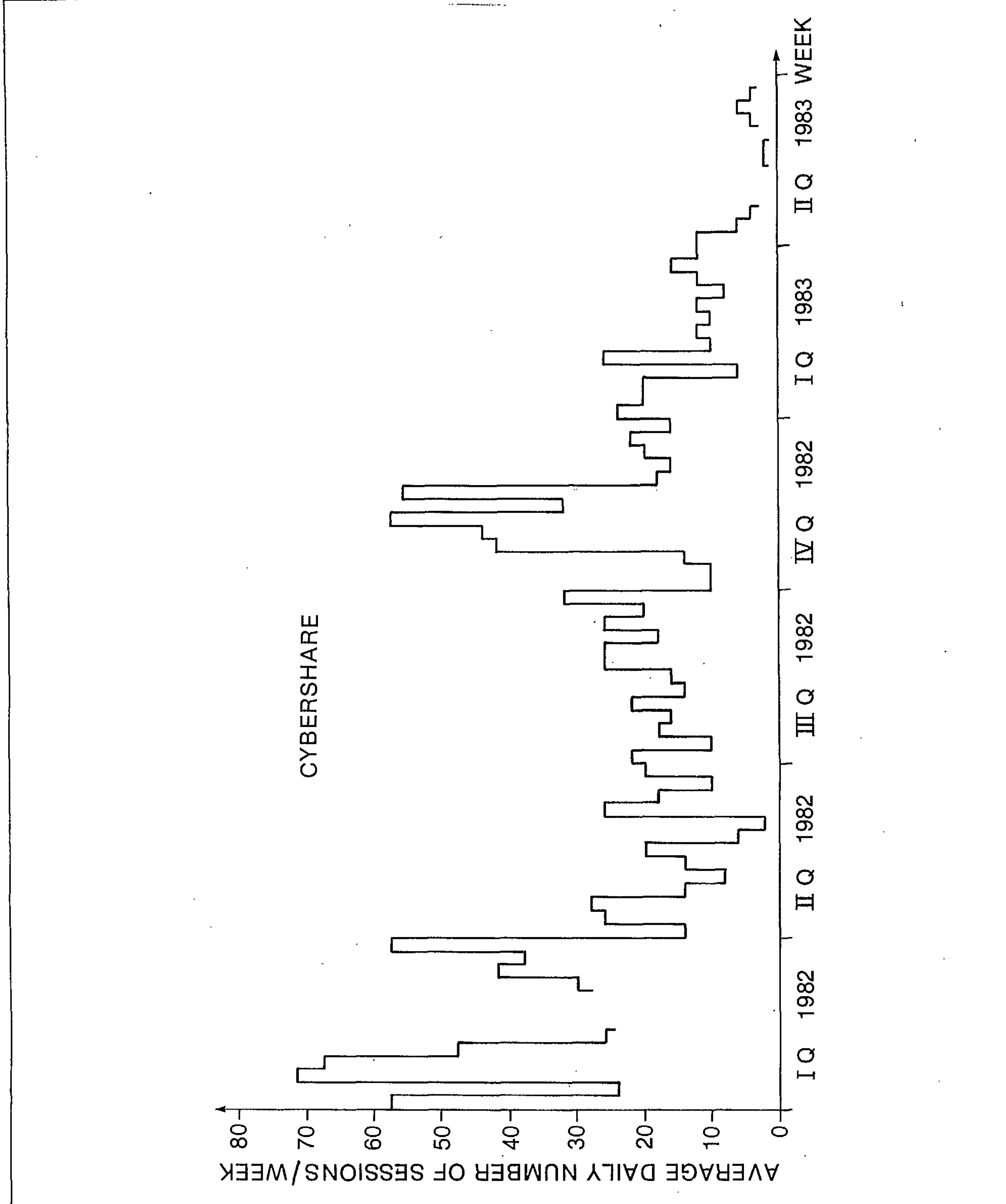


Figure 10.4 Histogram of the average number of sessions per day for each week for the Cybershare Telidon data base

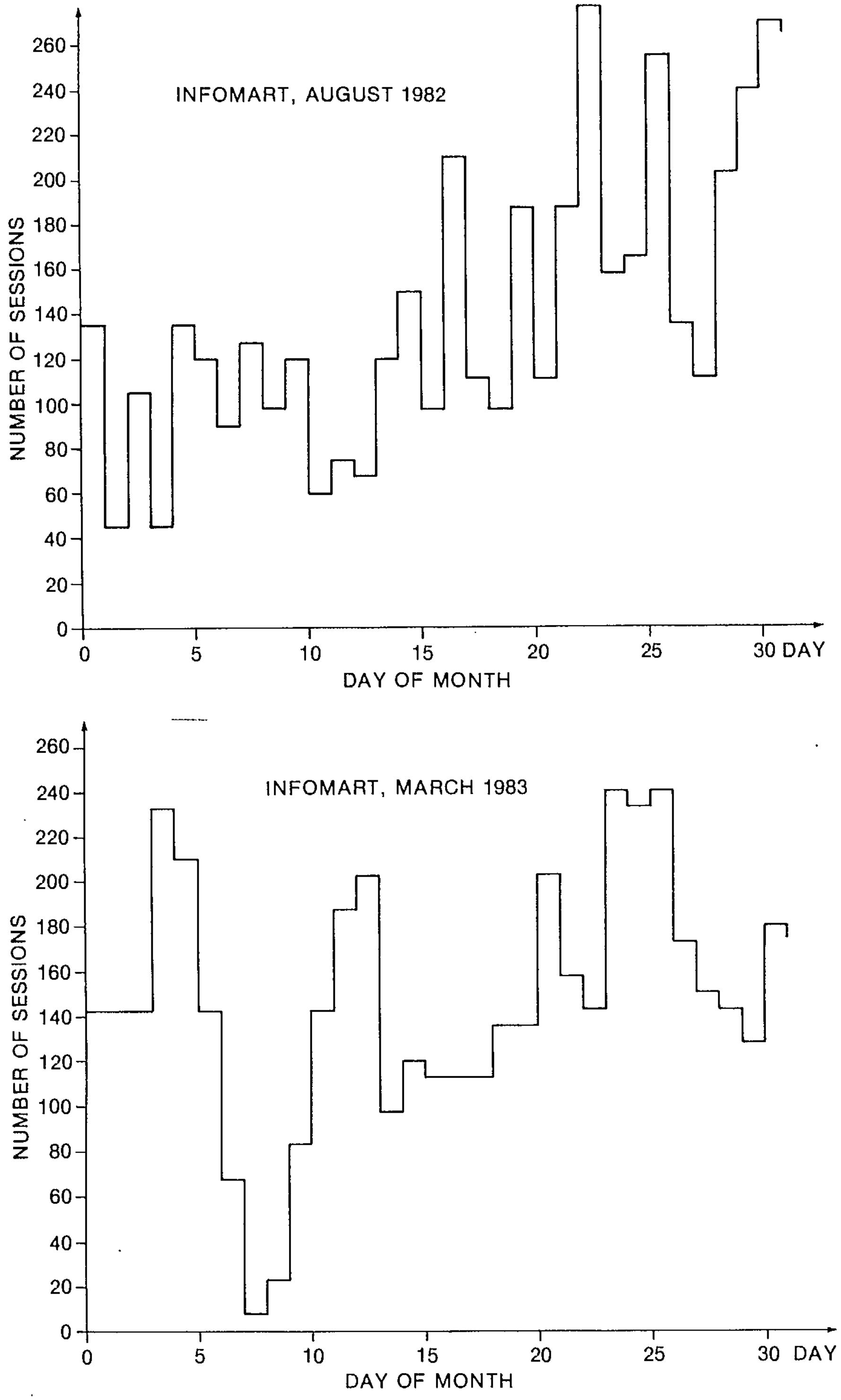
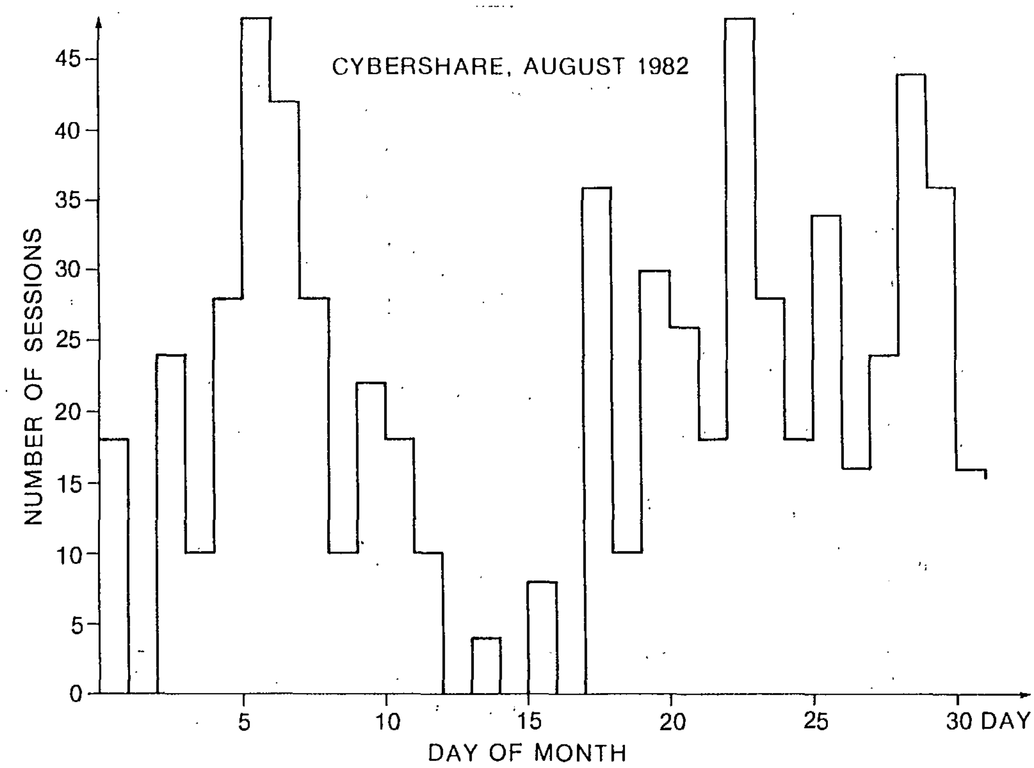


Figure 10.5 Histogram of the daily number of sessions for two months for the Infomart Telidon data base



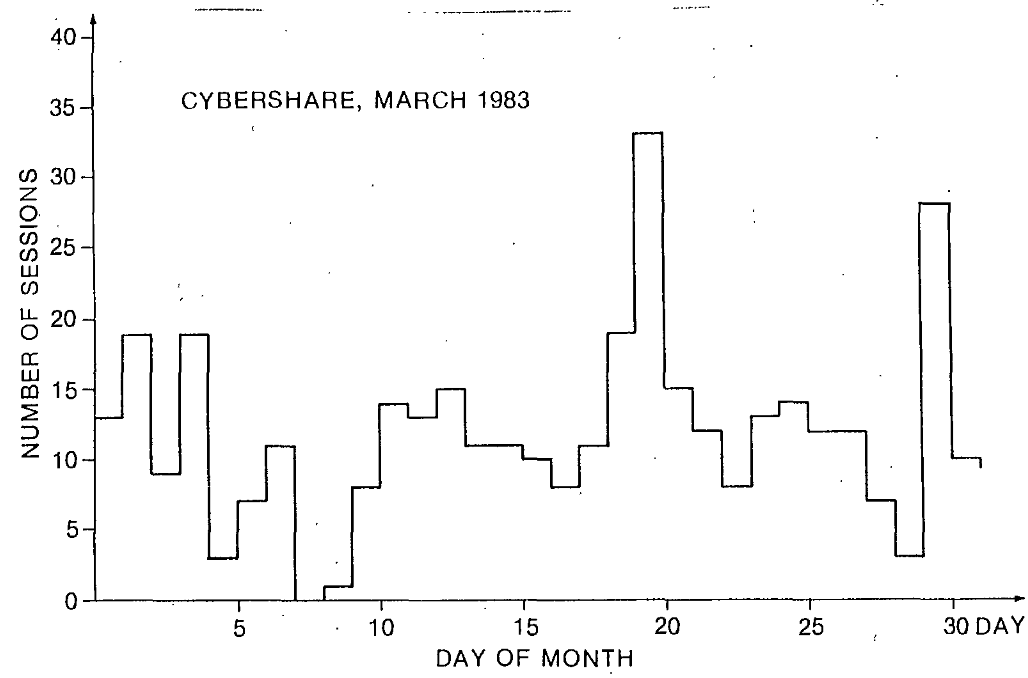


Figure 10.6 Histogram of the daily number of sessions for two months for the Cybershare Telidon data base

respectively. The significant drop in the use of the Cybershare data base from August 1982 to March 1983 may be due to the fact that the content of this data base remained fairly constant, whereas the Infomart data base constantly grew in content as well as significant parts of that content was regularly updated.

In Figure 10.7 a histogram of the average daily session lengths is shown for the use of the Infomart data base during the months August 1982 and March 1983. The average session lengths for August 1982 and March 1983 were 17.1 minutes and 14.2 minutes respectively. Although average session lengthy are certainly useful for network planning purposes they by themselves are not very meaningful unless one also knows the distribution of session lengths. A discussion of session lengths will follow the presentation of such data in figures 10.8 and 10.9. Data to construct histograms of the average daily session lengths for the use of the Cybershare data base also exist. However, since the rather small number of sessions per day do not allow statistically reliable inferences to be made, they have not been shown here. The average session lengths for the months August 1982 and March 1983 for the use of the Cybershare data base were 14.4 minutes and 23.7 minutes respectively. The last number is the result of a few but very long sessions during March 1983, which obviously distorted the entire average.

From the available usage data the distribution of session lengths for both Cybershare as well as Infomart were studied. Figure 10.8 shows the distribution of session lengths for Infomart for August 1982 and March 1983. It is important to note that in both months about 40% of the sessions were no longer than one minute. Session lengths up to 30 minutes include about 90% of all sessions. In the remaining 10% of the sessions, there were some which lasted up to 5 hours. Figure 10.9 shows similar data for Cybershare. Although again the largest percentge of sessions lasted less than one minute, their proportion was not as high, only 33% and 24%. Otherwise both sets of data show the

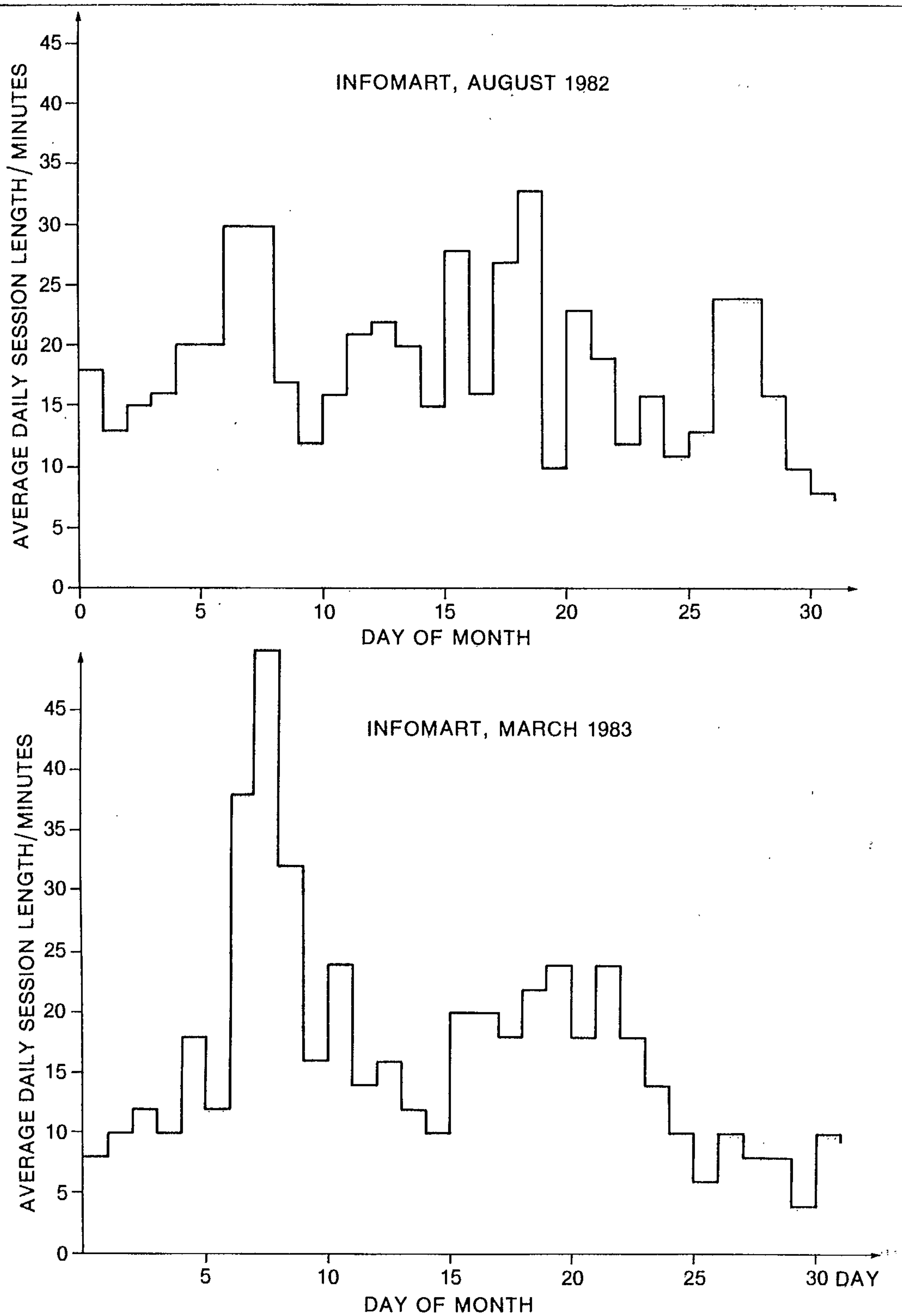


Figure 10.7 Histogram of average daily session lengths for two months for the Infomart Telidon data base

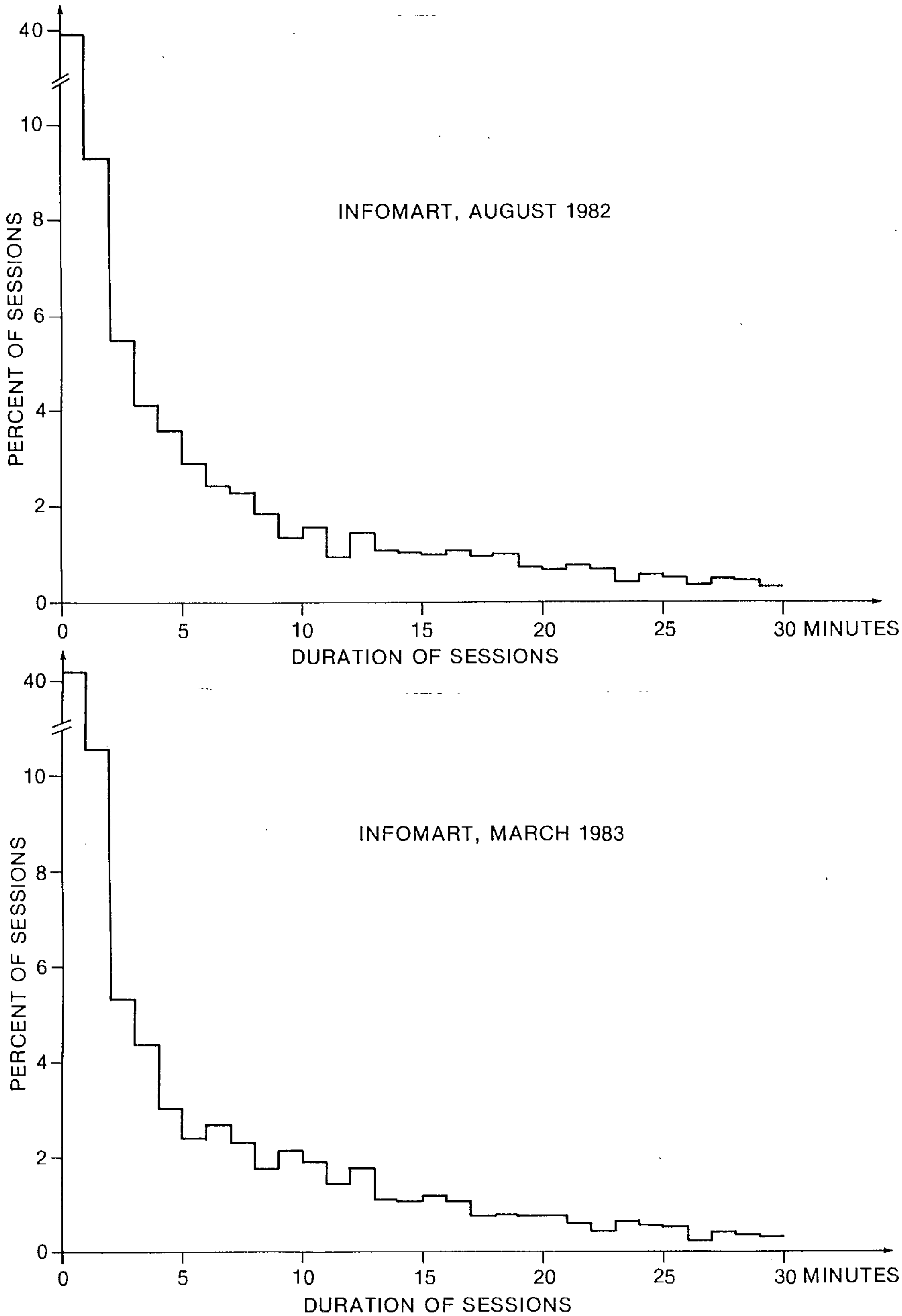


Figure 10.8 Distribution of session lengths for two months for the Infomart Telidon data base

