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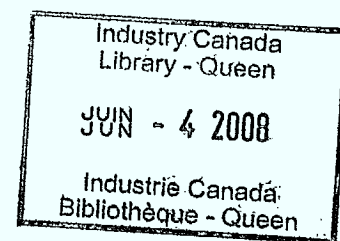
FINAL REPORT

AN ECONOMIC AND COMMERCIAL  
VIABILITY STUDY FOR THE DEVELOPMENT  
OF LOCAL PUBLIC COMMERCIAL MICROWAVE  
SERVICES IN MAJOR URBAN AREAS



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## EXECUTIVE SUMMARY

This study, commissioned for the Department of Communications (DOC), assessed the potential economic viability of developing local public commercial microwave services in large urban centres, identified radio-communication applications tailored to business user needs, and evaluated the relative demand for microwave radio-communication services. Goss, Gilroy & Associates Ltd., assisted by SkyWave Electronics Ltd., were retained to undertake this study.

The study reviewed applications that have already been made to the DOC for private commercial services in Canadian centres as well as examined the United States' experience in local public commercial microwave applications, prior to developing a number of postulated delivery models for providing microwave service. The postulated delivery models were compared to alternative distribution methods to determine economic viability. Those models that were considered to be potentially economically viable, were then presented to both service users and service providers to obtain their views on the likelihood of respectively adopting and offering local public microwave services.

A brief overview of the study's findings are given below:

### Current Situation

In Canada, 12 applications have been made to the DOC to obtain private microwave service. An examination of the applications found them to be largely geographically isolated, with 4 potential users in Toronto and 2 in Montreal. Of the 12 applications, only one could not be satisfied by a point-to-point network.

In the United States, the study concentrated on reviewing their experience with Digital Termination Systems (DTS), a fixed point-to-multipoint digital microwave system used for intra-urban communications.

The implementation of DTS in the U.S. appears to have proceeded more slowly than may have been originally expected, primarily because of Federal Communications Commission (F.C.C.) delays and a slow market. The market demand has not manifested itself for several reasons including the uncertainty of the regulatory climate, uncertainty over the ability of new firms to deliver quality and consistent service, and the lead time required for any corporation to make the commitment to a new technology.

### Microwave Models

In view of the low density of exposed users in Canada and the lower than anticipated rate of penetration in the U.S., it was concluded that a system founded exclusively on some point-to-multipoint delivery model would not best suit the needs of the user community. As a result, both point-to-point and point-to-multipoint models were investigated. The following provides a brief synopsis of the results of an economic comparison of local microwave distribution with other distribution methods, broken down by application.

1. Low Speed Point-to-Point Data (2400/4800 bps).
  - microwave distribution is **not economical viable** by a factor of 2:1 with either Bell Canada's Digital Channel Service (DCS) or a switched telephone line equipped with modems.
2. Medium Speed Point-to-Point Data (48-512 Kbps).
  - at data speeds up to, and including, 56 Kbps, microwave distribution is **less economical** than Bell's DCS service.
  - at data speeds above 56 Kbps, microwave distribution is **economically superior** to cable or fibre-optic systems which are considerably more expensive or unavailable.
3. High Speed Point-to-Point Data (1.544 Mbps or multiple thereof).
  - at high speeds, microwave distribution is clearly **economically superior** by a factor of 2 to 5 over Bell Canada's Megaroute service for the first system, and in most cases will be superior for subsequent systems.

4. Video Point-to-Point.

- for video transmission, microwave distribution is clearly **economically superior** to alternative distribution methods such as fibre optic systems by a factor of 3 to 4.

5. Point-to-Multipoint Data.

- for fixed assignment, point-to-multipoint microwave is **never competitive** with average interconnectivities of less than about 5.
- for demand assignment, point-to-multipoint microwave **may be competitive** for data rates in the ranges of 2.4 to 56 Kbps if the number of low demand subscriber nodes is large and sufficient interconnectivity is required (e.g., about 5 points).
- for high speed data, point-to-multipoint microwave is generally **not viable** with average interconnectivities of less than 5. This number of interconnections is impossible for fixed assignment, and highly unlikely for demand assignment.
- for high speed data and low usage (e.g., a few minutes per day), and required interconnectivities of 3 or more, demand assigned point-to-multipoint microwave **may be a viable** alternative to point-to-point microwave.

The reader is cautioned that the above conclusions are general in nature, and do not necessarily accurately reflect the situation of an individual application. Consequently, the adoption of our general results to justify specific "micro" planning decisions would be risky given potential parameter variability.

## Market Assessment

The potentially economic microwave models were presented to both service users and service providers to obtain their views on the likelihood of respectively adopting and offering local public microwave services. Due to the limited resources available for this part of the study, the survey was restricted to eight large service users and three service providers. The service users were carefully chosen to select organizations with large telecommunication requirements, and ones with operations that might have a need for local point-to-multipoint microwave service. Because of this process of selection, the reader is cautioned not to infer that the survey findings are representative of business in general.

For the service users, they were generally satisfied with the level of service currently provided by the common carriers, but would be interested if significant cost savings could be realized. Some organizations expressed an interest in ownership and/or new carriers, as they would have a positive impact on prices and would improve the selection of available services. Although there was little interest in the point-to-multipoint applications, there was considerable interest in point-to-point systems capable of at least one T1 channel and preferably several T1 channels. Applications included linking PBXs, linking data centres to other data centres and to groups of terminals and, as their use grows, linking local area networks.

For the service providers, Bell Canada expressed the opinion that they had not found too many opportunities for local microwave, although for certain applications involving more than 4-5 56 Kbps circuits, digital microwave is more cost-effective. As a result, Bell plans to introduce a digital point-to-point microwave service in the early part of 1986.

CNCP Telecommunications views microwave as an alternative method of providing local service. CNCP's intent is to use primarily fibre optics to build its local infrastructure, but for speeds below 1.544 Mbps, for situations where ducts are not available and as a temporary solution, CNCP is considering microwave. Currently, CNCP is considering three possible microwave configurations for high, medium and low speed traffic.

Cantel is potentially interested in microwave applications that could use their existing network. They view local microwave service as a separate service offering, rather than a technology choice within a specific service.

All three carriers noted the need for spectral efficiency given the limited amount of spectrum available. It was further noted that to facilitate microwave implementation, carriers require flexibility with minimal regulatory requirements in providing specific installations.

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## 1.0 INTRODUCTION

The Federal Department of Communications (DOC) is currently assessing its radio licensing policy for the establishment of local public commercial microwave services in major Canadian urban centres. To provide essential information, the DOC commissioned a study to:

- examine the economic viability of developing local public microwave services in large urban centres;
- identify radio-communication applications tailored to meet business user needs; and,
- evaluate the relative demand for microwave radio-communication services.

As a result of a Request-for-Proposal issued by Supply and Services Canada (SSC) on behalf of the DOC, Goss, Gilroy & Associates Ltd. (GGA) assisted by SkyWave Electronics Ltd. were retained to carry out this study.

The results of the study have been documented in the following sections:

- **Section 2 - Market Assessment and Responsive Models -** provides information on Canadian applications to date, the U.S. experience and on postulated microwave systems that might address Canadian requirements;
- **Section 3 - Economic and Commercial Viability Assessment of Candidate Local Microwave Service Offerings -** provides an economic assessment of the postulated microwave systems and compares them to current alternatives.
- **Section 4 - Market Assessment -** describes potential service user and service provider reactions to the possible introduction of microwave services in Canada.

## 1.1 BACKGROUND AND MOTIVATION

Recent radio licence applications to the Department of Communications serve as empirical evidence of existing demand for local microwave services in urban Canadian centres. It is clear that the applicants, mostly private, perceive these specialized services to be profitable (or otherwise economically viable) if obtained under the conditions of their own proposals. On the other hand, the common carriers have not been eagerly attracted by this limited market, and thus may see it as unprofitable "in their hands".

Given that a thin edge of a demand wedge (of unknown proportion) is evident, the following question assumes importance to the government regulator: "What type of response will best serve the economic community at large?" Possible answers to this question include:

- (i) grant licences to private applicants for services as proposed;
- (ii) allow or encourage free enterprise to develop this market to the fullest extent practicable by installing suitable plant and offering services on a competitive basis to the "public";
- (iii) allow or encourage the tariff regulated common carriers to respond to the public market demands by offering the requested services.

The Department of Communications' (DOC) motivation for this study thus stems from a recognition of the existing but unquantified demand for local microwave radio services, and the resulting need for an answer to the question of appropriate response. This will clearly influence regulatory policy relating to the services in question.

## 1.2 OBJECTIVES AND METHODOLOGY

In short, the global objectives of the study are to quantify market demand, then render conclusions regarding the applicability of a public network to meet these market demands. These two objectives cannot be addressed independently, however, since (hypothetical) service offerings must be responsive to (anticipated) market demand if economic viability is to be a likely outcome.

The methodology to be applied thus consists of the following steps:

- (i) qualitatively assessing the market by:
  - . reviewing recent applications for special services by private (i.e. self-serving) and public (i.e. retailing) applicants;
  - . reviewing the U.S. experience in the subject area; and,
  - . extrapolating and inferring salient features of the Canadian market profile;
- (ii) postulating a variety of public service offerings (candidates) that are at least collectively responsive to the perceived Canadian market profile;
- (iii) assessing the economic viability of the various candidates through cost and tariff comparisons;
- (iv) selecting the most promising candidate(s); and,
- (v) assessing the market size for the preferred candidate(s), now having relevant cost data.

Results of the above analysis, combined with applicable social factors (e.g. efficient spectral utilization, long-term social implications etc.), will then put DOC in a position to favour or oppose one or more of propositions (i) to (iii) of Section 1.1.

Throughout this report, the terms "private" and "public" shall convey the same sense of meaning as in Section 1.1 above. That is, they refer to the institutional level of the services (and users), rather than any particular feature(s) of the technical configuration (e.g. private vs. switched circuits). Hardware configurations will usually be contrasted as point-to-point vs. point-to-multipoint, where a point-to point configuration usually serves a single user. Hence, although the title of the report reflects only the terms "local public commercial microwave services", an inherent objective of the study is to compare these services to corresponding private microwave (and non-microwave) local distribution services, on the basis of economic and commercial viability.

To achieve the above objectives, the candidates must be characterized at two levels, which are:

- (i) the technical level - to quantify communications capabilities, costs, spectral requirements, etc. (Tasks 1 and 2), and
- (ii) the service offering level - for "presentation" to the market to obtain reaction (Task 3).

These two levels of characterization are facilitated through introduction of the "delivery model" and the "public service model", which are formally defined in the following list of definitions.

#### **PRIVATE APPLICANT**

An APPLICANT that proposes to provide a service that would serve only its own organization, hence not available to the PUBLIC.

#### PUBLIC APPLICANT

An APPLICANT that proposes to provide a service that would be offered (retailed) to the PUBLIC, consisting of one or more PUBLIC USERS. The APPLICANT would become the SERVICE PROVIDER.

#### SERVICE PROVIDER

An organization or commercial entity that implements a public microwave system to serve others (the PUBLIC).

#### DELIVERY MODEL

The technical and cost parameters of a local microwave system that performs the communications function on a point-to-point or point-to-multipoint basis.

#### PUBLIC SERVICE MODEL

The geographic confines, accessibility, capabilities and tariff structure of the set of local microwave services offered by the SERVICE PROVIDER.

This study is primarily concerned with users, service providers, and applications of local microwave technology, although some relevant background material is presented in terms of applicants and applications for licences and services.

In the case of a private applicant, the most cost-effective delivery model would usually be point-to-point, although in certain topologies it might be point-to-multipoint. On the other hand, the public service offering(s) of a service provider could be realized by a combination of one or more point-to-point and/or point-to-multipoint delivery systems. Until the density and topology of demand are understood, there is no basis for restricting possibilities. Therefore, classification of the delivery model as point-to-point/point-to-multipoint does not institutionally categorize the service as private/public, although a point-to-multipoint delivery system is more likely to find application in the hands of a public service provider than of a private applicant.

The highest and lowest levels of "model" considered in this study therefore are respectively the "local commercial microwave public service model", and the "point-to-point delivery model".

In light of the above discussion and terms of reference, one of the questions that should be answered by the study is whether there are economically viable applications of public point-to-multipoint (or point-to-point) microwave systems in meeting existing and future demand for special radio services in major urban areas.

Having stated and clarified the objectives and methodology, it should now be noted that the degree of success realized in meeting these objectives will be resource limited. The total contract value is slightly less than \$30,000, and the need to consider the entire Canadian market precludes the detailed technical and economic characterization of any specific system(s) or network(s) tailored to the needs of a specific market sector (e.g. Toronto). The study is thus parametric rather than case-specific.

## 2.0 MARKET ASSESSMENT AND RESPONSIVE MODELS

In applying the methodology of Section 1.2, we start by examining two bounds to the Canadian market profile. The lower bound is taken to be the Canadian "market exposures", consisting of the group of recently volunteering private applicants, identified primarily through their applications for licencing. The upper bound will be inferred from the United States' experience to date.

### 2.1 CANADIAN MARKET EXPOSURES

The DOC has received 12 applications for private commercial services in Canadian centres. By way of qualitatively assessing the market, we wish to examine these exposures from the point of view of the users, applicants, and applications of local microwave technology that they represent. Accordingly, they are classified in Exhibit 2.1. "Point-to-point" and "point-to-multipoint" are denoted by "P-P" and "P-M" respectively.

#### 2.1.1 Comments and Observations

From inspection of Exhibit 2.1, the following comments and observations can be made:

- (a) From a technical point of view, for each of entries 4, 7, and 8, the applicant could equally have been the user or service provider since in each case, the user initiated the proposed application, but the services may ultimately be "retailed" to the user by a service provider (e.g., Bell Canada, AGT).
- (b) In all cases but #10, the proposed application has been initiated by the user.

Applicant			Application/Delivery Model	
#	Location	Classif'n	Classif'n	Technical Services Requested
1	Montreal	private (user)	P-P	one-way video, surveillance
2	Montreal	private (user)	P-P	one-way data, police information, two hops
3	Longueill	private (user)	P-P	one-way video, two channels, surveillance
4	Toronto	private (user)	P-P	bidirectional internal data, 6-12 T-1 channels
4a	Toronto	public (service provider)	P-P	(same as above, but "retailed" by Bell Canada)
5	Windsor	private (user)	P-P	two-way voice/data, PABX trunking facilities, 16 T-1 channels
6	Toronto	public (service provider)	P-M	multidirectional video, one way distribution to several groups of users
7	Edmonton	private (user)	P-P	one-way video plus two-way data , 24 circuits, surveillance and control
7a	Edmonton	public (service provider)	P-P	(same as above, but "retailed" by AGT)
8	Toronto	private (user)	P-P	two-way data between Processing Centres
8a	Toronto	public (service provider)	P-P	(same as above, but "retailed" by Bell Canada")

Exhibit 2.1: Summary of Canadian Market Exposures Seen As Users, Applicants and Applications of Local Microwave Technology.

Applicant			Application /Delivery Model	
#	Location	Classif'n	Classif'n	Technical Services Requested
9	Chicoutimi	private (user)	P-P	one-way video, 3 channels, surveillance
10	Toronto	public (service provider)	P-P	single hop, high capacity message, trunk extender
11	Glace Bay	private (user)	P-P	one-way video, surveillance
12	Vancouver	private (user)	P-P	one-way aural stereo studio/transmitter link

Exhibit 2.1: (Cont'd) Summary of Canadian Market Exposures Seen As Users, Applicants and Applications of Local Microwave Technology.

- (c) Of the 12 cases considered, 11 of the delivery models are clearly point-to-point. Of these, only the second and eighth entries may have a need for secure communications\*. The remainder could apparently be satisfied by an appropriate point-to-multipoint delivery model, if economically viable.
- (d) Of the 12 cases considered, there are:
  - (i) two users in Montreal, one for video and one for data (#'s 1 and 2)
  - (ii) four users in Toronto, one for video and three for voice/data (#'s 4, 6, 8 and 10)
  - (iii) four geographically isolated users for video, one co-located with a two-way data requirement ( #'s 3, 7, 9 and 11)
  - (iv) one geographically isolated user for voice/data (#5)
  - (v) one geographically isolated user for aural stereo (#12)
- (e) There are a total of 6 users for video (#'s 1, 3, 6, 7, 9, and 11) and 7 users for voice/data (#'s 2, 4, 5, 7, 8, 10, and 12).

#### 2.1.2 Conclusions

From the above comments and observations, we can draw the following tentative conclusions based on the preliminary market sampling represented by the Canadian market exposures:

- (a) Due to the geographic isolation of the majority of users, point-to-point delivery models cannot be eliminated from consideration. This is emphasized by the interest shown by public applicants (service providers) in point-to-point applications (#'s 4a, 7a, and 8a).

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\* Even here, user-shared equipment may not pose a problem.

- (b) The point-to-point delivery model(s) of (a) could constitute components of a point-to-point/point-to-multipoint network (public service model).
- (c) Because of the higher user density, some form of point-to-multipoint delivery model might be appropriate in Toronto and, to a lesser extent, in Montreal.
- (d) Isolated but specialized users might occasionally justify some form of point-to-multipoint delivery model.
- (e) Extrapolating into the future, (c) and (d) prevent elimination of point-to-multipoint delivery models from further consideration.

In the next Section, the United States' experience in local public commercial microwave applications is reviewed. Greatest emphasis is placed on the Digital Termination System (DTS), which as will be seen, is representative of point-to-multipoint delivery systems.

## 2.2 THE UNITED STATES' EXPERIENCE

### 2.2.1 Introduction

In this Section, the U.S. experience with the Digital Termination Systems (DTS) form of local public microwave radio, which is provided as part of a Digital Electronic Message Service (DEMS), is reviewed. Types of service, radio applications, customers, suppliers, economics and feasibility are examined. The information for this Section has been obtained through a literature review and telephone interviews with the Federal Communications Commission (FCC), user representatives, carriers, equipment manufacturers and trade associations representing service suppliers.

The most important observation which can be made of the U.S. DEMS industry is that it has not developed at the rate originally projected by its proponents. At this time, there are only a handful of public stations in operation and no private stations. Contributing to the slow development are three primary factors:

- a general uncertainty over the size and characteristics of the market for digital communications in general, and DTS type of systems in particular;
- prospects of competing technologies (e.g., existing wire pair and optical fibre cable); and,
- delays in the authorization of systems by the FCC.

In this Section, the above observations are expanded through an examination of the environment, equipment used, the current status of existing and proposed networks, and the future prospects of the technology. However, before continuing, some of the terminology is defined.

#### 2.2.1.1 Definition of Terms

##### **Digital Termination Systems - DTS**

A fixed point-to-multipoint digital microwave radio system. Operates in the 10.5 GHz and 18.5 GHz bands in the United States. A central termination node serves a number of subscriber nodes within its range (typically 6-10 miles depending on the frequency, weather, terrain and equipment). The FCC has assigned space for private as well as public DTS in both bands. In addition, the 18 GHz band can also be used for point-to-point microwave services. In urban areas, where more than one termination node is required to provide geographic coverage and/or sufficient capacity, the DTS termination nodes are placed in a cellular arrangement permitting frequency re-use.

