TELECOMMUNICATIONS FUTURES

A Technology Perspective and Update to Telecom 2000

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ecus Informatics Inc.

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and
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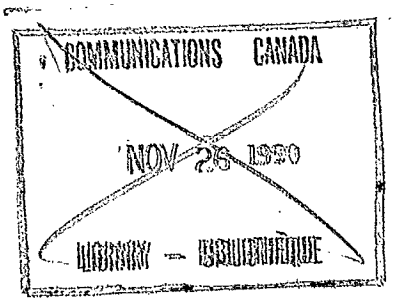

Foreword

Telecommunications Futures: A Technology Perspective, is the first part of a two-part study. The entire study, conducted under the direction of Tom and Brenda McPhail of the University of Calgary, provides direction for Canada's telecommunications sector through a review of the technology policy options and regulatory issues which will require attention over the next fifteen years. The study has been funded by many of Canada's leading corporations and agencies in the telecommunications industry.

A study was undertaken in 1984 on the behalf of the federal Department of Communications, of the telecommunications scene in Canada, that resulted in the preparation and publication of *Telecom 2000: Canada's Telecommunications Future*, by Tom and Brenda McPhail. This current study provides an update to *Telecom 2000,* and in addition, extends its scope in the light of technical and regulatory changes introduced in the interim. Researchers at the University of Calgary will use this report in their own work on the second part of this study addressing the market, policy and regulatory issues in telecommunications in Canada in the period up to 2005.

Loecus Informatics Inc and Lapp-Hancock Associates Ltd cooperated on the research conducted for this study. Loecus Informatics assumes full responsibility for any errors and omissions from this report.

Telecommunications Futures: A Technology Perspective

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SUMMARY

• Introduction

This report provides forecasts of the state of telecommunications in Canada over the next fifteen years. It does so from a technical perspective, moderated by views of how the marketplace for communications services will change over this near future.

Telecommunications is one of the glues that binds Canadians together. We all share in the use of telephone, radio and television systems and services. There are social forces at work independent of technical capability, that shape the nature of these telecommunications tools. While the tools may be defined by the technologies they use, they cannot be identified purely in technical terms. Market forces, and the regulatory environment will have as much an effect on Canada's telecommunications facilities as the technologies themselves.

This report is not however, the result of market research. Our approach has been to develop a considered view of the technologies that will influence the growth of telecommunications in Canada, based on the experience and opinions of experts within its component industries. Analysis extended this consensus into a set of three qualitative forecasts. Before reviewing these forecasts, we will introduce the technologies studied for this report.

• The Technologies

Telecommunications services are provided using a large number of different technologies. For the purposes of our analysis five sets of technologies were identified:

- distribution: propagation technologies, materials and methodologies;
- electronics: processing technologies, including software;
- terminals: a variety of device technologies involved in interaction with network services;
- power: battery and transformer technologies; and
- standards: technologies providing a structured and common environment for the implementation of technology.

In each of these areas, significant technical innovations are to be expected over the next fifteen years. Whether these innovations result in service changes, depends on the extent to which the technology changes alter the price, function or performance of the services or not. For example, recent work in superconductivity suggests that room temperature superconducting materials will be found. Applications of this development will most likely be beyond our fifteen year time period. Alternatively, work in multiple processor systems is very likely to lead to rapid advances in real-time speech recognition with interesting impacts on communications services.

There are several technical innovations which we consider to be pivotal in their effect on telecommunications in the near future.

Firstly, in the field of computing, extensions in the power of computers will continue largely unabated. Whereas the typical machine of today operates with a single processor, it is forecast that most machines by the year 2005 will be multi-processors. "Multi" is likely to mean several hundreds of processors. Such "transputers" will provide capabilities beyond current machines, particularly in the areas of speech recognition and language translation.

In the field of battery power, batteries of significantly greater power, yet with very reasonable size, are forecast to be readily available within the decade of the nineties. Such power packs will make

many devices portable, that today are not even movable. It is expected that the availability of such powerful portable batteries will enable a whole new generation of portable telephones and data devices to be developed and marketed.

Facsimile has been a technology "sleeper." It is now undergoing a rapid expansion in use within the business community. It is anticipated that facsimile technology, combined with copier capabilities, will provide a new generation of residential appliances. This will generate the market for data into homes providing market support for the introduction of a full complement of ISDN services.

The digitalization of television and radio signals is a technology that promises considerable improvements in video and audio quality for programmed services. There are competing standards today for high definition television that will be resolved. Many changes in commercial and residential equipment will follow agreement to HDTV standards and the introduction of HDTV services.