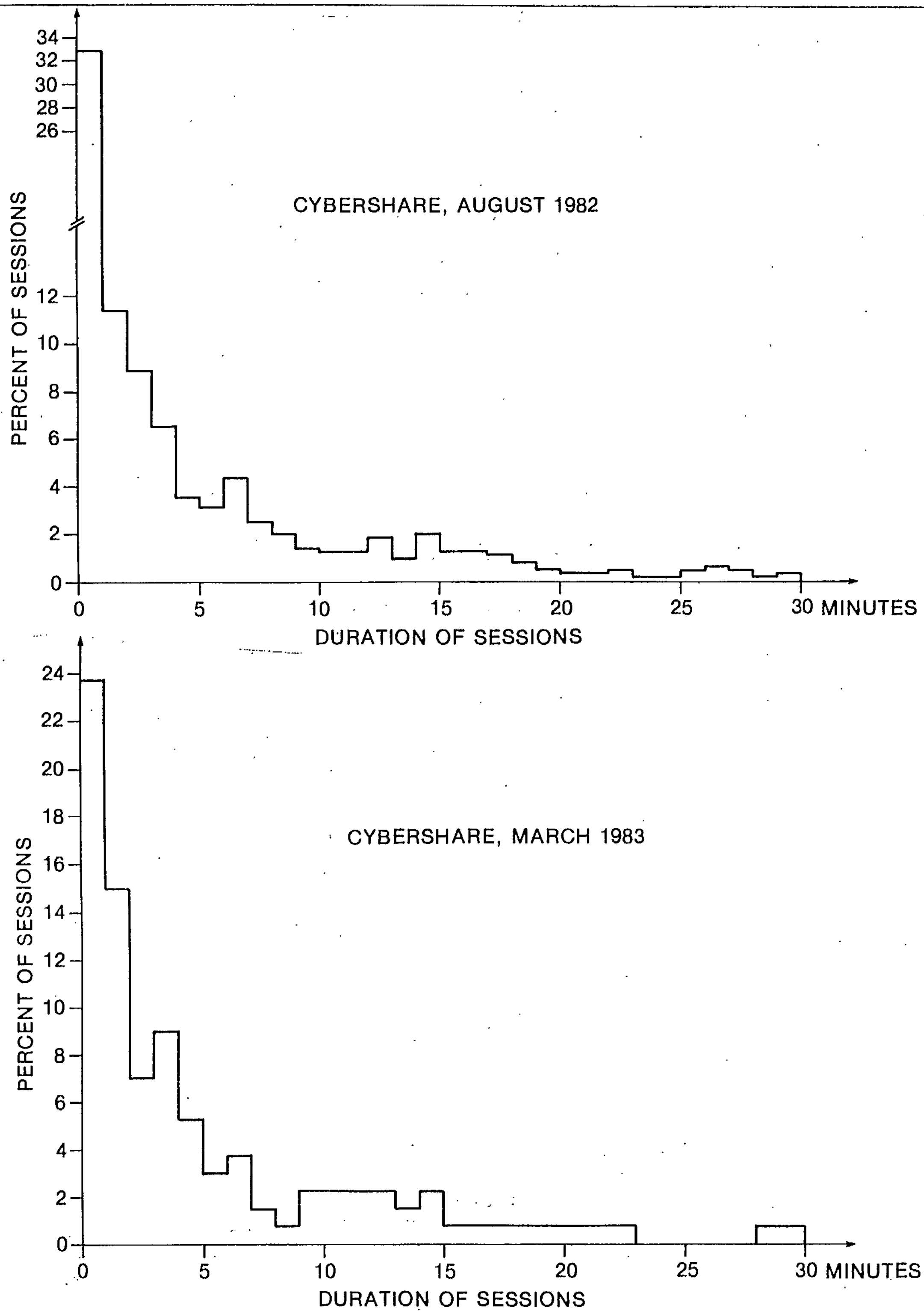


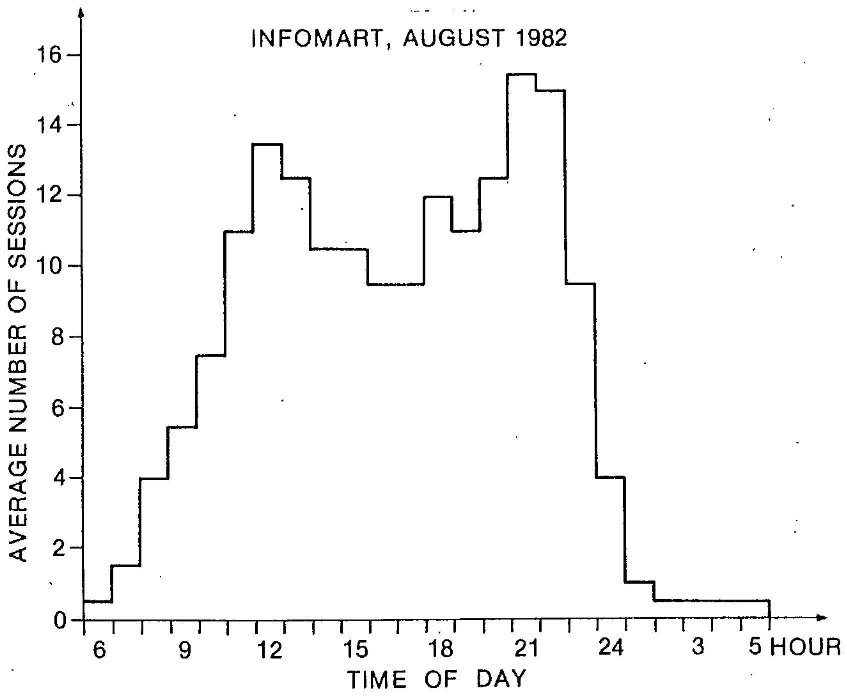
Figure 10.9 Distribution of session lengths for two months for the Cybershare Telidon data base

same characteristic exponential distribution. Although 50% of the sessions do not exceed a duration of 3 minutes, it is the small number of rather long sessions which cause the average session length to be in the 15 to 20 minute range. The distribution of session lengths found in this trial is similar to the data gathered by the Helsinki University of Technology in Finland for a videotex service in Finland during 1980/81 [10.5]. Their average session length, however, was only 9 minutes. The difference in results may be due to the fact, that the data bases for the Elie - St. Eustache trial contained games and educational courses, which may have caused the few but rather long sessions, whereas the Finnish data base was strictly an information retrieval data base.

Finally the distribution of Telidon sessions throughout the day was analyzed. The one month average number of sessions per hour during one day are shown for August 1982 and March 1983 for Infomart in figure 10.10 and for Cybershare in figure 10.11. The heaviest usage time appears to be in the evening, with a secondary peak around noon time. The exception to this is the distribution of sessions for Cybershare in August 1982, where there is a larger peak around noon time. However since the number of sessions were small as the scale on the ordinate shows, the statistical validity of the results for Cybershare is less reliable. An other observation that can be made is the time shift of the usage peak in the evening from the later evening hour (21 hour) in August 1982 to the earlier evening hour (18 hour) in March 1983. Since the data for other months has not been systematically analyzed it is not possible to conclude, whether this shift in time of peak usage is a seasonal phenomenon or not.

10.4.2.3 General Comments on Telidon Usage Data

In analyzing the Telidon usage data it should be borne in mind, that this service was provided free of any charges to the trial participants. Therefore it is not possible at this point



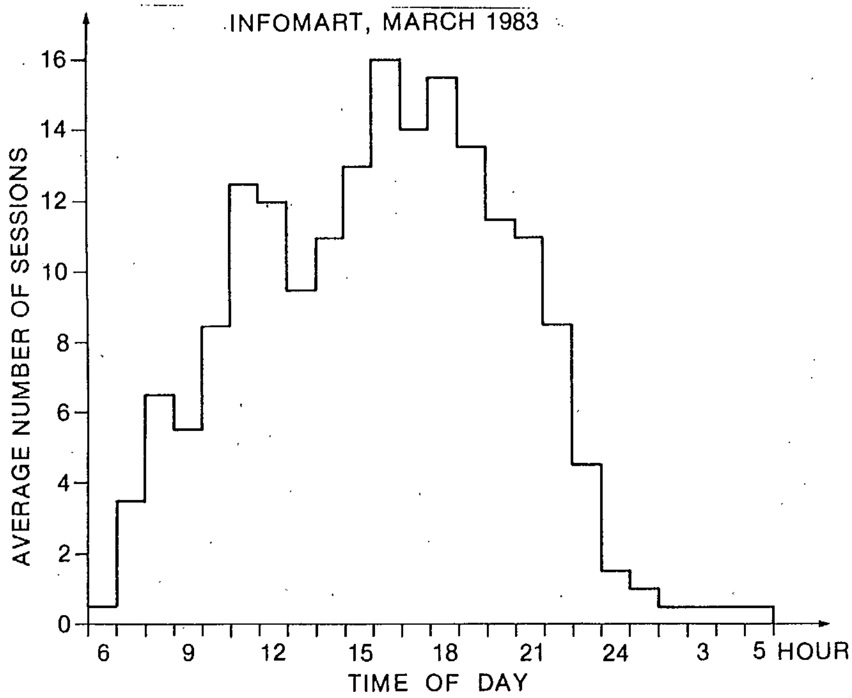


Figure 10.10 Distribution of the number of sessions per hour for one day averaged over one month for the Infomart Telidon data base

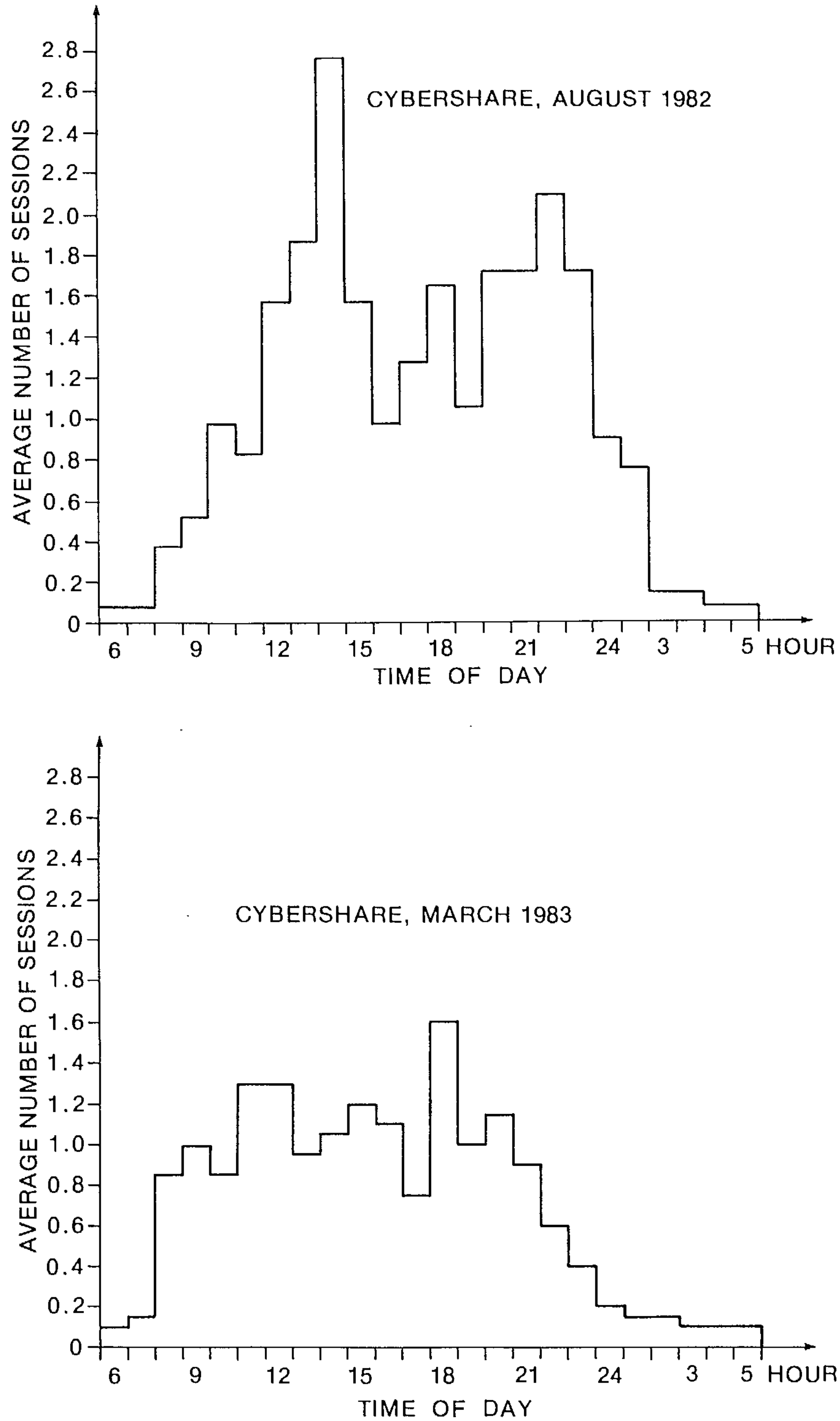


Figure 10.11 Distribution of the number of sessions per hour for one day averaged over one month for the Cybershare Telidon data base

in time to know, if the usage pattern would be modified at all and at what price levels, effecting the traffic data as was collected. Data that might be effected by any type of usage charges could be the number of sessions and the duration of sessions, the latter in particular if a duration dependent usage charge is applied, as it is the case for the commercial Grassroots service in Manitoba. How a time-of-day dependent usage charge may effect the hourly distribution of sessions is another question. Although there appears to be peak usage occuring in the evening hours when other traffic on the telephone network is lighter, this peak is not a very dominant one. Whether more Telidon sessions could be transferred to the telephone networks off-peak hours, if that is desirable, by a pricing strategy, has yet to be determined. The analysis presented in section 10.4.2.2 is obviously not exhaustive, although it provides information on the major traffic aspects of the Telidon service. No attempt has been made, for example, to associate Telidon usage habits with the demographic data of each household. This would require significant more effort for analysis of the data, which was beyond the scope of this project.

References

[10.1] Goldfarb Consultants; Telidon Field Trial - Elie - St. Eustache, Phase I; A Research Report for Department of Communications Telidon Operations, Manitoba Telephone System and Infomart; November 1981

[10.2] Western Opinion Research, Inc.; Survey of Elie - St. Eustache Fibre Optics Field Trial Participants; Prepared for: Manitoba Telephone System; March 24, 1982

]10.3] Western Opinion Research, Inc.; Survey of Elie - St. Eustache Fibre Optics Field Trial Participants; Prepared for: Manitoba Telephone System; February 28, 1983

[10.4] Western Opinion Research, Inc.; "Spring 1983" Elie - St. Eustache Fibre Optics Field Trial Survey; Prepared for: Manitoba Telephone System; May 25, 1983

[10.5] K. Rahko; Taffic Measurements on Finnish Videotex Systems, Helsinki University of Technology, Otaniemi (Finland). Telecommunications Switching Lab. 9/81. National Technical Informations Service (NTIS) Springfield, Va. 22161, U.S.A., Publication Code: PB83 - 103515.

APPENDIX 10 - 1

LIST OF BUSINESS ESTABLISHMENTS

LIST OF BUSINESS ESTABLISHMENTS

In the Elie area

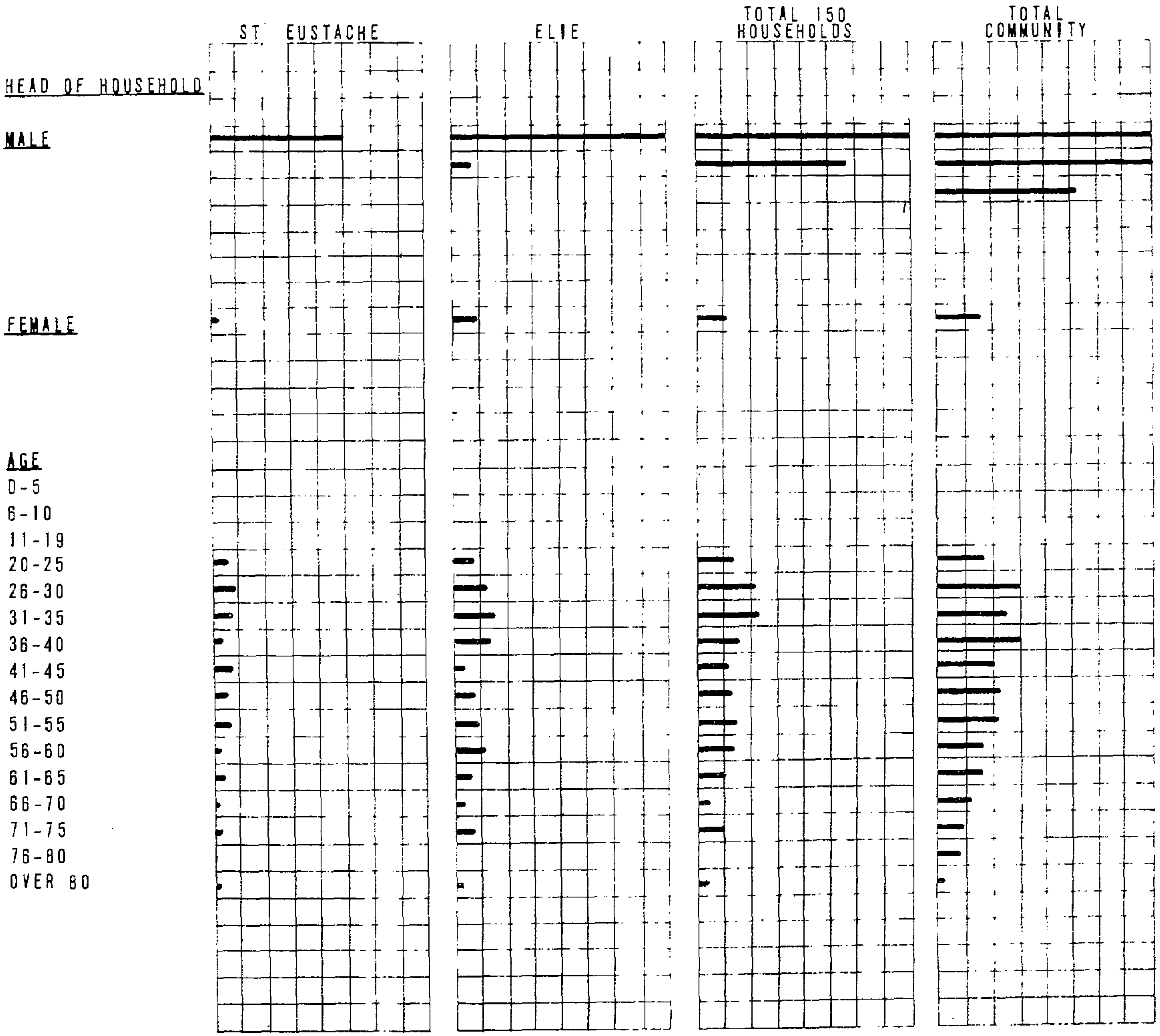
3	Farm Implement Dealers (one grain dryer only, two full range of service).
2	Grain Elevators
2	Auto Dealers with Sales and Parts Service (1 with gas service).
1	Hotel with Restaurant
2	Restaurants
1	Service Station
2	Recreational Vehicle Dealers including one with tire sales.
1	Trucking Firm (hauling)
2	Grocery Stores including one with Liquor Commission.
1	Insurance Agency
1	Credit Union
1	Car Wash
1	Autobody Repair
1	Hardware Store
1	Bulk Fuel Agency
1	Army Navy Airforce Hall
1	Farm Implement Manufacturer (truck mounted sprayer)
8	Clubs - i.e. Legion, Kinsmen, etc.

In the St. Eustache area

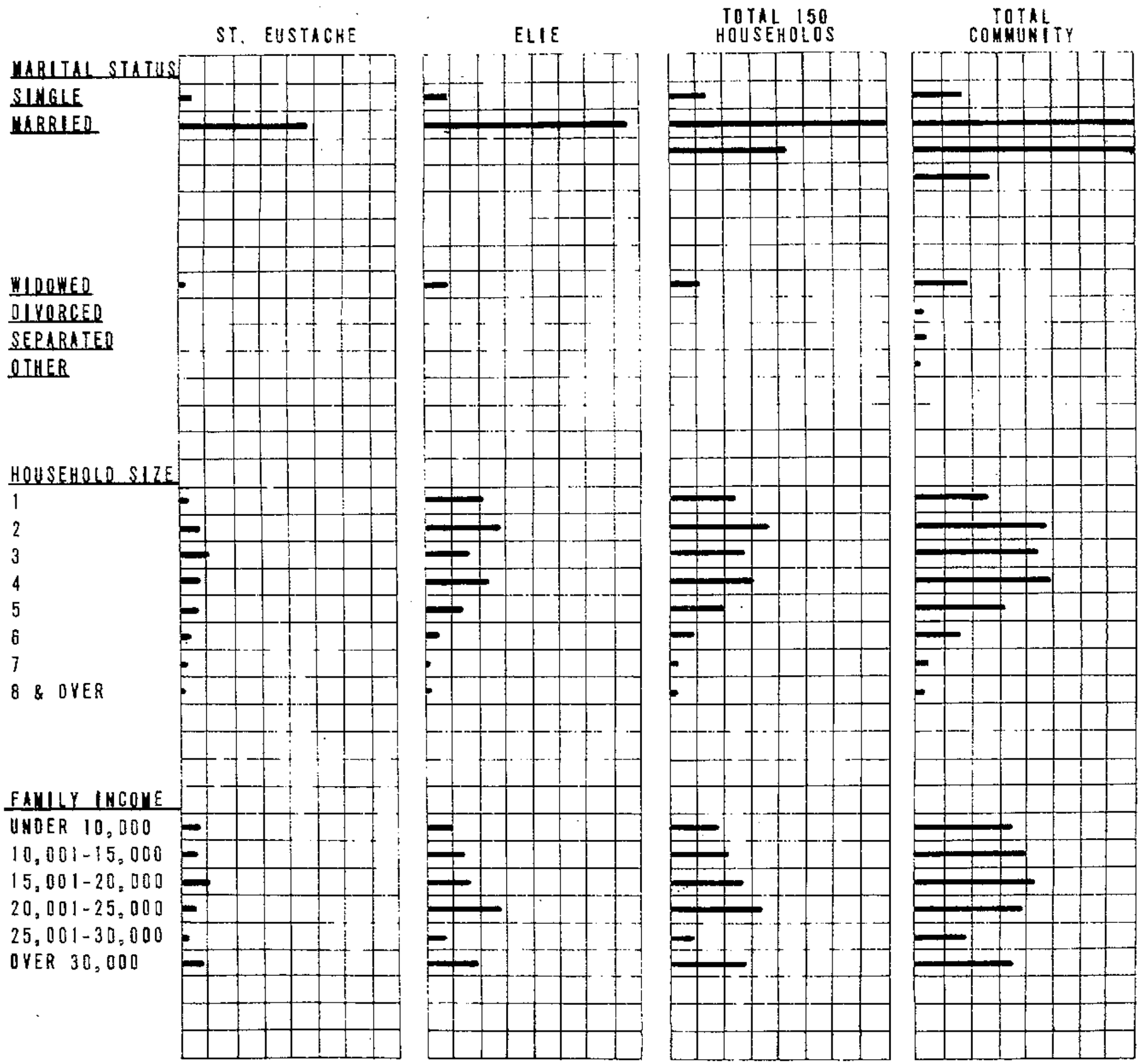
1	Ready Mix Supplier
1	Auto Repair with Gas Station
1	Grocery Store including Liquor Commission
1	Trucking Firm (hauling)
4	Clubs - St. Eustache - i.e., Hockey Club
8	Farm Corporations
5	Hutterite Colonies.