##### **Multipoint Distribution Systems - MDS**

Multipoint distribution systems broadcast multiply addressed material to different fixed receivers. Unlike DTS, there is no transmitter at the subscriber site thus restricting MDS to one-way communications. The system was initially used for the distribution of pay television signals to hotels, apartments, and cable companies. More recently, MDS has also been used to distribute information services to businesses and households (e.g., updates from large databases). Because of the lack of two-way transmission, the system is likely to have only limited data communications applications and will not compete with DTS in the same market.

##### **Point-to-Point Microwave**

As its name implies, point-to-point microwave provides two-way communications between two points. It can be used as a form of bypass (of telephone company facilities) or to provide voice, data or video communications services where telephone facilities are unavailable. The link can be between two user sites or from the user site to a telephone central office (CO) or to a teleport (a location providing access to a number of satellite earth stations).

Until recently, point-to-point microwave provided only analogue links. However, digital systems such as the 23 GHz General Electric GEMLink system which provides data rates from 1.0 Million bits per second (Mbps) to 3.152 Mbps are now available.

#### **Digital Electronic Message Service - DEMS**

A two-way domestic end-to-end fixed radio service utilizing DTS for the exchange of digital information. In addition, the service may make use of point-to-point microwave facilities, satellite facilities, fibre optics and other communications media.

The FCC has designated two types of DEMS: Extended and Local. An Extended DEMS is a network of interconnected DTS serving 30 or more Standard Metropolitan Statistical Areas (SMSA). A Local DEMS is restricted to less than 30 SMSA.

There appears to have been some confusion as to whether a distinction exists between DEMS and DTS. The DTS is an integral component or subsystem in the DEMS. By linking one or more of DTS in a region or across the country a DEMS can be provided. As noted, the DEMS is not limited to using only DTS as the communications medium.

#### **Integrated Services Digital Network - ISDN**

As defined by the CCITT: "A network evolving from the telephony Integrated Digital Network (IDN) that provides end-to-end (digital) connectivity to support a wide range of services, initially up to 64Kbps, to which users have access by a limited set of standard multipurpose interfaces." [1,2]

The ISDN will eventually allow the customer to connect all his communications equipment including that for voice, data (computer), facsimile and video. The first step in the creation of the ISDN is the introduction of the digital PBX and CO equipment. Currently, the bottleneck in the system, at least in systems provided by the local telephone companies (telco), is the cabling between the customer and the

CO. Most copper cable (twisted) pair are not currently capable of carrying the high data rates required by some applications. The laying of new lines (usually fibre optic cable) or the conditioning of existing lines is a labour and time intensive process and thus very expensive (and likely only to increase in cost). However, technologies to enable existing 2-wire (64 Kbps up to 5.5 km and 512 Kbps up to 1.2 km) to handle full duplex data on a switched and/or private line basis are being introduced in the U.S. and Canada.[3,4,14]

## 2.2.2 The Environment

### 2.2.2.1 History

The original application for the provision of a DEMS in the United States was made by Xerox in November, 1978. [5] The Xerox system, known as XTEN (Xerox Telecommunications Network), proposed the establishment of nationwide common carrier networks that would provide for the high speed end-to-end two-way transmission of digitally encoded information.

In April 1981, the FCC issued a First Report and Order (General Docket 79-188) which allocated spectrum in the 10.55 - 10.68 GHz (10.6 GHz) band for DTS and internodal DTS links, and outlined the rules for common carriers using DTS. The FCC did not give Xerox the exclusive license for DEMS that they had requested. Instead, the FCC supported singly owned extended intercity DEMS networks through the definition of two classes of authorizations: extended DEMS and local DEMS. The extended DEMS was to be made up of a DEMS serving 30 or more Standard Metropolitan Statistical Areas (SMSA). The local DEMS is restricted to less than 30 SMSA.

In May 1981, Xerox announced the discontinuation of its proposed XTEN service. The company indicated part of the reason was its original expectation that the market would not be as competitive as the FCC allowed. [6] XTEN would also have required an expenditure of at least \$500 million at a time that Xerox was facing increasing competition from Japanese suppliers in its principal market of photocopiers. However, a number of other entities were already developing service proposals of their own.

In September 1983, an additional 200 MHz was allocated to DEMS in the 18 GHz bands.

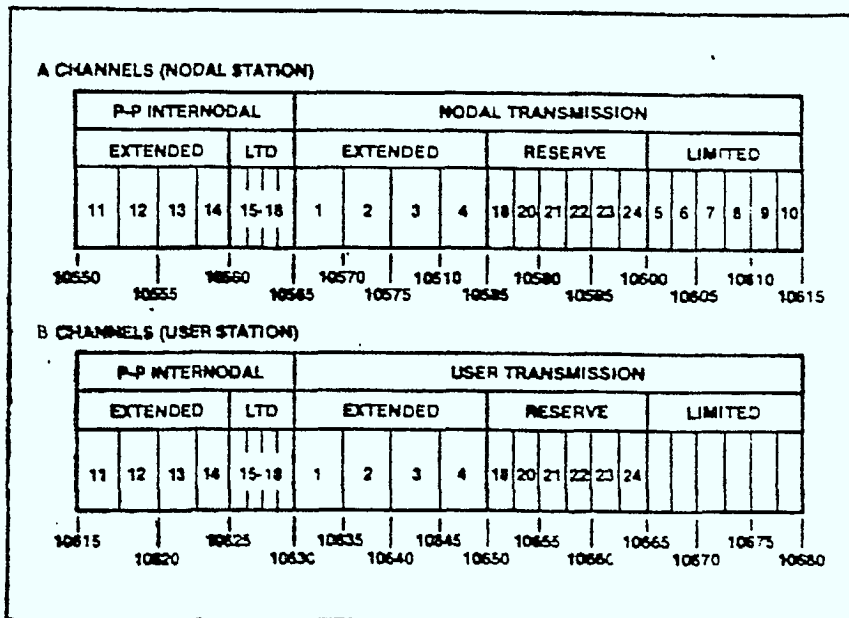
#### 2.2.2.2 Frequency Allocation Process

Exhibit 2.2 shows the original DEMS frequency allocation at the 10.6 GHz band. Note that the communications between a termination node and the subscriber station requires two channels (one transmit and one receive) and thus 10 MHz of bandwidth for an extended DEMS and 5 MHz for a local DEMS. (Extended DEMS has been assigned wider bandwidth channels to accommodate an anticipated demand higher than that for local DEMS.) The FCC added additional spectrum to DTS in two 100 MHz bands at 18.360 - 18.460 GHz and 18.940 - 19.040 GHz. As well, private radio licensees were permitted access to the 10.6 and 18 GHz bands for DTS and private point-to-point systems were permitted access to the 18 GHz bands in December 1983. [7] Since then, the 18 GHz band has been rechannelized twice (i.e., the positioning of the 5 and 10 MHz channels within the 100 MHz bands was changed).

A minimum spectrum efficiency of 1 bit per hertz has been specified by the FCC. However, the efficiency is based on the gross data transfer rate and thus will include the overhead data communications (e.g., handshaking, error checking) which is required by the system. No requirement is made for the bit error rate (BER) of a system.

The FCC has not mandated any particular form for the arrangement of termination nodes within an area (e.g., cellular), nor have they specified subchannel bandwidths, nor set nationwide interconnection standards. The reason for avoiding these areas was the concern that any selected standard might prevent the introduction of more advanced or efficient schemes as they become available. Section 2.2.3 contains descriptions of the DEMS and DTS configurations and the techniques used to permit channels to be reused within the same geographic area.

EXHIBIT 2.2: DEMS FREQUENCY ALLOCATIONS  
AT 10.550 GHz TO 10.680 GHz



FCC DTS rule making 3247 — frequency allocations (MHz)

Source: "The Digital Termination Systems Solution for High Speed Local Distribution"; Microwave Journal, January 1983.

To obtain the authorization to provide a private or public DEMS, which may include 1 or more DTS, an entity must first make application to the FCC stating the city or cities to be served and the channels in each city which are to be used. From the date of the first application for a channel in a particular area, all other interested entities have 30 days to apply for that channel. It is noted that an application for a DTS as such is not made. The application is to provide a DEMS which will consist of one or more DTS.

Once a system has been authorized, the entity officially has 5 years to complete its facilities and be licensed in the cities granted. However, should a firm not be "well underway" by the end of about 3 years, the FCC will begin to exert pressure on the company to start construction.

#### 2.2.2.3 Current Status

As of the middle of January 1985, some 68 separate entities have applied to provide service in 206 SMSA. Since March 1983, the FCC has authorized 24 public DEMS consisting of:

- 55 networks; and,
- 286 radio stations (termination nodes).

Only 19 termination nodes have been licenced in 11 SMSA, the majority of these in the past 6 months. The issuance of a license indicates that the station is operational while the 286 authorized radio stations are assumed to be under construction. Although, it is too early in the life of the service for any entity to lose its authorization(s), some firms are already being pursued to speed up their construction.

As of the end of January 1985, there were 503 applications for private DTS radio stations pending with the FCC. **No private DTS stations have been licensed.** Thirty-five percent of the applications involve more than one mutually exclusive application for the same channel. The FCC

authorization process has only recently been finalized for private DTS. Development of private DTS service has also been delayed by the rechannelization of the 18 GHz band twice in the past year.

Forty-four DEMS are currently waiting for authorization. As well, between 200 and 300 individual radio station authorizations have been delayed because of more than one mutually exclusive application for the same channel in a city. The process has also been delayed by petitions to deny authorization to a particular entity. The FCC has yet to review any of the disputed applications (concentrating instead on approving the clear channels as quickly as possible). In one case, a firm was granted authorization, but then sold 40% of its shares to a local telco. The competition in the affected regions filed a petition to deny authorization. As well as obviously placing a heavy burden on the entity(ies) involved by preventing them from constructing and operating a system and thus earning revenues, the delays serve to tie up that portion of the spectrum which has been applied for (i.e., the channel is not "buildable").

The administrative delays cannot completely explain the slow development of DTS since its conception - only 20 of the 286 nodes have been licensed. Section 2.2.4, as well as describing the current market and service suppliers, includes a summary of the comments of the various groups involved in the development of the service and possible explanations for the delay.

### 2.2.3 Configuration

The following presents a brief outline of a DEMS configuration and the DTS subsystem. More detailed descriptions of the equipment and features of DTS are contained in Section 3.

As noted in Section 2.2.1, a DEMS is an end-to-end digital communications network providing local and intercity data links. The service consists of DTS providing the "last mile" connection to the customer, which are linked together by point-to-point microwave, fibre optic cable and/or satellite facilities. A typical configuration is shown in Exhibit 2.3.

The digital termination system consists of a point-to-multipoint microwave transmitter/receiver at the termination node and a point-to-point transmitter/receiver at the customer premises. The channel assigned to the supplier is divided into 3 or 4 subchannels, each of which is used in a pie shaped sector radiating from the termination node. The subchannelization of a 5 MHz channel in the 10.6 GHz band will limit the transmission capacity in each subchannel, and thus within a sector, to about 1.8 Mbps depending on the equipment used. (The efficiency of spectrum usage - typically 1.2 bits per hertz of bandwidth today - is expected to increase as technology improves.)

Transmission from the termination node is via a continuous, time division multiplexed (TDM) carrier per sector. User transmissions are received at the termination node in a time division multiple access (TDMA) mode, where each user in a given sector shares a common transmit frequency for burst transmission in a sequential, non-overlapping manner. The allocation of capacity on a TDM/TDMA carrier can be fixed assigned or assigned on demand. Exhibit 2.4 illustrates a typical DTS configuration.

To provide coverage in a large city, the DTS termination nodes are arranged in a cellular format. By polarization of the subchannels, the frequency assigned can be reused without interference. Since the termination nodes will likely be packed closely together in a dense urban area, users will usually be within the nominal range of several nodes. The user site can then be assigned to the termination node which affords

EXHIBIT 2.3: TYPICAL DEMS CONFIGURATION

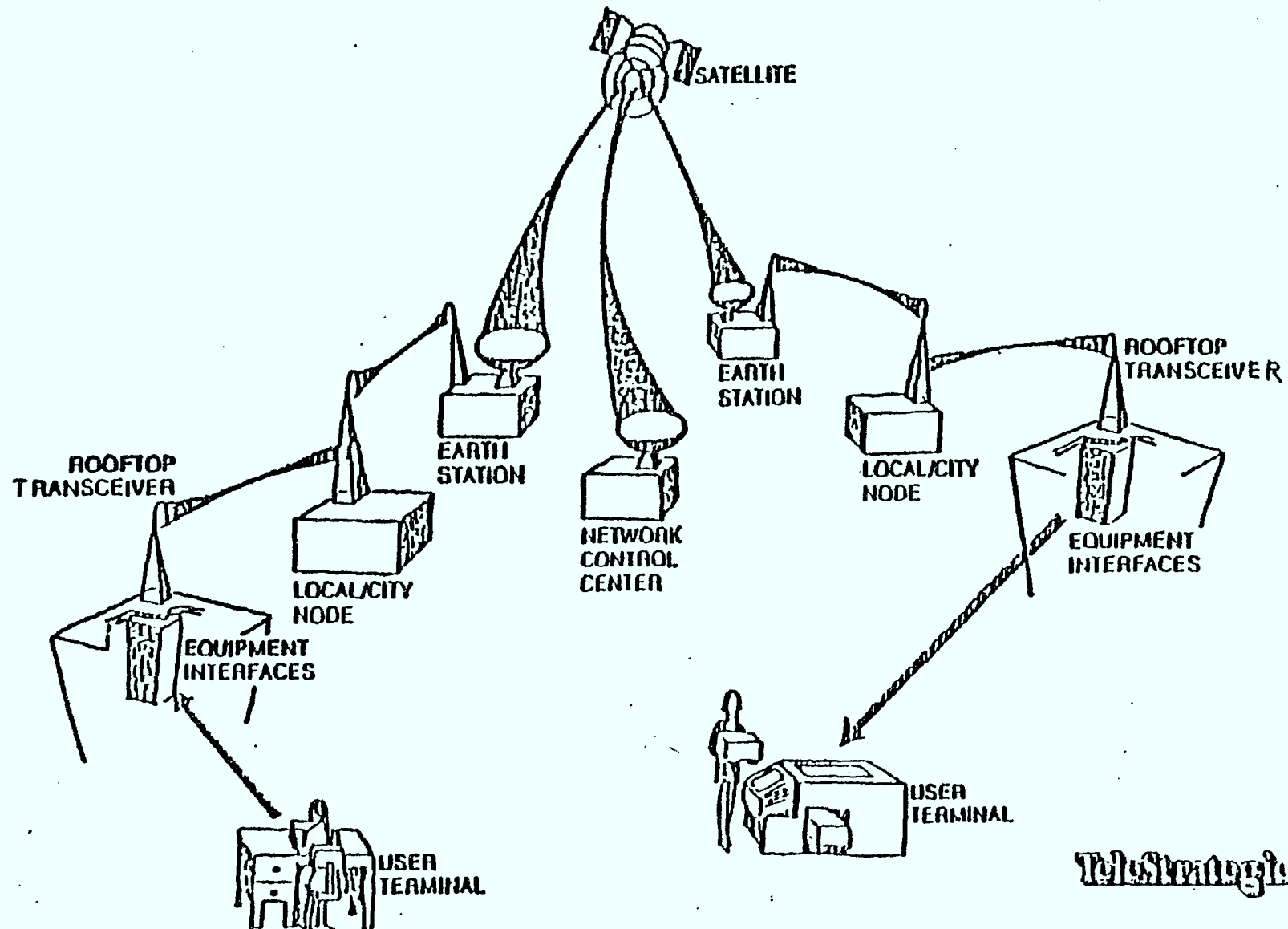
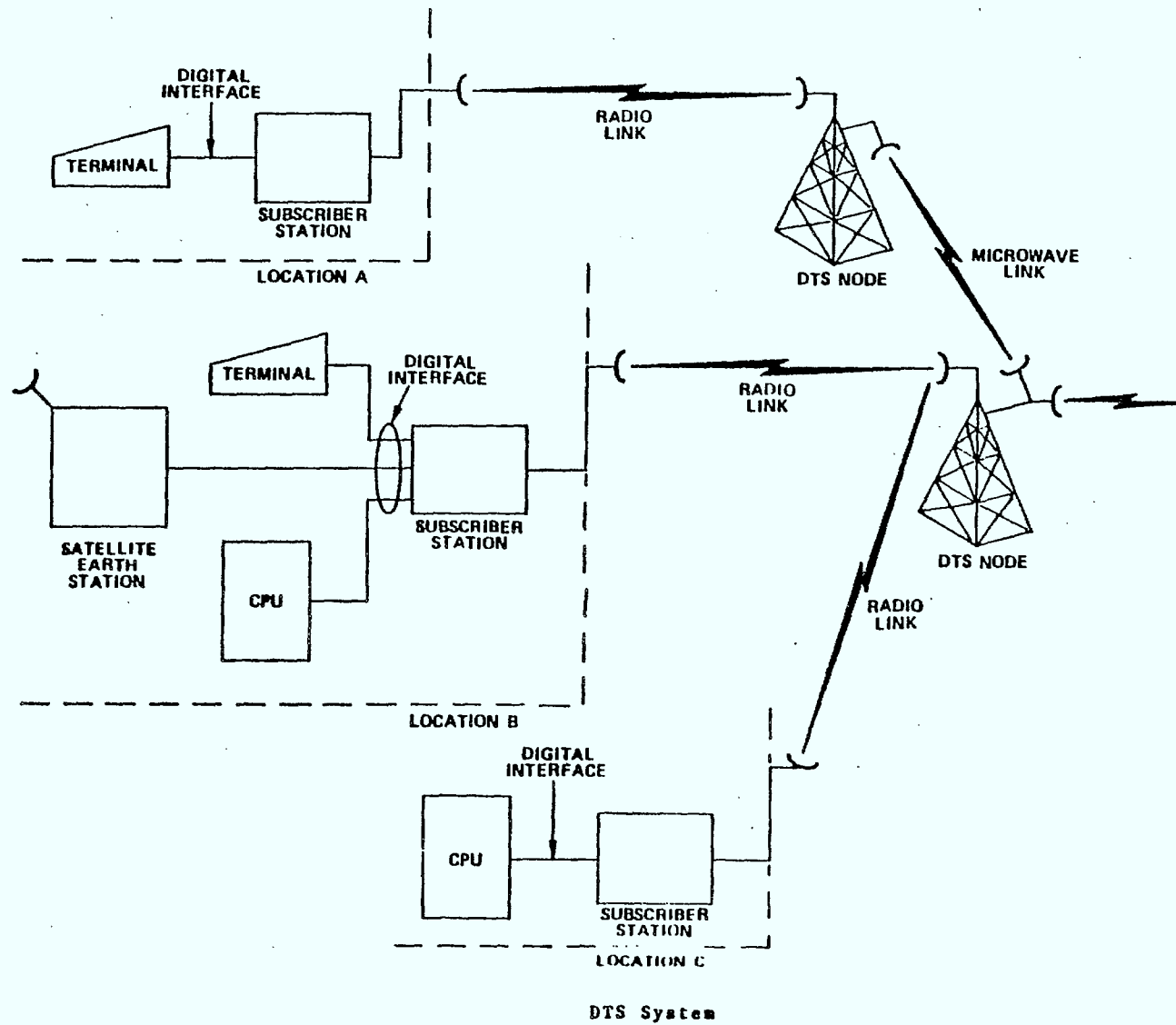


EXHIBIT 2.4: TYPICAL LOCAL DTS CONFIGURATION



the best signal path. Depending on the location and frequency, the system has a range from 8 to 16 km for a 0.6m parabolic antenna at the user station. The range can be extended several kilometers by upgrading to a larger, 1.2m antenna.