Lastly, major research programs are in progress with photo-electronics. Materials that can switch at much higher speeds and provide for the switching of light signals, using photo-electronic effects, will permit integration of fibre optic transmission with economic switching, as well as lead to the availability of photonic computing. These technologies are likely to mature early in the twenty-first century and lead to an overhaul of switching equipment used for all telecommunications services.

• Forecast Overview

Three forecasts have been developed. They reflect differing views of economic health, as a high growth forecast, an evolutionary forecast and a low growth forecast. "Growth" implies growth in the economy as a whole. "High" implies a generally buoyant economy, while "low" implies a generally weak economy. "Evolutionary" implies a middle course, with no radical departures in either direction from current trends.

The health of the economy will be a contributing factor but not the deciding factor in determining what happens to Canada's telecommunications markets. Some telecommunications services may falter in a high growth situation, while others may evolve rapidly in periods of low-growth. Each forecast assumes a stable environment both for Canada's trading partners and for Canada. Clearly, regulation will also have a significant role to play in determining the introduction schedule of all innovative services.

• The Forecasts

In preparing the forecasts, a consistent structure has been adopted, permitting the discussion of each forecast independently and comparatively. This structure presents the forecasts according to:

- Technology Milestones: anticipated introduction of new technologies;
- Carriage Services: impact of technology on telecommunications transmission services, in turn considered under two headings: backbone and value-added;
- Content Services: impact of technology on the nature of services provided using the various backbone and value-added carriage services; and
- User Applications: impact of technology on the kinds of applications users will employ.

The three forecasts are referred to as T-1, T-2 and T-3, being respectively the high-growth forecast, the evolutionary forecast and the low growth forecast. The main items in the forecasts are

now discussed and are shown in chart form at the end of the Summary.

Carriage Services

Backbone services are defined as the basic transmission of information compared to value-added services which are provided in addition to the transmission function, for example voice messaging and storage.

The Backbone forecasts show:

- ISDN introduction phased across the forecasts as economic activity justifies the investment;
- Mobile satellite delay in the T-3 forecast;
- Home fibre installation commonplace by 2000 in the T-1 forecast but that state not reached by 2005 in T-3; and
- Decay of physical mail and courier services to business as inter-corporate electronic mail provides faster and more economical alternative by 1995 in T-1 and 2005 in T-3.

The Value-added forecasts of services highlight the research work on text-to-voice conversion and the more difficult voice-to-text facility. In particular, the forecasts show:

- Text-to-voice messaging availability on public services prior to 1991 in T-1 but delayed until 1996-2000 in T-3;
- The evolution of Metro-LANs, city-wide, wide-area networks linking office blocks between 1991 and 1995 for T-1 but delayed 10 years in T-3;
- Use of voice mail to the home delayed until 2000-2005 in T-3 forecast;
- The provision of multi-media services in the early 1990s except for T-3 in which case they will be launched during the following five year period; and
- Emergence of Hyper-publication by 1991 in T-1, a service which automatically routes specific updates on public databases to a user's terminal (e.g. when a stock quoted rises more 5% in a specified period of time).

Content Services

These services make use of the basic transmission services and may also require value-added services to provide their content sensitive products. Points to note are:

- HDTV transmitted by satellite for specific business and entertainment applications by 1995 in T-1; and
- ISDN used as a base for content services by 1995 in T-1.

User Applications

These comments in the forecast describe general trends in the application of telecommunications services over the forecast period.

- For T-1 we see continued growth in inter-corporate telecommunications for voice, data and other forms of transmission. For example, suppliers, manufacturers and distributors of products linked electronically to speed communication and reduce errors.
- There will be an increase in the use of television as an information medium in the

corporate world both for internal use (IBM uses it for training) and for the public (chain stores to show products across the country in all their stores).

- Electronics will come into the home in a big way with cellular telephones, facsimile-copiers, picture phone re-introduction, digital radio and HDTV. In fact in the T-1 high growth forecast, many homes will be as well equipped as offices and allow individuals the choice of working location.
- The availability of text-to-voice and voice-to-text linked to automatic translation will allow people to communicate verbally in different languages. These services will be available in the business sector first.

• Conclusions

The forecasts presented are dependant upon many assumptions which may not be supported over the period as events unfold. They have however been reviewed by the leading personnel in the telecommunications industry in Canada and thus can be said to represent the accumulated comments of the industry early in 1989.

We were particularly impressed with the following considerations with respect to the future of telecommunications in Canada:

1. The need to communicate is increasing and will continue to do so. This is reflected in the growth of basic voice and TV services based on population increase, and a higher growth rate in data and text services.

2. The integration of voice and data/text services will increase driven as much by carrier cost considerations as by increasing market demand.

3. Continued migration from analogue voice and data/text services to digital and the start of this process on TV and radio broadcasting.