APPENDIX 10 - 2

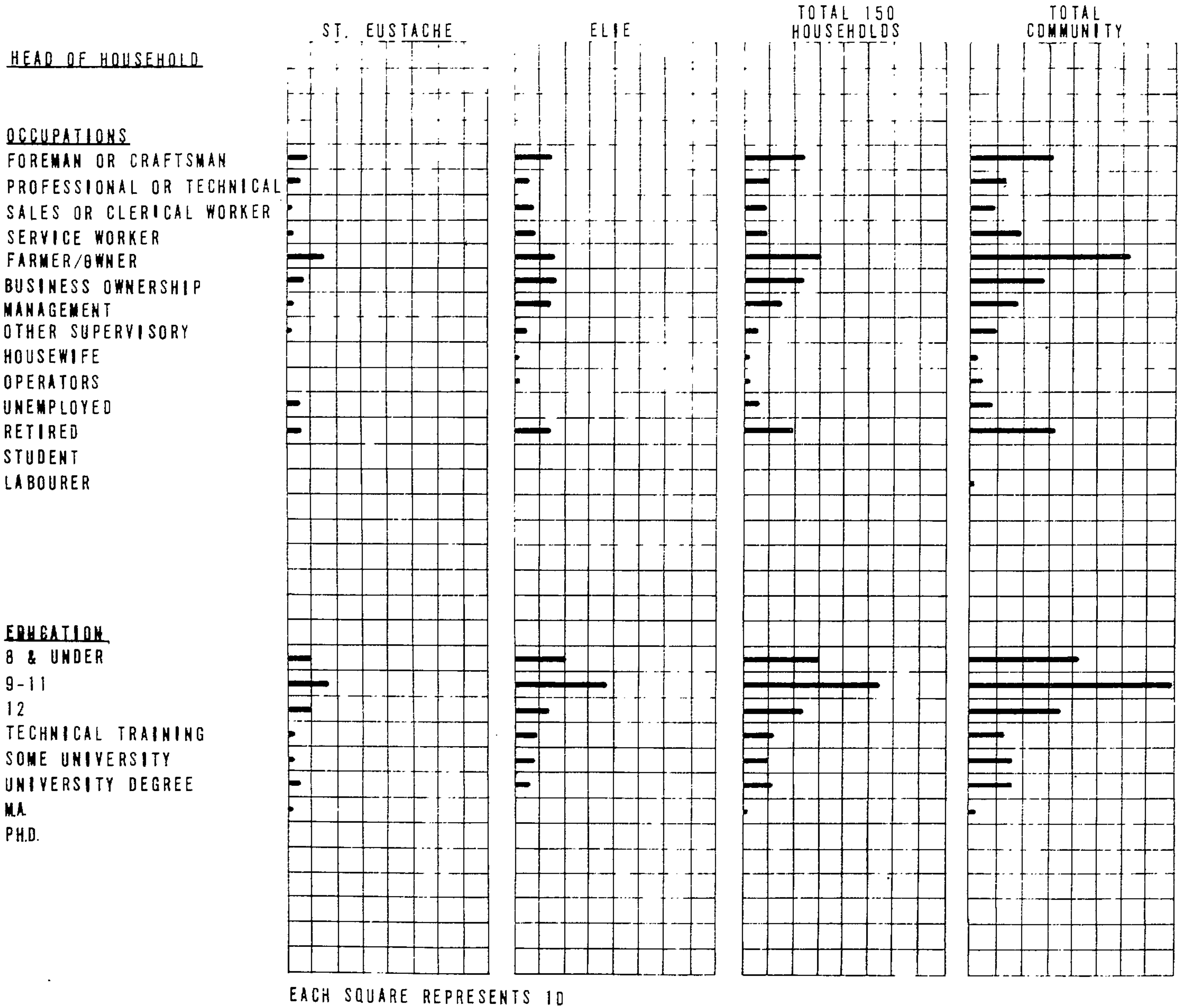
DEMOGRAPHIC DETAILS OF THE ELIE - ST. EUSTACHE AREA (IN 1979)

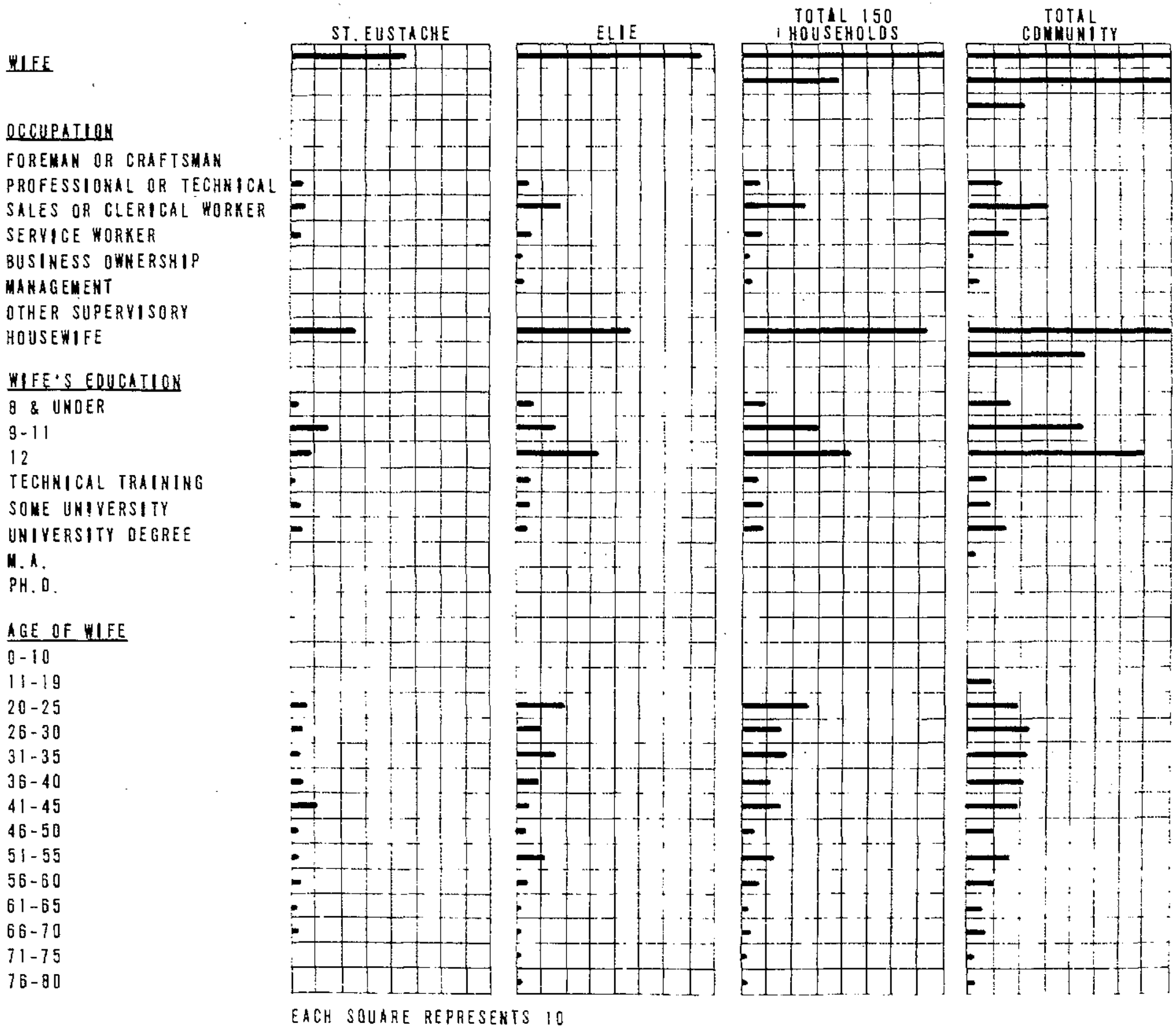


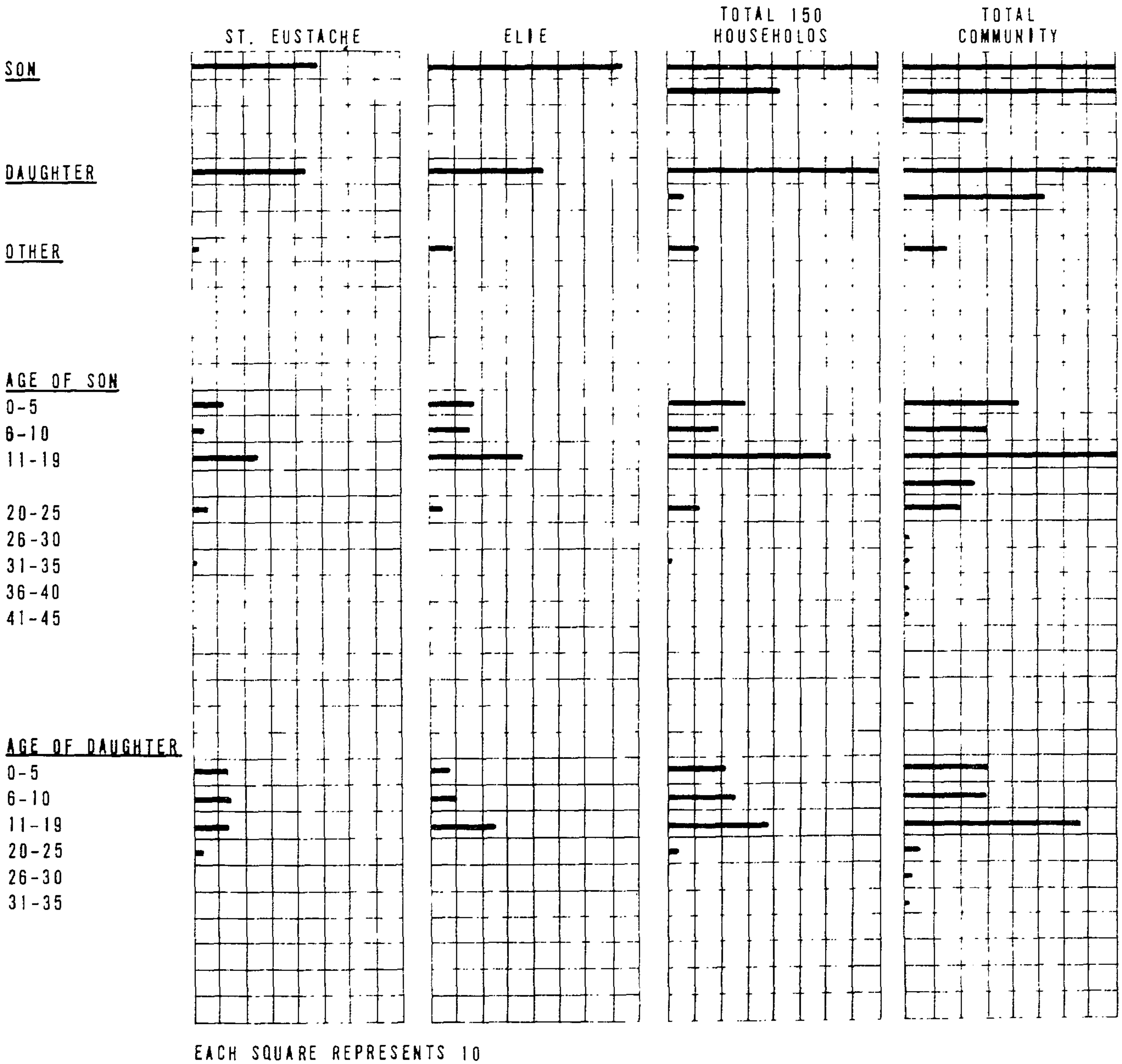
EACH SQUARE REPRESENTS 10



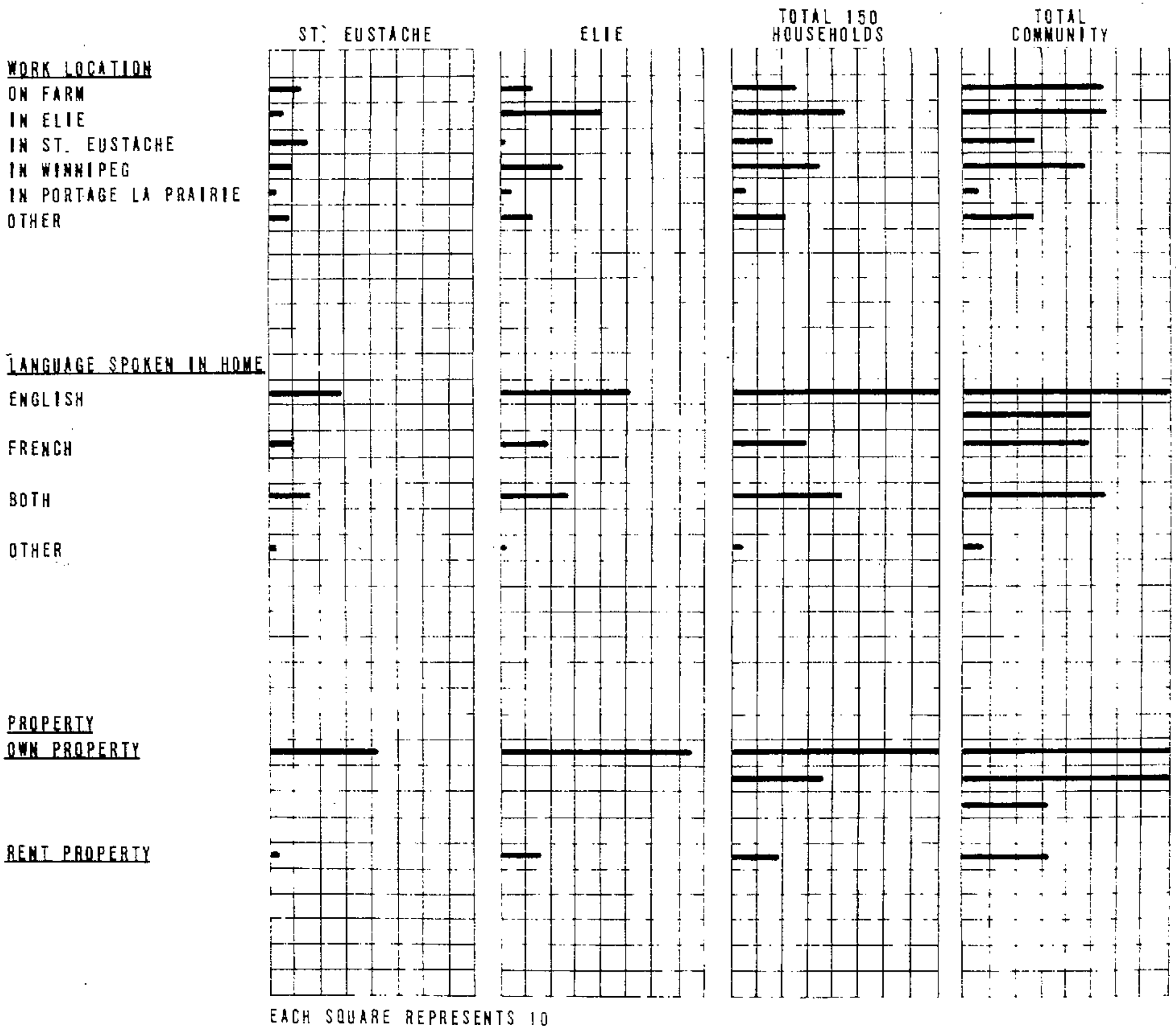
EACH SQUARE REPRESENTS 10

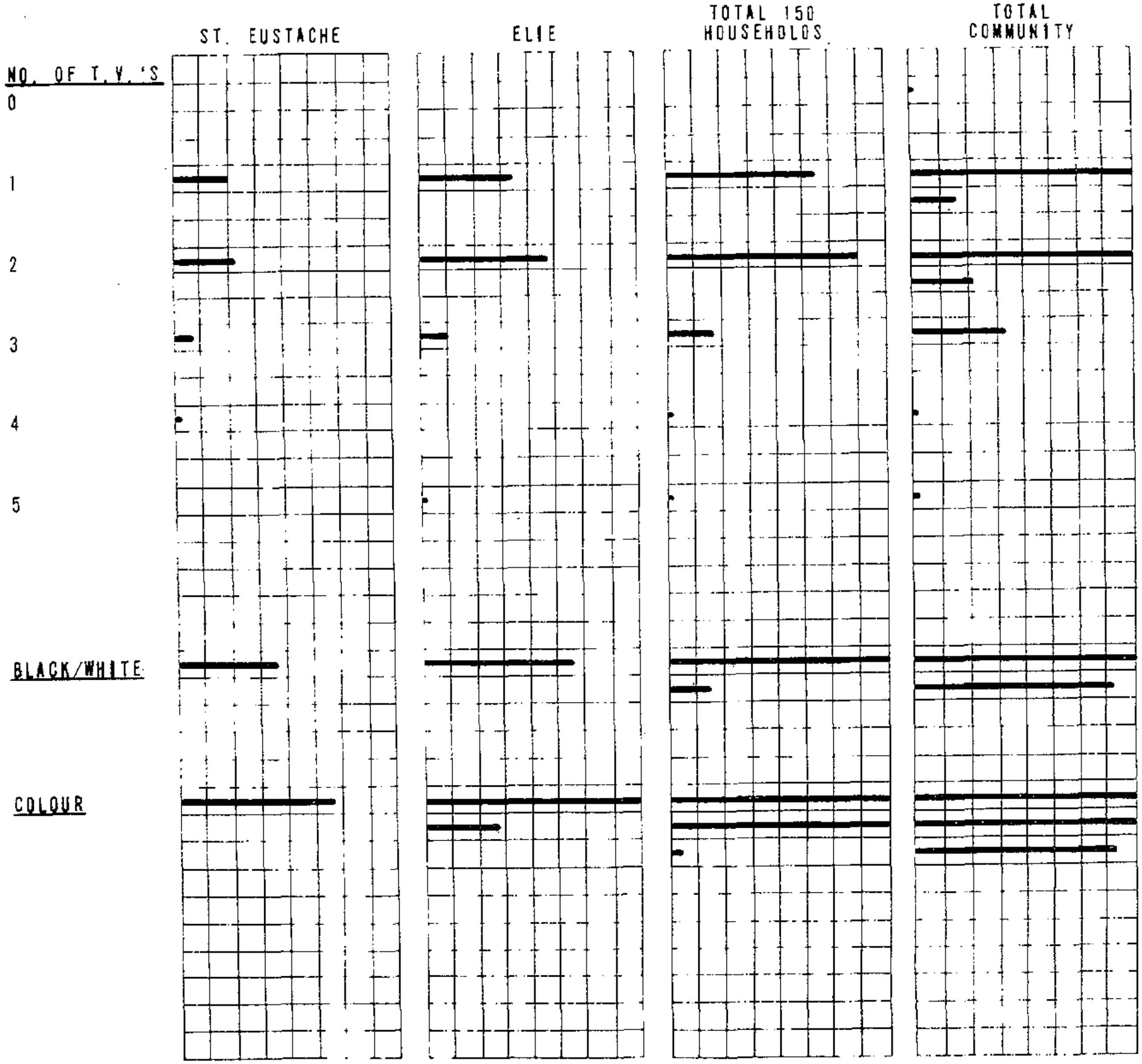

HEAD OF HOUSEHOLD
ST. EUSTACHE
ELIE
TOTAL 150 HOUSEHOLDS
TOTAL COMMUNITY
OCCUPATIONS
FOREMAN OR CRAFTSMAN
PROFESSIONAL OR TECHNICAL
SALES OR CLERICAL WORKER
SERVICE WORKER
FARMER/OWNER
BUSINESS OWNERSHIP
MANAGEMENT
OTHER SUPERVISORY
HOUSEWIFE
OPERATORS
UNEMPLOYED
RETIRED
STUDENT
LABOURER
EDUCATION
8 & UNDER
9-11
12
TECHNICAL TRAINING
SOME UNIVERSITY
UNIVERSITY DEGREE
M.A.
PH.D.
EACH SQUARE REPRESENTS 10


ST. EUSTACHE
ELIE
TOTAL 150 HOUSEHOLDS
TOTAL COMMUNITY
WIFE
OCCUPATION
FOREMAN OR CRAFTSMAN
PROFESSIONAL OR TECHNICAL
SALES OR CLERICAL WORKER
SERVICE WORKER
BUSINESS OWNERSHIP
MANAGEMENT
OTHER SUPERVISORY
HOUSEWIFE
WIFE'S EDUCATION
8 & UNDER
9-11
12
TECHNICAL TRAINING
SOME UNIVERSITY
UNIVERSITY DEGREE
M.A.
PH.D.
AGE OF WIFE
0-10
11-19
20-25
26-30
31-35
36-40
41-45
46-50
51-55
56-60
61-65
66-70
71-75
76-80
EACH SQUARE REPRESENTS 10



ST. EUSTACHE
ELIE
TOTAL 150 HOUSEHOLDS
TOTAL COMMUNITY
SON
DAUGHTER
OTHER
AGE OF SON
0-5
6-10
11-19
20-25
26-30
31-35
36-40
41-45
AGE OF DAUGHTER
0-5
6-10
11-19
20-25
26-30
31-35
EACH SQUARE REPRESENTS 10


ST. EUSTACHE
ELIE
TOTAL 150 HOUSEHOLDS
TOTAL COMMUNITY
WORK LOCATION
ON FARM
IN ELIE
IN ST. EUSTACHE
IN WINNIPEG
IN PORTAGE LA PRAIRIE
OTHER
LANGUAGE SPOKEN IN HOME
ENGLISH
FRENCH
BOTH
OTHER
PROPERTY
OWN PROPERTY
RENT PROPERTY
EACH SQUARE REPRESENTS 10



EACH SQUARE REPRESENTS 10

CHAPTER 11 - PUBLIC RELATIONS

11.1 Purpose of the Public Relations Program

As the technical work progressed, it became apparent that positive action would be required in order to maintain participant understanding, interest and satisfaction throughout the trial. With this in mind, 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, MTS.

- Show that Canada is at the leading edge of telecommunications including research and development, manufacturing, application and provision of services.

- Highlight the trial as an example to the general public of what can be achieved through industry-government cooperation.