The service can be sold to a subscriber in one of two formats as illustrated by the following offerings. Dama Telecommunications Corporation of Parsippany, NJ, offers a demand assigned multiple access (DAMA) system - DamaNet - which operates much like a switched network. Customers pay on the basis of their connect time and the speed of the channel. Tymnet DTS Inc. of San Jose, CA, sells channels like dedicated phone lines - a fixed monthly price for the link, varying in price with the speed required.

Currently, there are three manufacturers of DTS equipment supplying equipment to carriers:

- Local Digital Distribution (LDD) Company of Rockville, MD, a subsidiary of M/A COM which sells a system known as RAPAC;
- Nippon Electric Corporation (NEC) of Fairfax, VA, selling the Local Distribution Radio (LDR) system; and,
- Ericsson of Stockholm, Sweden.

Although Ericsson apparently has a system available, all the carriers for which information was available were using either the LDD or NEC systems. Of these, the LDD system appears to be more popular despite their difficulty meeting bandwidth leakage specifications.[8]

#### 2.2.4 The DEMS/DTS Market

##### 2.2.4.1 Applications

DTS provides the "last mile" link to a subscriber, which when connected by internodal and intercity links using microwave and other medium, permits a firm to provide the DEMS. Ports with data speeds ranging from 2.4 Kbps to 1.544 Mbps, or higher depending on the capacity of the termination node, can be supplied to the user.

The types of applications which a DEMS can be used for include:

- computer to computer communications, speeds required depending on the hardware and interface software;
- computer to peripherals communications, e.g., high speed laser printers can handle up to 96 Kbps, the IBM 3270 terminal can operate at 19.2 Kbps;
- facsimile transmission - documents and electronic mail - requiring speeds up to 64 Kbps depending on equipment and priority;
- videoconferencing, requiring from 64 Kbps to 1.544 Mbps depending on the degree of motion required and the compression techniques employed; and,
- voice, requiring from 9.6 Kbps to 64 Kbps depending on the equipment used and the data compression techniques employed.

Until recently, the limitations of the communications link have often forced the hardware to operate well below its capacity - an unconditioned leased 4-wire telephone line can support 9.6 Kbps full duplex, and dial-up lines (2-wire) can only support 2.4 Kbps full duplex. With the advent of echo cancellors, dial-up lines will support 9.6 Kbps full duplex.[9]

It should be noted that in the original DEMS application (XTEN), with the exception of videoconferencing, Xerox did not intend that DEMS be used to provide voice circuits. In fact, in the configuration proposed by Xerox, only 43 voice circuits per square kilometer could be provided - a tiny fraction of that used in a dense urban area.

To serve the above applications, DEMS provides in many locations, an alternative to existing systems - telco twisted pair and fibre optics, coaxial cable and point-to-point microwave - and in some locations provides a service which otherwise would not be available - i.e., a high capacity data communications link. In comparison to the alternative media, the DTS local loop is seen to offer the following advantages to its users:

- low installation cost, low sunk costs;
- quick installation;
- low maintenance, easily upgraded;
- high quality link providing a low bit error rate (BER);
- low relocation cost, easily relocated;
- all digital link within the DEMS system;
- the service can be transparent to the users;
- relatively portable equipment which can be moved with the customer; and,
- reuse of the equipment at a new location when a customer terminates service.

The most marketable of the advantages appear to be the low sunk costs, and the quick installation possible with DTS. These features are particularly useful if the customer moves offices frequently. Merrill Lynch & Co. which has considered investment in a DEMS network, moves about 150 offices each year.[15] As long as the subscriber stays within the range of a termination node, he can be reconnected to the network in as much time it takes to remove his equipment at the old site and set it up at the new location. By contrast, in many cities, it takes several months for the local telephone company to supply a line capable of carrying data at even low to medium speeds. An existing line must be

specially conditioned or a new line (usually fibre optic cable) must be laid - an expensive, labour intensive process and thus not likely to be subject to future cost reductions. Of relevance is the predicted doubling to tripling of local telco exchange tariffs resulting from deregulation.

However, some DEMS suppliers have found that it can take 4-6 weeks to install a subscriber node if construction and roof access permits must be obtained and the work cleared through unions. If the subscriber's antenna can be installed with line of sight to the termination node through a building window, then the system can be installed in 1-2 days. Upgrading or changing the subscriber's capacity can be accomplished by changing or adding a card at the subscriber's premises.

Several factors present limitations to the DTS end of a DEMS:

- ultimately the bandwidth assigned to the service will limit the volume of data which can be carried;
- similarly, the capacity of each termination node will be limited by the bandwidth of the assigned channels (5 or 10 Mhz);
- interference between the nodes will prevent the nodes sharing the same channels from being placed too closely together. Combined with the limited bandwidth, these restrictions will place an upper limit on the volume of data which can be carried in a fixed geographical area;
- cost and delay associated with spectrum management, which will increase as the number of emitters and systems increase;
- transmission over water or during heavy rainstorms can suffer signal degradation resulting in an unacceptably high BER; and,

- if security is a concern, then the user must encrypt his transmissions to prevent eavesdropping which could be accomplished by simply placing a receiver within the beam user node.

The capacity limitations will be overcome to an extent by improvements in the technology used to process the transmitted data. The improvements are expected to increase the spectral efficiency of the systems - prototype systems already exist for digitized voice at 9.6 Kbps, down from the 64 Kbps required several years ago. More bandwidth could also be allocated to DEMS by the FCC. However, it is unlikely that the frequency allocation will be increased in the near future. The current level of demand will not push the service to its limit for sometime.

#### 2.2.4.2 Current Market Status

The original market estimates made by Xerox in the XTEN application predicted a peak busy hour rate of 105 Mbps in the SMSA of highest demand (New York) in 1990. [5] The estimates also projected that the bulk of demand for digital communications will be of a long-haul (intercity) variety. The FCC also noted an increasing trend toward higher transmission speeds, particularly those of 56 Kbps and greater. Thus, at the time the XTEN service was proposed, there appeared to be a substantial growing market for which DEMS was suited and for which the existing services would not be sufficient to completely supply.

In the almost 4 years since the DEMS service was approved by the FCC, very few termination nodes have been licensed. With the exception of one or two nodes, those which are operational have been granted their licenses in the past six months and none of the proposed networks have been completed. Thus, there is virtually no operational experience with DTS in the United States at this point in time and it is not possible to define the market (size, types of data to be transferred, growth, etc.) with any more certainty than the original projections.

As authorizations have only been granted since March 1983, many firms have only been able to start their construction in the last year. Typically, nodes are established in the best markets first, with cities being added to the network in discrete steps. Substantial sections of several networks are expected to be completed during 1985. Examples of the networks under construction are:

- Dama Telecommunications, authorized in 52 SMSA, expects to have about 30 termination nodes operational this year, 3 are operational now; and,
- Tymnet DTS, authorized in 50 SMSA, operational in 3, expect to be operational in more than 20 in the next year.

The firms which intend to provide DEMS in the United States fall into one of three groups:

- independent DEMS suppliers;
- Other Common Carriers (OCC) or their subsidiaries or partners; and,
- Regional Bell Operating Companies (RBOC) or their subsidiaries or partners.

Independents include firms such as DAMA Telecommunications, Contemporary Digital Service (CDS) and First Communications Inc. The OCCs include MCI (authorized in 42 SMSA), Tymnet and SBS (planning a 32 city DEMS). Since the FCC granted its first authorization to a telephone company in May 1984, most of the RBOCs have been working to develop a DEMS of their own or with a partner (e.g., Pacific Bell, Southern New England Telephone and Telegraph).

The RBOCs and the OCCs have the advantage of being able to build on an existing market base. DTS enables an OCC to add a local loop to their service and thus become completely independent of the telco lines, their tolls and access charges. For the RBOCs, DTS can supplement their existing services quickly without the expense in labour and time required for laying cable (or act as an interim system until higher capacity cable - fibre optic - is installed).

Because the service is so young, interviews with suppliers did not produce a firm consensus on the details of the market. Typical comments on the following three areas included:

#### **Types of Data to be Carried**

- In general, DEMS/DTS is not viewed as a voice bypass service. Service provided by the local telco is more economical. However, DEMS is able to fill the gap for an easily and quickly installed, efficient digital transmission network.
- In contradiction with the opinion that the service was not economical for voice, Tymnet DTS anticipates that most of its demand will be for voice grade circuits. Most of the capacity they have sold to date have been for voice, but typically a large user and only one user per node.
- DAMA Telecommunications originally projected that 70-80% of its demand will be for voice. However, most of its users have wanted multiple data channels at low speeds with dial back-up.

- Both DAMA and Tymnet felt that the current demand for digital data communications (excluding voice) is not sufficient to support a public DEMS on its own. If suppliers expand too fast, they could quickly extend themselves beyond the point where they can service their debt until the market grows to provide a profitable base.
- All the suppliers and user representatives agreed that it is premature to project the breakdown of data traffic. Both Tymnet and DAMA only have 3 or 4 termination nodes installed (each) with at most one customer for each node. Thus, their findings cannot be used to form a picture of the existing or future DEMS market.
- Although there has been a great deal of interest and media coverage of videoconferencing, a significant market has not materialized. AT&T has recently closed some of their videoconferencing centres. (Videoconferencing requires typically from 64 Kbps to 1.544 Mbps depending on the degree of motion required and the equipment used.) Video links would also quickly use up the capacity of a DTS node.
- Other wideband applications (but with lower rates than video) such as computer to computer links and computer to remote high speed printers appear more promising, particularly with the development of lower cost laser printers. Banks and insurance companies are the largest potential users of these features.

#### **Causes of the Delays in Establishing the Service**

- Equipment has been a stumbling block to the introduction of systems. Initially suppliers have been unable to meet all the technical and quantitative demands of the DEMS carriers. Typically, the net information transferred is only half the

capacity of the channel (the balance is used for overhead - handshaking, error checking, etc.). As a result, the subscriber must purchase a higher capacity and more expensive channel to meet his needs. The equipment suppliers are basically radio transmitter manufacturers and thus little work has been done on the processing of transmitted data (e.g., improving compression, demand assignment of channels, etc.).

- Some suppliers are unable to build because of construction has been blocked by the FCC. As previously noted, the FCC must review mutually exclusive applicants for the same channel or petitions to deny authorization to a supplier. Pacific Bell has had several nodes ready to be licensed for sometime, but has been stalled while the FCC decides the classification of the subscriber equipment and whether Pacific Bell is permitted to own it.
- Apparently, the only value in some firms is the authorization for a system they have obtained from the FCC. They have no real intention of building, but wish to sell the company (i.e., the authorization and construction permits) to a firm interested in building and operating a DEMS. Because of the uncertainty of the market for the service, it is difficult to sell the firm at this time. However, they have up to 5 years to complete the service, thus effectively blocking channels for that time.

#### **Customer Hesitation**

- Telecommunications growth and changes are still in limbo since the divestiture of AT&T. Many firms are still waiting to see how the changes will affect them - where the price of long distance will settle, what access charges will be imposed, what the cost of local services will be, etc.?

- Several suppliers noted that because the service is relatively new, users are unaware of its capabilities and unsure of its reliability. Most suppliers are just out of beta test, while the potential users, particularly of the high speed channels, want months of experience before committing themselves. The switch to digital communications (DEMS or other systems) will take time. The cycle within a large company from consideration to approval and construction will take 1.5 to 2 years in most medium to large corporations.
- The Adhoc Telecommunications Users Committee which represents 25 very large corporations in the United States stated that to their knowledge, none of their members were using a public or private DEMS/DTS system nor have they expressed any plans to use the service. It is noted that the committee supported the creation of the service and the competitive allocation of frequency.

To summarize, the establishment of the U.S. DEMS appears to have proceeded more slowly than may have been originally expected primarily because of FCC delays and a slow market. The demand has not manifested itself for several reasons including the uncertainty of the regulatory climate, uncertainty over the ability of new firms to deliver quality and consistent service, and the lead time required for any corporation to make the commitment to a new technology. Finally, it should be re-emphasized that the service is just beginning to get off the ground and better projections will not be possible until companies have had time to gain some operational experience.

#### 2.2.4.3 Rates

Access to a DEMS can be charged in two basic ways. Systems not capable of dynamically assigning capacity are forced to provide the equivalent of a dedicated line from the user to the termination node. The user would thus be charged a flat monthly fee for his line (e.g., \$2000/month for 56 Kbps line). The fee will vary with the speed of line required. In addition to the recurring monthly fee, the customer will be charged a non-recurring installation fee of \$10,000 to \$25,000 per site.

In a demand assigned system, the user can be charged for the volume of data transferred each month. Rates charged by DAMA Telecommunications' DamaNet for several example speeds are shown in Exhibit 2.5. All rates are in U.S. dollars as of 1 October, 1984.

EXHIBIT 2.5: ILLUSTRATIVE DEMAND ASSIGNMENT RATES [10]

DAMA Telecommunications - DamaNet

Speed (kbps)	Charge/0.1 Minute	Maximum Monthly Charge*			
		Zone 1	Zone 2	Zone 3	Zone 4
2.4	\$0.016	\$ 288	\$ 480	\$ 672	\$ 960
9.6	0.020	360	600	840	1200
56.0	0.075	1350	2250	3150	4500
64.0	0.085	**			
512.0	0.800	**			
Voice	0.025				

Monthly Recurring Fees:

- \$75 per voice or data port
- \$40 per port for 7/8 data encoding - improves
- BER from 1 to 10 7 to (up to) 1 in 10 12.

Non-Recurring Fees:

- \$25,000 - processor, DTS radio/antenna and/or TDMA CABLE MODEM.
- \$75 per port per data encoder if installed after initial installation.

Relocation Charges are cost + 15% for all items.

Additional ports can be installed, depending on available capacity for a non-recurring fee of \$100.

\* Zone 1 = 0-300 miles, Zone 2 = 301-950 miles, Zone 3 = 951-1600 miles, Zone 4 = Over 1600 miles.

\*\* Availability, terms and conditions based on an analysis of customer requirements.

#### 2.2.4.4 Competitive Services

The microwave DTS competes with other last mile media such as copper, coaxial and fibre optic cable, and point-to-point microwave. The primary sources of the cable services are through AT&T and the local telcos. Currently, some data communication needs are met through AT&T services such as Digital Dataphone Service (DDS) and Wide Area Telephone Service (WATS). AT&T has recently cut the price of its DDS offering. As shown in Exhibit 2.6, the new rates would push the cost advantage of DDS over a typical DEMS for a point-to-point application from 550 miles (885 kilometers) to 1100 miles (1770 kilometers).

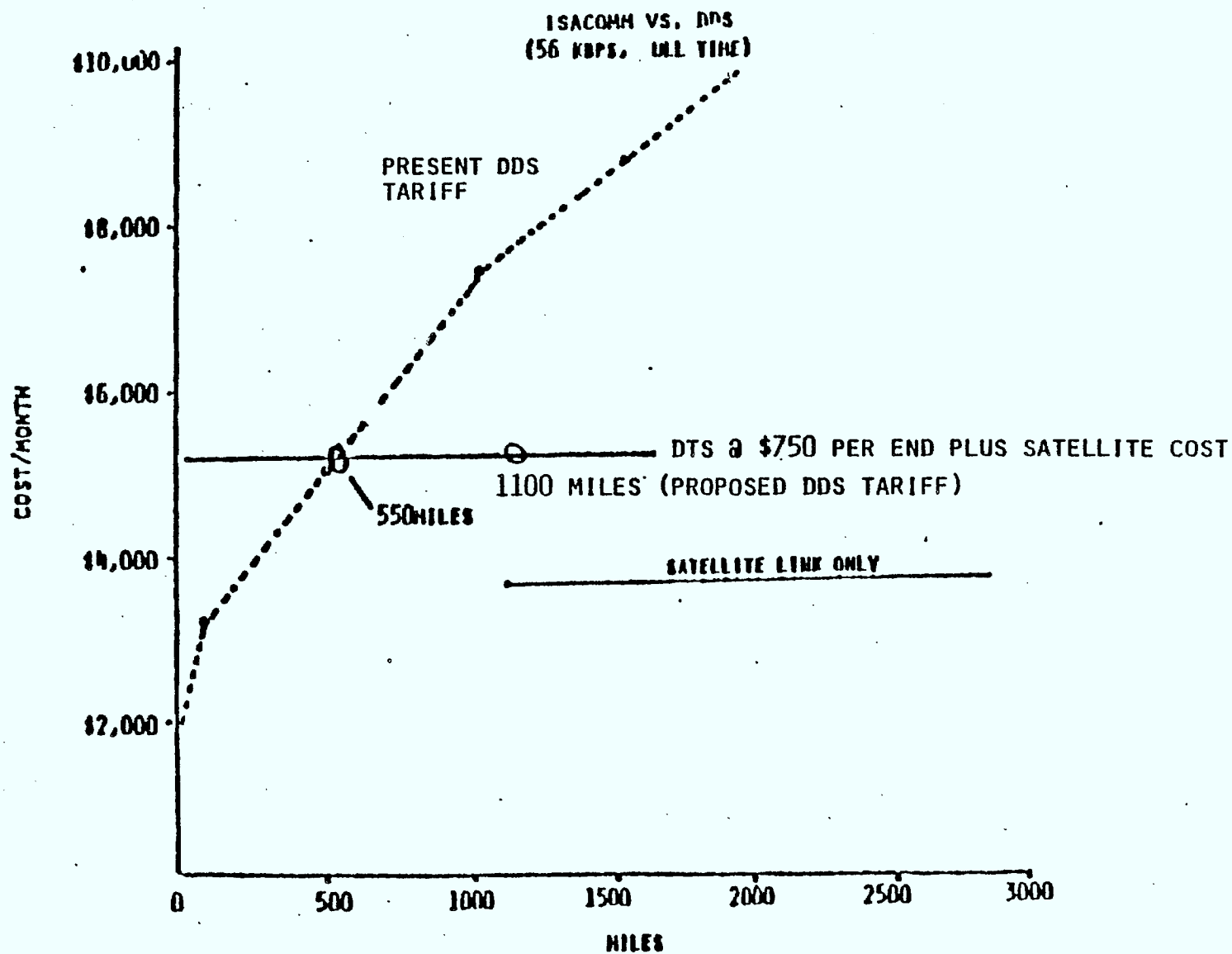
AT&T and the RBOCs cannot be expected to stand idle while other firms attempt to establish new DEMS networks in competition with the existing and future telephone network services. As well as cutting the cost of some of its existing services, AT&T has also announced new switched digital services:

- Circuit Switched Digital Capability (CSDC) offers a metered 56 Kbps line through the local loops and exchanges used for voice; and,
- ACCUNET provides a switched 1.544 Mbps line at a fixed cost of \$200 (US) per half hour, available on demand.  
(Currently, a full-time T-1 line costs \$30,000 (US) per month from AT&T.)