4. Increasing involvement of data processing vendors in telecommunications market with products and services which diminish the differentiation between computing and telecommunications.

5. Emergence of technologies which reduce the need for telecommunications such as the publishing of on-line database information on optical disks which can be accessed directly by a personal computer thus saving telecommunications costs.

6. Opportunities for telephone companies to provide data/text services to the home market and for the cable companies to compete in the business market.

7. No clear indicators on migration of business to private systems from public or vice versa.

8. No evidence came to light on U.S. vendor intentions for the penetration of the Canadian market.

9. There was major concern over the role of the regulator in the telecommunications process. The regulator tends to introduce a serious disincentive for new technologies and services, because of the constraints imposed on timeframes - increasing lead times, and on profit margins - reducing them.

Technology Milestones

	up to 1990	1991 - 1995	1996 - 2000	2001 - 2005
HIGH GROWTH - T1	Erasable optical discs Home FAX/Copiers introduced FAX as peripheral common	Nano-chip PCs Mega-processors standard Mega-processor PCs Stand-alone VRUs common Battery compactness breakthrough HDTV & NTSC compatible Car phones standard ISDN-2 in development	Automatic translation "Instant" databases Picturephone re-emergence	ISDN-2 adopted by CCITT Photonic Switching Superconductivity Practical
EVOLUTIONARY - T2	Erasable Optical discs FAX as peripheral	Nano-chip PCs Mega-processor standard Car phones standard Battery compactness breakthrough HDTV & NTSC compatible Home FAX/copier	Mega-processor PCs Automatic translation Stand-alone VRUs common ISDN-2 in development	"Instant" databases Picturephone re-emergence
LOW GROWTH - T3	FAX as peripheral	Nano chip PCs Erasable optical discs common Battery compactness breakthrough	Mega-processors standard Car phones standard HDTV & NTSC compatible Home FAX/copier	Mega-processor PCs Stand-alone VRUs common Automatic translation "Instant" databases ISDN-2 under consideration

	up to 1990	1991 - 1995	1996 - 2000	2001 - 2005

Carriage Services - Backbone

HIGH GROWTH - T1	Business - fibre to premises Cellular universal	ISDN common: Centrex B-ISDN available leakywire building standard MSAT operational Reduced need for physical business mail	ISDN common: business Home fibre installations common Decay of traditional data services as ISDN grows	ISDN common: home Minimal physical postal delivery service for business customers
EVOLUTIONARY - T2	Cellular widespread	ISDN common: Centrex Cellular universal MSAT operational Business - fibre	B-ISDN available Leaky-wire standard Electronic communications reduces need for business mail	ISDN common: business Home fibre installations common Home ISDN growth Decay of traditional data services as ISDN grows
LOW GROWTH - T3		Business - fibre Cellular universal	ISDN common: Centrex MSAT operational	In-building leaky wire standard B-ISDN available Reduced physical business mail

Carriage Services - Value-added

HIGH GROWTH - T1	Text to voice messaging FAX universal EDI widespread	Voice to text messaging Metro-LANs common Integrated multi-media services Voice Mail to the home	Transparent multi-network data services	
EVOLUTIONARY - T2	FAX universal	Text to voice messaging Integrated multi-media services EDI widespread	Voice to text messaging Metro-LANs common	Transparent multi-network data services
LOW GROWTH - T3	FAX universal		Text to voice messaging Integrated multi-media services EDI widespread	Voice to text messaging Metro-LANs common

	up to 1990	1991 - 1995	1996 - 2000	2001 - 2005
Content Services				
HIGH GROWTH - T1	Public Voice Mail: business Hyper-publication takes off	HDTV by satellite Home data services introduced ISDN based services Digital FM radio services	HDTV by cable Hyper-publication general	Broadcast HDTV Home data services general
EVOLUTIONARY - T2	Public Voice Mail: business	Home data services common Hyper-publication takes off ISDN related services	HDTV by satellite Voice Mail to the home Hyper-publication general Digital FM radio services	HDTV by cable
LOW GROWTH - T3		Public Voice Mail: business	Hyper-publication takes off Home data services ISDN-based services widespread	HDTV by satellite Voice Mail to the home Hyper-publication general Digital FM radio services
User Applications				
HIGH GROWTH - T1	Rapid increase in intercorporate communications	Business HDTV introduced Business TV in general use Non-business cellular growth Mobile data growth	Home HDTV Picturephone re-introduction Increase in DB use Voice & text in native language	Home picturephones common Home office installations common
EVOLUTIONARY - T2	Moderate increase in inter-corporate communications	Business HDTV introduced Non-business cellular growth Mobile data growth	Home HDTV Business TV in general use	Picturephone re-introduction Increase in DB use Voice & text in native language
USER APPLICATIONS LOW GROWTH - T3	Slow increase in corporate communications		Business HDTV introduced Non-business cellular growth Mobile data growth	Home HDTV Business TV in general use Increase in DB use

1 PREAMBLE

Telecommunications is one of the glues that binds Canadians together. The use of telephone, radio, television and computers ties us to common networks of shared experience. The networks are both physical and technical in the sense of machine systems that provide services to us all; and they are also social and political, in that, being all pervasive, rules have been established for their management in the best interests of us all, tempering the effect of economic and market forces.