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

11.2 Organization of Public Relations Activity

The five organizations, DOC, CTCA, MTS, NTCL and Infomart, formed a Public Relations Committee to plan, organize and control the public relations activities. It was recognized that it was important for the success of the trial that all contacts with the participants must be conducted with tact to ensure that a friendly rapport and empathy was maintained. In order to achieve this, care was taken to select and appoint a Public Relations Coordinator with a personality that could relate well to the participants. The PR Coordinator's responsibilities included: Community relations, tours and demonstrations, news media relations, FTC display area, general record keeping, maintenance of a slide bank and mailing list, and writing periodic updates and regular status reports to the participants and the PR Committee. The PR Coordinator was responsible to the PR Committee which in turn was responsible to the Program Manager. In order to conduct the PR activities efficiently, the PR Coordinator maintained close liason with the MTS Project Manager. Including the name and phone number of the PR Coordinator on every piece of correspondence to the participants was instrumental in keeping their positive attitude toward the trial and its sponsors. It was important to let the participants know, that someone was always available to help if they had any problems.

The presence of at least one MTS installer or repairman in the community almost daily augmented the participants' sense of being looked after. The fact that some of these were well known in the community contributed to the success of the public relations activities.

11.3 PR Activities in the Community

11.3.1 Participant Contacts

Numerous meetings were held with participants and residents throughout the trial period. These meetings served to familiarize residents with the purpose of the trial, the on-going trial activities, and the sponsors. They also served to provide the sponsors with first-hand knowledge of the participants' concerns and comments. The overall atmosphere at these meetings was friendly and informal.

During meetings prior to the commencement of the project, the residents were informed of the details of the trial and were given a form to sign indicating their interest and willingness to participate. Participants were asked if they wished to receive information in English, French or both. From then on correspondence was sent to them in the language of their choice.

From the PR activity with the community and the participants, also some valuable lessons were learned. It was found that any statements containing uncertainties that can create any false expectations are to be avoided. A case in point was the subscription fee for cable television. Initially, it was not known whether a subscription fee for this service was required. Trial participants were therefore informed accordingly, leading many to wrongly conclude that this service was to be free. It would have been preferable to tell them that there would be a subscription fee and if such a requirement did not materialize, to waive such charges at the time the service was introduced.

A series of meetings were held to enable the participants to meet representatives of the sponsors, ask questions and give feedback. The more important meetings are discussed in the following paragraphs.

The first of such meetings was held in June of 1981 with the sponsors, the participants and other local residents to discuss the progress of the trial and restate its purpose prior to the actual operational period. In March of 1982, after the trial had been operating for almost six months, another meeting with the trial participants was held to give them an opportunity to ask questions to each sponsors representative present at the meeting. The sponsors learned of some potential problems with the trial services about which they were not previously aware. In early April, 1982, an "Open Trailer" was held to let the participants see what is installed in the Field Trial Centre. The PR Coordinator and one of the installers were on hand to explain the equipment's role in the trial.

On October 23, 1981, a high profile opening ceremony of the trial was held in Elie at St. Paul's Collegiate. A senior representative from each sponsoring organization spoke to the audience. Speakers included: The Honourable Francis Fox, Federal Minister of Communications; The Honourable Donald Orchard, Minister responsible for MTS; David Golden, Vice-Chairman of the Board, CTCA; David Vice, Group Vice-President, Transmission, Northern Telecom Canada Ltd.; and David Carlisle, President, Infomart.

The audience included the trial participants, other local residents, the news media, representatives of MTS and the other sponsors, and political representatives. The trial services were demonstrated and the participants were able to meet and talk with members from all sponsoring organizations clarifying for them that the trial was not just an MTS event, but an important Canadian event. Many articles and newscasts appeared immediately after, indicating good response by the news media.

In addition to these meetings a Telidon demonstration was held, in October, 1981, in the Rural Municipality office in Elie to acquaint participants with the service. Futhermore, Telidon training was conducted in small groups to instruct participants in the operation of the system. In May, 1982, Infomart representatives visited each participant to demonstrate two new features in their data base. The PR Coordinator attended some of these visits to ensure that PR needs were met and to learn these new features for future reference.

The PR Coordinator and project managers for MTS and Infomart also participated in the local high school teacher's "in service" day. The trial was explained with suggestions of how to involve the school and students in the opportunities of the trial. This meeting resulted in an increased awareness of the importance of computers, which are an essential part of a Telidon system, and prompted the introduction of a computer program in the school in September 1982. A request for a second Telidon set for the high school was received shortly afterwards which then was provided.

On October 26, 1982, one year after the inaugural ceremony, a "birthday party" was held in Elie with approximatley 50 of the participants in attendance. The participants were updated on events of the trial and questions were answered by the sponsors. This was another good opportunity to learn more about the trial services and network "quirks".

December 4, 1982 was the date for a Christmas party held for the participants. Approximately 50 children and 30 adults attended. This was not a business meeting but an evening of fun to show the sponsors' appreciation of the participants' continued cooperation.

The final event was a dinner held on April 12, 1983, which was attended by approximately 200 participants and family members. This signalled the end of the 18 month trial and the participation by CTCA, Northern Telecom Canada and DOC. Representatives from each participating sponsor organization attended and gave a short presentation. It was an informal affair with no news media or political personalities invited. The participants were also informed that negotiations to extend the trial were going on but that no definite length of time for such continuation had been decided upon at that time. The final event was deliberately kept low-key since its intention was a final "Thank you" to those who had cooperated for almost two years with the sponsors. The success of the trial hinged on the attitude of the participants and they certainly were a willing group.

11.3.2 Newsletters

A newspaper called "Dialogue" was distributed to the participants before the start of the trial as a means of introducing the residents to the technologies and services they would be using. During the trial, Newsletters and individualized letters were sent to the participants. The Newsletters included updates on trial activites, enhancements or instructions about trial services, general information on the technical status of the trial, news of visitors to the trial site, and reminders of who to contact for problems. These Newsletters were normally sent out bi-monthly and more often when required. Messages were also sent via the Telidon messaging service.

11.3.3 User Surveys

There were four surveys conducted during the 18 month trial. The first in September, 1981, was very poorly handled. This was unfortunate, since one such bad experience could have damaged the sponsor/participant relationship, so important to the success of the trial, permanently. In this case, for example, only males were interviewed and interview times were not always prearranged. Frequently, participants were inconvenienced by unannounced interviews at home or the office. In addition, some of the interviewers were rude to several participants. The rude manner and forcefulness of the interviewers was reported to the PR Coordinator by several of the participants.

In order to avoid a similar situation for the succeeding surveys, the PR Coordinator met with the interviewers and instructed them on the approach to be taken with the participants. Consequently, these surveys were conducted much better and the goodwill of the participants was restored.

In addition to the four surveys, two of the trial sponsors conducted surveys for their own needs by groups associated with them. Since the participants did not realize that these groups represented two of the sponsors their response was extremely low. It demonstrated the importance of limiting the number of surveys with the participants as well as the importance of keeping them informed of the purpose and need for such surveys.

11.4 Information to the News Media and the Public

Two signs identifying the trial were constructed and placed, one at the Field Trial Centre in Elie and the other at the Remote Distribution Centre near St. Eustache. Visitors and local residents could quickly recognize the locations of the trial sites.

The trial sponsors also produced a general information brochure on the trial for distribution to the news media and any interested public. Along with the brochure, a general fact sheet on the trial was printed for inclusion with the brochure in an information kit. Each sponsor had a supply of these kits for distribution in their area. These kits prompted the news media to research and write articles on the trial and encouraged numerous visitors to the site.

Finally, a videotape on the trail was produced in English and in French. Copies were made available to all sponsors for their use in demonstrations and presentations. In addition, a photographer took slides and prints of the progress of the construction of the trial network, the inauguration ceremony and the first community event. This slide bank was created for the trial sponsors for use in presentations and for the news media for use in articles. Some of the photographs taken were used in the brochure, the information kit and also for supplementing photography for the videotape.

11.5 Visitors to the Trial Site

The trial brought many visitors to Elie and St. Eustache and numerous articles were written on the trial. Requests to visit the site were handled through the PR Coordinator. The PR Coordinator often made arrangements to pick up the visitors at the airport, transport them to the site and, along with the MTS Project Manager, give a tour and talk about the trial site and services available. These tours did frequently last a full day or more with each group. Whenever possible and appropriate, representatives of the other sponsoring organizations also attended these "tours". This was a good method of providing visitors with a broader view of the trial, supplementing that of MTS', although the Coordinator would always emphasize the involvement of all five sponsors. The PR Coordinator would give a general overview of the trial and services whereas technical explanations were provided by experts of MTS and the other sponsors. A list of visitors, until about the end of 1983, is given in Appendix 11-1.

11.6 News Media Coverage

Good coverage of the trial was provided by articles in newspapers, technical periodicals and newscasts. A list of these, until about end of 1983, is given in Appendix 11-2.

11.7 Technical Conferences and Symposia

Papers were presented and articles printed in the proceedings of fourteen technical conferences in six countries around the world. A list of these, until about end of 1983, is given in Appendix 11-3.

APPENDIX 11 - 1

LIST OF VISITORS

LIST OF VISITORS

Visitor's Name	Affiliation	Date
David Wright	DOC	Apr. 81
Bill McGowan, Lorna Weir, Bob Kirk	MTS	18 Jun. 81
Ian Sutherland	Manitoba Gov't	22 Jun. 81
Joe Jarema, Jim Forsyth	MTS	25 Jun. 81
Leigh Sigurdson, Bruno Leps & Gary Enns	Infomart	7 Aug. 81
Harold Paige, Terry Prentice & Ashley Blackman	B.C. Gov't Sask. Gov't	11 Sept. 81
Donald Orchard	Man. Gov't	23 Oct. 81
Gordon Holland, Dennis McCaffrey and other company officials	MTS	23 Oct. 81

(a number of MTS, DOC, CTCA and NTCL guests at the inauguration on 23 Oct. 81 visited the trailer after the ceremony.)

Visitor's Name	Affiliation	Date
Graham Inglis	CTCA	2 Nov. 81
Mr. Schuetz, Dr. Zimmerman Dr. Klimak & Dr. Seetzen	West Germany	12 Nov. 81
C. Schultz, Keith Chang	DOC	12 Nov. 81
Craig Nisbett & guests	Korea	12 Nov. 81
Messrs. Liu, Zhao, Dong, Shi & Lu	People's Republic of China	1 Dec. 81
Greg Mattern, Michael Olson	Prairie Public TV	17 Dec. 81
Pierre Juneau, Charles McGee, William Johnston	DOC Ottawa & Winnipeg	18 Jan. 82
Gideon Lev, Director General Mr. Zipori, Minister of Communications	State of Israel	26 & 27 Jan. 82
René Dehove, Yves Launay Mr. Brévost & Dietmar Hofacker	France & West Germany	16 Mar. 82
R. Otridge, V.J. Bakman	Elect. Supply Comm. South Africa	29 Apr. 82
Messrs. Poirier & Champigneul	CNET, France	5 May 82
Police Chief Association	Canada	7 May 82
John Terris, Opposition MP	New Zealand	26 May 82

Visitor's Name	Affiliation	Date
Dr. Martin Chown	ITT, England	25 Jun. 82
Geoff Burrell	New Zealand	6 Jul. 82
Lance McKechie	New Zealand	23 Jul. 82
Lynda Leonard	TCTS, Ottawa	27 Jul. 82
Hiroma Fujikawa	Mitsui, Japan	Aug. 82
Noel Dean, John Banks	BICC Telecom, UK	10 Aug. 82
Kenneth Bullock, George Yan	Cybershare, Winnipeg	10 Aug. 82
Arthur Ballegeer, Burt Buchanan	Cybershare, Winnipeg	28 Aug. 82
William Oliver	OISE & Homecom, Toronto	28 Aug. 82
Glenda Galvin & Jean Brodshaug	Internat. Fibre Optics & Commun. Boston (Journal)	28 Aug. 82
Judy Wilgren, Maureen Harapiak	"Project Telidon" Saskatchewan	9 Sept. 82
W.K. Ritchie, Dr. Fox, I. Morgan	British Telecom	21 Sept. 82
Jean-Luc Popovic	CIT Alcatel, France	23 Sept. 82
Watanabe, Nodo, Inoue	NTT, Japan	27 Sept. 82
Thomas Latawiec	Pacific Tel. Washington	22 Sept. 82
Tim Chapman	Butler Cox & Partners, UK	29 Sept. 82
W. Schlueter, R. Burkhardt	SEL, Germany	20 Oct. 82
Sekiguchi, Hoshino, Kitami, Nihei	NTT, Japan	11 Nov. 82
Dr. Lebanon	Telecom Corp., Israel	22 Nov. 82
CVCC Subcommittee	Canada	22 Nov. 82
J. Miyabe	Nomura Research Institute, Japan	10 Dec. 82
M. Chan & F. Shida	Sony Canada	21 Jan. 82
D. Biren, G. Arie-Ariely & P. MacArthur	Advanced Tech., Israel; External Affairs, Ottawa	22 Feb. 83
Alec Keith	Bank of Canada	26 Apr. 83
CVCC Committee	Canada	28 Apr. 83

Visitor's Name	Affiliation	Date
Kathy Boyes (contact) and guests	Northern Telecom; Southern Bell Atlanta	3 May 83
Jean Compagnon (contact) and guests	Northern Telecom; Southern Bell-VIPs, Atlanta	10 May 83
Peter Taylor	Telecom Australia	18 May 83
Shuzo Yamamoto	Hitachi, Japan	8 Jun. 83
Party of seven, Bell U.S.A.	Central Services Org., Bell, U.S.A.	27 Aug. 83
Howard Gough	Radio New Zealand	9 Sept. 83
Takashi Ohtsuka	Journal of Science Tokyo, Japan	11 Oct. 83
François Comet	PTT, France	24 Oct. 83
Bob deBoer	Telecom Australia	1 Nov. 83
Gord Matheson (NTCL) & Party of six-Jutland Tel.	Jutland Telephones Copenhagen, Denmark	22 Nov. 83
Masahiro Kawahata & Party of three	Hi-Ovis, Japan	7 Dec. 83

APPENDIX 11 - 2

LIST OF NEWS MEDIA ARTICLES AND REPORTS

LIST OF NEWS MEDIA ARTICLES AND REPORTS

Name of News Media	Date
Toronto Star	26 Apr. 81
Ottawa Citizen	22 May 81
Carmen Valley Leader (Manitoba)	4 Nov. 81
Manitoba Co-operator	5 Nov. 81
Brandon Sun	24 Oct. 81
Northern Manitoba Review	4 Nov. 81
Winnipeg Free Press*	3 Apr. 81
Winnipeg Sun*	3 Apr. 81
Portage Daily Graphic	24 Oct. 81
Winnipeg Free Press	24 Oct. 81
Winnipeg Sun	26 Oct. 81
Globe & Mail	24 Oct. 81
Dauphin Daily Bulletin	12 Nov. 81
Micros Journal	Apr. 81
Telephony Magazine	23 Nov. 81
Insight - BNR	Jun. 81
Worldwide Videotex Update	Dec. 81
Toronto Star	24 Oct. 81
Pacific Computer Weekly	20-26 Mar. 81
En Route Magazine	Nov. 81
Financial Post	11 Apr. 81
Portage Leader	25 Mar. 81
Royal Commission on Newspapers Vol. 8 "Newspapers & Computers; An Industry in Transition"	
Broadcaster Magazine	Apr. 82
Electronic Times (London, Eng.)	Jul. 82
Data Communications	Jan. 82
Desktop Computing (mention trial)	Apr. 82

* These stories & articles were generated by the DOC/MTS announcement re Telidon service as Phase II of the trial.

Name of News Media	Date
Farm Journal (mention trial)	Apr. 82
VideoScene	Mar./Apr. 82
Popular Science	Sept. 82
Omni Magazine	Dec. 82
International Fibre Optics & Communications	Nov./Dec. 82

Newscasts

CBC-24 Hours, Winnipeg	23 Oct. 81
CBC Radio Winnipeg	12:50 p.m., 23 Oct. 81
CBC Radio Canada International (Montreal)	Nov. 81
CKND*	2 Apr. 81
CFRW*	3 Apr. 81
CKRC*	2 Apr. 81
CBWFT (CBC French)	22 Dec. 82
CBWFT (CBC French)	31 Dec. 82

* These stories & articles were generated by the DOC/MTS announcement re Telidon service as Phase II of the trial.

APPENDIX 11 - 3

LIST OF TECHNICAL PRESENTATIONS

LIST OF TECHNICAL PRESENTATIONS

Names of Speakers and Affiliation		Presented to	Date
John Adam	MTS	International Telephone Expo 81 (Intel Expo) Los Angeles	14 - 17 Sept. 81
Ken Harris	CTCA	IEEE Toronto	Oct. 81
John Adam	MTS	French Gov't Marseilles	Oct. 81
Jane Stewart	PR Comm	Kiwanis Club	20 Nov. 81
George Tough	MTS	U. of Wpg. Computers in Education	14 - 15 Dec. 81
William Krawetz/ Dennis McCaffrey	MTS	U. of Wpg.	14 - 15 Dec. 81
Metin Akgun (Written by M. Akgun, Y.F. Lum, K. Chang, (DOC), C. Harwood (Infomart), G. Tough (MTS))	DOC	International Symp. on Graphics and Text Communica-tions, Paris France	16 - 18 Nov. 81
William Krawetz	MTS	MAUM, Norman Regional Development Corp.	Fall 81
Rod Kachulak	MTS	Rural Electrification Assoc., U.S. Dept. of Agriculture, Washington, D.C.	Apr. 82
Ken Harris	CTCA	Annual Meeting of the American Public Power Association, Los Angeles	Mar. 82
George Tough	MTS	ICC '82 (IEEE) Philadelphia	Jun. 82
Ken Harris	CTCA	ICCC, London, U.K.	Sept. 82
Metin Akgun (written by M. Akgun and L. Sigurdson (Infomart))	DOC	Cdn. Communications & Energy Conference (IEEE), Montreal	Oct. 82
George Tough	MTS	National Comm. Forum 83, Chicago	24 - 26 Oct. 83

Names of Speakers and Affiliation		Presented to	Date
Metin Akgun (written by M. Akgun, K.B. Harris (CTCA), L. Sigurdson, (Informart), G.A. Tough (MTS))	DOC	ITU Forum 83 Geneva, Switzerland	29 Oct. - 1 Nov. 83
D.A. Kahn (written by D.A. Kahn M. Akgun & E.H. Hara (DOC), G.A. Tough (MTS))	BNR	IEEE Globecom 83 San Diego	28 Nov. - 1 Dec. 83

CHAPTER 12 - COST ANALYSIS OF THE TRIAL SYSTEM

12.1 Introduction

In general new technology or new systems are introduced in the telecommunications network for one or more of the following reasons:

- To reduce the cost of providing existing services
- To improve the quality of service without increasing cost
- To provide a delivery system for new services that cannot be provided otherwise.

In all cases, the cost of the system is of paramount importance. Therefore, an attempt is made in this chapter to identify the various costs of the Elie - St. Eustache trial system through the phases of engineering and manufacture, installation and construction, and operation. The costs which are presented in this chapter reflect the costs of this experimental system only and no inference should be made as to what a mass-produced integrated services fibre optic subscriber access system may cost in the future. Since the trial system was developed as one of a kind, it was not necessarily optimized for large scale production and therefore certain costs are rather high. Furthermore, the technology used represents the state of fibre optics technology of the late 70's and is, therefore, considering the rapid development that has occurred since then, already not necessarily indicative of how a future system may be designed.

Despite these reservations, it is believed that this cost information is nevertheless useful in that it will help to identify major cost centres of the system and thereby allowing researchers, designers, manufacturers and system operators to concentrate their effort in areas that require the largest cost reductions in order to arrive at an economically feasible integrated services fibre optics subscriber access system.

Where feasible and available, costs will be provided in two main categories:

- Supplier costs

- Operating company costs

Supplier costs will include manufactured equipment costs and some installation costs as normally provided by suppliers. Operating company costs will include engineering, construction, installation and maintenance costs.

12.2 Basis of Cost Analysis for the Trial System

A breakdown of costs for the Elie - St. Eustache trial system into individual equipment units, particular installation, construction or maintenance activities is rather difficult since the costs on which the contracts were awarded were fixed and lump sum, including all costs. Admittedly, these lump sum prices were based on cost estimates for various activities. However, since these estimates were mostly for new pieces of equipment and for new procedures, it is not known whether the actual costs did indeed match the estimates because the contractors were not paid on the basis of actual costs, but on predetermined quarterly amounts, provided that certain activities were completed and milestones achieved, and therefore the contractors did not need to keep very detailed records. For taxation reasons there are only some records available for the total cost of manufactured or purchased equipment which were delivered by NTCL for the trial which exclude the R&D costs. These records however, still do not allow for a detailed cost breakdown leading to individual unit costs. As mentioned before, even this very coarse cost-breakdown reflects only the cost of prototype units with a low volume of production. Furthermore, since there was little previous experience to call upon, the development of new procedures had to be liberally costed.

Three main contracts and one subcontract were signed between the parties involved in this project for the design, manufacture, installation, operation and maintenance of the trial system.

1 - Contract between DOC/CTCA and NTCL - $5,525,000

This contract included the design, engineering, furnishing, installation and repair of the basic system. The overall responsibility for maintenance and repair, provision of appropriate practices and the training of MTS craftspeople were also included. Obviously a considerable amount of R&D was included. This contract included a subcontract between NTCL and MTS.

1 (a) - Subcontract between NTCL and MTS - $158,000

With this subcontract NTCL delegated to MTS the responsibility for installing all outside plant including splicing and testing and for installing the equipment and wiring on subscriber premises. It did not include however, wiring for Telidon service since this service was not included in the first phase of the project.

2 - Contract between DOC/CTCA and MTS - $580,000

This contract covered the cost of activities and functions that are usually considered the responsibility of an operating company. Included in this contract were cable route engineering, routine system maintenance, provision of

CATV head-end, provision of trouble reporting functions, telephone set installation, provision of a usage measurement system and project management.

3 - Contract between DOC and MTS - $686,000

This contact covered the cost of implementing facilities to provide Telidon service over the data channel provided by the basic system. It included some design and engineering work, installation of transmission switching and subscriber premises equipment, and provision of maintenance. Included in this contract were also the costs of subscriber surveys. Costs of Telidon terminals, data sets, the data switch and the trunks were not included. Cost of such hardware was estimated at $714K and was provided by DOC and MTS separately.

In the following sections of this chapter, costs of various items are based on either actual costs as they were recorded or on estimates provided by the manufacturer or the operating company. The costs presented here are therefore not hard, firm and precise. They are, however, representative and accurate enough to be used for the planning of other field trials of similar nature.