These new AT&T offerings could be successful at stemming some of the demand for DTS.

As well as installing fibre optic cable (which can take advantage of existing conduits), the telephone companies can be expected to enhance the performance of existing copper cables. Increases in the digital capacity of unconditioned lines to 64 Kbps will shortly be possible between the customer and the digitally switched CO. A service which can take advantage of the existing cable with minimal modification could have a tremendous cost advantage over offerings requiring new installations (fibre optics or microwave).

EXHIBIT 2.6: DTS - DDS COST COMPARISON DEDICATED  
POINT-TO-POINT SERVICE



The FCC and the service suppliers indicated that the availability of DTS (public point-to-multipoint service) has not slowed the demand for private point-to-point microwave services. The choice between the two systems would be based on several factors:

- **Application** - very high speed, high volume point-to-point requirements will favour point-to-point microwave;
- **User capabilities** - a private system will require the user to apply for authorization, construct, operate and maintain the link;
- **Degree of control desired** - a private system is under complete user control;
- **Location** - non-urban or other low density areas will tend to favour a point-to-point system; and,
- **Budget** - ultimately, when all factors are considered, the choice will be based on the cost of the competing systems. Generally, a price can be associated with each of the above factors which will lead to a total system cost for comparing the above alternatives.

The high speed/high volume applications tend to favour point-to-point microwave because of the limited capacity in each sector of a termination node. If a user's requirements are such that most of the node's capacity must be dedicated to him (and/or if there are few subscriber nodes at each termination node), then he would probably be better served by a point-to-point system which would avoid the extra cost of multipoint and multiuser capabilities. (As an example, the optimum speed with respect to cost on the DamaNet service occurs at about 64 Kbps.)

Users will find that in application, the differences between public and private, point-to-point and point-to-multipoint services tend to blur. Most private services are subcontracted and become transparent to the user.

If there is only one subscriber node linked to a termination node, the system appears the same as a dedicated point-to-point link.

DEMS should be able to offer a flexible, reasonably priced, end-to-end digital network which can be supplied quickly to the users. The telco offerings and private microwave services have not been able to deliver these features. Unfortunately, the delays in authorization of systems, slow construction and customer response have meant that DEMS is currently not able to deliver its promised features. The following section explores the possible future of DEMS and DTS.

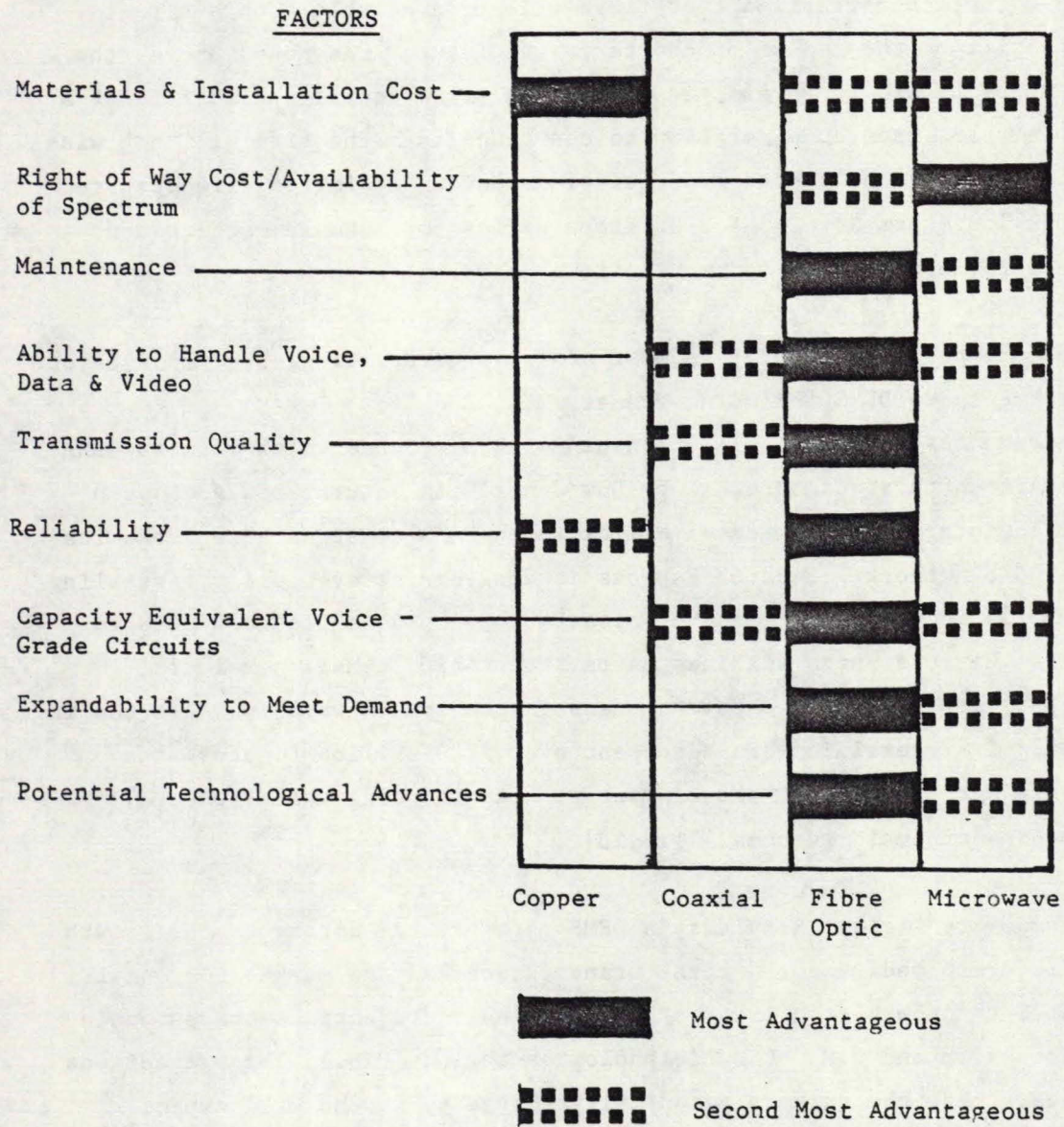
#### 2.2.4.5 The Future of DEMS/DTS

The development of new competitive offerings by AT&T and the RBOCs present the greatest threat to the success of DEMS in the United States. Users are currently attracted to DEMS (when available) if the local telephone facilities are not technically adequate and/or the local facilities are too expensive. As noted, AT&T has already taken steps to improve the cost and performance of its systems and can be expected to continue to develop new competitive products.

The upgrading of CO equipment to digital switches and improvements to the local loop will eventually lead to the integrated services digital network (ISDN) over the next 10-20 years. The ISDN, in itself, will not be a threat to DEMS, providing DEMS supplied by independent carriers can be connected to other networks if so desired. In fact, the installation of DTS by some of the telephone companies as part of their networks, indicates that DTS could simply operate as another medium providing local loops along with fibre optic and copper cable.

It has been estimated that by 1990, fibre optics will be the medium of choice for local and intercity transmission (see Exhibit 2.7) [11]. The former is dependent on the successful realization of low cost equipment to enable many subscribers to be connected to a single wideband optical fibre. Microwave is shown to be second most advantageous after fibre optics for a local transmission medium by 1990. Such analysis does

EXHIBIT 2.7: LOCAL TRANSMISSION MEDIUM SELECTION IN 1990



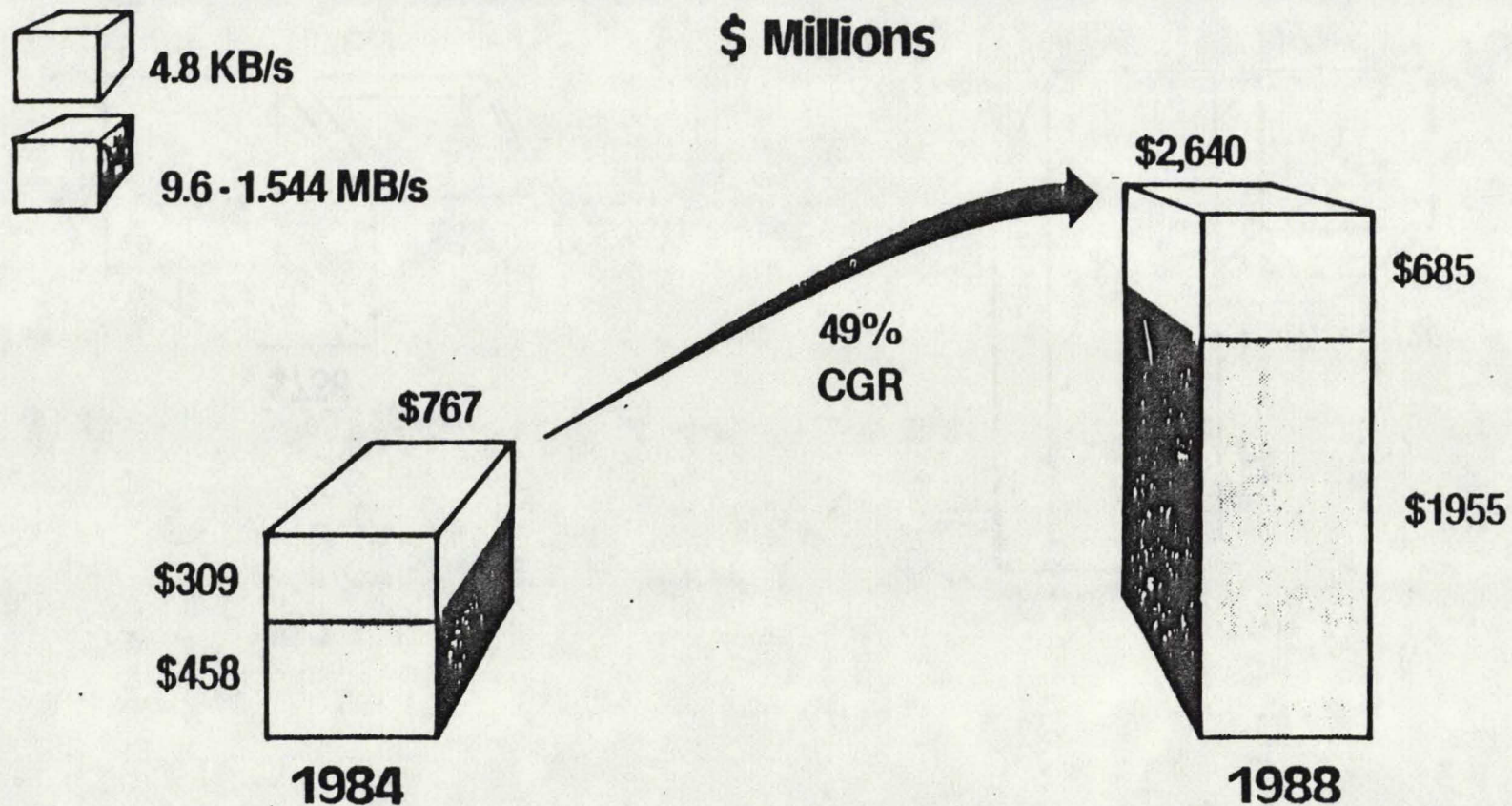
Source: "New Directions in Telecommunications"; Arthur, Anderson and Company, 1984.

however ignore the large existing investment in copper plant, and the motivation and possibilities of improving the digital carrying capacity. DTS must not only compete with current offerings on other medium, but also with this perception that fibre will be available soon and that fibre will be the medium of choice in the future. As noted above, the switch by a firm to an all digital system will require a lead time of a couple years from consideration to construction. The firm will not wish to commit funds to a system perceived as having a limited life compared to the long-term development of fibre optics for example, or limited access to more powerful communications networks.

In a more positive light, a number of large corporations have made major commitments to DEMS including Tymnet, MCI, and SBS. DAMA Telecommunications has a relationship with Dow Jones which permits DAMA to share earth stations owned by Dow Jones. In return, Dow Jones can take advantage of the microwave link which DAMA constructs to serve its local DTS network. Federal Express is considering eventually installing facsimile machines in client premises which could be linked by DTS to Federal Express earth stations as part of their ZapMail service. (ZapMail is a two-hour document transmission system which was started in mid-1984. Federal Express has spent over \$100 million to start the service and \$30 million per quarter to keep it going while so far producing minimal revenues.) [12,13]

Contemporary Digital Services, a DEMS carrier, has estimated the growth of different medium for digital transmission and the market for local digital transport from 1984 to 1988 and their projections are shown in Exhibits 2.8 and 2.9. (New technologies include DTS.) The projections indicate that the markets potentially served by a DEMS will expand rapidly over the next several years. Although wire and fibre technologies will continue to serve the largest part of the market, new technologies are expected to substantially increase their share (from 1.5% to 20%) of the growing digital communications market.

# Growth of Local Digital Transport will Continue in 1984 - 88 Period

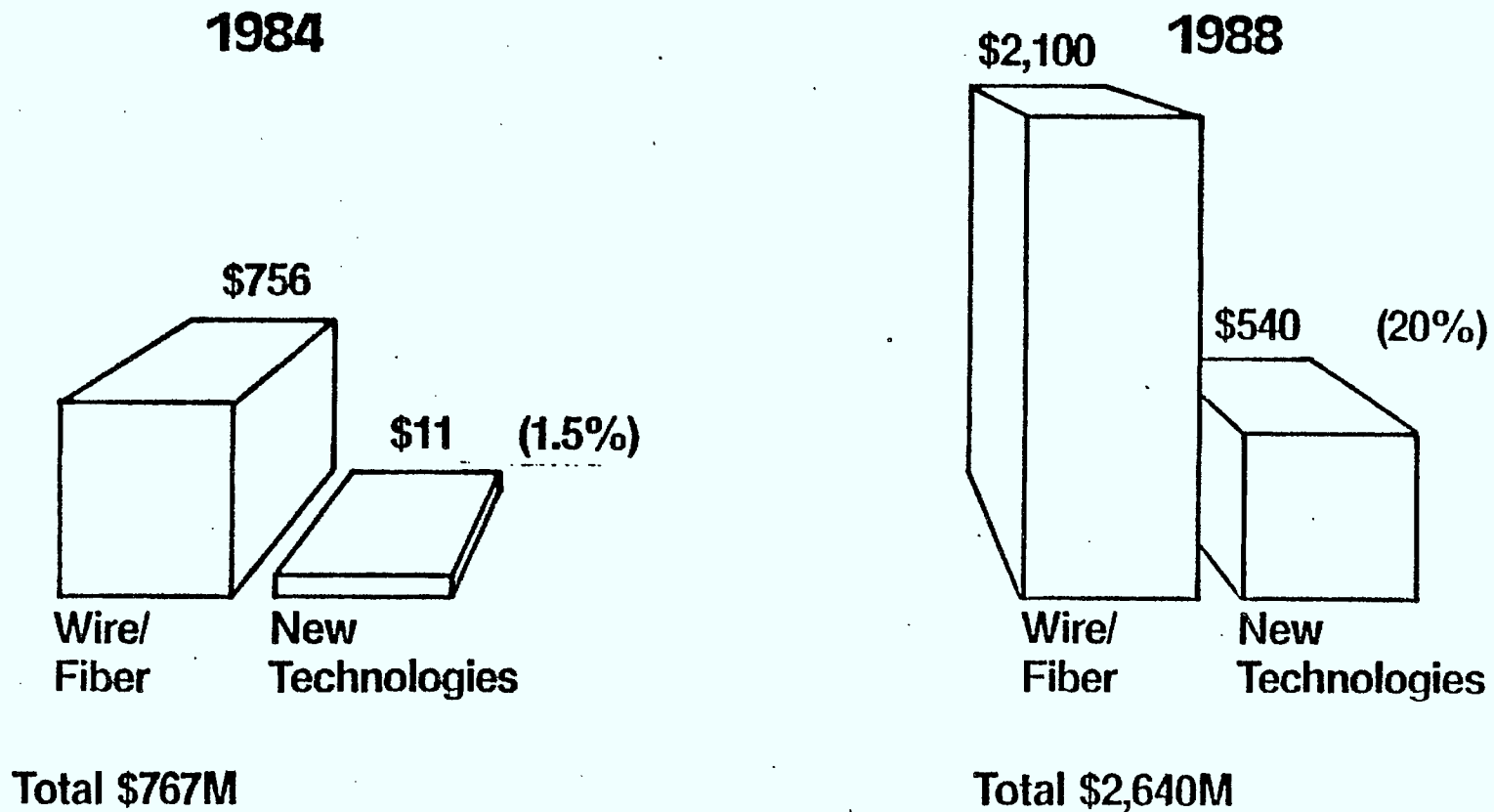


\*Constant Dollars

*Contemporary Digital Services, Inc.*

# Improved Price Performance of New Technologies will Increase Market Acceptance:

\$ Millions



**Contemporary Digital Services, Inc.**

The OCCs are also expected to increase the value of their market from \$2.5B U.S. in 1984 to \$9B U.S. in 1990 as shown in Exhibit 2.10. The OCCs could be one of the largest market for DTS, using the systems to provide their equivalent of a local loop to large subscribers. (However, the projections indicate that while their market will continue to grow in absolute terms, their market share will peak in 1986 at just over 10% falling thereafter to under 7.5% in 1990.) Thus, it appears that the market which DEMS/DTS could serve will grow over the next 5 years. However, the projections provide general trends and do not clearly indicate the extent to which DEMS (or any particular technology) will be able to capture the market.

All parties involved have stressed the lack of certainty in all market estimates, particularly considering the rapid changes in technology and the regulatory environment affecting both the communications equipment and the needs of the users.

#### 2.2.5 Conclusions

The U.S. DEMS service is very early in its life. The market for the service including the local point-to-multipoint feature offered by DTS is still uncertain. This uncertainty, combined with the fact that many systems have only been authorized in the past 18 months, has meant that none of the systems are near to completion (typically only 5-7% of authorized nodes have been installed). Of the termination nodes installed, none are operating near capacity (as noted, with the exception of several nodes in New York City, these nodes have only become operational in the past six months). The parties involved with DEMS/DTS (suppliers, regulators and users) generally agreed that the service has been slower to develop than originally anticipated.