While the regulations that govern our telecommunications systems and services may be peculiarly, and necessarily Canadian, the technologies know no boundaries. The technologies are common to all peoples in their national and international communications. Canada has no monopoly. Not only do we need to take advantage of the best the world has to offer, we need to offer our best to the world. This report examines the current and future state of the technologies that supply our telecommunications networks and services.

It is recognised that technical merit alone is insufficient to promote particular technological solutions: market need is also required. And not only need, but also the entrepreneurial drive to address that need in its implementation. Our forecasts place the technologies of telecommunications into services contexts. We provide estimates of which technologies will be accepted by the market place, and the nature of packaging, or their structuring into end-user services to meet communications applications needs.

We should note -- a warning both to our reader, and to ourselves in preparing this material -- that forecasting any future pattern is fraught with difficulty. We have attempted in the collection of information for this report to gather expert opinion from vendors and users across the telecommunications industry in Canada. We have researched the technical literature and we claim a consensus in the predictions we have made. Making these forecasts requires a peculiar mixture of humility and bravado. We trust we have found the right mixture: if we have erred, we hope to have erred on the side of common-sense.

The study has drawn on the experience of the Principals in the study, senior communications consultants with Loecus Informatics Inc and Lapp-Hancock Associates Ltd. Material for the technology section was drawn from a literature search, the interviews and our own knowledge. A total of some 20 interviews were conducted at senior levels throughout Canadian industry and academia. Interviewees were drawn from the principal telecommunications carriers, manufacturers and research organizations, and from the consumer community. Preliminary forecasts were created prior to the interviews and were used as the basis of the interviews. While some conflicting views surfaced in reactions to these forecasts; in general, the response was uniform. The insights of the interviewees supported the development of the forecasts in that they correctly represent the abilities of the technologies examined and an educated sense of the service innovations that they will encourage.

The technologies relevant to telecommunications are described in the next chapter, while the grouping of these technologies into services is described in chapter three. Our views of the future of telecommunications in Canada are provided in the forecasts of chapter four which cover the period to 2005. These forecasts provide varying estimates of the impact of technology on telecommunications services. While the report describes the impact of technologies on telecommunications services, it concludes with commentary on related social, regulatory and economic issues.

2 TECHNOLOGIES

The technologies reviewed in this study are described in the following sequence:

- Distribution,
- Electronics,
- Terminals,
- Power, and
- Standards.

Distribution technologies include transmission materials and methodologies. Electronics technologies include all the processing technologies, as well as the techniques of software. The terminals section reviews all devices that may be used on a communications network. Power technologies are addressed as critical to device, central office and head-end operation. Standards are included as a separate set of technologies in their enabling role for whole suites of telecommunications services.

2.1 DISTRIBUTION

2.1.1 Cable

2.1.1.1 Twisted pair

Twisted copper pair has been used for wiring for nearly all telephone and data circuits. It is ubiquitous, and represents a significant installed base of equipment. Nearly all local loops are provided by twisted pair cable.

Twisted pair can support bandwidth up to 1.544 Mbps[1], depending on the length of cable used and the use of repeaters. It is subject to electrical interference, or crosstalk.

Twisted pair is inexpensive. Direct compatibility between central office switches and subscriber equipment minimizes installation difficulties. For local loops, it is still less expensive than alternatives, though it is expected that optical fibre will become competitive. On interexchange routes, other media are preferred: microwave radio, and optical fibre. These have largely replaced twisted pair in this application.

2.1.1.2 Leaky COAX

Leaky COAX is an in-plant cabling system that allows local radio broadcasting and reception, permitting mobile telephony for both voice and data within a wired complex. There are advantages in building maintenance, since recabling for relocations is unnecessary, and in high-activity situations where constant access to mobile individuals is required.

This wiring is in operational use in tunnel and mine situations but not in office situations. It is anticipated to be widely in use over the forecast period, being introduced in parallel with greater use of in plant mobile telephony.