12.3 Engineering and Manufacture of Equipment and Cable

This section covers all the costs of the engineered and manufactured equipment and cable delivered by the manufacturer. It also includes the manufacturer's costs for installation of the equipment in the FTC and RDC trailers. These costs are listed in Table 12.1. They represent the cost of each item as it was incurred for the trial.

ITEM	PROTO-TYPE COST $	COMMENTS
1 - Subscriber Premises		
SEU	5,500	
STU	150	
Telephone Set	77	
Telidon Terminal	2,400	Includes TV Monitor, Decoder, Keyboard
Data Set	340	
2 - FTC, RDC Equipment		
LIU	4,500	There are 150 Units
DMS-1	750	Both Ends. There are 150 Units
Data Multiplex	300	One End. There are 60 Channels
TV Processors	51,000	For 9 Channels
Alarm System	25,000	
Bays, Shelving	3,000	
Jack Field	7,000	
Power Supply (RDC)	20,000	
Trailer (FTC)	23,500	
Trailer (RDC)	18,700	
Ducts	N/A	Only overall cost available
3 - Fibre Cables		
Distribution and Trunk	780,000	Includes Enclosures, Pedestals, Strand and all sizes of Cables (3-36 Fibres)
4 - Trunk Equipment		
FD-1 (Voice)	50,000	3 Systems in 2:1 Protection mode
FD-2 (Data)	26,000	2 Systems in 1:1 Protection mode
RM-3 (TV, FM Radio)	70,000	10 Transmitter/Receivers
FA-1 (TV, FM Radio)	85,000	10 Systems
5 - CDO Equipment		
Power Supply (FTC)	N/A	Only System overall cost available
CATV Head-End	30,000	Includes ICBN connection
150 Telephone Lines	N/A	Only overall cost available
Telidon Switch	157,000	Includes MUX/DEMUX, Data Sets
6 - Miscellaneous		
Test Equipment	10,000	

N/A Not Available

Table 12.1 Equipment and Material Costs of the Trial System

12.4 Operating Company Engineering

MTS provided some engineering effort, primarily for cable route engineering. Other work was also performed relevant to the trial but from an operating company point of view of a more standard provisioning nature.

12.4.1 Cable Routes

This work involved the location and sizing of cables, the location of splices complete with a study of trade-offs with cost of enclosures and pedestals vs longer cables, the buried and aerial cable detailing and the preparation of construction plans.

All this work was "first time" work - no fibre distribution design had been done before. MTS engineering personnel worked very closely with BNR outside plant people in a mutual learning process. The design procedures by BNR and the route engineering by MTS proceeded hand in hand. Much extra work (as viewed from traditional paired cable design) was required for this job (e.g. every cable length had to be precisely measured so that cables could be delivered precut).

A total of 435 manhours of work was estimated to complete the layout work which resulted in a series of work orders and plans for the outside plant construction forces to follow. A figure of $27 per hour (1979) was used, reflecting a composite figure for outside plant engineering personnel.

12.4.2 Power Plant (FTC)

A decision was made early in the system design to house the FTC equipment in a trailer adjacent to the MTS dial office in Elie. The 48 volt D.C. power was to be supplied by MTS from the dial office. Once the power load was provided by NTCL, MTS prepared a work order to purchase and install a properly sized rectifier plant including batteries. This represented the use of standard practices and procedures by trained experienced equipment engineering staff. No unusual work or problems were encountered.

12.4.3 Additional Telephone Lines

The total system required 150 additional telephone lines to be made available in the Elie dial office. Since these were already in place in the office, no additional work or expense was necessary.

12.4.4 CATV Head-End and Delivery System

MTS was contracted to deliver TV signals to the trial system. A head end picking off-air four Canadian TV channels and six Winnipeg FM stations was installed at Elie. A break-out of MTS's Intercity Broadband Network was also provided to obtain the four USA TV network signals. This required experienced design personnel to prepare a specification outlining the design, after which standard practices and procedures were used by trained, experienced equipment engineering staff to prepare orders for the purchase and installation of the required equipment. No unusual problems were encountered. The total cost of this effort is estimated at $5,000.

12.4.5 Telidon Switching and Delivery System

MTS provided the data switch at Elie required for the participants to be able to select either of the Telidon data bases. MTS also provided the data trunks from Elie to the two data bases located in Winnipeg. The design work was the responsibility of a special services data group because of the uniqueness of the requirement and the one-of-a-kind design effort required. This group, in consultation with suppliers, prepared a design layout and specification. Standard practices and procedures were then followed by trained, experienced engineering staff to prepare orders for the purchase and installation of the required equipment. No unusual problems were encountered. The overall cost of this effort is estimated at $16,000.

12.5 Outside Plant Construction

NTCL, not equipped to perform this work, subcontracted MTS to do the actual outside plant construction work. Material was supplied by NTCL.

12.5.1 Field Fibre Splices

As in all unit cost calculations, the time per splice includes not only the time to actually splice the fibre, but also the aggregate times of moving to the splice location, setting up, arranging and preparing cables, preparing the closure, installing the organizer, splicing, closing up, removal and cleanup. This total operation averaged out at 11 hours. There was an average of 10 splices made at each location taking 15 minutes per splice for a total splicing time of 2.5 hours which is included in the 11 hours. The loaded cost of a craftsman (1980) was $25.68 per hour. A total of about 600 splices were made for the entire system. The total cost amounted to $16,948.80.

12.5.2 Fibre Cable Testing

Each fibre loop was tested from the house terminal to the appropriate trailer once the loop splices had been completed.

Again, the activities included moving, setting up, measuring and removing for a total of 4.2 hours per home. The loaded cost of a tester (1980) was $25.68 per hour. The total cost amounted to $16,178.40.

12.5.3 Buried Cable

The cost includes the actual ploughing of the cable and placement of pedestals. Not included were the additional costs of pipe pushing under paved roads and of ploughing through the small LaSalle River. The cost was $1.40 per metre in 1981. Since there is a total of 52.5 route km of buried cable, the total cost for buried cable placement amounted to $73,500.

12.5.4 Aerial Cable and Strand

The cost of placing strand was $0.53 per metre in 1981. To place the aerial cable and lash it to existing strand costed $1.00 per metre. Since there is a total of 22.5 route km of aerial cable, the total cost of aerial cable placement amounted to $34,425.

12.6 Trailer Equipment Installation

All the equipment in the two trailers was installed by NTCL. For this purpose NTCL prepared standard installation specifications. Floor mounted equipment was arranged in typical lineups with normal overhead racking and frame grounding. Installation was done by regular central office installation crews. The location of the trailers at the development laboratory allowed that the activity could be performed under the close supervision of the design engineers for this first installation. Such an installation in trailers is typical of many small CDO's at a cost of around $85,000. Since both trailers' equipment were installed at the manufacturer's site, this cost represents the total amount for the two trailers.

12.7 Subscriber Premises Equipment Installation

The installation of equipment in the homes was coordinated so that there was a minimum number of visits to the homes.

During the first visit, telephone jacks and wiring, and coaxial cable to the TV set and FM radio, if available, were installed. The outside house terminal, the conduit into the house, a backboard for the SEU and the inside fibre wiring were also installed during this visit.

The required times for the above installation were:

Telephone wiring	2.25 hours per house
CATV wiring	2.75 hours per house
Fibre wiring	0.75 hours per house

The loaded cost of an installer in 1980 was $25.68 per hour. Wiring cost per home was therefore $147.66.

During a second visit to the home, the SEU was installed and connected, the new telephone was installed and the STU was installed and connected to the TV set.

The required times for the above work were:

SEU	0.5 hours per house
Telephone	0.5 hours per house
STU	0.5 hours per house

Terminal equipment installation cost per home was therefore $38.52.

In addition, loop acceptance tests and customer training were performed at this time. Subjective and operational tests were performed on the telephone, CATV and FM radio. A loop around test was performed on the data channel. Testing time was 2.0 hours per home. Testing cost, therefore, amounted to $51.36.

A third visit was required at which time the Telidon terminal (TV monitor, decoder and keyboard), the associated modem and the wiring were installed and tested. The time for this operation was 2.0 hours per home. Telidon installation cost amounted to $51.36.

In all the above visits, the work was performed by an experienced installer. While the equipment to be installed was the same in each home, the wiring job was different and involved working in a completed home with finished walls, woodwork and flooring.

12.8 Summary of Engineering, Construction and Installation Costs

Engineering, Construction and Installation costs are summarized in Table 12.2. All costs shown, with the exception of the FTC, RDC equipment installation cost of $85,000, are those incurred by the operating company.

12.9 Cost per Subscriber

From the foregoing sections on cost of equipment, engineering, construction and installation it is possible to derive a cost per subscriber for the system. Table 12.3 was assembled to allow identification of major cost items. The table was assembled using costs as they were incurred for the actual trial system. Percentages were allocated for the six major categories. No comments have been shown here, since these are already included in Tables 12.1 and 12.2. Subscriber premises costs of previous tables have been multiplied by 150 and other unit costs in the FTC and RDC have been multiplied by the appropriate quantities to arrive at total system costs.

The per subscriber costs obviously represent an averaged cost. Since trunk facilities and trunk fibre cables were only

ITEM	ENGINEERING $	CONSTRUCTION OR INSTALLATION $	COMMENTS
1 - Subscriber Premises			
SEU	--	238	Includes installation of house fibre cable, TV, FM Radio coax, telephone wiring and jacks, SEU, STU, telephone and testing
STU	--		
Telephone Set	--		
Telidon Terminal	--	52	Includes installation of TV monitor, decoder, keyboard and house wiring
Data Set	--		
2 - FTC, RDC Equipment			
LIU	--	85,000	Engineering costs are included in equipment and material costs
DMS-1	--		
Data Multiplex	--		
TV Processors	--		
Bays, Shelving	--		
Jack Field	--		
Alarm System	--		
Power Supply (RDC)	--		
Trailer (FTC)	--	800	
Trailer (RDC)	--	700	
Site Preparation	--	9,000	Includes trailer foundations, road grading
Ducts	N/A	N/A	Only overall cost available
3 - Fibre Cables			
Buried Cable Placement	11,700	73,500	
Aerial Cable Placement		34,500	
Cable Splicing		17,000	
Cable Testing		17,000	
4 - Trunk Equipment			
FD-1 (Voice)	--	--	Engineering cost is included in equipment cost. Installation cost is included in FTC, RDC equipment installation cost (Item 2)
FD-2 (Data)	--	--	
RM-3 (TV, FM Radio)	--	--	
FA-1 (TV, FM Radio)	--	--	
5 - CDO Equipment			
Power Supply (FTC)	N/A	N/A	Only system overall cost available
CATV Head-End	5,000	15,000	Total could reduce to $10,000 in future
150 Telephone Lines	N/A	N/A	Only overall cost available
Telidon Switch	16,000	75,000	Includes installation of MUX/DEMUX and data sets, and facility conditioning
6 - Miscellaneous			
Test Equipment	--	--	

N/A Not Available

Table 12.2 Engineering, Construction and Installation Costs of the Trial System

ITEM	ENGINEERING $	CONSTRUCTION OR INSTALLATION $	MATERIAL $	TOTAL SYSTEM $	PER SUBSCRIBER $	PER SUBSCRIBER %
1 - Subscriber Premises						
SEU	--		5,500*			
STU	--	35,000	150*	894,050	5,960	
Telephone Set	--		77*			
Telidon Terminal	--		2,400*	418,700	2,791	
Data Set	--	7,700	340*			
SUB-TOTAL				1,312,750	8,751	33.4
2 - FTC, RDC Equipment						
LIU	--		4,500*			
DMS-1	--		750*			
Data Multiplex	--		300*			
TV Processors	--	85,500	51,000			
Bays, Shelving	--		3,000	1,014,500	6,763	
Jack Field	--		7,000			
Alarm System	--		25,000			
Power Supply (RDC)	--		20,000			
Trailer (FTC)	--	800	23,500	24,300	162	
Trailer (RDC)	--	700	18,700	19,400	129	
Site Preparation	--	9,000	--	9,000	60	
Ducts	N/A	N/A	N/A	8,000	54	
SUB-TOTAL				1,075,200	7,168	27.3
3 - Fibre Cables						
Distribution and Trunk			780,000	780,000	5,200	
Buried Cable Placement		73,500				
Aerial Cable Placement	11,700	34,500				
Cable Splicing		17,000		153,700	1,025	
Cable Testing		17,000				
SUB-TOTAL				933,700	6,225	23.7
4 - Trunk Equipment						
FD-1 (Voice)	--	--	50,000	50,000	333	
FD-2 (Data)	--	--	26,000	26,000	173	
RM-3 (TV, FM Radio)	--	--	70,000	70,000	467	
FA-1 (TV, FM Radio)	--	--	85,000	85,000	567	
SUB-TOTAL				231,000	1,540	5.9
5 - CDO Equipment						
Power Supply (FTC)	N/A	N/A	N/A	34,000	227	
CATV Head-End	5,000	15,000	30,000	50,000	333	
150 Telephone Lines	N/A	N/A	N/A	40,000	267	
Telidon Switch	16,000	75,000	157,000	248,000	1,653	
SUB-TOTAL				372,000	2,480	9.4
6 - Miscellaneous						
Test Equipment	--	--	10,000	10,000	67	
SUB-TOTAL				10,000	67	0.3
T O T A L				3,934,650	26,231	100.0

N/A Not Available
* Unit Cost

Table 12.3 Total and per Subscriber Costs of the Trial System required for subscribers in St. Eustache, the average cost of the carriage system for those subscribers is obviously higher than that for subscribers in Elie. Nevertheless such an overall average figure is still meaningful for broad planning purposes.

12.10 Operating Costs

Operating costs consisted mainly of maintenance and repair costs. During most of the time that the trial operation was going on, an excessive amount of failures of the SEU occurred due to insufficient electrical protection as has already been discussed in earlier chapters. Only during the last few months, maintenance and repair reduced to a level that could be considered as being typical for such a system. However, because of the very short time, it is not possible to derive a statistically meaningful average cost. Since the trial system is still operating, and is now behaving as predicted, such data may be assembled at a later time. Therefore, regrettably no operating cost figures can be presented in this report.

12.11 Discussion of Costs

In the earlier sections of this chapter the costs to manufacture and install the trial system were developed, excluding research costs. The results were summarized in Table 12.3, which shows the costs for the major subsystems and equipment such as the subscriber premises equipment, outside plant, centralized equipment, etc. Also shown there, are the relative costs of these items with respect to the total cost, in order to highlight the major cost centres which would require particular attention with respect to any future cost reduction effort. It should once more be emphasized, that the costs, as shown in this chapter, reflect only the cost of the Elie - St. Eustache trial system, which was designed and manufactured as a one-of-a-kind system and was therefore not meant to be a prototype of a system to be mass-produced. Nevertheless, some discussion of these costs is both useful as well as appropriate.

The largest costs are associated with equipment and cable, both of which are controlled by the manufacturer. Two of the major cost items are the SEU and the LIU. Their cost is critical, since one of each is required for every subscriber. Even without the use of any major new technologies and development effort, but by taking advantage of large scale integration for the electronics and repackaging the design for mass production cost reductions of up to 80% are possible for these two items. Such a cost reduction would, however, still not be sufficient to achieve an economically viable system. Further research and development in areas such as integrated optics and VLSI techniques will be required to provide technologies that can achieve further cost reductions of the SEU and the LIU.

With respect to fibre cables, no major cost reductions are expected in the near future, since such cable are already produced in large volume and cost is not a major concern in their present most common application in short and medium haul trunks for telephony. Some cost reductions could be achieved by sharing the same fibre between upstream and downstream transmission as well as multiplexing several subscribers by using WDM techniques. This technique would more readily be applicable if long wavelengths and single mode fibres are used, since the reduced fibre loss would more than offset the loss introduced by WDM couplers.

The trial also revealed, that there were certain costs encountered by the operating company which were larger compared to those for a comparable copper plant. Such additional costs, although not as significant as those for the SEU, LIU or fibre cable costs, were the result of the particular design chosen by the manufacturer. Examples of such areas are:

- Requirement for higher skilled personnel to engineer the outside plant. The trade-offs and alternatives such as considerations of the number of splices in order to reduce loss, insertion of various attenuators for different loop length, etc., which were inherent in the design require more than the usual skills.

- Requirement for more personnel for splicing and testing, because of the additional time needed to perform these operations including preparation of splice enclosures.

It would be desirable to introduce design changes, that could reduce such costs.

CHAPTER 13 - LESSONS FROM THE TRIAL

13.1 Introduction

Throughout the preceding chapters various aspects of the design, manufacture, installation and operation of the trial system and services have been presented. Also the various rather unique problems that were encountered, only some of which had been anticipated, and their resolutions have been discussed. The purpose of this chapter is to bring together in one place all these experiences that are dispersed in all the other chapters and also to review them in the context of the objectives of the trial. It will therefore be useful to recall here once more what the objectives of the trial were.

13.2 Objectives of the Trial

The objectives of the two phases of the trial were as follows:

- Assess the technical and economic feasibility of utilizing fibre optics technology for improving communication services in rural areas.

- Test the application of fibre optics technology under real environmental and operational conditions.

- Provide both government and the industry with technical, economic and marketing data required for possible decisions in respect of policies, regulatory requirements and future system choices.

- Assist Canadian industry in developing new products and services to meet Canadian and foreign requirements for improved rural and urban communications systems, and provide Canadian industry with an incentive to develop domestic systems capability in fibre optics technology.

- Assess the socio-economic impact of new services on subscribers living in rural communities.

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

All these objectives have been addressed successfully by this trial. Substantial amounts of information have been collected which have been and will continue to be of value to manufacturers, service providers, network operators and governments. The trial also has already contributed significantly to the establishment of new services and has very positively advanced the development possibilities of new products. Details of actual achievements will be discussed in the remaining sections of this chapter. How some of the objectives, which are of an on-going nature, can be supported with future activities will be discussed in the last two chapters.

13.3 Design Experiences

- The concept of a integrated services access system was successfully implemented. The trial has proven that a variety of signals of digital and analog nature can be transmitted successfully over a single carriage network from a technical and an operational point of view.

- The trial established the fact that fibre optic cables and components will withstand all environmental conditions that a subscriber access network may be subjected to, without excessive failures or degradation in performance.

- Custom designed and developed equipment for the trial worked satisfactorily, but was obviously very expensive, because no custom LSI circuits were used to reduce component count and also only a very small volume of this equipment was manufactured.

- With the fibre optic technology (multi-mode fibres and short wave lengths) and signal transmission and modulation technique used, the maximum repeaterless reach with laser transmitters was limited to 5 km. The maximum reach for LED transmitters was only 2.5 km. This reach is not sufficient for rural applications where long loops are very common. In order to extend the reach, the concept of a remote distribution centre was applied (RDC). With the maximum repeaterless fibre optic trunk of 9 km between the FTC and RDC, the effective reach of the system was increased to 14 km. Although this approach was very successful, it would require, for economic reasons, sufficient number of subscribers in a cluster (St. Eustache represented such a situation with respect to the CDO in Elie). As there are usually a significant number of remote and isolated subscribers in rural areas, the concept of a remote distribution point may not always be applicable to serve them.

- Since the system was designed to serve only a fixed number of subscribers, nothing equivalent to a cross-connect field was provided for the fibre optic distribution plant. During the life of the project it was observed, that there was a rather high rate of movement of the selected trial participants within the community. The lack of a cross-connect field did not allow easy shifting of the trial service to another location. Therefore the trial had to be confined to a given location rather than a particular subscriber. A means of cross-connection should be included in future systems.

- The 56 kb/s data channel to each participant was terminated at the SEU electrically with a RS 422 compatible interface which did not include any control leads. Therefore, to connect the Telidon equipment, an additional unit, a "data set" had to be used both to convert the asynchronous RS 232C compatible interface of the Telidon terminal to the synchronous RS 422 interface of the SEU and to adapt the 4.8 kb/s terminal data rate to the 56 kb/s data rate of the system data channel. If further services were to be connected to the data channel, a more sophisticated multiplex/demultiplex unit would be required instead of the simple "data set" used in the trial. This situation is the consequence of not having defined the details of the data services at the start of the project. Several separate data ports could have been provided in the design of the SEU and LIU with very little additional cost.

- Remote and centralized switching of TV channels was demonstrated successfully. This method has several advantages over conventional tree-structured coaxial cable systems where only a limited number of channels (currently maximum about 50) are available at the subscribers premise. The number of channels a subscriber can access is not limited by the transmission system, which needs to make available simultaneously only 1, 2 and may be 3 channels to each subscribers premise. The number of channels can be increased at the central point and is virtually unlimited. Such a system also provides a very simple means for controlling access to channels for a Pay-TV service and measuring usage for billing purposes in case of a pay-per-view Pay-TV service. In this trial system the switch, which is based on conventional TV-converter technology, would limit access to about 20-25 channels maximum. A different technology would be required in a future system. Electronic control from a central point to enable or prevent access to certain channels by the customer, which would be required for any Pay-TV service, was not available in the trial system, since Pay-TV was not considered. However, the addition of such a feature would virtually add no additional cost to such a system and therefore should be included in any future system.

- Bi-directional transmission over a single fibre using wavelength division diplexing was implemented as a technology trial for a limited number of subscribers. No problems were encountered and no degradation in signal quality was observed. Wavelength division diplexing and multiplexing appears, therefore, feasible, and could reduce fibre cable cost particularly for long loops, as well as provide for growth without additional outside plant.

- Use of local power with a battery back-up for subscriber premises equipment operation did not cause any problems with respect to reliability of service. Initial concerns with respect to possible user resistance because of the additional cost of electric power to them, proved to be unfounded. In the trial system the power requirement for the SEU was only 20 watts. In the future, where changes to subscriber terminal equipment design are very likely, a reduction in power requirement can be expected. In the trial system, power for the SEU was derived through a transformer plugged into a wall outlet. In some instances the transformer was either inadvertently or intentionally unplugged by the subscriber, causing a minor alarm. In future systems, a tamperproof or a direct and permanent power connection arrangement should be considered.

- The trial revealed, that the subscribers premises can represent a rather harsh and sometimes unpredictable electro-magnetic environment. The prime example was the initial high failure rate of the SEU, mainly due to the destruction of CMOS circuitry at the data port. Additional protection circuitry had to be added. Since maintenance and repair of subscriber premises equipment is very costly, careful consideration should be given to environmental protection of such equipment in the design of future systems.