The availability of a public point-to-point microwave system has yet to attract customers who may have wanted the microwave service but not the responsibility of operating their own private system. At the same time

## EXHIBIT 2.10

PROJECT GROWTH IN THE INTER AND INTRALATA TOLL TRAFFIC MARKET, 1984-1990\*

Year	\$ Billions	AT&T Communications	ATTCOM % Share	7 Reg. Bell Cos. + Ind. Telcos (IntraLATA Only)	% Share	Occs/Others i.e., MCI, Sprint, SBS, et al Plus Resellers	% Share
1984	\$ 51.9	\$35B	67.5%	\$14.4B	27.7%	\$2.5B	4.8%
1985	59.7	40	67	14.7	24.7	5	8.4
1986	68.7	48	69.8	13.7	20	7	10.2
1987	79	58	73.4	13.5	17	7.5	9.6
1988	90.9	68	74.8	14.9	16.4	8	8.8
1989	104.5	80	76.5	16	15.3	8.5	8.2
1990	122	96	78.7	17	13.9	9	7.4

\* Includes all MTS, WATS, and Private Line toll traffic, both interLATA and intraLATA.  
Excludes International Telecommunications Revenues.

c Information Age Economics, Inc., 1984.  
Table prepared by Alan Pearce, Ph.D.

the availability of the DTS has not slowed the growth of private point-to-point microwave services. One factor which could at least partly explain this finding is the inability of the DTS based DEMS to handle large volumes of traffic (e.g., for full-motion video which is a popular point-to-point application) from individual subscriber nodes.

There seems to be little doubt that the market for digital data communications will grow. However, the delays in the establishment of DEMS could be extremely detrimental to its potential to capture a section of the data communications market. New offerings from the telcos and AT&T, groups with whom the potential customers already have links, could greatly reduce the market available to DEMS. As well as having to sell a new, unfamiliar technology to customers, some DEMS suppliers will suffer from being "new kids on the block". They will have difficulty instilling the confidence in potential subscribers that they can provide consistent quality and will still be in business in the long run.

In the long run, DEMS will probably capture a share of the digital communications market. The DEMS carriers will be most successful where the telco is slow providing adequate service at reasonable cost or is unlikely to provide service because of insufficient demand to support the introduction of new cable. (Of course, the telcos themselves will be able to take advantage of DTS as a local loop medium where cost effective.) However, the longer DEMS takes to be established, the more time AT&T and the local telephone companies have to reduce the cost of their cable services and to overcome technical inadequacies where they exist, thus giving them the ability to reduce the market share available to DEMS carriers.

### 2.3 MARKET-RESPONSIVE DELIVERY MODELS

Sections 2.1 and 2.2 provide the necessary background to postulate various candidate systems that are hopefully responsive to the implied Canadian market. Although the private use of local microwave systems should not be ruled out as a theoretical option at this stage, for the purpose of assessing the market and postulating responsive service offerings, the private applicant (characterized by his requirements) can be viewed as a potential public user. Thus, the approach employed in this study is to assume that a public applicant or entrepreneur installs the plant and offers the services to the public (represented in part by the private applicants and their requirements).

The Statement of Work in Task (a) states that the "microwave system model is to cater to a number of customers and a range of transmission requirements and provide a broad coverage of part or the whole of an urban area." In view of the low density of "exposed" users (even in Toronto) and the somewhat disappointing "materialization rate" experienced in the U.S., it is concluded that a system founded exclusively on some point-to-multipoint delivery model would not best suit the needs of the user community. The most responsive single model thus appears to be a public service model incorporating (as applicable) both point-to-point and point-to-multipoint delivery models. Neither should be forced to stand alone if overall economic viability can be enhanced by their mutual (and more competitive) attraction of market support, and neither should be ruled out for the reasons given below:

#### (i) Point-to-Point

This may be the only economically viable means of serving many isolated users in the present and near future. A common application is point-to-point video for remote surveillance. Point-to-point also allows the service provider to defer the cost of an equipment-compatible point-to-multipoint configuration until local market penetration warrants it.

(ii) Point-to-Multipoint

Although as yet there is little demand in evidence (see Exhibit 2.1), the point-to-multipoint service has not yet been presented to the Canadian market in the trappings of a public service model. Hence, potential demand is largely unquantified, and this is a significant objective of the subject study.

As defined in Section 1.2, the public service model embodies the set of parameters (including tariffs) that define the service offering(s) of a given service provider in a given geographic region. This clearly implicates the applicable delivery models and their associated costs. Before further characterization of the public service model(s), it is thus necessary to further specify and characterize the appropriate set of delivery models. Again with reference to Exhibit 2.1 and the U.S. experiences, five representative delivery models have been selected and are enumerated in Exhibit 2.11. Collectively, these models cover what is thought to be the majority of foreseeable applications in Canada, and could be implemented jointly or separately to form the technical basis for a range of (specific) public service models collectively applicable to the whole Canadian market.

Exhibit 2.11 shows traffic capacity, coverage, applications and typical commercial equipment types associated with each delivery model. Supporting technical documentation for all equipment is contained in Attachments 2 and 3.

Although equipment manufactured by General Electric and Local Digital Distribution Company have been taken as typical, there are a number of other manufacturers of generically similar equipment (e.g., NEC, Ericsson, Digital Microwave Corporation, RACON, Etc.)

Model	Traffic	Classification and Coverage	Typical Applications	Typical Equipment
I	Low Speed Data (2400/4800/9600 bps)	Point-to-point 6 miles typ.	Computer Data	GE LSD-082A 23GHz
II	Medium Speed Data (48 kbps - 512 kbps)	Point-to-point 6 miles typ.	Data, digital voice, digital video Telecon- ferencing	GE LSD-092A 23GHz
III	High Speed Data (1.544 Mbps)	Point-to-point 6.5 miles typ.	Data/24ch voice/ Video Teleconferencing	GE LSD-122A 23GHz
IV	Video (BW/Colour)	Point-to-point 2.5 miles typ.	Surveillance, Teleconferencing	GE LSV-112A 23GHz
V	Multi User Data (4.2 Mbps Aggregate with 2 RF carriers)	Point-to-Multipoint 360° (1-240° and 1-120° sector) 8-10 miles	Data/Digital Voice	LDD RAPAC 1021, Configuration E (10 GHz)

Exhibit 2.11: Delivery Models and Typical Equipment

### 2.3.1 Technical and Cost Characterization of Delivery Model V

As indicated in Attachment 3 (page 3), there are three RAPAC (point-to-multipoint) Models: 1008, 1018, and 1021; which have aggregate transmission rates per RF carrier of 800, 1800 and 2100 kbps respectively. As well, there are a number of possible coverage sector configurations, as indicated in Section II.A of Attachment 4. At this point, we have no justification for dismissing any data rate up to 1.544 Mbps, so that the Model 1008 is tentatively ruled out. Now referring to Attachment 4, there is no price difference between the 1018 and the 1021, so we might as well take advantage of the higher capacity of the Model 1021. The next question is one of configuration. Again, we have no reason to rule out 360° coverage, which leaves configurations C, E, F and G. These have respectively 1, 2, 3 and 4 RF carriers, for aggregate transmission rates of 2.1, 4.2, 6.3 and 8.4 Mbps. Note that prices increase correspondingly.

Consider that there might be one user of full-duplex 1.544 Mbps data (with subscriber stations in different sectors). His total throughput would be 3.088 Mbps, which rules out Configuration C. On the other hand, there is little justification for going beyond Configuration E, for which the US domestic retail price (central station) is \$70,500. Thus, RAPAC Model 1021, Configuration E, is selected as representative of Model V.

Figure 2.2 of Attachment 3 shows the typical hardware associated with one central station and one subscriber station for the RAPAC point-to-multipoint system. The system is designed to accommodate demand and/or fixed assignment. The Monitor and Test Unit and Printer (which essentially comprise the Network Management Facility, see page 7 of Attachment 4) are optional, and perform the functions indicated on page 27 of Attachment 3. In Section 3.3, separate public service models (and tariff structures) are associated with the demand and fixed assignment modes. For the purposes of costing, it is reasonable to assume that the Network Management Facility would be indispensable for demand assignment, but could be deleted for a fixed assignment network

(due to the longer duration of circuit connections and simplified monthly billing procedures). Thus, the central station costs will differ by \$25,000 (U.S. domestic retail, see page 7, Attachment 4) for the fixed assignment and demand assignment public service models. (Had the Network Management Facility been included, the fixed assignment and demand assignment tariffs would correspond to alternate offerings from a single system. In this case a crossover point in terms of utilization could be identified at which a permanent connection is more economic for the user.)

We can now summarize the equipment items and (U.S. domestic retail) costs associated with the central station and one subscriber station of Model V as follows (see Attachment 4):

(a) Central Station

<u>Item</u>	<u>Cost (\$ US)</u>
RAPAC Model 1021, Configuration E	\$ 70,500
Hot Standby Option for above	\$ 28,150
Network Management Facility*	\$ 25,000

(b) Subscriber Station

Subscriber Station (non-redundant)	\$ 9,900
Transceiver Test Unit**	\$ 4,000

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\* Not required for fixed assignment network.

\*\* One only required per node - cost to be associated with the central station.

### 3.0 ECONOMIC AND COMMERCIAL VIABILITY ASSESSMENT OF CANDIDATE LOCAL MICROWAVE SERVICE OFFERINGS

#### 3.1 INTRODUCTION

With the identification and technical characterization of the five delivery models listed in Exhibit 2.11, steps (i) and (ii) from Section 1.2 have been completed. These delivery models and their direct (annual) costs are applicable to both private and public applications. However, for the viability assessment of the delivery models performed in this section, the direct costs are only used to determine tariff structures associated with offering the services via public service models. For private applications, the direct costs can be taken as the total costs to the user, although they could vary depending on the user's application, organization and financial position (e.g., cost of raising capital). For future reference, the delivery models shall be identified as indicated below:

- (I) Point-to-point low speed data link
- (II) Point-to-point medium speed data link
- (III) Point-to-point high speed data link
- (IV) Point-to-point video link
- (V) Variable rate point-to-multipoint data link

In this Section, steps (iii) and (iv) from 1.2 are addressed as outlined below:

- (i) The delivery models are typified by the equipment identified in Exhibit 2.11. Cost models, including recurring and non-recurring costs, are then developed (Section 3.2) with reference to this typical equipment. This yields the direct annual costs.

- (ii) We then develop (Section 3.3) typical service rates or tariffs which would be necessary to support each delivery model based on the assumption that the service is leased to the users, for a fixed monthly charge (plus in Model V(B) a usage charge), by a service provider. This necessitates the development of a separate public service model for each delivery model, which necessitates additional assumptions on utilization, management cost, return on investment, etc. that are not embodied in the delivery model costs.
- (iii) Next (Section 3.4) we identify competitive distribution methods which can potentially be used as an alternative to provide a similar service to each of the five microwave public service models. For each alternative method, cost estimates, tariff estimates, or actual published tariffs are presented.
- (iv) A tariff comparison between each microwave public service model and the competing distribution model(s) is made (Section 3.5).
- (v) Finally a discussion (Section 3.6) of the pros and cons of possible Canadian delivery systems for local microwave distribution is presented. This includes:
  - . circumstances under which private networks may be the preferred approach;
  - . circumstances under which public networks may be the preferred approach;
  - . service capacities and spectrum usage; and,
  - . equipment compatibility issues between Canadian and US/European systems, as the subject may impact potential Canadian exporters of equipment.

### 3.2 LOCAL MICROWAVE DELIVERY MODEL COST ELEMENTS

Cost elements for each of the five local microwave delivery models are presented in Exhibit 3.1 in terms of non-recurring costs and recurring costs. U.S. domestic retail equipment price lists are included in Attachments 2 and 4, with the exception of Model IV, for which the price used is that quoted by a Canadian distributor. See also Section 2.3.1.

Non-recurring costs include:

- . Capital cost of equipment
- . System planning costs
- . Installation costs

Recurring costs include:

- . Maintenance (labour & material) costs
- . Administration and operating costs

Power consumption for the equipment (typically under 200 w per terminal) is negligible and the costs are not included. Models used in the derivation of Exhibit 3.1 entries are stated below.

#### 3.2.1 Estimation of Non-Recurring Costs

##### 3.2.1.1 Canadian Equipment Prices

In order to convert US domestic retail equipment prices to Canadian prices a factor of 1.82 has been used. This is made up as follows (multiplied together):

CDN-US Exchange	= 1.39
Duty *	= 1.11
FST	= 1.1
Cdn Distributor Handling Cost **	= 1.07
Total US - CDN Conversion	= 1.82

The conversion factor has been verified by a written quotation obtained from a Canadian distributor.

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\* Tariff Item 44533-1

\*\* The wholesale price to the distributor is not known, and this factor represents a mark-up relative to the U.S. retail price.

Delivery Model	Description	Costs (1985 \$CDN)	
		Non Recurring	Recurring & Annualized
I	<u>Low Speed (2.4/4.8/9.6 kbps) Datalink Full Duplex</u>		
	LSD-082A Gemlink Equipment	14,469	2,778 (1)
	System Planning - Est.	3,000	1,029 (2)
	Installation - Est.	2,000	686 (2)
	Administration (incl. licensing)		1,000
	Maintenance (Labour and Material) per year - Est.		<u>1,158</u>
	Totals	19,469	6,651/yr
II	<u>Medium Speed (48-512 kbps) Datalink - Full Duplex</u>		
	LSD-092A Gemlink Equipment	18,655	3,582 (1)
	System Planning - Est	3,000	1,029 (2)
	Installation - Est.	2,000	686 (2)
	Administration (incl. licensing)		1,000
	Maintenance (Labour & Material) per year - Est.		<u>1,492</u>
	Totals	23,655	7,789/yr
III	<u>High Speed (1.544 Mbps) Datalink - Full Duplex</u>		
	LSD-122A Gemlink Equipment	21,840	4,193 (1)
	System Planning - Est	3,000	1,029 (2)
	Installation - Est.	2,000	686 (2)
	Administration (incl. licensing)		1,000
	Maintenance (Labour & Material) per year - Est.		<u>1,747</u>
	Totals	26,840	8,655/yr

Exhibit 3.1 Cost Elements - Local Microwave Delivery Models

NOTES: (1) Interest Rate = 14%, Depreciation Rate = 10%  
(2) Interest Rate = 14%, Depreciation Rate = 25% (see 3.2.2)

Delivery Model	Description	Costs (1985 \$CDN)	
		Non Recurring	Recurring & Annualized
IV	<u>Video Link - Simplex</u>		
	LSV-112A Gemlink Equipment	6,964	1,337 (1)
	System Planning - Est.	3,000	1,029 (2)
	Installation - Est.	2,000	686 (2)
	Administration (incl. licensing)		1,000
	Maintenance (Labour & Material) per year - Est.		557
	Totals	11,964	4,609/yr
V	<u>Point-to-Multipoint, Demand-Assigned, 360°</u>		
	<u>Variable Rate Data Network</u>		
	(A) <u>Central Station</u>		
	RAPAC 1021 Central Station - 2RF Carriers,	128,310	24,636 (1)
	360° coverage, 4.2 Mbps Aggregate Rate		
	Hot Standby Transmission Equipment		
	Option for above	51,233	9,837 (1)
	Network Management Facility (3)	45,500	8,736 (1)
	Transceiver Test Unit	7,280	1,398 (1)
	System Planning - Est.	50,000	9,600 (1)
	Installation - Est.	20,000	3,840 (1)
	Maintenance (Labour & Material) per year - Est.		18,586
	Administration (incl. licensing)		14,000
	Totals	302,323	90,633
	(B) <u>Subscriber Station</u>		
	Subscriber Station (non-redundant)	18,018	3,459 (1)
	System Planning - Est.	2,000	686 (2)
	Installation - Est.	1,000	343 (2)
	Maintenance (Labour & Material) per year		1,441
	Administration (incl. licensing)		1,000
	Totals	21,018	6,929/yr

Exhibit 3.1 Cont'd - Cost Elements - Local Microwave Delivery Models

- NOTES: (1) Interest Rate = 14%, Depreciation Rate = 10%
- (2) Interest Rate = 14%, Depreciation Rate = 25% (see 3.2.2)
- (3) Not required for fixed assignment network

### 3.2.1.2 System Planning Costs

System planning tasks will typically include:

- . market analysis and business plan (Model V only)
- . selection of equipment, configurations, options, interfaces, etc.
- . frequency co-ordination and licensing application
- . site selection (path profile, antenna locations and heights, establishment of line-of-sight)
- . radio equipment location
- . cabling and prime power considerations

Total labour for the above tasks will be highly site dependent, but for Models I to IV, may typically amount to 15 person days of engineering effort per link. At \$200 per day (no allowance for institutional overhead) this amounts to \$3,000.

For Model V, the market analysis and business plan (including growth projections and strategies, tariff structures, cash flow projections, financing strategies, etc.) would probably involve considerable consulting effort. This task is equivalent to developing a detailed and specific public service model. Allowing a total of 100 (mixed) person days at an average rate of \$500 amounts to \$50,000. For the other items of system planning, the costs per link can be taken as somewhat less (say 2/3) of that for an equivalent point-to-point link. This amounts to \$2,000 per link, which can be associated with the subscriber station.

### 3.2.1.3 Installation Costs

Installation will typically include the following tasks for each station:

- . site preparation (build supporting structure, install cable runs, equipment room furnishings, prime power, etc.)
- . installation of antennas and radio equipment
- . test and alignment

For Models I to IV, this may take typically 20 person days of technician effort at \$100 per day, for a total of \$2,000.

For the central station of Model V, some type of premises will have to be purchased (or leased) and equipped as an installation and operations centre. The cost of this will be highly location dependent, and may consist of a mix of recurring and non-recurring costs. It seems reasonable however to assume an equivalent non-recurring cost of \$20,000 for the whole installation. For the subscriber station, the overall installation cost can be taken as half that of an equivalent point-to-point link, or \$1,000.

### 3.2.2 Annualization of Non-Recurring Costs

As shown in Exhibit 3.1, each non-recurring cost must be annualized to reflect financing and asset depreciation costs, resulting in a corresponding effective (annual) recurring cost. These annualized costs are essentially inherent to the delivery models, as they stem from current interest rates and the finite useful life cycle of each asset (including system planning and installation). The annualization of the non-recurring costs has been done as follows.

Assume that each non-recurring cost is funded through a separate loan at  $i\%$  per annum, and that each asset depreciates at an applicable rate of  $d\%$  of its initial cost each year. Also assume that each loan is amortized over the life cycle of the corresponding asset, and that equal payments are made at the end of each year of operation. This will result in a break-even situation at the end of the life cycle; that is no debt and no asset. Thus, given the depreciation rate (inverse of life cycle) and the borrowing rate, the "annualized interest and depreciation" cost will simply be the annual loan repayment.