2.1.1.3 Optical Fibre - Telecommunications

Optical fibres bring revolutionary capabilities to telecommunications transmission. They offer bandwidth up to several gigabits/sec for a single strand and are not subject to electrical interference. With significant increases in the quality of optic fibres since their introduction, i.e. improvements in their loss characteristics, much longer runs between repeaters can now be installed. This combination of bandwidth and repeater spacing has resulted in optical fibre replacing

[1] Acronyms and abbreviations are explained in the glossary.

other land lines for long distance circuits: they are economically attractive not only at installation time but also from a maintenance perspective.

The application of fibre to local loop installations is still marginal. It is installed in some new buildings for local area networks. And there have been some trials of full service delivery (telephone and TV) using optical fibre. The principal issue today is the cost of transducers for the conversion of the optic signal into an electrical signal. While transducers are economical in the long-haul multiplexed circuits, single circuit use is not yet cost-effective.

Nevertheless, it is expected that local loop installation of optical fibre will become the standard communications cabling system to both business and residence within the next 15 years. Interrelationships with other technologies exist. The faster new services are adopted, the greater the justification for higher bandwidth capabilities met by optical fibre, and vice versa. The introduction of Broadband ISDN (B-ISDN) is predicated on the existence of optical fibre for delivery to subscriber premises. B-ISDN provides a 20Mb bandwidth, accommodating not only voice and data but a high quality video signal as well.

Optical fibre is seen as the prime trans-national telecommunications link, meeting requirements for both local inter-exchange and long-haul communications. It is vulnerable though to mechanical damage, and parallel links through satellite and terrestrial radio back-up will be required.

2.1.1.4 Optical Fibre: Cabletelevision

Optical fibre cable for cable-TV is the same type and construction as that for telephony, i.e. multifibre (usually increments of 12), single mode, optical fibre cable usually containing cladding, protective tubes, strand and frequently an armored shield with an abrasion resistant jacket.

Optical fibre may be used for significantly greater distances between amplifiers than co-axial cable. Constraints on its introduction are: cost, usable bandwidth, inability to use as drop cable due to TV interface incompatibility and the current capital investment in co-axial cable.

Changes in the larger cabletelevision systems in Canada are expected in their use of distribution technology as co-axial cable is phased out and replaced by optical fibre cables. The basic tree architecture would be maintained with ring architecture local loops for subscriber connection. A ring architecture enables transmission in either direction to occur. While single direction transmission is normal, redundancy is provided for cable break situations.

TV signals today are exclusively analogue. The implementation of true digital TV will almost certainly need optical fibres as a major distribution medium. Optical fibre is only just capable of carrying the same number of TV channels as co-axial cable but, in the study timeframe, this will change and optical fibre cable will routinely have a significantly greater usable bandwidth than co-axial cable.

2.1.1.5 Co-axial Cable Telecommunications

Co-axial cable as a telecommunications distribution method is considered to be a mature technology with no major break-throughs or improvements expected. It is used for local area networks and permanently connected terminal to mainframe systems within a mile radius, with bandwidths up to several hundred MHz. In these situations it provides a sturdy reliable cable not subject to magnetic or electrical interference.

2.1.1.6 Co-axial Cabletelevision

Co-axial cable is the dominant technology used for the distribution of entertainment TV over cable TV networks. It is a mature distribution technology ideal for small and medium cabletelevision systems. It is unlikely to be displaced from these applications to a significant extent over the next 15 years.

Little in the way of technological improvements is expected as current high quality, well installed, trunk cable has a lifetime in excess of 20 years.

Over 60% of all Canadians subscribe to cable TV systems. In most major cities between

80% and 90% of the population subscribes. Thus use of co-axial cable is very significant. Co-axial cable for cable TV represents a significant investment. The majority of cable companies have replaced much of their co-axial cable over the last ten years.

2.1.2 Broadcast

2.1.2.1 Microwave Radio

Together with satellite and optical fibre long-haul systems, point-to-point microwave provides the inter-city and transcontinental communication links throughout Canada. The majority of microwave links are common carrier owned and controlled. A small number of private inter-city microwave links have been licenced and short haul Very Heavy Capacity Microwave (VHCM) systems are used by cable companies for intra-city carriage of a multiplicity of TV signals.

Microwave systems make use of very significant portions of the radio spectrum and in most parts of Canada it is difficult if not impossible to obtain new licenses due to frequency congestion. The introduction of digital compression of microwave signals will allow more systems to make use of the same allocation of the frequency spectrum.

Although a number of recent projections show a major decline in the use of long haul microwave radio technology, as long distance optical fibre trunks come into use, it now seems likely that this technology will continue to be used to a very significant extent. Indeed upgrading to digital systems from analogue and the interconnection requirements to the optical fibre systems could well force more R&D within this mature technology, particularly in the field of gallium arsenide microwave integrated circuits (MICS).