- In order to extend the repeaterless reach of the system, as a technology trial, laser diode transmitters were used for downstream signal transmission for a limited number of subscribers. The design provided for monitoring the optical output power and the bias current. The latter was used to provide an alarm, should the current exceed a predetermined level, indicating aging and ultimately end of life. Due to this alarm mechanism, a relatively large number of laser diode LIU's had to be replaced. Subsequent analysis has revealed that, due to temperature sensitivity of the optical output power of the laser, changes in the ambient temperature caused an increase of bias current during warmer times. Readjustment of the alarm level was required to prevent such "non-real" alarm conditions. NTCL has indicated that present laser diodes are manufactured with an integral cooling device and therefore such false alarms due to ambient temperature variations are eliminated. As a result, future systems should not be plagued by such a problem.

- The design of the fibre and the cable permitted them to withstand all handling with standard telephone laying equipment during placement provided care was taken not to exceed the minimum bending radius at any time. The light weight and small diameter of the cable particularly facilitated its handling.

- The method of splicing of fibres by fusion and the fusion splicer that was used proved to be satisfactory in field use for both buried and aerial cables.

- In order to minimize overall transmission loss, route engineering had to minimize the number of splices as much as possible. This also required that accurate route lengths had to be established, and uncut cable lengths up to 2000-m had to be manufactured and placed. These requirements complicated manufacture, engineering, logistics of supply and construction, and hence increased cost. Since the actual cable and splice losses, on the average, were below the assumptions on which the system design was based, more standard route engineering, construction and manufacturing practices could have been used reducing the cost of outside plant. In future system designs, therefore, an overall tradeoff study should be made which should consider number of splices vs. cable lengths, engineering and construction costs, and complexity of supply and stocking.

- Again as part of the requirement to reduce the number of splices, in situations where a branch cable was to be spliced with some of the fibres of a through cable, the procedure used to obtain splicing slack on those fibres was both time consuming and not very practical. Furthermore, the remaining fibre in the through cable was left unused, representing a waste.

- In cases where two independent TV channels were provided to the subscriber, laser diode transmitters were used for power requirement reasons. It proved to be extremely difficult to meet all video signal quality requirements for both channels, in particular with respect to noise and intermodulation. In a significant number of cases it was decided to accept a reduction of up to 10 dB in the signal to intermodulation ratio, since the pictures still proved subjectively to be acceptable. Even with this relaxation, laser diodes still had to be selected for linearity. The practical feasibility of large scale production of future systems for multi-channel video transmission will require significant improvement in laser linearity or application of other transmission and modulation methods.

- In the present trial system within the maximum repeaterless reach of 5 km, four different loop designs exist with respect to downstream signal transmission:
  i) loops up to 2.5 km with LEDs
  ii) loops between 2.5 and 5 km with lasers
    (a) loops just above 2.5 km required a 10 db optical attenuator to prevent optical receiver overload
    (b) longer loops used a 5 db optical attenuator
    (c) longest loops used no optical attenuator

In comparison to the simple resistance design of present copper pair subscriber loops requiring very little outside plant engineering, the necessity to take into account four different fibre optic subscriber loop designs significantly adds to the outside plant engineering effort and cost. In addition, it also makes any subsequent outside plant rearrangements quite complex. Furthermore, it requires a larger inventory of LIU spares for both repair and plant rearrangement. Since subscriber access plant cost has always been a significant part of the overall cost of a communications network, a reduction of loop designs, ideally to one, is therefore highly desirable in future applications.

13.4 Construction and Installation Experiences

- The installation of the outside plant essentially met the goal of employing the usual construction crews using their normal construction equipment and tools, and following standard procedures and practices. No real problems were encountered either during installation or later during repair of cut cables.

- The layout of the aerial drop cables called for a slack span to be installed from pole to house. A drop cable was then lashed to the slack messenger. This was time consuming, and lashing to a slack messenger was not easy. Development of a self-supporting drop cable would facilitate installation.

- The splicing of the optical fibres was performed without any difficulties. With only one week of training, the splicers learned how to prepare cables and enclosures for splicing and perform the actual splice operation. They soon became confident enough that splice testing was discontinued on the distribution cables.

- Practices and procedures developed by NTCL were detailed, error-free and well enhanced with many sketches and drawings allowing easy understanding by all crafts people. In some cases, particularly for route engineering, MTS provided inputs to the practices based on their practical experience, which both reduced development time as well as resulted in better practices.

- The installation of subscriber premises equipment and wiring did not create any problems for the usual installation team.

- Since there was considerable equipment to be installed throughout the subscribers' homes, and the need for different types of wiring, MTS developed a sketch of each home showing the location of equipment, and routes for wiring. Since the actual installations were phased over three visits, these sketches proved to be very useful particularly when different crews did the installations.

- Installing the FTC and RDC equipment in trailers proved to be a successful solution for implementing a field trial system. This approach allowed the installation and testing of the equipment to be completed under the close supervision of the design team and thereby avoiding costly and time consuming debugging of the system in the field.

- Some problems causing signal degradation were encountered in the installation of the CATV head end in the Elie CDO and the video processing equipment in the FTC. During system acceptance tests it was found that the picture quality at the subscriber's premises was unacceptable due to excessive noise and crosstalk. Subsequent analysis revealed that both degradations were caused by high level signal leakage resulting from faulty connector installation and use of single braid shielded coaxial cables, pointing towards the need of revised installation practices.

- Since Telidon switching and trunking was provided with standard equipment, no difficulty during installation was experienced.

13.5 Operation and Maintenance Experiences

- A sophisticated monitor and alarm system was installed with the Elie system. This allowed system status to be viewed at the FTC and at remote locations by way of dial-up data circuits. The alarm system was also connected to the 24 hour control centre in Winnipeg. This system allowed easy identification of problems and locations of faulty equipment and thereby facilitated the maintenance of the system. The success and operational value of the monitor and alarm system has prompted NTCL to indicate that similar facilities would most likely be considered for any future subscriber access systems using relatively complex electronic equipment.

- The creation of a single subscriber trouble reporting centre for all services proved to be very successful. Leaving the segmentation of a reported trouble to a technically oriented organization (in this trial MTS, the telephone operating company) allowed speedy restoration of service. The responsibilities and the interaction between MTS and the service providers were determined and documented prior to the trial. As a result the cooperation between all service providers was excellent.

- The performance of the system was very satisfactory. The failure rates for the services were generally less than predicted and comparable or better than present accepted norms in the industry, once the initial high failure rate of the SEU was reduced through additional protection circuitry.

13.6 Service Experiences and User Reaction

13.6.1 Telephone Service

This service was satisfactory with respect to quality. In fact the quality on local calls was noticeably higher due to the absence of noise, because of digital voice transmission and absence of induced noise from nearby power lines. User satisfaction with this service was also very high.

13.6.2 Cable Television Service

Final acceptance was based on subjective evaluation. Since the acceptance team did not have training in categorizing picture quality according to the DOC BP-23 standard, difficulty was experienced in the acceptance process. One problem which contributed to this difficulty was the fact that the picture quality of most local channels was somewhat degraded relative to the off air signals, by exhibiting noticeable noise ("snow"). However, additional objective measurements confirmed that all channels were meeting at least the minimum requirement of 40 db signal/noise ratio. Two major conclusions can be drawn:

1- Acceptance should either be done by personnel trained in subjective assessment of picture quality, or preferably it should be based on objectively measurable tests.

2- Modern cable systems generally can provide picture quality in excess of the minimum requirements of the BP-23 standard. Therefore future fibre optic system designs should aim at a superior specification than offered by the BP-23 standard.

Users were generally satisfied with the service and its quality. Although this was the only trial service for which they had to pay ($10/month) all subscribers who had a television set subscribed to the service. This high subscription rate indicates that at this monthly rate and probably even higher, there exists a good market for this service in rural areas.

13.6.3 Telidon Service

The overall reaction of the trial participants to the Telidon service was very positive. Hardware features, access procedures and data base contents received favourable comments.

Use of a large, full size keyboard, necessitated by some of the Telidon services, replacing the more common small hand-held keypad did not draw any adverse reaction.

As the Telidon service was totally new to the participants, instructions were prepared on its operation and a short training course was given at the beginning. Follow up instructions were issued as new features were incorporated into the system. The successful use of the service was not only due to its novelty and usefulness, but also to a large extent to the effort spent to familiarize the participants with the use on an on-going basis.

All Telidon services were provided free of charge to the participants. Therefore, it is not possible to make any reliable predictions about the usage of a chargeable future commercial service based on the recorded trial usage figures.

13.7 Public Relations Experience

While Public Relations may not be an essential item to the successful technical operation of a system, it is, however, essential to the acceptance of the system by the participants and others and to the understanding of what the trial is about and what its objectives are. It also promotes and supports the interest and desire for collaboration by the participants.

For this purpose one PR person was appointed as the prime contact for the participants, media, visitors, etc. This allowed in particular the participants to know who to contact whether it might be for information, for difficulties or complaints. At regular intervals or more often when required, participants were informed through newsletters of events surrounding the trial and thereby keeping their interests alive. Formal and informal public meetings usually with representatives from all sponsors proved extremely useful to discuss problems, likes and dislikes about the trial leading to corrective actions. Personal attention to participants has certainly removed much of the uneasiness usually felt when confronted with unfamiliar, new and high-technology equipment.

The PR department, however, was not the only source of PR. In this trial the regular appearance of the same MTS maintenance people in the area provided a continuous PR activity not found too often. MTS went so far as to have the telephone bills hand delivered by the maintenance people so that there would be a face to face meeting with each subscriber at least once every month. Such frequent personal contacts contributed significantly to the sustained interest and cooperation of the trail participants.

CHAPTER 14 - FUTURE OUTLOOK

14.1 Introduction

The Elie - St. Eustache Fibre Optic Trial System has demonstrated the feasibility, from a technical and operational perspective, of the use of optical fibre based systems in the rural outside plant. In terms of these objectives set out for it, the trial must be considered a success in every respect.

The next question is what one might expect to happen in the future with such systems. The cost of the total system as was presented in a chapter 12 would obviously not justify its large scale application unless significant cost reductions can be projected.

In order to explore the question of the future of integrated services fibre optic distriburion plant it will be useful to examine, whether further use can be made of the present trial system to further the understanding of technological, operational and service problems in the short term. For the long term it will also be necessary to review the approaches that are being taken by other countries and thereby trying to detect any common trends. Finally, since cost reductions will largely be influenced by technological advancements, required key technological developments need to be examined. Intimately tied to technical developments is the need for a real market to exist. Therefore, factors that may be favourable or unfavourable for such a market to exist will also be considered.

14.2 Future Use of the Elie - St. Eustache Trial Systems

The field trial was officially terminated on 31 March 1983 as was originally planned. Despite some of the problems identified and shortcomings recognized, all sponsors agreed that the system operated much better than might be expected from such an experimental system. It was also recognized that the system offers excellent opportunities as a test-bed for further technological, service and market trials due to many of its unique capabilities (broadband star topology, centrally switched TV, etc.).

With these considerations in mind, the ownership of the system was tranferred from the Government of Canada to MTS with the aim of continuing its operation by MTS as a national test-bed accessible for trial purposes by governments and industry.

Initial discussions between DOC and MTS have started to assess the technical and financial feasibility of new technology, services and market trials, all of which could include other organizations as well. Possible future trials considered, include:

- Technology trials
  - Application of long wave lengths to extend reach
  - Application of single-mode fibres to extend reach
  - Application of FM-FDM technique to improve TV signal transmission quality
  - Application of digital techniques to TV signal transmission

- Service trials
  - Demand Access TV
  - High Definition TV
  - Enhancement of Telidon Services
  - Alarms
  - Downloading of Computer Programs

Preliminary work has started to identify priorities, benefits to be derived from each project, required budget and possible partners.

The further use of the existing trial system will no doubt aid in advancing technology and services. However, such activity has to be regarded as a near-term approach to the on-going effort of developing access networks and services for the future. In a technology which is evolving as rapidly as fibre optics does, the capabilities of the Elie - St. Eustache system as a vehicle to advance subscriber access system technologies and services will eventually be exhausted. Therefore, in parallel to trials on the existing system, a well focused effort of R&D has to be pursued to develop technologies, devices and systems, which will, with the experience gained from the existing trial system, lead to commercially viable fibre optics access networks. In order to aid in the identification of the direction that future work should take, a brief review of related work, field trials and trends in technology and systems is provided in the following sections.

14.3 Other Field Trials and Developments

In Canada as well as in other countries, several trial systems have been built or are near completion to test new technologies, new topologies and services in order to gain hands-on experience on future integrated services networks.

14.3.1 IDA, Winnipeg, Canada

The IDA trial system used coaxial cable in a tree configuration with hierarchical distributed intelligent equipment units located along the cable. A block diagram is given in Figure 14.1.

The system was designed to handle virtually all voice, data and video services including:

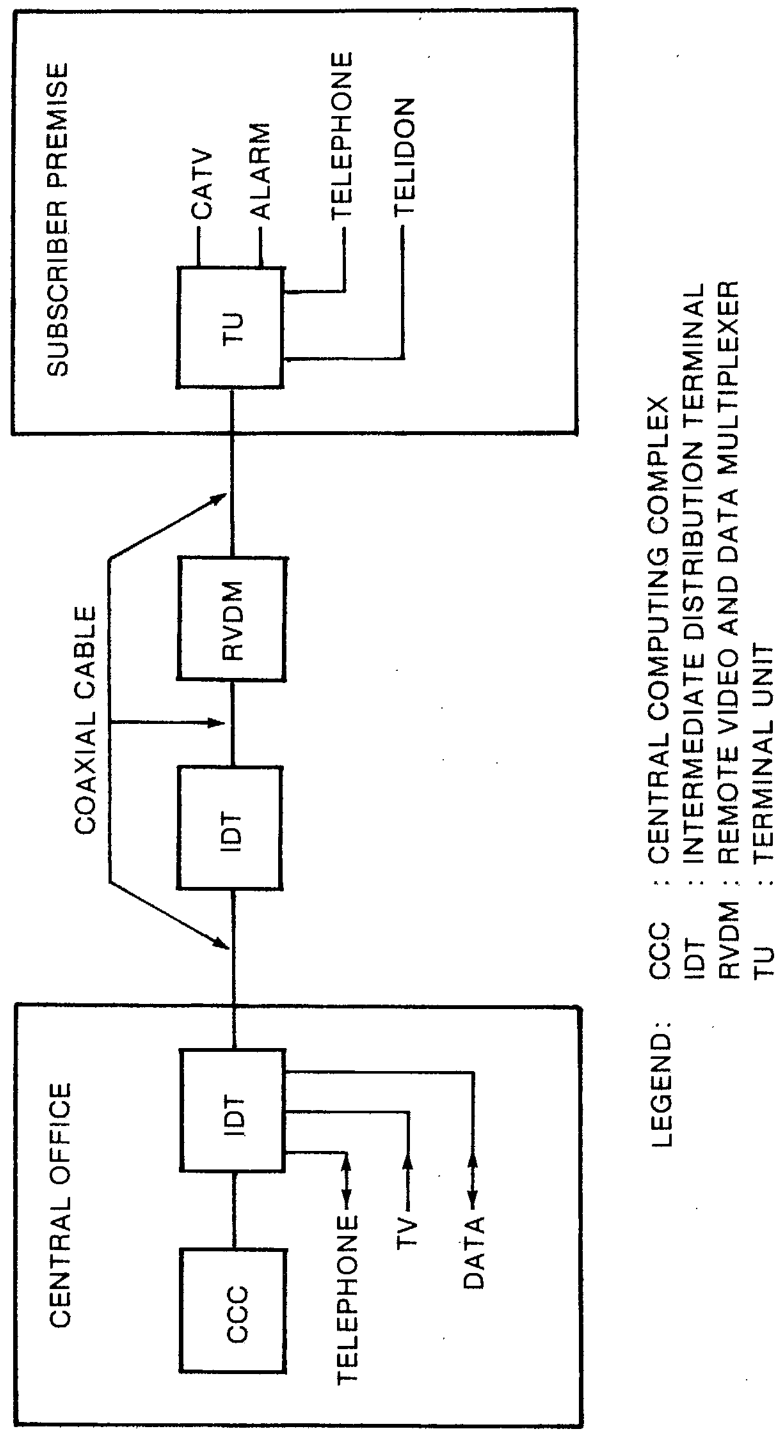


Figure 14.1 Block diagram of system architecture of the IDA trial in Manitoba, Canada

CATV, PAY-TV
Telidon (Videotex)
64 kb/s data
Alarm reporting (fire, burglar, medical)
Meter reading, load management
Stereo music
Telephone (digital, 64 kb/s)

No other facilities would be needed for any other services. It represents a true integrated services subscriber access system. The trial was conducted during 1981 and 1982 and was terminated. One hundred subscribers were involved in this trial [14.1, 14.2].

13.4.2 Biarritz, France

The Biarritz trial uses an optical fibre hierarchical star system. A block diagram is given in Figure 14.2.

Videophone was an important design consideration as it is with many European systems. Telephone service is provided by the voice channel of the videophone. The system provides two channels of switched video. A signal channel which exist primarily for control, could possibly be used for data services.

The system uses a transmit fibre and a receive fibre to connect each subscriber to the secondary office.

The trial of the system started in Spring, 1984. It is expected that ultimately 1500 subscribers will be connected to the system [14.3].

14.3.3 BIGFON, Germany

The BIGFON system is designed as an optical fibre distribution network in a star configuration. A block diagram is given in Figure 14.3.

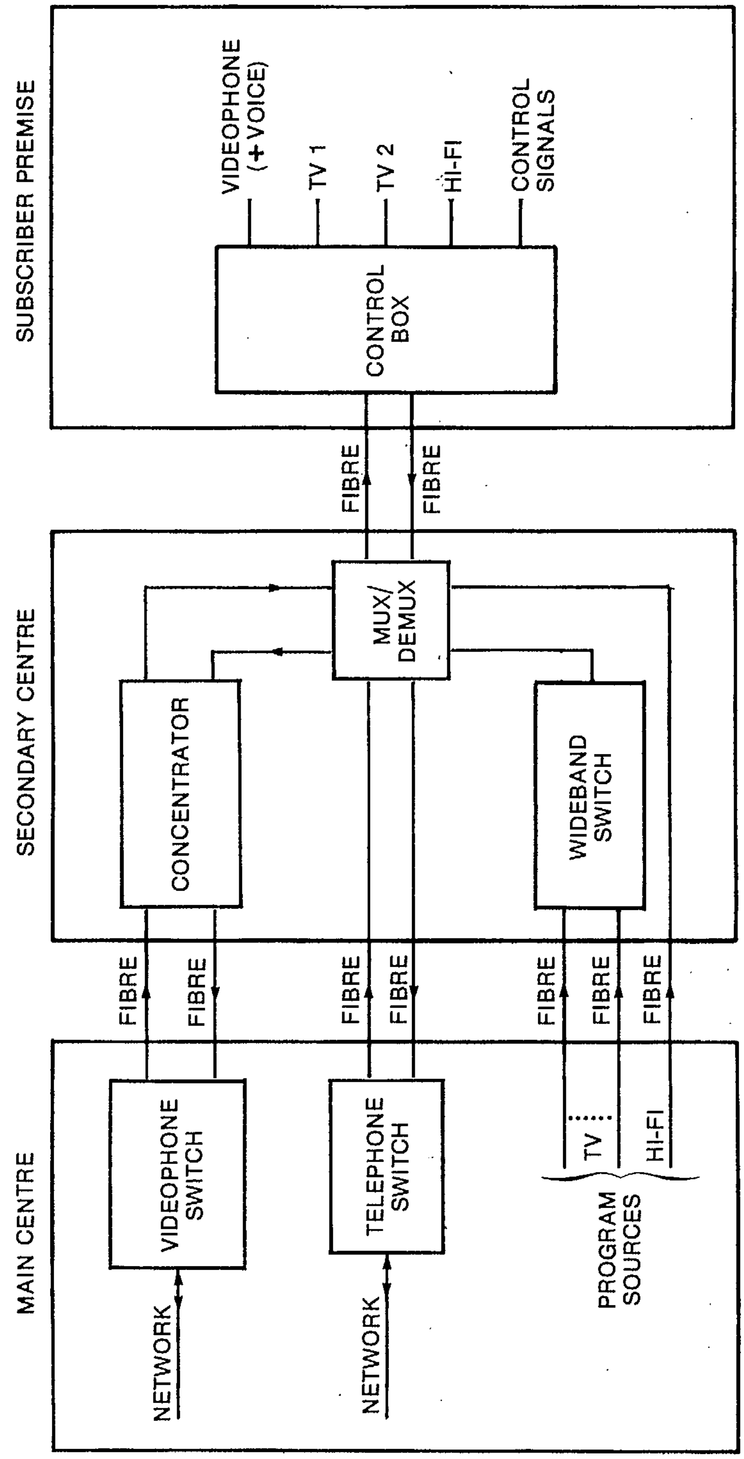


Figure 14.2 Block diagram of the system architecture of the Biarritz fibre optic trial in France

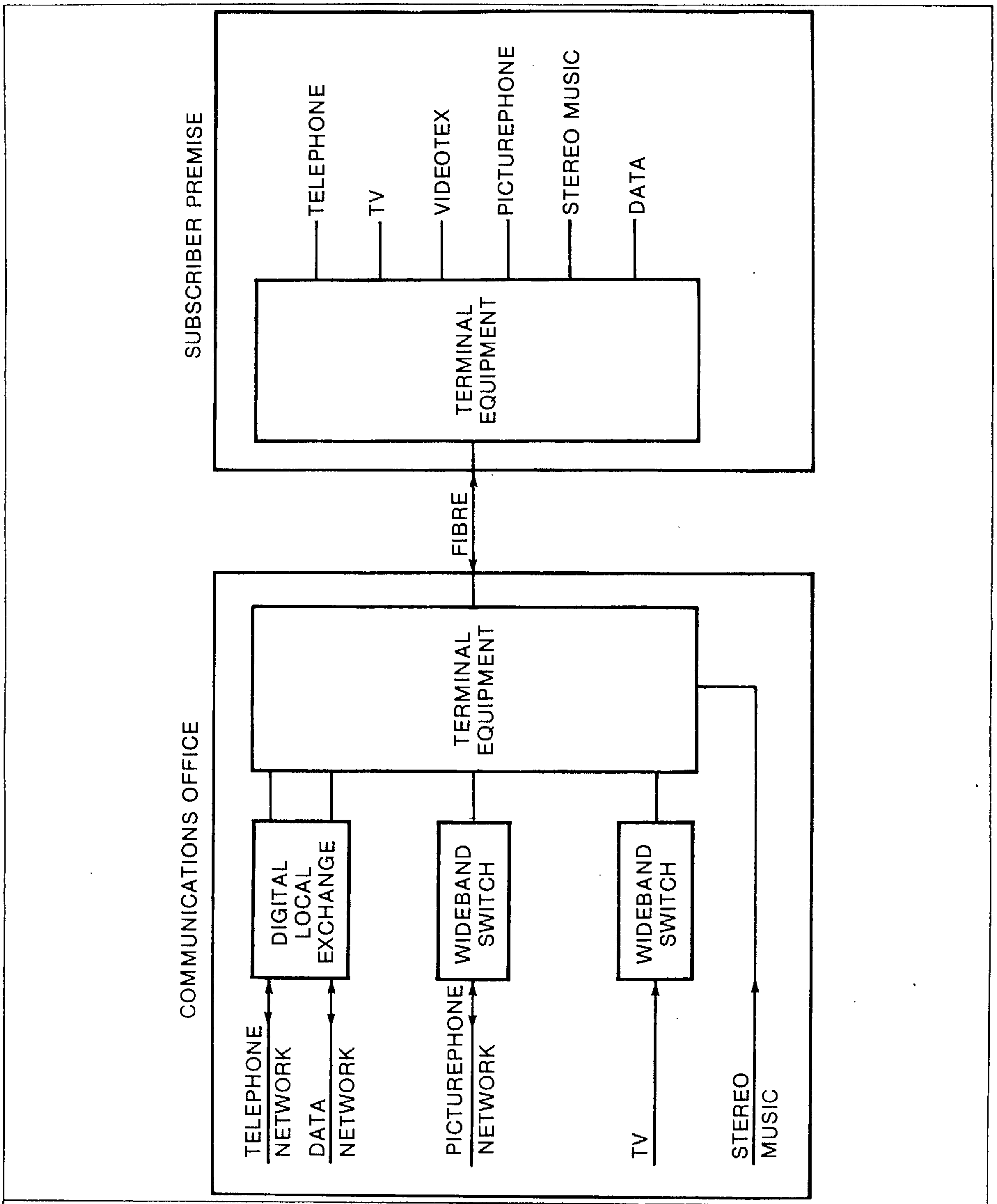


Figure 14.3 Block diagram of the system architecture of the BIGFON fibre optic trial in Germany

A wide range of services will be available over this system, including picturephone. A separate telephone channel is also provided. The system uses one bidirectional fibre between each subscriber's premise and the central office.