Consider then a debt  $D$  amortized through  $N$  equal annual payments, with an applicable interest rate of  $i\%$ . After the  $n$ -th payment of  $p$  dollars, the remaining debt will be

$$D_n = D_0(1 + \frac{i}{100})^n - \frac{100p}{i} [(1 + \frac{i}{100})^n - 1] \quad (3.1)$$

But since we require, after the last ( $N$ -th) payment,

$$D_N = 0$$

then

$$D_0(1 + \frac{i}{100})^N = \frac{100p}{i} [(1 + \frac{i}{100})^N - 1]$$

or

$$p = \frac{D_0 i (1 + \frac{i}{100})^N}{100 [(1 + \frac{i}{100})^N - 1]} \quad (3.2)$$

Now by definition

$$N = \frac{100}{d}$$

so that annualized interest and depreciation cost for a given asset will be

$$AID = p$$

$$= \frac{D_0 i (1 + \frac{i}{100})^{100/d}}{100[(1 + \frac{i}{100})^{100/d} - 1]} \quad (3.3)$$

Exhibit 3.2 shows the AID per \$1.00, for interest rates of 8%, 11% and 14%, and depreciation rates of 10%, 15% and 25%, as calculated by the above formula.

Dep'n Rate	Interest Rate		
	8%	11%	14%
10%	.149	.170	.192
15%	.199	.219	.240
25%	.302	.322	.343

Exhibit 3.2 Annualized Interest and Depreciation Cost per \$1.00 of Asset Cost

For the entries of Exhibit 3.1, the non-recurring costs have been annualized according to the following assumptions:

- (i) The applicable interest rate is 14% per annum for all items.
- (ii) The depreciation rate for equipment is 10% per annum (10 year life cycle).
- (iii) The depreciation rate for system planning and installation is 25% for Models I to IV and the subscriber station of Model V. (This assumes an average service period of 4 years.)
- (iv) The depreciation rate for system planning and installation is 10% for the central station of Model V. (This assumes an average service period of 10 years.)

### 3.2.3 Estimation of Recurring Costs

#### 3.2.3.1 Administration and Operating Costs

Annual administration and operating costs (including network planning, licensing, accounting, billing, etc.) have been estimated to be \$1,000 per link for Models I to IV (e.g., 5 days @ \$200 per day).

For the central station of Model V, we can estimate two days per week of an operations manager, whose annual salary might be \$35,000. This amounts to \$14,000. Administration costs for each link can be taken as equal to that for the equivalent point-to-point link (\$1,000 per year), which can be associated with the subscriber station.

#### 3.2.3.2 Maintenance Costs

Annual maintenance costs have been taken as 8% of the equipment capital costs.\* The only exception is that in Model V, the maintenance costs reflect the capital cost of the network management facility whether or not it is procured. The reason for this is that it does not seem likely that maintenance costs should increase upon procurement of a facility whose purpose is partly to facilitate maintenance procedures (see Attachment 4, page 7).

At this point, the total recurring and annualized costs have been estimated for each delivery model. These costs are essentially independent of the structure of the service provider's organization(s), and can thus be termed "direct costs."

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\* Following discussion with the Technical Authority

### 3.2.4 Sensitivity of Costs to Interest and Depreciation Rates

The total annual costs of each delivery model will clearly be sensitive to interest and depreciation rates. To illustrate the sensitivity (and a method of re-scaling), consider Model I. From Exhibit 3.1, there is a total of:

(a) \$2,778/year based on  $(i,d) = (14\%, 10\%)$ ,  
for which AID = \$.192/\$1.00, and

(b) \$1,715/year based on  $(i,d) = (14\%, 25\%)$ ,  
for which AID = \$.343/\$1.00

If we wish to change the interest rate to 11% and retain the same depreciation rates, then from Exhibit 3.2, the new AID factors will be \$.170/\$1.00 and \$.322/\$1.00. Thus, we scale (a) and (b) above as:

(c)  $\$2,778 \times \left(\frac{.170}{.192}\right) = \$2,460/\text{year}$ , and

(d)  $\$1,715 \times \left(\frac{.322}{.343}\right) = \$1,610/\text{year}$

Then the new annual cost will be

$$2,460 + 1,610 + 2,158 = \$6,228/\text{year}$$

This is a reduction of 6%.

## 3.3 PUBLIC SERVICE MODELS AND THEIR TARIFF STRUCTURES

In this section we develop public service models and associated tariff structures for the five delivery models costed in Section 3.2. Although a public service model for a specific service provider serving a specific geographic region could incorporate several delivery models, for simplicity, a separate public service model (service offering and tariff structure) is associated with each delivery model. (In fact Model V requires two public service models -- one for fixed assignment and one for demand assignment.)

### 3.3.1 Basis of Tariff Structures

Assume that the service provider (entrepreneur) views the prospect as a retailing venture. He would then start with the "total cost of sales" and apply some reasonable mark-up -- say 10% -- to obtain the required "gross income from sales." This will determine the annual leasing tariff per delivery model, hence the monthly tariff. Recall now that although the recurring and annualized costs per Exhibit 3.1 reflect all direct pre-tax costs, they do not include a share of the general overhead associated with the service provider's organization. Hence, the "total cost of sales" must be obtained by first marking up the direct costs by an appropriate amount. This "overhead mark-up per item" will be strongly dependent on the service provider's organizational structure, the "turnover" (i.e. average number of subscribed systems) and the "inventory" (i.e. average number of unsubscribed systems, etc.). These factors are completely unknown in advance of postulating a specific public service model and undertaking a corresponding market survey. However, in the retailing business, total mark-ups typically range from 10% to 100%, and the same range can be assumed to apply here. Taking an optimistic view, a total mark-up of 15% will be assumed in the following analysis, keeping in mind that the resulting tariffs might have to be doubled to make ends meet. Systems that are non-viable on this basis will clearly be non-viable in reality.

The principle of equitable allocation of costs on the basis of actual utilization of communication system resources is to be followed. That is:

- (i) In models I-IV there is a single user who therefore attracts 100% of the (marked-up) costs.
- (ii) In Model V the costs are to be equitably allocated among a number of users. Allocation of costs for fixed and demand assignment is discussed further in Sections 3.3.3 and 3.3.4.

### 3.3.2 Public Service Models I-IV

Public Service Models I-IV, consisting of the service offerings and tariff structures associated with Delivery Models I-IV, are presented in Exhibit 3.3. A total cost mark-up of 15% has been assumed in computing the tariffs, but this parameter is conceptually floating to accommodate specific service provider/market scenarios.

Model	Service Offering	Direct Annual Cost	Direct Monthly Cost	Monthly Charge (Tariff)
I	<u>LOW SPEED DATA</u> (2400/4800/9600 bps) Full Duplex	\$ 6,651	\$ 554	\$ 637
II	<u>MEDIUM SPEED DATA</u> (48-512 kbps) Full Duplex	\$ 7,789	\$ 649	\$ 746
III	<u>HIGH SPEED DATA</u> (1.544 Mbps) Full Duplex	\$ 8,655	\$ 721	\$ 829
IV	<u>VIDEO</u>	\$ 4,609	\$ 384	\$ 442

Note: Monthly Charge = 1.15 X Direct Monthly Cost

All Amounts shown in 1985 \$CDN

Exhibit 3.3 Public Service Models I-IV

### 3.3.3 Public Service Model V(A)

This consists of Delivery Model V operated exclusively in the fixed assignment mode. That is, each user has a pre-assigned station-to-station circuit via the central station, so that the user tariff is based on the cost of two user terminals plus a share of the common equipment costs.

The total throughput capacity is 4.2 Mbps. The number of equivalent (duplex) point-to-point circuits will be approximately

$$N_{eq} = \frac{4200 \text{ kbps}}{2 R_{med}}$$

where

$R_{med}$  = the median throughput rate for the point-to-point system.

Thus, we have for:

$$\text{Model I: } N_{eq} = \frac{4200}{2(2.4 + 9.6)/2} = 350$$

$$\text{Model II: } N_{eq} = \frac{4200}{2(48 + 512)/2} = 7.5$$

$$\text{Model III: } N_{eq} = \frac{4200}{2 \times 1544} = 1.4$$

The above numbers suggest that in the present and near future, even in Toronto, an average utilization factor,  $F_u$ , of substantially less than 100% should be budgeted for. On the other hand, one user of medium speed data (Model II) and one user of high speed data (Model III) would incur respectively 13% and 71% utilization. Rather than attempting to prejudge the market at this point, tariff elements will be calculated for utilization factors of 10% and 50%. In reality, a market survey would give some indication of the likely number of medium-and high-speed data users (if any).

The central station tariff element will thus be

$$T_{cs} = \frac{1.15 \times 2 \times (\text{direct monthly cost})}{4200 \times F_u} \quad \text{per kbps/mo.}$$

and the subscriber station (pair) tariff element will be

$$T_{ss} = 1.15 \times 2 \times (\text{direct monthly cost}) \quad \text{per mo.}$$

Note that if the user required only a one-way (half duplex) circuit, the central station tariff element would be reduced by 50%.

The resulting tariff elements and tariffs are shown in Exhibit 3.4. Note that for lower data rates, the tariff is insensitive to the utilization factor (costs are dominated by the subscriber stations). Also, even one user of high speed data (1.544 Mbps) is inconsistent with a 10% utilization factor (and corresponding tariff structure).

The most important conclusion however is drawn from comparing Exhibit 3.4(b) to Exhibit 3.3. Even for the lowest data rate and the highest utilization factor, the tariff for Model V(A) is about twice that for Model I. This is not surprising, as the cost of each subscriber station in Model V(A) is comparable to that of the entire link in Model I (see Exhibit 3.1.). This means that Model I could support 100% overhead (or more) and still be competitive with Model V(A). Thus, there is no advantage in a point-to-multipoint system with fixed point-to-point assignment. A possible exception to this might be found in very high user-density regions, where the advantages of flexibility could offset the disadvantages of limited coverage by the central station. Otherwise, a scattering of point-to-point links would serve a larger geographic market than a single point-to-multipoint system.

Item	Direct Annual Cost	Direct Monthly Cost	Tariff Element	
			$F_u = 10\%$	$F_u = 50\%$
Central Station(1) (Shared)	\$ 81,897	\$ 6,825	\$37.38 per kbps/mo.	\$ 7.48 per kbps/mo.
Subscriber Station (2 req'd)	\$ 6,929	\$577 ea.	\$1,328/mo.	\$1,328/mo.

(a) Tariff Elements .

Full Duplex Data Rate (kbps)	Tariff (\$/mo.)	
	$F_u = 10\%$	$F_u = 50\%$
2.4	1,418	1,346
4.8	1,507	1,364
9.6	1,687	1,400
19.2	2,046	1,472
56	3,421	1,747
1544	N/A	12,877

(b) Tariffs for Different Data Rates

Exhibit 3.4 Public Service Model V(A)

Note(1): For fixed assignment, the network management facility is omitted (see Exhibit 3.1), so that direct annual cost will be \$90,633-\$8,736 = \$81,897.

If a single user has a requirement to interconnect several locations, he will require only one subscriber station per location. Then, for complete interconnectivity of more than three locations, the required number of subscriber stations with the point-to-multipoint network will be less than the number of links required in a point-to-point network. Under these circumstances, the point-to-multipoint system may offer an economic advantage. The economics of user subnets (i.e., more than two locations interconnected) is discussed further in the next section.

#### 3.3.4 Public Service Model V(B)

This consists of Delivery Model V operated in the demand assignment mode, which results in a usage sensitive tariff on central station equipment. Model V(B) also allows unlimited switching capability within the user subnet, which avoids the need to replicate subscriber equipment to achieve high connectivity within the subnet. As in Model V(A), a user subnet is assumed to consist of two or more fixed locations. Hence, each user will be billed for a subscriber station at each of his locations (two minimum) plus his fractional utilization of the central station. The topology is shown in Exhibit 3.5.

This model is not to be confused with the PSTN, in which there is a single and mutually beneficial service, and each subscriber is billed for only one station plus his originating calls. In the PSTN, there is potential benefit in both being accessible to and being able to access a large number of subscribers (i.e., you never know who you might have occasion to communicate with next). However, in a specialized digital network, useful interconnections are limited to an immediate subnet, and for billing purposes, we associate a single user\* with each such subnet.

This mode of operation may offer an economic advantage over Model V(A) in that

- (i) the advantages of usage sensitive tariff and flexible interconnectivity may attract low duty factor (per link) users that would otherwise find the service(s) too expensive for their purposes, and

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\* The user can be defined as the individual or organization that benefits from utilization of the service.

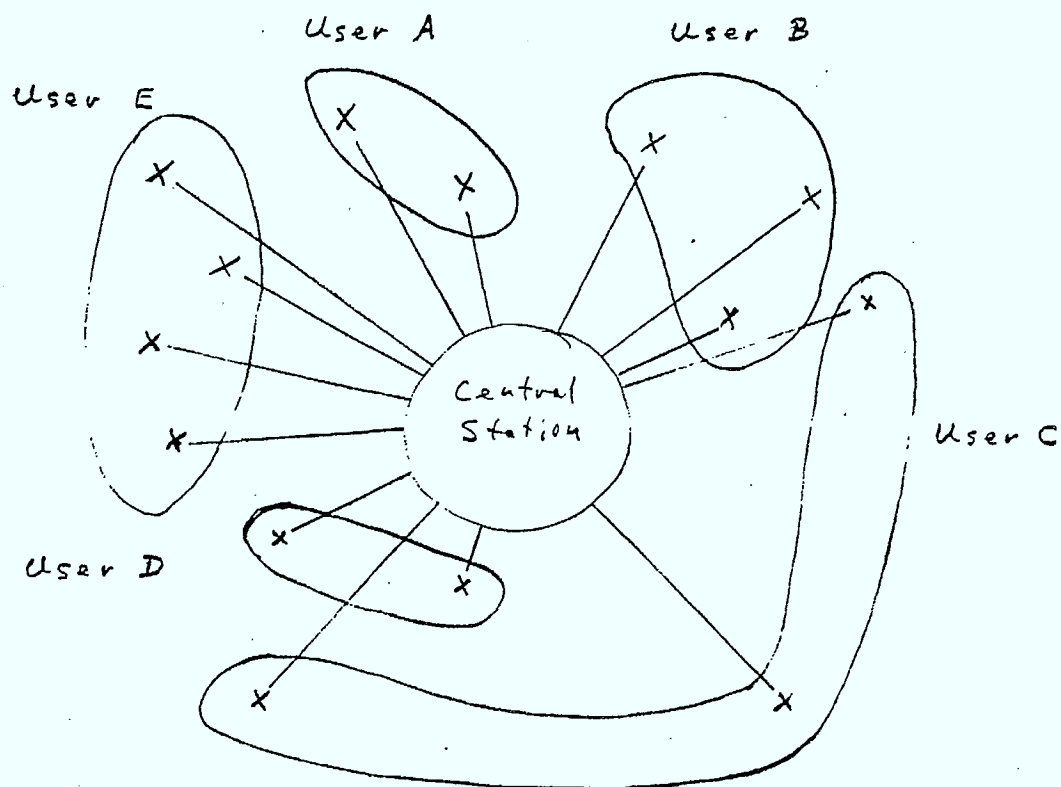


Exhibit 3.5

Public Service Model V Topology

Note: Each user receives a separate billing.

- (ii) if there is a sufficient number of such low duty factor links, the service provider can justify offering a tariff that assumes efficient time sharing of the common equipment.

Note that (i) and (ii) are coupled, since in order for the users' monthly billings for common equipment costs to be less on average than for Model V(A), there must be more users in total (even though the average utilization factor  $F_u$  might be less). Having considered a minimum utilization factor of 10% for Model V(A), anything less for Model V(B) might be pessimistic (although again it is impossible to prejudge the market), and this figure has been used in the following tariff derivation.

With the above assumptions, the central station tariff element will, for the first link in a user subnet, be

$$T_{cs} = \frac{2 \times 1.15 \text{ (direct monthly cost)}}{4200 \times .1 \times 60 \times 24 \times 30} \quad \text{per kbps/min.}$$

and the subscriber station tariff element will be,

$$T_{ss} = 2 \times 1.15 \times \text{(direct monthly cost)} \quad \text{per mo.}$$

The resulting tariff elements and tariffs are shown in Exhibit 3.6.

These tariffs are more favourable than those of Exhibit 3.4 ( $F_u = 10\%$ ) to all users requiring connection for less than 90% of the time. If we assume that the average usage is 1 hour per day, then for 10% utilization, the approximate number of (say) 4.8 kbps users would be (from 3.2.3)  $24 \times 350 \times .1 = 840$ . If in fact there were only 84 users (at one hour per day), or 840 averaging only 6 minutes per day, the usage components of Exhibit 3.6 would have to be increased by a factor of 10. Under those circumstances, consider a potential user of high speed data (1.544 Mbps) for one hour per day. His monthly charge (for a two terminal subnet) would be

$$\$1,328 + (10 \times 1.478 \times 60 \times 30) = \$27,937$$

Item	Direct Annual Cost	Direct Monthly Cost	Tariff Element
Central Station (Shared)	\$ 90,633	\$ 7,553	\$.00096 per kbps/min.
Subscriber Station (2 req'd)	\$ 6,929	\$577 ea.	\$1,328/mo.

(a) Tariff Elements for First Link

Full Duplex Data Rate (kbps)	Tariff
2.4	\$1,328 + .00230/min.
4.8	\$1,328 + .00460/min.
9.6	\$1,328 + .0092/min.
19.2	\$1,328 + .0184/min.
56	\$1,328 + .0536/min.
1544	\$1,328 + 1.478/min.

(b) First Link Tariffs for Different Data Rates

Exhibit 3.6 Public Service Model V(B)

This is clearly prohibitive in comparison to the \$829 per month for a point-to-point circuit (see Exhibit 3.3, Model III).

An element of self defeat is now apparent in Model V(B), as well as V(A). That is, if a single user accounts for a substantial fraction of the total utilization, he is strongly penalized by the usage tariff component, and would logically resort to a dedicated system. This fragments the market, making the whole proposition less viable. At best, with ideally equitable allocation\* of costs, 50% utilization by a single user would incur monthly charges of  $1,328 + .5 (7,553) \times 1.15 = \$5,671$ . This is still prohibitive.

Finally, assume the former scenario of 84 users of 4.8 kbps data for 1 hour per day (i.e. 1% utilization). For one circuit each, their monthly charge would be  $\$1,328 + (10 \times .00460 \times 60 \times 30) = \$1,411$ . Even here, the monthly cost of a dedicated circuit (Exhibit 3.3) is much less (\$637).

We conclude that for Model V(B) (with the best possible tariff structure) to be competitive with Models I to III (with the tariff structures of Exhibit 3.3), both of the following conditions must be met:

- (i) there must be substantial demand for multipoint interconnectivity among a sufficient number of locations, and
- (ii) there must be in total a sufficient number of independent "low capacity" users who are certain to collectively incur a minimum utilization factor of the order of 3%.

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\* As opposed to a pre-determined tariff structure such as Exhibit 3.6.

It is clear that if only condition (ii) were met, then for any typical circuit, the monthly tariff for the two subscriber stations alone (\$1,328) would be greater than that for the point-to-point circuits of Exhibit 3.3. If both conditions are met, then the tariff structure could be revised so that users who require multipoint connectivity (point-to-point models are poor competitors) pay extra so as to make this model more attractive (by lowering tariff) for point-to-point circuits. This is a departure from a strictly cost based tariff approach.