The driving forces behind this extension of technological life are the need for a back-up to optical fibre systems vulnerable to mechanical damage; the economic and corporate advantages of maintaining control of the "right of way"; and, the significant capital already invested in these long life systems. In particular the infrastructure of towers, antennae and the civil works associated with them have a virtually indefinite lifetime, surviving the technological changes in the electronic equipment used with them.

All microwave systems use radio frequencies high enough to be concentrated into narrow beams. Each link is approximately 30 miles long (line of sight) with transmit/receive repeaters at these intervals carrying the beam between major cities. A mature technology, microwave is very efficient and comparatively cost effective. Typical instantaneous bandwidths are 6 MHz per channel but this can increase to 300 MHz for short haul VHCM.

Microwave signals can be affected by atmospheric conditions causing significant fading and by electro-magnetic interference, although both of these can be reduced to a minimum by correct design. Such well designed microwave systems can achieve availabilities of 99.99%. Capital costs are high due to site costs but lifetimes of microwave systems are usually calculated to be 15 to 20 years.

2.1.2.2 Satellite Radio

Through Telesat Canada, Canada has had a domestic satellite system since 1973. Domestic communications satellites operate in the 6/4 GHz band (Anik D's: frequency shared with terrestrial microwave) and 14/12 GHz band (Anik C's: dedicated frequency band).

In 1990 Telesat Canada, a monopoly provider, will launch its Anik E series. Anik E will have a ten-year lifespan but it will offer no significant technological or operational advancements. For these reasons, no changes to Canada's fixed service satellites are expected before the year 2000.

It is predicted however that the generation of fixed service satellites after Anik E will draw upon a range of satellite technologies, currently being developed, that are aimed at making future communications satellites more flexible and hence more competitive. These technologies include:

- On-board processing and switching;

- Solid-state, phased array, electronically steerable and switchable spot beam antennae;
- Solid-state beam shaping antennae;
- Frequency band cross-stopping and switching of transponders;
- Facilities for inter-satellite communications.

Telesat Canada has formed a joint venture with CP Ltd. and C. Itoh Ltd., of Japan, Telesat Mobile Inc. (TMI) in December 1988, in which Telesat Canada has a 50% interest. TMI plans to launch a mobile satellite in 1993. MSAT technology, which is incompatible with the booming terrestrial cellular telephone technology, is extremely sophisticated with very wide coverage of the remote areas of Canada. It has been over 10 years in development, with at least four more years before it becomes operational. Industry analysts are of the opinion therefore, that the demand for MSAT will be reduced by alternate terrestrial and satellite technologies to an extent that will significantly affect its viability.

The major advantage of satellite distribution is cost insensitivity to distance and its point-to-multipoint capabilities at minimum incremental cost for additional receive points. Satellite links can be extremely flexible using mobile or transportable uplinks and downlinks. For any significant distance, satellite costs are considerably less than optical fibre trunks or terrestrial microwave. Significant distance in this instance usually means in excess of 500 kilometres but it can vary depending upon specific circumstances.

Canada has a number of orbital positions allocated to it, thus spectrum constraints in satellite communications are not a problem and will not be in the foreseeable future.

2.1.2.3 Fixed Station Broadcasting

Traditional radio and television broadcasting is considered under this heading. A number of major technological changes are predicted in this field over the next 15 years.

The first of these is likely to be the introduction and proliferation of one of several competing forms of high definition television (HDTV). This technology will greatly improve the quality of the received image, making it suitable for large screen projection. The aim is for TV quality to be comparable with theatre quality 35 mm colour movies. The technical cost of the distribution of such images is significantly greater radio spectrum requirements for each TV channel. There are several competing technologies attempting to minimize this increased spectrum requirement. At the same time a technology is needed that is compatible with NTSC (or PAL/SECAM) TV receivers concurrently and that maintains the potentially major improvements in viewing quality.

The second major technological change expected will be a move to digital transmission for both audio and TV transmissions. Digital radio will provide a high quality signal comparable to CD-audio. It would most likely be an extension to FM station capabilities. It is technically feasible, requiring only the availability of suitable inexpensive digital radio receivers, the allocation (or reallocation) of suitable spectrum and the modification of the FM radio transmitters. Digital TV transmissions are also technically feasible. Manufacturers are waiting for agreement on standards, and the resolution of the HDTV specification issue, before significant steps are taken to implement this major improvement in TV technology.

2.1.2.4 Mobile Radio

The use of the radio spectrum for private and public commercial use is included in this section. Thus cellular telephones and mobile networks, such as those required for taxis, couriers and paging networks, and railway mobile networks are included. Mobile radio telecommunications is the fastest growing sector of this market.