The trial started in December 1983 and will continue for three years. 350 subscribers in 7 cities including West Berlin are taking part in this trial [14.4, 14.5, 14.6].

14.3.4 Milton-Keynes, U.K.

The presently implemented Milton-Keynes trial system is a simplified version of a more sophisticated design concept. The design concept is essentially based on a multi-star, but contains elements of tree and single-star topologies. The actual trial system is a multi-star design offering cable television service. It is a centrally switched CATV system, offering simultaneously two channels to the subscribers. A three fibre cable including two wires (copper coated strength members) to carry signalling information, connects each subscriber to a flexibility point. A block diagram is given in Figure 14.4.

The trial started in 1982 and involves 18 subscribers [14.7, 14.8].

14.3.5 Integrated Services Digital Network (ISDN)

While the above examples indicate the interest in developing broadband integrated services networks employing different technologies and architectures, in a major parallel effort, involving a large number of countries, evolution of the present, largely copper pair based telephone network to provide digital transmission of all signals to the subscribers premises is being studied. In the near term this will provide an integration of voice and data, but exclude video, because of the inadequate

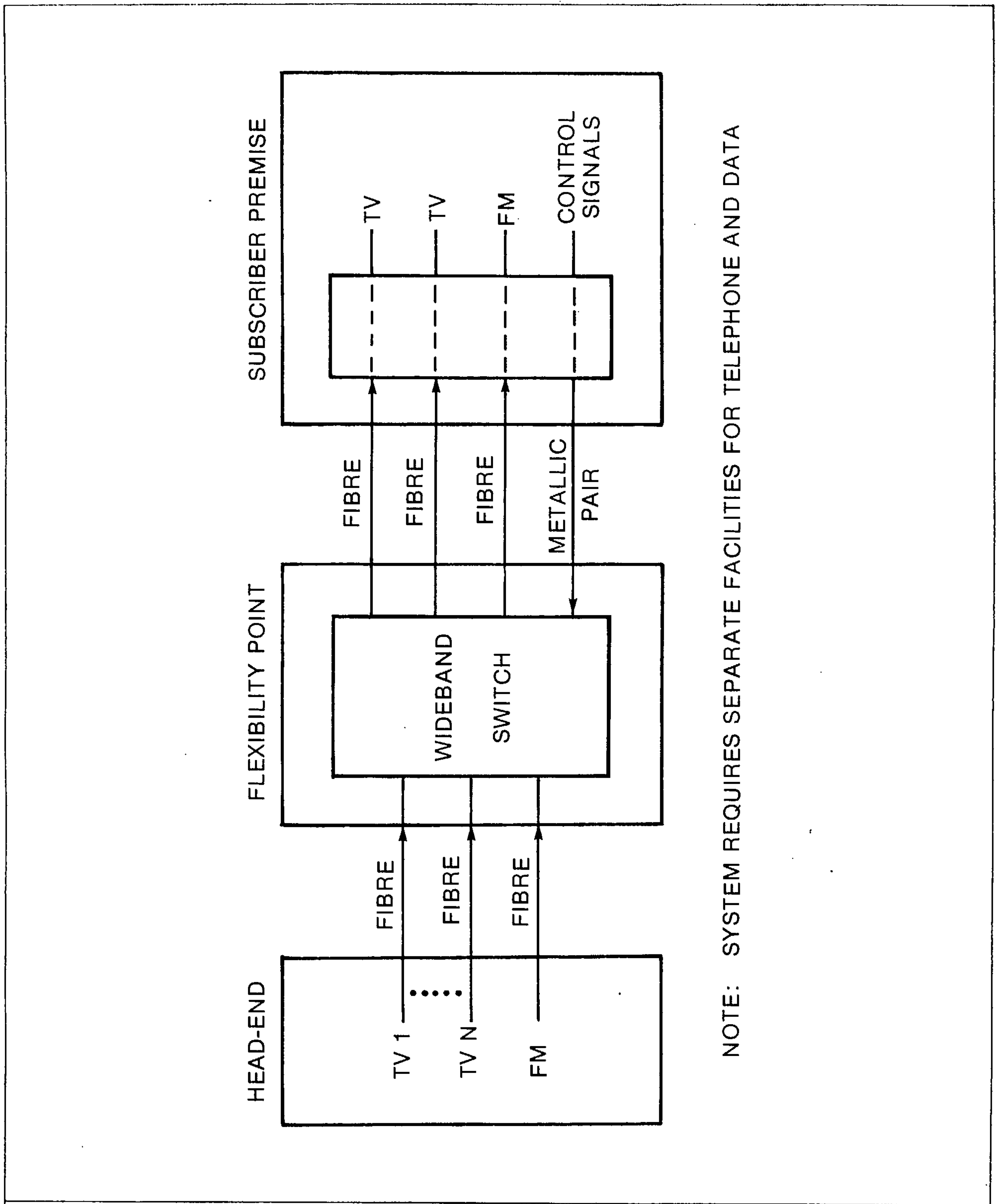


Figure 14.4 Block diagram of the system architecture of the Milton-Keynes fibre optic trial in the U.K.

bandwidth of the present copper based access network which for obvious economic reasons cannot be replaced very rapidly by a wideband transmission medium such as optical fibres. Present work at CCITT indicates that recommendations will be forthcoming at the end of the 1980/84 study period recommending a 144 kb/s digital transmission system on the subscriber access loop which will comprise 2 voice channels and 1 data channel (2 x 64 + 16 = 144 kb/s). The data channel will be used partly for signalling and the 64 kb/s voice channels may be used alternatively for high speed data.

It is expected, that in the next four-year study period of CCITT consideration will be given to include broadband and video signals into ISDN. Obviously, the transmission of such signals will require the use of wideband transmission media such as coaxial cable and much more likely optical fibres in the subscriber access network.

14.4 Network Architecture and Technology Trends

Previous sections described briefly some of the architectures and technologies being applied to some recent trials throughout the world. This section is not intended as a tutorial on system architecture and technology, but does attempt to provide a perspective of what is being considered and what direction integrated services access network evolution therefore might take in the future.

14.4.1 Network Architecture Trends

14.4.1.1 Two Facility Systems

These systems are not truly integrated networks, but may emerge as overlay networks to provide a broadband capability to existing narrowband facilities. The typical example is the addition of a coaxial cable based CATV network, essentially paralleling the paired cables in the existing telephone network. Although such an approach has answered emerging service needs in the past in urban areas, it has failed to do so in rural areas. Furthermore, it also remains to be seen whether this arrangement will prove to be adequate to cater to future new service demands. Since ownership of the two carriage networks is different in many cases, duplication of certain operation and maintenance efforts is likely unavoidable.

14.4.1.2 Tree Architectures

In section 14.3.1 the IDA system was described. This was an integrated services access network using coaxial cable technology. The primary advantage of this approach is that existing coaxial cable CATV plant can be converted into an integrated services access network through adding intelligence and multiplexing equipment into the outside plant.

A similar tree architecture may also be implemented using optical fibres. The larger bandwidth and lower loss of fibres and therefore the possibility of longer repeaterless spans will make them the preferred technological choice in the future. WDM techniques or multiple fibres may be used in the trunks and feeders of such networks in order to provide a large number of TV channels to the user.

14.4.1.3 Star Architectures

Present copper pair based telephone networks are essentially based on a star architecture, the local switching offices being the centres of such star access networks. Both AT&T and Bell Canada and their respective research organizations Bell Laboratories and Bell Northern Research are considering some kind of a "double star" architecture. The basic idea is to use remote concentrator terminals close to the end user. These terminals would be used primarily in conjunction with digital switching offices and would be connected to them along feeder routes by digital carrier systems for voice and data. TV and FM radio signals would be fed to these terminals by possibly additional fibre trunks. Connection between the remote concentrator terminal and the subscriber would also again be accomplished by fibre cables whereby all signals would be multiplexed onto one fibre. In order to achieve further cost reductions several subscribers would receive their services over the same fibre using wavelength division multiplex (WDM) techniques.

This approach can be compared with the concept where subscribers would be connected directly to the switching centre. The choice of one or the other method will be a matter of economics. Both methods have the appeal of allowing an evolutionary conversion from the present copper based plant to a fibre optic plant. It is likely that, in conjunction with the implementation of ISDN, copper pair feeder routes would be early candidates for replacement by fibre optic multiplex feeders whereas the connection from the remote concentrator terminal to the subscriber would initially remain copper based, in particular where it already exists. Such a mixed network would however not be able to carry video services.

The contemplated network architecture and the implementation strategy is particularly suitable for urban and suburban areas where a reasonable concentration is available that would make the remote concentrator terminal approach economically feasible [14.9]. Such an approach, however, may not necessarily provide also an answer to rural communication with its generally much lower subscriber density. Other approaches may be necessary.

It is worthwhile to notice that NTT in Japan is proposing an Information Network System (INS) which would carry data services on the same transmission media as telephony. All signals would be digital and the subscriber access network would use fibre optic cables. The whole concept is very similar to the one being worked on in North America. NTT expects that video services would initially be provided over a separate network, and only be integrated on the same network at a later stage, when it becomes economically feasible. A first implementation of this network is planned for 10,000 subscribers in Tsukuba Science City in 1985, coinciding with the International Exhibition in Tsukuba in that year. Expansion of this network to all of Japan is planned for the year 2000.

14.4.1.4 Local Area Networks (LAN)

Local Area Networks were conceived in the late 1970s, primarily to allow the interconnection of many data terminals and host computers through a high speed transmission system. Such systems were developed particularly to provide data and computer communications networks for limited distances such as large office buildings or several buildings of a university or research centre campus. At first glance, it seems that they may not have much relevance to the subscriber access network evolution problem. Although this is true in general, some of the work that is being done in this area could influence the development of the inside wiring problem in subscriber premises, where currently each service requires separate wires and hence installation effort. As the number of services increases, the required number of inside distribution wires and their separate installation will make a unified inside transmission system provided by an LAN, increasingly more attractive economically. Early LAN's used primarily coaxial cable in either bus or ring configurations. Current developments consider fibre optics as the transmission medium and are attempting to integrate voice and video with data.

14.4.2 Technology Trends

The purpose of this section is to examine trends in the evolution of fibre optics technology with respect to their relevance to subscriber access systems.

14.4.2.1 Technology - Network Architecture Overview

With present day fibre transmission systems, and those projected over the next decade or so, a single fibre will be unable to carry more than a small number of simultaneous video channels on an economical basis. The limitation exists regardless of whether digital or analog techniques are used. There is currently some research activity under way in several countries to examine "coherent" modulation techniques for fibre optic channels to co-exist on the same fibre and may lead to opportunities for totally new approaches to using fibre for video distribution. However, coherent techniques are at a very early stage of development, and there remain significant fundamental implementation issues to be researched before they could be seriously considered for application outside the laboratory. Most observers place this technology at least a decade from practical application. Thus for distribution systems which are required to carry several tens of video channels (the standard for present day CATV systems) the "centrally switched star" architecture used in the Elie trial will form the basis of the most effective systems in the medium term future.

According to estimates by telephone operating companies, for an integrated services fibre optics access network carrying telephone, data and also CATV services to be competitive vis-a-vis the traditional separate copper pair and coaxial cable networks, its cost per subscriber would have to approach somewhere between $1,000 to $1,500. The cost analysis of chapter 12 very clearly shows that significant effort will be required to achieve this objective.

The major cost elements of a "centrally switched star" architecture are:

i) The fibre cable itself, and the associated opto-electronic devices such as lasers and optical detectors.

ii) The "subscriber entrance unit" in the subscriber's home, translating the video and telephony signals from optical to electrical signals.

iii) The video switch, located in the Central Office or remote site, selecting the channel viewed in each residence under subscriber control.

Each of these cost elements is dependent on the evolution of a different technology for significant cost reduction.

14.4.2.2 Fibre Cables and Opto-Electronics

These areas of technology are common to systems now being used for large scale deployment of fibre optic systems in telephone trunk systems around North America and worldwide. Significant improvements have taken place in two areas since the design of the Elie trial:

- Lasers - these devices have now become accepted as the standard method of launching light into the fibre. Their reliability has increased to the point where lifetimes exceeding 10 years are typical. Another major change is the move from 850 nm to 1,300 nm wavelength which allows the use of the much lower intrinsic loss of glass fibres at this wavelength.

- Glass Fibres - With the almost universal move to the 1,300 nm wavelength for system operation, fibre loss has been reduced by about an order of magnitude since the design of the Elie system - 0.5 dB per kilometer of loss at 1,300 nm is now possible. In addition there has been a very recent move from multimode to single mode fibre which can further improve system reach (and bandwidth). Single mode fibres allow only a single ray of light to propogate, virtually removing any distortion due to pulse dispersion, such that system design can be based almost entirely on the simple signal loss through the fibre. The combination of these two evolutionary changes has led to system reach being extended to up to 40 km without repeaters on digital trunk systems being installed today.

The price of fibre has also declined since the Elie system was installed and top quality fibre is now available (uncabled) at under one dollar per meter. The cost of the cable itself and the cost of installation are thus becoming more significant than the cost of the basic fibre. However, fibre cable is still significantly more expensive than twisted pair cable, and than coaxial drop cable used for CATV systems. The price of fibre has now stabilized somewhat and it is not expected to reduce significanlty over the next five years.

While lasers have evolved considerably they are still expensive and their cost will likely dominate the cost of even a large volume "Subscriber Entrance Unit" and associated termination in the Central Office. However, continued high demand for these devices and on-going research should lead to significant cost reductions over the next 5 years or so.

The much improved reach possible through the combination of 1,300 nm systems and lower loss single mode fibre will, to a great extent, remove the very stringent loop length restrictions inherent in the design of the Elie system. While the impact on the hardware cost of this improvement would not be large, the outside plant design and installation would be considerably simplified.

However, with the removal of the loss constraint on fibre loop design, the potential for using wavelength division multiplexing (WDM) devices can be re-assessed. These passive optical devices allow the use of several different wavelengths (or colours) of light to co-exist on the fibre each with an independent information stream. While these devices contribute some loss of light intensity, this loss would not in general be signficant in loop systems operating with lasers at 1,300 nm. Architectures using a single fibre for clusters of several subscribers, split out to a single fibre per subscriber only 100 meters or so from the home, could significantly reduce the total amount of fibre required in a fibre loop system. As WDM devices cost in the order of a few hundred dollars today, and as their cost could reduce appreciably if deployed in large volumes, their use to save several thousand meters of fibre per subscriber is an attractive tradeoff.

14.4.2.3 Subscriber Entrance Unit

The two major cost elements of the "Subscriber Entrance Unit" are the opto-electronic transmitter/receiver and the interface electronics providing the standard electrical signals for telephone, television and the channel control (and data signal if required).

- The opto-electronics have already been discussed above, but significant improvements on the costs of the "Subscriber Entrance Unit" would require considerable further evolution of laser technology. Integrated optics, involving packaging both optical and electronic circuits on the same chip, manufacturable in large quantities at high yields, would be the key to major cost reductions. Such techniques are five to ten years away. Interim approaches using lower cost discrete lasers not requiring the elaborate drive and cooling circuits of today's devices may allow medium scale cost reductions in three to five years time.

- The interface electronics are very amenable to integration into one or two large scale silicon integrated circuits using available technology. Assuming digital transmission would be used for video transmission in a future system an additional high speed digital to analog convertor chip would be required, but the overall costs of the electronics per se are not likely to be a major item in a "Subscriber Entrance Unit" designed for large scale production.

Thus opto-electronic costs are expected to dominate the cost of the "Subscriber Entrance Unit" for at least the next five to ten years.

14.4.2.4 Video Switch

The Elie system design used conventional analog video and a standard TV convertor type frequency changing channel selection system. This approch was the most cost effective system available at the time for a small scale system. It did however lead to at least some of the quality degradation noticed by some of the users of the system, even though the system did meet required video performance.

One of the major system choices in the design of a future system will be whether to use analog or digital techniques for video transmission. At today's cost analog is still likely to be somewhat less expensive overall. However, the decreasing cost of the high speed digital to analog convertors required in each "Subscriber Entrance Unit" will give digital the lead in the very near future.

The design of the video switch is dependent on the selection of transmission technique. The preferred approach today and in the near future would be to use a digital "space" switch switching the required channel (or channels) onto each subscriber's fibre in digital format. The digital switch would require medium speed electronics but would simplify design and eliminate problems of crosstalk and other distortion. Overall the quality provided by a digital system would be virtually totally dependent on the quality of the signal provided into the system.

While the video switching arrangement described, when manufactured in large volume, should be considerably more cost effective than that used in the Elie system, it would still form a significant cost element of the system. Development of integrated optics, as mentioned earlier, may allow the design of an integrated optical space switch which would reduce the cost of the switching function considerably. This technology is not expected to be available for at least five years.

14.4.2.5 Conclusions

While many of the elements required for a fibre optic based integrated video, telephony and data system have evolved in technology and decreased in price since the design of the trial system, there still remain significant cost elements. The major elements are the opto-electronic devices, but also of significance are the fibre itself and the video switch.

With the technology currently available, the economics of a fibre based system, even if deployed on a large scale, would be unlikely to compete with conventional designs. However, with continued research into opto-electronics and lower cost high speed silicon integrated circuits for handling digital video, it is projected that a system meeting the costs of conventional technology would be feasible to design in two to three years for installation in about five years time. This would be an aggressive time scale requiring signficant commitment to research and development. Further progress in integrated optics could make a fibre based integrated video and telephony system more cost effective than conventional techniques during the five years following.

14.5 Funding of Fibre Optics Research

In this section we will briefly review where the majority of fibre optics research and development is done today, what needs and goals are driving this effort and how the necessary funding is provided in various countries. Finally we will review where Canada stands with respect to this technology, what future opportunities might exist and how Canada's leadership in communications can be maintained.

Leading countries in the development of this technology have so far been the U.S.A., Japan, Canada, the U.K. and to a lesser degree France and Germany. Research and development has either been conducted by government owned telecommunications monopolies such as the P.T.T.'s in the U.K., France, Germany and Japan (or through P.T.T. funding in the private industry) or by large private corporations such as AT&T, ITT, Corning Glass, etc. in the U.S.A. It has to be pointed out, however, that in the case of the U.S.A., appreciable amount of research and development funding is provided by the government. Although significant amounts of such funding are for military purposes, rather than for civilian public communications systems, the civilian systems nonetheless benefit from the development of military systems. The amount of funding from both private as well as public sources has been in the hundreds of millions of dollars. Some of the trials alone have been in the tens of millions if not hundreds of millions of dollars (Biarritz in France, BIGFON in Germany).

Present research in these countries is mainly driven by the near term need for higher capacity terrestrial and undersea trunks. Such need exists particularly in the U.S.A., the U.K. and Japan. The high population density and the geography require a high capacity backbone trunk system in Japan, which cannot be provided solely by terrestrial microwave or satellite systems. In the U.K. there is a need to provide high capacity fibre optic trunk systems with repeaterless transmission lengths of up to 50 km to connect most of the toll switching offices with each other. Similarly the high population densities and the resultant high communications traffic in the East and West coast of the U.S.A. are a major driving force for the development of longhaul fibre optic trunk systems. Furthermore, there is also a need for high capacity intercontinental fibre optic cable systems. The traditional supplier countries for such systems, U.S.A., U.K. and Japan, have been engaged in the development of such systems for some time.

In addition, the almost non-existence of coaxial cable based CATV systems outside the U.S.A. and Canada, and the mounting pressure by viewers for access to a greater variety in television programming also provide considerable incentive for the development of broadband systems resulting the allocation of significant funds for the research and development of fibre optic broadband subscriber access systems. Traditional subscriber access plants constituted in the past about 50% of the total capital costs of a communications network. Considering the large populations of those countries, it is evident that there are large potential future markets waiting for the right product. Many of the larger field trials being conducted in several countries are aiming at providing practical experience that could guide further development of fibre optic broadband subscriber access systems, eventually leading to competitive products.