It must be kept in mind, however, that the overhead of Models I to IV (15% total mark-up) might be too low, so that tariffs per Exhibit 3.3 could perhaps double in reality. If this were the case, then condition (i) above would not be a requirement, and we can estimate a "viability threshold" regarding condition (ii) as follows:

Assuming equal average utilization of resources, the central station costs must be shared among enough subscriber nodes to make each one's share small (say 10%) compared to the subscriber station costs. Thus, from Exhibit 3.6 (a), the minimum number of subscriber nodes would be

$$N_{\min} = \frac{\$ 7,553 \times 10}{\$577}$$
$$= 131$$

In conclusion, the major disadvantage of Model V is that the cost of the central station constitutes an overhead, which must be completely covered regardless of the number of users. In addition, the central station imposes a limit on the composite data rate, resulting in a high overhead-to-throughput ratio, which discriminates against high-capacity users. By contrast, with Models I to IV, the overhead (resulting only from the service provider's organization) can be managed in such a way as to grow in small steps, being roughly proportional to the number of users, and roughly independent of the composite data rate. Therefore, economic viability and tariff structures are not so sensitive to user characteristics, which cannot accurately be established until the service is actually offered.

The real advantage of Model V shows up if a substantial number of users require interconnectivity between several points. For one user requiring n-point interconnectivity, with Model V, the total tariff is essentially proportional to n (i.e., one subscriber station at each point). However, the resulting number of separate links will be  $n(n-1)/2$ , and since each separate point-to-point link would require two "terminals," a cost reduction factor of  $1/(n-1)$  results. This assumes that the cost of a point-to-point link is equal to the cost of two point-to-multipoint subscriber stations, which would be approximately true if Models I-IV required 100% mark-up for viability (see 3.3.1).

If the cost to a given user of the first point-to-multipoint link is CPM1, and the cost of an equivalent point-to-point link is CPP, then point-to-multipoint will be more economic when more than

$$P = \frac{CPM1}{CPP} + 1 \quad (3.4)$$

points must be fully interconnected.

In the above discussion, the baseline tariff structure is based on a utilization factor of 10%. However, it is useful to analyse user tariffs as a function of the utilization factor (and user demand), assuming for each utilization factor a separate cost based tariff structure. Define

D = user demand in kbps-hours/day

Then the monthly leasing charge will be

$$C = \frac{2D \times 1.15 \times CS}{4200 \times 24 \times F_u} + 2 \times 1.15 \times SS$$

where

CS = direct monthly cost of the central station  
= \$7,553 per mo.

SS = direct monthly cost of the subscriber station  
= \$577 per mo.

Hence,

$$C = \$0.172\left(\frac{D}{F_u}\right) + \$1,328 \text{ per mo.} \quad (3.5)$$

This equation is valid for C less than 1.15 (CS + 2 X SS) = \$10,013 per mo.

The cost function (3.5) is tabulated in Attachment 5 for various demands and utilization factors.

We can consider a user demand level (but not necessarily the system) to be viable if the first term of the cost function is 10% or less of the second. Thus, the maximum viable demand will be when

$$D = 772 F_u$$

Also

$$D = RT$$

where

R = data rate, kbps, and  
T = average daily usage, hours

Thus, for viable demand, the "maximum daily usage" will be

$$T_{\max} = 772 \frac{F_u}{R} \text{ hours} \quad (3.6)$$

This of course is only valid for  $T_{\max}$  up to 24 hours. The above function is also tabulated in Attachment 5.

Note that any group of users jointly determining  $F_u$  and individually not exceeding  $T_{\max}$  is a viable group by this definition. This only means that common equipment doesn't make the system economically unattractive; it can still be non-competitive on the basis of subscriber node costs, depending on subnet interconnectivity requirements.

### 3.4 COSTS AND TARIFFS FOR (NON-MICROWAVE) DISTRIBUTION METHODS

#### 3.4.1 Low Speed Data Link

The logical alternatives to the microwave low speed (2.4/4.8/9.6 kbps) full duplex data link are:

either (a) A switched network business line equipped with modems for 2400 or 4800bps.

Monthly charges would be approximately:

	<u>2400bps</u>	<u>4800bps</u>
2 Business Lines(Bell)	\$ 64	\$ 64
2 Modems	<u>\$ 140</u>	<u>\$ 260</u>
	\$ 204/mo	\$ 324/mo

or (b) A private line such as Bell Canada's Digital Channel Service (where available) for 2400, 4800 or 9600 bps. Monthly charges would be approximately \$300 for any of the above data rates.

#### 3.4.2 Medium Speed Data Link

The logical alternatives to the microwave medium speed (48-512kbps) full duplex data link are:

either (a) A private line such as Bell Canada's Digital Channel Service for 56 kbps (where available). Monthly charges would be approximately

Access	2 x \$105 =	\$210
Links	2 x \$120 =	\$240
Channel	2 x \$9 =	<u>\$18</u>
		\$468/mo.

or (b) A fibre optic link typically capable of transmitting data rates up to several Mbps for 5 km without repeaters - or further with repeaters. Monthly tariffs are estimated below, assuming i=14%, d=10% and 25% on equipment and installation, and a mark-up of 15%.

<u>Costs (\$CDN)</u>	<u>Non-Recurring</u>	<u>Recurring and Annualized</u>
2 Tx/Rx Units	\$16,000	\$3,072 per year
Multimode Jacketed Fiber	\$3.00/metre	\$.576 per year/metre
Installation	\$8.00/metre	\$2.744 per year/metre
Maintenance (est.)		\$1,000 per year
Administration (est.)		\$1,000 per year

From the above we can estimate the monthly tariff for a 48-512 kbps link to be

$$\frac{1.15}{12} [5,072 + (3.32 \times 1,000)/\text{km}] = \$486 + \$318.17/\text{km}$$

This amounts to \$2,077/mo. and \$3,668/mo. for 5km and 10km respectively.

The above costs are already dominated by construction costs. The \$8.00/metre construction cost reflects an aerial installation in a suburban environment. For downtown city environments construction costs may be several times higher and rights-of-way may be extremely expensive and time consuming to acquire unless already owned. The existing telephone company would have a clear advantage in this respect.

### 3.4.3 High Speed data Link

The logical alternatives to the microwave high speed full duplex data link are:

- either (a) A private digital repeatered cable facility such as the LD-1 system used for Bell Canada's Megaroute Service. The proposed Megaroute tariff is included in Attachment 6. Monthly tariffs are a function of the distance between subscribers and the serving wire centre (control office) and whether the circuit is the first system installed between the subscribers, or a subsequent system. A construction cost component is included in the tariff and is applicable for the initial service period (1,3 or 5yrs). Assuming an initial service period of 3 years the monthly tariff for a first system is between \$1700 and \$4000 dependent on distance. Subsequent systems are approximately half the tariff for the first system.
- or (b) A private fibre-optic link. Details and costs are included in Sec. 3.4.2(b) above.

Monthly charges are estimated as follows:

\$2,077/mo for a 5km link.

\$3,668/mo for a 10km link.

### 3.4.4 Video Link

The logical alternative to the simplex microwave video link is a private fibre optic video link which would be capable of operations over 3-4 km without repeaters. Costs are estimated as follows, making the same assumptions as before:

<u>Costs</u>	<u>Non-Recurring</u>	<u>Recurring and Annualized</u>
1 Tx Unit, 1 Rx Unit	\$8000	\$1,536 per year
Multimode Jacketed Fibre	\$3.00/metre	\$.576 per year/metre
Installation	\$8.00/metre	\$2.744 per year/metre

<u>Costs</u>	<u>Non-Recurring</u>	<u>Recurring and Annualized</u>
Maintenance (est)		\$1000/yr
Administration (est)		\$1000/yr

From the above we estimate the monthly tariff for a simplex video link to be

$$\frac{1.15}{12} [3,536 + (3.32 \times 1,000)/\text{km}] = \$339 + \$318.17/\text{km}$$

#### 3.4.5 Point-to-Multipoint Data

The logical alternative to a public microwave point-to-multipoint data distribution system is the use of the public switched telephone network (PSTN) to provide a switched data network service. At present, data transmission between two subscribers at rates up to 4800 bps over the public switched telephone network (PSTN) is possible using voiceband modems. Data rates higher than 4800 bps are presently precluded on the PSTN because of performance shortcomings of the portion of the circuit which connects the subscriber to his central office - that is, the subscriber loop. Interoffice transmission of data signals up to 56 kbps within the PSTN now is commonplace.

Replacement or upgrading of millions of subscriber loops to permit data transmission at rates above 4800 bps is not economically feasible, so attention has been focussed on advanced signal processing techniques to permit use of existing subscriber loops at higher data rates.

Northern telecom's "Datapath" technology, which is under development and may be in service in late 1985, will permit the existing subscriber loops to carry data at 2400/4800/9600 bps or 56 kbps and will result in a full switched data network at up to 56 kbps integrated with the PSTN. Details are included in Attachment 7.

As of March 1985 Bell has not filed a tariff with CRTC, however a public announcement on Datapath may be expected in the next few months so that costs and tariffs are not available for inclusion in this report. Note that there is a tendency toward hard-wired non-radio techniques for achieving variable data rate and video distribution (e.g., Northern Telecom's Dynamic Network Architecture).

### 3.5 COMPARISON BETWEEN MICROWAVE AND ALTERNATIVE DISTRIBUTION METHODS

Exhibit 3.7 summarizes the estimated tariffs developed in Sections 3.2 to 3.4 for local microwave distribution models I-V and compares them with the estimated and/or published tariffs for alternative distribution methods developed in Section 3.4. For Models V(A) and V(B), the average number of fully interconnected points per user subnet,  $\bar{P}$ , required to make the point-to-multipoint system competitive with the alternative distribution system is indicated. This has been calculated using formula (3.4), and assumes that total cost is proportional to the number of links for the alternative distribution systems.

For Model V(B), first link monthly tariffs for each data rate are based on  $F_u=0.1$  and one hour per day average usage. (The number of users is unspecified, but would have to be large enough to account for the assumed utilization factor.)

From the tariff comparisons of Exhibit 3.7, we can draw a number of conclusions as follows:

- (a) For low speed point-to-point data, (2400/4800 bps) microwave distribution is not economically viable by a factor of 2:1 with either Bell Canada's Digital Channel Service or a switched telephone line equipped with modems.
- (b) For medium speed (48-512 kbps) point-to-point data, Bell's DCS service at 56 kbps, where available, is more economical than microwave distribution. At data rates above 56 kbps microwave becomes economically superior; cable or fibre-optic systems are considerably more expensive or unavailable as service offerings.

Microwave Distribution System	Estimated Tariff \$/month	Alternative Distribution System	Tariff \$/month
<u>Model I Low Speed Data</u>		(i) <u>Bell Canada Digital Channel Service</u>	
2400 bps	637	2400 bps	300
4800 bps	637	4800 bps	300
9600 bps	637	9600 bps	300
<u>Model II Medium Speed Data</u>	746	(ii) Bell Canada DCS(56 kbps) or Fibre Optic Link (48-512 kbps)	468 2000-3500est.
48-512 kbps			
<u>Model III High Speed Data</u>	829	(iii) <u>Bell Canada Megaroute</u> (1.544 Mbps) or <u>Fibre Optic Link</u> (1.544 Mbps)	1700-4000(1) 2000-3500est.
1.544 Mbps			
<u>Model IV Video (Simplex)</u>	442	(iv) <u>Fibre Optic Link</u>	1500-2500est.

Note (1): Tariff is distance dependent and shown for first link, subsequent links approximately half this tariff.

Exhibit 3.7 TARIFF COMPARISON BETWEEN MICROWAVE AND ALTERNATIVE LOCAL DISTRIBUTION MODELS

Microwave Distribution System		Estimated Tariff \$/month		Alternative Distribution System	Tariff \$/month
<u>Model V</u>		First		(vi) <u>Bell Canada DCS</u>	
<u>Point-to-Multipoint</u>	<u>Data</u>	<u>Link</u>	<u><math>\bar{P}(3)</math></u>		
(A) <u>Fixed Assigned</u> $F_u=0.5$	2.4 kbps	1,346	5.5	2.4 kbps	300
	4.8 kbps	1,364	5.5	4.8 kbps	300
	9.6 kbps	1,400	5.7	9.6 kbps	300
	19.2 kbps	1,472	N/A	19.2 kbps	N/A
	56.0 kbps	1,747	4.7	56.0 kbps	468
	1.544 Mbps	12,877	5.5	Bell Megaroute 1.544 Mbps	1700-4000
(B) <u>Demand Assigned</u>					
$F_u=0.1$ , 1hr./day	2.4 kbps	\$1,332(1)	7.5	Switched line+2.4 kbps modems	204
	4.8 kbps	\$1,336(1)	5.1	Switched line+4.8 kbps modems	324
	9.6 kbps	\$1,345(1)	5.5	Assume tariff as above (2)	300
	19.2 kbps	\$1,361(1)	N/A	N/A	N/A
	56.0 kbps	\$1,424(1)	4.0	Assume tariff as above (2)	468
	1.544 Mbps	\$3,988(1)	2.4	Assume tariff as above (2)	1700-4000

Exhibit 3.7 CONT'D

TARIFF Comparison Between Microwave and Alternative Local Distribution Models.

- Notes: (1) Assumes one hour per day average usage  
(2) No current equivalent available  
(3)  $\bar{P}$  is the average number of interconnected points per user subnet at which point-to-multipoint becomes economically competitive with the alternative distribution system.

- (c) For high speed, point-to-point data, (1.544 Mbps or multiples thereof) microwave distribution is clearly economically superior by a factor of 2-5 over Bell Canada's Megaroute for the first system, and in most cases will be superior for subsequent systems, although this should be verified for subsequent, very short haul (1-2km) systems on a case by case basis.
- (d) For video point-to-point, microwave distribution again is clearly economically superior to alternative distribution methods such as fibre optic systems by a factor of 2-4.\* The main reason for this is the virtual absence of construction costs for the microwave system.
- (e) For point-to-multipoint data, the economics for microwave distribution (compared to the alternative distribution methods of Exhibit 3.7) are such that:
  - (i) For fixed assignment, the point-to-multipoint network is never competitive for required interconnectivity of less than about 5 points on average, i.e.,  $\bar{P} = 5$ . This conclusion is based on the tariff structure of Exhibit 3.4, with  $F_u = .5$ , which may in fact be optimistic.
  - (ii) For demand assignment, the "first link" monthly cost (and  $\bar{P}$ ) will depend on the actual tariff structure and average usage (per user). The minimum  $\bar{P}$  will result if there is a sufficient number of low demand subscriber nodes that (with an appropriate tariff structure) first link cost is dominated by subscriber terminal costs rather than usage. This would be true for 131 equal demand subscriber nodes (see Section 3.3.4).

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\* For the first link of a user subnet.

- (iii) Demand assigned point-to-multipoint may be competitive with the non-microwave alternatives for data rates in the range of 2.4 to 56 kbps, as the user scenario of (ii) may be realizable. Note that with 131 equal demand subscriber nodes (and an appropriate tariff structure), first link cost would be (see Exhibit 3.4(a)).

$$1,328 + \frac{(6,825) \times 1.15}{131} = \$1,388$$

for each subnet. From this,  $\bar{P}$  would be typically (see Exhibit 3.7)

$$\bar{P} = \frac{1388}{350} + 1 = 5$$

A plausible scenario then is 26 equal demand users, each requiring full interconnectivity of 5 points. This is a crude benchmark for assessing the potential user characteristics. Note that viability will increase with more users and/or more required interconnectivity per user subnet.

- (v) For (full duplex) high speed data and fixed assignment (and the tariff structure used in Exhibit 3.7), point-to-multipoint is not viable in comparison to the Bell Megaroute System for a  $\bar{P}$  of less than about 5.5. This is impossible for Model V because of the implied aggregate transmission rate of  $2 \times 5.5 \times 1.544 = 17$  Mbps. In addition, first link monthly tariff for the point-to-point microwave system (Model III) is much less (\$829), greatly favouring point-to-point for low interconnectivity subnets.
- (vi) For (full duplex) high speed data and demand assignment (and the tariff structure and average usage used in Exhibit 3.7), point-to-multipoint appears to be

competitive with the Bell Magaroute System for a  $\bar{P}$  of about 2 (i.e., a minimal subnet). However, a single high speed user, at one hour per day, would account for an average monthly demand fraction of

$$\frac{60 \times 30 \times 2 \times 1.544}{24 \times 60 \times 30 \times 4.2} = 3.1\%,$$

but would require an instantaneous fractional capacity (when using) of

$$\frac{2 \times 1.544}{4.2} = 73.5\%$$

Then, only 26.5% of total aggregate capacity would be available to the numerous other users required to make up the remaining utilization factor of  $10\% - 3.1\% = 6.9\%$ . This would impact grade of service to the other users. In addition, for the minimal subnet under consideration, point-to-point microwave (Model III) is still much more economic, at \$829 per month. Even assuming negligible usage, this cost cannot be undercut by point-to-multipoint for a  $\bar{P}$  of less than (see Exhibit 3.6(a))

$$\bar{P} = \frac{1328}{829} + 1 = 2.6$$

Therefore, the only high speed users that are consistent with demand assigned point-to-multipoint (Public Service Model V(B)) are those requiring at least 3-point interconnectivity and negligible usage (e.g., a few minutes per day, see Attachment 5). Such users may be hard to find, but should not be ruled out in the market survey (Task 3).

Finally, if for some reason there were sufficiently more institutional overhead associated with Model III than with Model V(B), the subnet interconnectivity constraint above would not apply, and the only constraint on high speed users would be that their usage be essentially negligible. For this to be true, the actual tariff for Model III would have to equal the subscriber station pair tariff for Model V(B), which is \$1,328 per month (see Exhibit 3.6(a)).

### 3.6 GENERALIZATIONS AND GUIDELINES APPLICABLE TO THE CANADIAN ENVIRONMENT

In keeping with the methodology outlined in Section 1.2, we can now assess the six public service models described in the previous section as follows:

Model I (low speed point-to-point data)

- . not viable by comparison to alternative services available

Model II (medium speed point-to-point data)

- . not viable where alternative service is available, with possible exception of 56 kbps and above

Model III (high speed point-to-point data)

- . viable

Model IV (point-to-point video)

- . viable

Model V(A) (fixed assigned point-to-multipoint data)

- . not viable by comparison to Model V(B) and Model III

Model V(B) (demand assigned point-to-multipoint data)

- . possibly viable, especially with market concentration, for low and medium speed data, and "negligible usage" high speed data subnets of 3 or more fully interconnected points

It is inconceivable that any proliferation of point-to-multipoint networks could economically absorb all demand for Models III and IV. On the other hand, "close relatives" of Model V(B) may find their places in

larger centres. Therefore none of the above models should be ruled out by regulatory policy, as each may capture a legitimate share of the market. We therefore retain Public Service Models III, IV and V(B), as the most promising candidates, to be presented to the market for assessment of demand. (Task 3).

### 3.6.1 Network and Institutional Guidelines

The detailed technical and institutional characterization of a specific public service model matched to the perceived characteristics of a specific local market or market sector is beyond the scope of this contract. However, this exercise will no doubt be undertaken by D.O.C. to support policy decisions and the review of public/private service applications.