Cellular telephone networks permit very effective use of the radio spectrum by frequency reuse by computer control of all mobile telephone messages and automatic handover between calls. Interconnection of the cellular telephone system with the public switched telephone data networks provides great flexibility in a cost effective manner.

Major changes are expected over the next 15 years in this rapidly expanding group of technologies. The requirement for more spectrum-efficient technical approaches will result in use of 5 kHz channels instead of 30 kHz channels. Also, the success of cellular telephone technology is likely to increase even more with the advent of digital technology by 1991. This will lead to portable cellular telephone sets being used in the office, home, or when walking and travelling, rather than only in a car. The telephone set connected to a jack will become much less common. Digital technology and the popularity of car cellular phones will be major forces in this change. Perhaps the key factor will be improvements in battery technology permitting the powering of the transmitter-receivers in the portable cellular phones for long periods between charges without excessive weight penalty.

In mobile radio, data transmissions will take the place of many voice mobile systems in use today, thus making more effective use of the spectrum. New protocol and architecture technologies will be used to provide very low bit error rates needed for these mobile data systems. An example is the use of Reed Solomon error correction schemes which can be implemented cost effectively by use of VLSI circuits.

2.2 ELECTRONICS

Electronics technologies are critical to telecommunications because they provide the essential switching, processing and data manipulation capabilities needed in all telecommunications networks.

2.2.1 Processors

2.2.1.1 Analogue Processors

All items of analogue signal processing equipment used in any type of network are discussed in this section. These can include frequency changers at cable television headends, digital to analogue converters, automatic frequency control and frequency changing equipment, analogue telephone switches and similar equipment.

Most of this category of equipment is being replaced by digital equipment which tends to be cheaper, more efficient and more reliable. This trend from analogue to digital processors is mainly restrained by current capital investment and, in some cases, by the fact that quantities do not justify the design costs of very large integrated circuits for inexpensive manufacture of the digital equivalent of the analogue circuits.

Significant strides are anticipated in the miniaturization of analogue/digital interfaces such that more flexibility will be available to terminal equipment designers.

2.2.1.2 Digital Processors

This is the major technology driving the information society in this period. It is confidently expected that there will be continued growth in the capacity in the principal underlying technologies of chip fabrication (CMOS and Bipolar CMOS). Plants are manufacturing to 1.2 micron dimensions on 1/2 inch chips. Reduction in size to 0.05 microns (5-fold every 8 years) will provide an on-chip capacity increase from 300,000 active elements today to 300 million by the end of the period.

These changes in technology will lead to the availability of several new computer variants from nano-chip PCs to multiple-CPU computers, as well as providing significant increases in the power of conventional computers and microcomputers and of central office telephone switches. The Mega-CPU is likely to become a standard mainframe configuration. Multiple CPU workstations are now becoming available and this trend is expected to accelerate.

The effective increase in performance due to changing technology and improved techniques is estimated as 32-fold over the forecast period (i.e. standard desk-top micro of today with 0.5

Mips processing power, expected to have 16 Mips by 2005).

Digital technology has produced the high technology revolution of the last decade. It is used to process data, to switch voice circuits in telephones, and to provide local functions for both voice and data such as voice mail, PBX and key systems, personal computers, network concentrators, terminals and other devices. Development of enhanced telephony services is dependent on this technology. Further examples are electronic mail, ISDN and other value added carriage services.

Digital technology is gradually replacing analogue technology in the broadcast (radio) field as well as in consumer products (audio recorders, VCRs etc.). Digital technology is being used more and more in the home and in automobiles, encouraging the implementation of new digital data and voice telecommunications services. This technology also provides more choices of communicating to these devices with tailored services.

2.2.1.3 Photo-electronic

Photo-electronic technologies today convert light signals to and from electrical signals. The potential of direct optical signal switching is being explored. Interest is growing in Gallium-Arsenide (GaAs) semi-conductors, and similar materials, which possess photo-electronic properties. Recently a semiconductor "mirror" was demonstrated that switches a light signal. A number of cooperative research programs are now in progress. These include programs separately established by the National Research Council and the National Optics Institute. Bell-Northern Research is actively engaged in opto-electronic research. Photo-electronic switches using these new technologies are likely to be available in the time-frame of this study, combining normal digital control with optical switching and full optical fibre transmission.

2.2.2 Software

With the growth in the use of digital computers there has been a great increase in the use of software. There is growing application of this technology in all sectors of the economy at a steady 4-5 times the rate of economic growth.

As a tool, software brings "intelligence" to the hardware on which it operates. It complements the abilities of the hardware allowing information processing systems to be developed. Yet software can only do what the hardware permits it to.