Canada has been able until now not only to maintain equality in this field of high technology but has indeed demonstrated leadership in several areas, such as the first long haul application of fibre optics in Saskatchewan and the first fully integrated services fibre optics subscriber access network trial in Elie-St. Eustache in Manitoba. Such projects were partly funded by private industry and partly by governments or crown corporations. Compared with other countries' expenditures, the funds allocated to the Canadian projects have been relatively modest but nevertheless have resulted in significant achievements. It is doubtful, however, whether expenditures at present levels will be able to maintain Canada's leading position. There are signs that Canada may fall behind particularly in device technology which could also lead to a stagnation in applications and systems design. Considering the significantly larger efforts being spent on fibre optics technology R&D in other countries, which receive significant amounts of public funds and thereby reduce the risk taking of the private sector, more funding will have to be allocated to this technology in Canada not only by the private sector but by the public sector as well. Public sector funding would particularly be desirable in furthering the development of new technologies, such as integrated optical devices and coherent optical communications which are considered to be key areas for making fibre optic technology a competitive alternative for subscriber access system applications, but involve appreciable unknowns, uncertainties and risks, which are probably too high to be dealt with by private industry alone. Considering the huge market potential for subscriber access systems, as mentioned earlier, efforts that would lead to breakthroughs could, however, be very rewarding. Research and development in such areas should therefore be seriously considered as prime candidates for government support.

14.6 Non-Technical Considerations

Although technology is one of the important factors in the evolution of future access networks, there are many other considerations which also have major influences. One of the most important considerations is obviously the type of services that will be demanded and consequently have to be carried by the delivery system. At this time the known services which are being delivered to most subscribers (particularly residential) are telephony and cable TV.

Future new services that may be provided are limited only by one's imagination. However, there are forecasts that contain those services that are more likely to be offered in the near future. These include:

Videotex (Telidon)
Alarms (Fire, Burglar, Medical Emergency, etc.)
Teleshopping
Telebanking
Electronic Mail, Messaging
Meter Reading, Load Control
Pay-TV
Demand Access TV
Computer Program Downloading

In the last few years some of these service have become a subset of the Telidon videotex service. Among these are teleshopping, telebanking, electronic mail and messaging, and to some degree computer program downloading.

Obviously any future network should be flexible enough to be able to carry not only the above listed services, but other future services as well, since such networks are usually placed for a service life in the order of 25 years or more so that costs can be kept at a reasonable level. In the near term, in order to make an optical fibre based broadband integrated services subscriber access system even marginally attractive the revenues of both telephony and cable-TV would be required, since these are the only well developed services as mentioned before.

This latter requirement may however not necessarily be achievable because of present institutional arrangements and regulations as well as possible competition for carriage of services at the subscriber access plant level. Historically, the telephone network and the coaxial cable television networks have developed separately. Current regulations, which reflect this situation, make it rather difficult if not out-right impossible for the telephone companies in Canada to carry cable TV signals on a future integrated services subscriber distribution plant.

Another issue is competition. In the era of deregulation, providing communications networks is not any longer seen as the monopoly of the traditional telephone company. In the U.S.A., for example, other organizations are permitted to provide certain service carriage in competition with the telephone companies. Such carriers do not necessarily provide carriage for all services but only for those that are economically attractive. Furthermore, such carriage may not be offered everywhere, only again in areas considered economically advantageous.

All these situations however do promote the continuation or the creation of separate networks and could at least delay the introduction of truly service integrated subscriber access networks since with only a potentially small market for such networks there may not be sufficient incentive to invest large funds into the required research and development as discussed earlier. The discussion whether this is desirable or undesirable is however beyond the scope of this report. It has been presented here as an example of the possible influence of factors other than purely technical on the evolution of integrated services networks.

14.7 Probable Future Scenario

From a purely technical point of view, assuming that other considerations will promote rather than inhibit the realization of integrated services networks, the evolution scenario could likely be as follows:

It appears from the foregoing discussions in this chapter, that a star architecture with remote concentrators is the approach which is currently being favored by the major carriers in several countries. This approach allows for an evolutionary progress from today's copper pair based network towards a fibre optics based integrated services network. Initially one will see the replacement of copper pair feeders by digital multiplex fibre feeders in conjunction with remote concentrators. The distribution from such concentrators to the subscriber will remain as copper pairs, at least for the near term. Video signal distribution will remain either on coaxial cable systems where it already exists, or it may not be provided, where it does not exist, until that last portion of the access plant is also replaced by fibre. This appears to be the approach that for example France may take. However, initially installing coaxial cable systems until fibre optic systems will become economically feasible is an approach considered by some other countries including Germany, Japan and the U.K.

For economic reasons wavelength division multiplex and wavelength division diplexing techniques will be used in the distribution plant between the remote concentrators and the subscribers. Only one or two video channels on the subscriber loop will be carried; selection of video programs will be accomplished by broadband switching techniques at a central point, such as the remote concentrator. Although there is unanimous agreement that voice and data will be carried digitally, no clear direction is seen as yet for the transmission of video signals. It is expected that, for cost reasons, video may be carried in analog form in early systems. However it is most likely, that digital transmission will also be adopted for video in the long term.

Most of the planning is concentrating on urban and suburban areas where the relatively high population densities and relatively short loop lengths make such integrated services networks much easier economically and technically feasible. How much of these approaches are relevant and technically feasible for rural areas with low population densities and long loops has to be assessed separately. While multimode fibres and short wavelength techniques appear to be adequate for the needs of urban and suburban applications, it is likely that long wavelengths and single-mode fibres will be required for rural applications. Since there is already a trend of migration towards long wavelengths and single-mode fibres for present applications, it is to be expected, that this newer technology will ultimately become the main fibre optic technology for communications purposes. Therefore, the question of the adequacy of short wavelength and multimode fibre technology may become academic.

References

[14.1] R. Newman; Project IDA - A First in Manitoba, Micros Magazine, Vol. 1, No. 1, September 1980.

[14.2] N. Toms; Omnitel II: New Services for Home Owners, Micros Magazine, Vol. 1, No. 1, September 1980.

[14.3] B. Marc, M. Dupire, A. Panafieu; The Wired City of Biarritz, International Fiber Optics and Communications, Vol. 3, November/December 1982, pp. 30-35.

[14.4] A. Naab, M. Lange; The BIGFON Project of the Deutsche Bundespost, International Fiber Optics and Communications, Vol. 3, November/December 1982, pp. 27-29.

[14.5] E. Braun; BIGFON: The Biggest Fiber Optic Project Ever Undertaken, Telephony, 25 July 1983, pp. 38-52.

[14.6] K.D. Schenkel, E. Braun; BIGFON - An All-Service Subscriber Communication System Goes into Operation, Forum '83, 4th World Telecommunication Forum, Technical Symposium, Vol. 3, Geneva, 29 October - 1 November 1983, pp. 3.11.7.1-3.11.7.6.

[14.7] J.R. Fox; Initial Experience with the Milton Keynes Optical Fiber Cable TV Trial, ISSLS 82 Proceedings, Toronto, 20 - 24 September 1982, pp. 230-235.

[14.8] J.R. Fox; The Fibrevision Trial at Milton Keynes, International Fiber Optics and Communications, Vol. 3, November/December 1982, pp. 7-14.

[14.9] Final Report, The Application of Fiber Optic Technology to The Access Network Evolution, Bell-Northern Research, Prepared for: Department of Communications, October 1983.

CHAPTER 15 - CONCLUSIONS AND RECOMMENDATIONS

15.1 General

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 systems relating to this project. Although the results from the trial have already been discussed in detail in all the foregoing chapters, they will be summarized here with two particular purposes in mind: One is to determine to what extent the objectives set for this trial were achieved and the second is to recommend what future activities are required that will lead to the development, manufacture and operation of commercially viable integrated services fibre optics subscriber access systems.

15.2 Objectives of the Trial

In order to establish the proper perspective, the objectives of the trial are presented here once more. Since the trial was conducted in two phases the objectives are listed separately.

The objectives of Phase I of the trial were:

- To assess the technical and economic feasibility of utilizing fibre optics technology for improving communication services in rural areas (15.3.1).

- To test the application of fibre optic technology under real environmental and operational conditions (15.3.2).

- To provide both government and the industry with technical, economic and marketing data required for possible decisions in respect of policies, regulatory requirements and future system choices (15.3.3).

- 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 (15.3.4).

The objectives of Phase II of the trial were:

- To assess the socio-economic impact of new services on subscribers living in rural communities (15.3.5).

- To provide a test bed for service providers to obtain knowledge about the kinds of services that are relevant to the rural community (15.3.6).

The numbers in the brackets at the end of each objective indicate the subsection in which the related conclusions from the trial are listed. The conclusions are therefore an indicator of the extent to which the objectives were achieved.

15.3 Conclusions

Conclusions include favourable as well as unfavourable aspects of the trial.

15.3.1 Technical and Economic Feasibility

Overall, 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 individual subscribers in a rural environment is technically feasible. The project also provided detailed system and component costs thereby identifying major cost issues that will require future attention.

15.3.1.1 Technical Feasibility

Specific technical strengths of the trial system were:

- Among a variety of possible system configurations identified in the chapter on future outlook, the trial system has proven the concept of a switched star configuration with success.

- The trial system has proven that the digital multiplex systems FD-1 and FD-2 and the analog system FA-1 originally developed for trunk applications, can be used successfully for voice, data and video transmission respectively in subscriber access system feeders.

- Simultaneous transmission of digital and analog signals on the subscriber loop was successful. While the multiplexing plan of future systems may be different, the mixture of analog and digital signals created no problems.

- Bi-directional transmission of optical signals over a single fibre is feasible. Trial of bi-directional transmission made up part of NTCL's contractual obligation of "Technology Demonstration" of newer developments in fibre optics technology.

- The concept of centralized CATV switching and the transmission of only the TV channels (one or two) selected by the subscriber, rather than transmitting all available channels to the subscriber premises for local selection, was proven feasible. This approach reduced loop bandwidth, and optical transmitter power and linearity requirements.

- One additional possible feature of a centrally switched system, recognized but not exploited at Elie, is the feasibility of centrally controlling the CATV switching to control access to Pay-TV to authorized customers and to block CATV service to delinquent customers.

- The lossless optical power monitor devised for LED transmitters was a development that was patented and it represents an advance in design.

- The optical fibres and the design of the cable proved to be suitable for this application and they developed no problems over the period of installation and operation.

- The fusion splicing method and equipment were capable of performing consistent low loss splices in the field for both buried and aerial fibre.

Specific technical weaknesses of the trial system are:

- With the multimode and short wavelength fibre optic technology used in this trial only subscribers up to a maximum of 5 km from the distribution centres could be served without repeaters. This is not sufficient for rural applications.

- Although simultaneous transmission of two CATV channels was possible, it was very difficult to meet all signal quality requirements with the chosen AM-FDM transmission technique.

- While meeting the minimum requirements of BP-23, the TV signal quality was considered to be lower than the quality that is being obtained with modern coaxial cable CATV systems. Future fibre optic systems need therefore be designed to provide better quality TV signals than allowed by BP-23. The results also point to a need for upgrading the BP-23 standard that will bring it more in line with present technological capabilities of both coaxial cable and fibre optics.

- The life of the lasers provided (1978-80 vintage without integral cooling) was shorter than both the LED transmitters used in the system and lasers of recent design. The absence of integral coolers for the lasers resulted, bias current variations with temperature causing several unnecessary alarm conditions.

- Rearrangement of plant, to cope with subscriber movements was not possible since no optical fibre equivalent to a distributing frame or cross-connect box was provided. Although this was not required by the contract it needs to be included in any future system.

- A slack strand was required to support the aerial drop cables to the homes. Lashing a drop cable to a slack strand is difficult and should be avoided in the future by using a self-supporting drop cable. Such a cable can be manufactured, provided there is sufficient demand.

- Four different subscriber loop designs were required to meet all transmission requirements for loop lengths between 0 km and 5 km. This would require additional transmission engineering and plant administration efforts as well as additional spare part stocking and handling expenses in the future. Future designs should aim at reducing design alternatives.

- The 56 kb/s data channel interface did not provide any control signals and was also not flexible enough to serve several low speed data services simultaneously. It required additional interface equipment for proper operation. This deficiency was the result of the sponsors not identifying the services and their interface requirements before the system design was made. Proper interfaces could have been provided at both the SEU and the LIU at virtually no additional cost.

15.3.1.2 Economic Feasibility

The Elie-St. Eustache trial system was built as a one-of-a-kind system and therefore the design of optical and electronic circuits and subsystem was not necessarily optimized for mass production. Therefore, the following economic feasibility conclusions were not based only on cost figures derived in chapter 12.

- Although there are economies in integrating services, it is not yet economical to use fibre optics technology for the transmission of a variety of integrated services to individual premises in rural areas. The reasons for this unfavourable conclusion are, that in a subscriber access system, equipment and fibres can only be shared to a limited degree as contrasted to inter-office or toll trunk applications, where fibre optic technology has already proven to be economical because of the high degree of multiplexing of voice and other signals. Although fibre costs will gradually decrease due to increasing production volumes, the costs of the SEU and LIU, which were the major contributors to the overall cost in the trial system, will still render such systems uneconomic even when manufactured in large quantities, unless relevant new technologies are developed which will reduce their cost.

- For subscriber access systems which require only narrow bandwidths, fibre optic systems are not likely to become economical in the foreseeable future.

- The demand for broadband services, particularly TV signals, which today require a separate distribution network with its associated cost in addition to the copper pair plant, would accelerate the economic feasibility of a fibre optic subscriber access network provided that it is designed as an integrated services system.

- The most likely early application of fibre optics in the subscriber access network will be in feeders using remote concentrator units and digital multiplex techniques to serve a group of subscribers. Because of the higher subscriber densities such systems are more likely to be introduced in urban, and suburban rather than rural areas.

- In the process of providing a coaxial cable distribution network to serve all households in the two communities with cable-TV service, as required by CRTC in granting licence for the trial, it was once more realized that it is economically difficult or most often unfeasible to provide this service to small rural communities at subscription rates comparable to those of urban areas. The reasons for this are:

  ° lower household density per route
  ° the proportionally large overhead constituted by the head-end facilities
  ° the proportionally large overhead constituted by the community channel program generation facilities.

Although some economies can be realized in the distribution plant in the long term through cost sharing by the use of an integrated services fibre optic system, the problems of head-end and community channel costs will remain. Therefore, the solution of the economic problem of CATV service in rural areas may require some form of social subsidization.

15.3.2 Environmental and Operational Conditions

The trial has very clearly provided evidence, that fibre optic cables and equipment do withstand all the environmental extremes encountered in subscriber access plant, and that they can be operated and maintained without undue difficulty by the normal operations personnel.

15.3.2.1 Environmental Conditions

- Fibre cables can be buried at the same depth as copper cables within the frost zone without suffering transmission impairments or mechanical damage.

- Aerial fibre cables do not suffer transmission impairments due to the extremes of temperature or mechanical stresses caused by wind.

- Stray voltages, transients, ground potentials from lightning, etc., are a characteristic of the electrical environment in the rural home, and can create problems. The design of equipment such as the SEU must therefore include protection of the device from such an environment and be capable of operating satisfactorily in such an environment.

15.3.2.2 Operational Conditions

- Construction crews can easily and reliably learn to splice the fibres by taking a short course. The trial proved that it is not necessary to make a transmission test of every splice.

- Construction crews can use the regular tools such as ploughs, winches and lashers to place the fibre cables after brief instruction on the peculiarities of fibre cables such as not to exceed the bending radius at any time.

- Installers and repairmen can install and maintain the system effectively after a brief period of training. The procedure of replacing and returning plug-in units for repair, which is common for complex electronic equipment, simplifies the maintenance job.

- A single trouble report centre is desirable for integrated services, because it relieves the subscriber of the need to analyze the symptoms in order to determine to whom a trouble should be reported. It also results in economies for all organizations that are involved.

- An automatic and remotely accessible alarm and maintenance facility provided with the trial system reduced maintenance effort and provided early warning of potential service troubles and enhanced preventative maintenance capability.

- Performance of the system and the subscriber trouble rate for each of the services was comparable to those provided over traditional access systems.

15.3.3 Data for Decision Making

All data and experience collected throughout the trial have obviously relevance with respect to providing governments and industry with information regarding future systems choices, and policies and regulations that may be required for the orderly introduction of such systems. Conclusions reached in these respects are:

15.3.3.1 System Choices

- The application of fibre optics for the provision of many services in a star configured integrated services network is technically feasible.

- At this point in time, fibre optic subscriber access systems are economically unattractive compared to present copper based networks, unless major new technologies are developed.

- The star configuration used in the trial will allow the present telephone network, which has the same basic topology, to gradually evolve into an integrated services network through application of fibre optics technology into those parts where it becomes economically attractive.

- The multimode and short wavelength technology used in the trial does not provide sufficient reach to serve typical long rural loops. Long wavelength and single mode fibre optic technology is required to provide the necessary reach.

- Amplitude modulation techniques for analog transmission of more than one video channel on multimode fibres although economically most attractive, is technically difficult to use if video signal quality requirements are to be met. Frequency modulation for analog transmission and ultimately digital transmission are expected to provide technically better solutions.

15.3.3.2 Policy and Regulatory Issues

- In order to ensure the successful commercial implementation of fibre optics integrated services access systems, governments and regulators must address a number of policy and regulatory issues, including the optimum arrangements for ownership of various elements of the distribution hardware. This is to ensure that systems 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 to all users.

- With the possibility of more terminal equipment ownership by the subscriber, interface standards and requirements will have to cover a wider range of terminal equipment than present standards cover (The provision of a non-standard data interface in this trial complicated the attachment of the Telidon terminal equipment to the system).

- Some consideration may have to be given to the transmission format on the fibre loop itself so that industry standards could be set leading to lower costs of equipment through competition.

- The use of a single carriage system by a variety of service providers will require the establishment of some guidelines and rules as to the rights and liabilities with respect to access, operation, maintenance and subscriber damages resulting from failures and service interruption. The arrangement worked out between the telephone company and the service providers in the trial, whereby the prime responsibility for maintenance was placed with the carrier, was successful and could serve as a model for the future.

15.3.4 New Product and Service Opportunities

15.3.4.1 New Product Opportunities

- The trial received worldwide interest as a result of many papers that were presented at technical conferences and symposia and articles published in technical journals, increasing consciousness of other countries of the advanced technical capability of the Canadian telecommunications manufacturing industry.

- The trial site was visited by many representatives of telecommunications organizations from within Canada and around the world, which are interested in the deployment of optical fibres in subscriber access networks. Such visits may lead to new products in the long run.

- There were two significant visits to the Elie - St. Eustache site with a serious interest of applying fibre optics into the subscriber access plant. One visit was by Bellsouth, a newly formed Regional Bell Operating Company covering Florida, Georgia, the Carolinas, Kentucky, Tennessee, Alabama and Mississippi. This was followed by Central Services Organization of AT&T who would consult Bellsouth in this matter. These visits, which are the direct result of the trial, have significantly enhanced product opportunities for the Canadian industry, in this case Northern Telecom.

15.3.4.2 New Services Opportunities

- As a result of the field trial, a local cable television operating company was formed which now serves not only the trial subscribers, but other subscribers in the communities of Elie and St. Eustache as well.

- The trial has also proven that there exists a market for cable television with high penetration rate in rural communities, provided that the subscription rate is comparable to those in urban centres.

- This trial has accelerated the development of the commercial Grassroots Telidon service in Manitoba and enabled the implementation of highly interactive services such as messaging, farm and financial management programs and electronic games that would otherwise have been delayed.

- The success of the commercial Grassroots service has resulted in the expansion of the service to Alberta, Saskatchewan and Ontario and also in a modified form to parts of the U.S.A.

- The software developed and tested in Manitoba has helped Infomart to market Telidon systems throughout North America and the world.

15.3.5 Socio-Economic Impact of New Services

- User surveys conducted prior to and after the trial with respect to the trial participants' activity patterns do not indicate any statistically significant change as a result of the introduction of cable-TV and Telidon services. Due to the relative short time that the trial paritícpants have used these services, it may indeed be difficult to expect any major impact.

- The trial has created an awareness of new services and an appreciation of their potential. It also provided an opportunity to familiarize the participants, representing typical rural community residents, with computer systems, how to access and how to use them. It was evaluated by all participants as a worthwhile and positive experience.

15.3.6 Identification of New Services Needs

- Although generally well known from usage in urban centres, the trial has proven that rural residents also have a desire for a greater variety of TV programming that cable-TV systems can provide.

- The high usage of Telidon for Electronic Games indicates a desire for additional entertainment and thus an opportunity for service providers.

- Survey questionnaires indicate that alarm services, which could be provided over the existing data channel, were considered by the majority as the most desirable additional new services not provided in this trial.

15.4 Recommendations

In the following subsections recommendations for future activities in various areas are provided as a result of what was directly learned from the trial as well as by observing trends in technology and similar activities elsewhere. Although all recommendations do form an integral set of activities for achieving the goal of maintaining Canada's leadership in the development, application and operation of fibre optic based integrated services subscriber access networks and systems, they are addressed to government and various sectors of the industry separately, with a view that the identified sectors can be most influential in the pursuit of these activities. The recommendations made here represent the views of the authors and are not necessarily the official views of their respective organizations.

15.4.1 Manufacturers

The major efforts 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.

15.4.2 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 of the 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.

15.4.3 Governments

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

- Investigate how an integrated services fibre optic subscriber access system may reasonably benefit the users, service providers and manufacturers. What services and benefits are unique to integrated services fibre optic subscriber access systems? What trade-offs are involved? Could it adversely affect the user's ability to select service providers and services they wish to utilize? (These are some of the aspects being raised also by ISDN's common digital access channel for integrated services).

- Examine the impact and appropriateness of present communications policies and regulations that affect integrated services networks and make changes where necessary and desirable, to promote the orderly and efficient development of telecommunications networks. Studies should cover areas such as:

  ° Study whether there is a need for hardware ownership of parts of the delivery system by service providers. Such a requirement, for example, as it exists now for CATV system operators regarding subscriber drops, is incompatible with the notion of an integrated services network.

° Should service integrated subscriber access systems be considered desirable, rules and guidelines have to be established regarding:

  - Conditions and rights for access and use of such networks by service providers
  - Basis for cost allocation to service providers for carriage of service by network operators
  - Responsibilities and obligations of network operators and service providers towards end users.

Such information should become available as soon as possible in order to assist all sectors of the industry in their long range network and services planning.

- Promote and develop in collaboration with the telecommunications industry, required new standards related to service integrated networks through participation in national and international standards making organizations.

- Review and upgrade existing video signal quality standards as specified in BP-23 to promote improved signal reception at the subscriber terminal, in view of what present and future transmission technologies can provide and what subscribers will expect due to significant advances being made in terminal equipment picture display quality.

- Analyze and make recommendations concerning possible financial support or incentive schemes for industry for long-term and high-risk technology and systems research and development including field trials in the area of fibre optic subscriber access networks.

- Consider whether there is a need for additional advisory bodies such as the Communications Research Advisory Board (CRAB) and in particular groups of a more specialized nature to advise in specific areas.

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. As pointed out earlier, the recommendations represent intertwined sets of conditions which require the concerted action of industry and governments.