To assist in such future undertakings, we now present some guidelines applicable to the formulation of successful network and institutional structures for the Canadian environment. Further technical background is given in Appendix A, "Design Considerations" and Attachments 2 and 3, "Gemlink Technical Data Sheets" and "RAPAC Point-to-Multipoint System Description."

By comparison to the U.S., European and many other countries, the Canadian market is presently characterized by a low geographic density of users. This permits the formulation of thoughtful and evolutionary growth strategies that go beyond meeting today's requirements.

The single most important parameter governing commercial success of a service offering in Canada seems to be the "overhead costs" relative to some "direct baseline costs." There is less sensitivity to direct baseline costs as these are generally proportional to benefit to the user. Furthermore, since each user would no doubt reckon the benefit to his organization in dollars per month, the architecture strategies for any public service model under consideration should revolve around identification and minimization of the "average user overhead ratio" (AUOR). Since a specific public service model implies a specific

service provider, coverage area and user community, the AUOR can in principle be decreased by:

(i) increasing the number of users sharing a fixed overhead; i.e.,

- . increase coverage area
- . enhance and/or diversify service offering(s)
- . seek most attractive (generally not cost based) tariff structure by service for given demand (time of day variable) and competition
- . decrease tariffs through decreased average user revenue

(ii) decreasing the common overhead shared by the (tentatively fixed) user community; i.e.,

- . reduce common equipment costs
- . graceful introduction of common equipment
- . reduce common institutional overhead
- . graceful increase in common equipment and institutional overhead versus user population growth, e.g., trade common overhead for user related overhead subject to a net decrease in total user overhead; and,

(iii) decreasing the user related overhead, i.e.,

- . reduce subscriber equipment costs
- . reduce user related institutional overhead
- . trade user related overhead for common overhead subject to a net decrease in total user overhead

Recognizing the coupling among the above propositions serves to emphasize the improbability of postulating a near-optimal public service model without an accurate characterization of the user community. Furthermore, a truly optimal system for certain market sectors might incorporate both point-to-point and point-to-multipoint delivery systems. However, certain generalizations can be made relevant to point-to-point and point-to-multipoint applications in the Canadian environment.

(a) Point-to-point

- . has inherently low common overhead
- . network need have no geographic bounds
- . can offer any practical range of services
- . tariff structure is not sensitive to number of users, hence predictable
- . presents less of a gamble to potential investors

(b) Point-to-multipoint (data)

- . should be designed for maximum coverage area
- . should possess highest possible degree of flexibility, including highest practical aggregate data rate and demand assignment
- . tariff structure should be based on careful market assessment and projected growth profile into operational life
- . service provider should consider operating at a loss initially to attract users

### 3.6.2 Regulatory Guidelines

Regulatory policy should allow for an appropriate and variable mix of both point-to-point and point-to-multipoint systems in a given network. A typical network would then start off with a scattering of point-to-point links, and when justified by user density, point-to-multipoint stations would be implemented. This means that subscriber equipment should be compatible with both point-to-point and point-to-multipoint system designs. Specifically, for similar services (e.g. data), spectral occupancy for both should be allowed in the same frequency band.

The point-to-multipoint system design should have the greatest possible coverage area. Exhibit 1 of Appendix A shows typical range versus frequency. It is clear that the 10 GHz band is greatly favoured over the 23 GHz band. Therefore:

- (i) Point-to-multipoint allocations should be made in the 10 GHz band.
- (ii) Allocations for point-to-point systems offering compatible services should also be made in the 10 GHz band.
- (iii) Allocations for incompatible point-to-point systems (e.g. video) should be made in the 23 GHz band.
- (iv) Private applicants, when licensed, should be allocated to the 23 GHz band when possible.
- (v) Allocations for temporary, transportable and/or short range applications should be made in the 23 GHz band.

- (vi) Allocations for high speed data should be considered (on a case-by-case basis) in both bands. Although it is generally economically incompatible with point-to-multipoint topology, it should not be denied the longer ranges offered by the 10 GHz band.

#### 4.0 MARKET ASSESSMENT

This Section addresses the market response to the various potentially economic delivery models developed in Section 3.0. The models were presented to both service users and service providers to obtain their views on the likelihood of respectively adopting and offering local public microwave services.

The scale of effort available for this part of the study was only sufficient to survey eight large service users and three service providers. The service users were carefully chosen to select organizations with large business telecommunication requirements, and ones with operations that might have a need for local point-to-multipoint microwave service. The firms surveyed included a large manufacturer, a power utility, several financial institutions, a provincial government ministry and a lottery corporation. The potential public service providers interviewed were Bell Canada, CNCP Telecommunications and Cantel.

In addition, it is further noted that the surveying effort for service users was targetted at business communications users and providers, and not towards possible video applications where microwave is already in common usage.

##### 4.1 APPROACH TO DATA COLLECTION

The information collected on the level of interest for the various economic delivery models, was obtained through telephone and in-person interviews. The three potential service providers were interviewed in-person, while telephone interviews were used for all potential service users except one which was conducted in-person.

The survey focussed on finding the most appropriate individual in an organization to answer questions on the organization's interest in local public microwave service. Before exploring in detail the interviewees' level of interest in local public microwave services, the microwave

models determined to be potentially competitive with existing services earlier in this report, were briefly described and the general communications needs of the organization explored. Following this, each economically viable microwave model was discussed in turn with the interviewee.

#### 4.1.1 Survey of Potential Users

The questions posed to potential users for each model covered the following characteristics of data traffic:

- the number of places where traffic is generated and where it is to be received - point-to-point or point-to-multipoint involved;
- range of transmission speeds (bps);
- continuous or sporadic requirement;
- the need for security - public or private encryption required;
- what cities are affected - what geographic area to be covered;
- how the service is being currently provided or how has the service been provided in the past. Costs involved in obtaining the service; and,
- features that would encourage the use of microwave: cost, security of equipment, back-up to other transmission methods, speed of implementation (temporary links), and quality required (BER). The order of importance of these features.

The above questions were posed for future as well as current needs, for the years: 1985, 1990, 1995. Where available, the interviewer attempted to determine latent needs including possible and planned services which should be included in the forecast.

Once the definition of needs was complete, an assessment of the likelihood of employing microwave (privately owned or leased) was performed by discussing the following points with the contact:

- a timescale of when the traffic would start to use microwave;
- whether or not the availability of the microwave service would affect market position (i.e., product line, pricing);
- how the purchase decision would be made in the organization. Would lease or buy be preferable? What does each company see as the pros and cons of each? What factors would affect the decision to use a private or public local microwave service? Have any opportunities been foregone because this service has, to date, not been available?; and,
- if public microwave distribution of data and voice service was to be available at: same price, 20% lower, 40% lower than existing distribution services presently available from a public service provider:
  - what kind of data services would be potential candidates?
  - does that traffic have to be interconnected to the public data network or the PSTN?
  - what service features would be required?

At the conclusion of the interview, the contact was asked if he wished to contribute any further information and/or comments to the study.

#### 4.1.2 Survey of Potential Service Providers

Interviews with three potential service providers (i.e., Bell Canada, CNCP Telecommunications and Cantel) were similar to those for potential service users. Questions related to specific organization requirements (e.g., network overview, locations where data generated, etc.) were omitted, while several aspects were added:

- types of digital/data service anticipated (e.g., bit rates, dedicated or demand assigned, etc.);
- market centres in which a need for local public microwave is perceived;
- whether the organization would be interested in developing a service (e.g., similar to the DTS systems in the United States) if the spectrum was allocated by the DOC; and,
- the approach to be taken if the service is to be developed - number of systems or operators in each area, eligibility of applicants, etc.

Information from the earlier user interviews was used to supplement the discussions with service providers and to compare these findings with the market perceptions of the service providers.

#### 4.2 FINDINGS - POTENTIAL USERS

The survey of potential users was conducted during June and July of 1985, using the approach described in Section 4.1. This section provides a summary of the survey findings as they relate to the delivery models presented earlier in the report and to local public microwave systems in general.

It is noted that the organizations interviewed were specifically selected because they might have a need for local point-to-multipoint microwave service. Thus, the reader is cautioned therefore, **not to infer** that these findings are representative of business in general.

Before discussing the findings pertaining to each economically viable microwave model, our general observations are provided below:

#### 4.2.1 General Findings

Following are the general findings of the study:

- Users interviewed expressed general satisfaction with the level of service currently provided by the common carriers. Unlike the situation in the United States, there were no complaints with such aspects of service as: installation time, repairs, transmission quality and the general responsiveness of the carrier to the customer requests;
- The only major and consistent complaint with the existing services of Canadian common carriers was its cost. Canadian data communications cost-per-mile were estimated by interviewees to be as much as 8 times that of comparable service in the United States;
- No user was able to cite situations where they had to forego opportunities because of difficulties in obtaining adequate communications services;
- For most large corporations whose main product is not computing services, the bulk of communications traffic is still voice (80% to 85% voice vs. 15% to 20% data). It is expected that this ratio will not change dramatically in the next 3-5 years. However, as noted below, the volume of both voice and data traffic will continue to increase with a trend to systems which integrate voice and data;

- Most data communication is provided at 9.6 Kbps and below. As much as half of low speed communications traffic takes place at 2.4 Kbps. Most users felt that these speeds were adequate for their current needs;
- While some of the organizations interviewed had made corporate decisions not to develop their own private network, several of the larger users stated that owning their own systems would be a large positive factor in the decision to use local microwave. For those users interested in ownership, service provided by new common carriers would also be attractive, although less so. The least attractive choice would be for the service to be provided solely by the existing carriers. Although the technical service provided by the existing carriers is satisfactory, the competition which would be introduced by permitting ownership and/or new carriers would have a positive impact on prices and would improve the selection of available services;
- Higher speeds would likely be used if the price differential with lower speeds decreased. Most users reported an increasing demand for higher speed data services, typically to 56 Kbps up from the 2.4 to 9.5 Kbps range, as the price of the medium speed data communications continues to fall. Further, they expect an increasing demand for integrated voice and data services;
- Many applications require dedicated lines. Delays that might be imposed by a demand-assigned system would not be acceptable. Peak usage periods of most users occur at similar time periods in the day;

- There was no consensus on the requirement for linking a microwave network to the PSTN and/or the public data network. In fact, there were users who would require interconnection while others, who for security reasons, did not want any link to a public network; and,
- Similarly, there was no consensus on the requirement for encryption on the microwave network. However, some users would require encryption and thus, it should be available as an option on the system.

#### 4.2.2 Point-to-Point Microwave at 56 Kbps and Above

Of the configurations felt to be potentially competitive, the greatest interest was expressed for point-to-point systems capable of at least one T1 channel and preferably several T1 channels. Applications included linking PBXs, linking data centres to other data centres and to groups of terminals and, as their use grows, linking local area networks (LANs). (Ultimately, PBX/LAN links would be part of an ISDN.)

Users were interested in having the high capacity which they (not the carrier) could then divide into a number of voice and/or data channels as required. This would facilitate immediate user control over the allocation of bandwidth.

Interest was also expressed in the use of point-to-point microwave to connect locations between which long distance charges would otherwise be incurred. Local connections would then be provided through the telco's local loops. Point-to-multipoint microwave might be considered for the last mile service but only if it was proven to be as reliable and transparent as existing wire plant and that its price would be sufficiently competitive to overcome the "inconvenience factor" involved in switching to and supporting a different technology.

It is noted that the use of speeds of 56 Kbps and above is still relatively uncommon for most data communications. Even communications between computers or data centres is often handled by groups of lines at speeds of 9.6 Kbps or perhaps 19.2 Kbps. Thus, the high speed microwave must compete with aggregates of lower speed lines as well as current high speed data service. Most users would multiplex a number of slow speed links into a single high speed trunk.

#### 4.2.3 Point-to-Point Video

Very little interest was expressed in microwave video communications links; however, our focus in surveying was on firms with business (particularly data) communications requirements. Several organizations expressed interest in the ability to use the microwave link for video-conferencing intermittently, while retaining the capability to use the same link for data and/or voice at other times.

Some interest was also expressed for microwave to serve to backhaul videoconferencing traffic between user premises and satellite receiving stations.

#### 4.2.4 Demand Assigned - Low Speed (2.4 - 56 Kbps) Point-to-Multipoint

Most users did not see microwave as an alternative for low speed point-to-multipoint applications. They felt that a microwave system could not compete with the cost and service of existing carrier offerings. Furthermore, the viability of the model was constrained by the restriction to low demand subscriber nodes which would be unacceptable to many users who require high network availability and fast response times throughout the day. (Most current applications cited by interviewees used and required dedicated links.)

Concern was also raised over the availability of line-of-sight in dense urban areas, the availability of additional bandwidth for expansion of capacity when required, electromagnetic interference (EMI), and security.

Despite the lack of interest in this delivery model, it should not be immediately dismissed for several reasons:

- Users are least familiar with the application of microwave communications in this configuration and thus may not be aware of its capabilities and advantages. A demonstration test system might help to overcome concerns with the system performance; and,
- More detailed information on the delivery model and the specific users' communications requirements are required to assess whether the configuration has sufficient capacity to meet availability and response time criteria and remain competitive with existing services.

It should be noted that to be competitive the system would have to meet performance criteria at a lower cost than existing systems to overcome the inconvenience and uncertainty of having to switch equipment and possibly the carrier. To a lesser extent, this would also apply to a potential new user.

#### 4.2.5 High Speed Point-to-Multipoint

No match in the current needs of users was found for the high speed point-to-multipoint model because of its restriction to low usage. As with the lower speed point-to-multipoint model, further detail on the model and the specific user applications would be required to conclusively eliminate the model from consideration. In other words, applications may exist but they would definitely be exceptions to the typical range of data communications applications, and would therefore not likely form the basis for the implementation of a public system.

#### 4.3 FINDINGS - POTENTIAL SERVICE PROVIDERS

The three service providers interviewed (i.e., Bell Canada, CNCP Telecommunications and Cantel) are positioned differently in the marketplace. As a consequence, it was not possible to draw generalized conclusions about the carriers' perspective. Therefore, the results of the three interviews are discussed in turn below:

##### 4.3.1 Bell Canada

Bell Canada have assessed the market for services similar to the U.S. DTS system, and currently have not found too many opportunities. Bell has also examined the economics of point-to-point microwave, and has determined that in certain cases where over 4-5 56 Kbps circuits are required, digital microwave is more cost-effective.

The Bell analysis is predicated on what they refer to as "economic bypass" and "non-economic bypass". The distinction between the two categories is based on a comparison of Bell's postulated point-to-point microwave configuration with the true costs of their existing service, rather than their tariffed charges. However, a user's perspective could be different in that the cost of a specific microwave configuration might be cheaper than an alternative existing service offered by Bell through tariffed charges, while Bell might perceive it as "non-economic bypass" because the true costs of the alternative existing service are lower than its tariffed charges.

To address those situations which it considers appropriate for economic bypass, Bell plans to introduce a digital point-to-point microwave service in the first part of 1986. The service would be offered in major market centres and would operate at 18 GHz. Bell's rationale in offering the microwave service is to provide comparable service at a lower cost to the user, as well as speed implementation. At this point, the service has not been priced.

Bell expressed concern that an artificial market would be created, if long distance competition was allowed and competitive microwave services were permitted in the local area. As a result, users might utilize microwave to bypass telco facilities altogether and thus avoid payment of compensation (e.g., access charges) for use of telco local loop facilities.

With regard to the microwave models, Bell felt that for point-to-point applications, they were not in complete agreement with the economic results developed in Section 3.0. Bell provided information on their point-to-point analysis, and it was carefully reviewed by our project team. The Bell analysis used different assumptions with respect to cost and application, and a simplistic method of determining viability (i.e., simple payback). As a result of the review, we did not find any reason to modify our analysis, and firmly believe that ours adequately represents a generalized situation.

Comments were also provided on the licensing of competitors and on frequency allocation. Concern was expressed about the availability of spectrum and to how it would be distributed. To facilitate applications, there should be a simplified licensing procedure for a carrier to obtain a license to install a microwave link. More specifically, Bell, to facilitate microwave implementation, would like to be allocated several dedicated frequencies that would be the same in each of its major urban service areas.

#### 4.3.2 CNCP Telecommunications

CNCP has been examining microwave as an alternative method of providing local service. Unlike Bell Canada, CNCP does not have the in-place, local-loop plant, to carry voice and data to its long distance facilities.

CNCP's long-term strategy is to build its infrastructure in the local area primarily using fibre optics. However, for speeds below 1.544 Mbps, for situations where ducts are not available, and as a temporary

solution, CNCP is considering microwave. Currently, CNCP is considering a high speed TDMA application, a point-to-multipoint application for data speeds of 56 Kbps and below, and packet radio (without directional antennae) for low speeds of up to 2400 bps on a cellular basis. They currently have a field trial of the medium speed application using the CN Tower in Toronto. For the low and high speed applications, CNCP is examining available technology, and will shortly implement a packet radio application also using the CN Tower. Just recently, CNCP implemented a high speed point-to-point link at 18 GHz.

The centres being considered for microwave include Toronto, Vancouver, Montreal, Calgary and Edmonton. Other centres such as Ottawa, Winnipeg, Halifax and Moncton (transocean traffic) are possible in the future.

CNCP is interested in microwave but not as a standalone business. They view microwave as being essential to their overall business in the future, as a means of providing the connection to customer premises. The decision on which technology (e.g., fibre optics, microwave, leased line) to use will depend on which is most cost-effective (to CNCP) at acceptable quality. It was pointed out that the economics associated with the higher frequencies is very volatile as new equipment is continually reaching the market.

Their interest is in the 18-23 GHz range as new less-costly equipment is becoming available. Further, their preference is to build their own network so as to have total control over quality of service.

In terms of the regulatory environment, CNCP believes DOC should make it easier for non-dominant carriers to obtain access to microwave, thereby allowing them to react to situations more quickly. Thus, carriers require flexibility with minimal regulatory requirements in having specific installations approved. It was also noted that ground rules for the higher frequencies need to be set.

#### 4.3.3 Cantel

Cantel is a supplier of cellular telephone service in 23 major cities across Canada. In each of the 23 cities, an alternate supplier (i.e., Telco) of cellular telephone service is also available as a competitive offering to Cantel. Cellular telephone is a new service which has just recently been introduced in the last few months. The plan for cellular telephone is to have it offered across Canada in major urban centres and along some major transportation corridors.

At this point in time, Cantel's energies are focussed on implementing cellular telephone in the 23 cities across Canada. However, as they are utilizing microwave to communicate between cells, they are potentially interested in other applications that could use the network, as well as being complementary to their existing traffic. At present, they have done no marketing studies to determine whether or not there are opportunities, but are prepared to make the necessary investment if justifiable.

Cantel stated that microwave service should be provided as a separate service, rather than as a technology choice within a specific service. They noted the need for spectral efficiency given the limited amount of spectrum available. As a consequence, they further noted that DOC would therefore need to consider the public interest in allocating spectrum among the designated carriers and users. In terms of frequency, Cantel prefers 10 GHz, although 18 GHz could be considered for shorter distances.

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