New techniques in software technology are being implemented which improve the efficiency of developing systems and allow less experienced people to develop such systems. The combination of machine power, software management and development techniques will ease the implementation of a variety of new products and services.

Several results of these improvements in software management and development techniques will be demonstrated in the utility of new tools and services. The potential of artificial intelligence will be realized. Easily operated data-base tools will be available for the non- professional. Language translation tools will be generally available, including real-time voice conversions and translations benefiting from research into neural networks.

2.2.3 Storage

Storage technologies are considered critical in a telecommunications context since their capacities and performance determine the utility of various telecommunications services. Central offices in telephone systems depend increasingly on more data that are actively used and modified in the course of service delivery. Video storage for T.V. enables innovations in program preparation to be considered and implemented. Massive storage capacities available to individuals may influence their decisions on how to gain access to data whether by communications or by local devices.

2.2.3.1 Magnetic

Magnetic technology has become the medium for long-term data storage. Many different forms of the medium are available to suit quick access and archival applications such as diskettes, tapes and hard disks.

Performance and capacity improvements are likely to continue unless research funding is reallocated to alternative technologies such as optical disks.

2.2.3.2 Optical

Optical disk memory systems promise dramatic improvements in device capacities and dramatic reductions in cost. They have been promising such drama for many years but until recently have not delivered. The recent introduction of the CD-ROM and of read-write optical disks are evidence of significant changes to come over the next fifteen years.

There will be dramatic growth in the capacities of optical disk memories: capacities today range from 100Mb to 4Gb. It is expected that simple portable read-write diskettes will permit multi-gigabyte memories to be marketed. In turn, mainframe on-line memory devices, already offering gigabyte capacities, will offer hundreds of gigabytes per device.

Remotely accessed data base services will suffer through the availability of locally legible read only, individual copies of the same data. Database services that depend on the immediacy of their data will survive and will flourish with local data on optical disks complementing the data available on-line.

The performance of optical disks is typically slow though providing access to massive amounts of data. Performance improvements will be introduced leading to replacement of magnetic memories by erasable optical memories using new magneto-optic technologies.

2.3 TERMINALS

Canada's telephone networks today support about two million business lines, nine million residential lines and close to eighteen million telephone sets. By the same token, ninety-eight percent of Canada's nine million residences have at least one television set.

2.3.1 Telephones

2.3.1.1 Phones - Fixed

The telephone has become a ubiquitous device. Evolution, through interconnect, has introduced considerable variety in the types of telephone that are available, few of which have altered the telephone in any technical sense. As the power of telephone services grows, particularly with the advent of ISDN, the ability of the telephone to undertake additional functions will be enhanced.

Almost certainly an attempt will be made to remarket some form of picture phone. This could become more attractive if a local TV set or computer screen is used as the display device. Other visual information could be communicated to the same device.

2.3.1.2 Mobile Phones

Mobile telephone terminals are high volume, high technology products making full use of digital frequency changing, frequency sensitization, automatic recall, frequently called number storage and the like. Sales of cellular telephones are increasing at approximately 25% per year and will continue at that rate.

Cellular phone terminals are designed to be compatible with all North American cellular systems and can be used in a "roaming" mode throughout North America. Costs are still dropping rapidly with a bottoming of the cost curve expected in three to five years.

A potential constraint is frequency availability. One solution to this is new modulation

schemes which are spectrum efficient. If these are introduced new cellular terminals will be required because the narrowband modulation schemes will not be compatible with current equipment.

2.3.1.3 MSAT Receivers

These are low frequency receivers (1.7 GHz) compared with other satellite systems and also have a much broader beam to receive and can be omnidirectional. The antenna can therefore be much smaller (30cm high) and mobile compared to 1.8-5m of other systems. It is this small size which allows portability and is likely to attract trucking and other industries which require mobile data links.

2.3.2 Radio Sets

Domestic radio sets are a mature, high volume, low cost technology, primarily manufactured in the Far East. No major changes are expected in domestic radio sets until the advent of digital broadcasting, probably towards the end of the period under consideration.

Digital broadcasting is likely to improve quality of reception very significantly at the expense of making all current receivers obsolete. It is expected that in a comparatively short time after the advent of digital radio broadcasting, digital radio receivers will be available in the same high volume, low cost form, as analogue receivers are today.

2.3.3 TV Sets

Domestic TV set manufacture is again a high volume, low cost technology with manufacturing primarily based in the Far East.

The domestic TV industry is on the brink of three major changes in technology. These are:

. Full digitization of the TV signal;
. the advent of High Definition Television (HDTV);
. the advent of flat screen liquid crystal displays.

It is expected that in this study period all three changes will be implemented to a greater or lesser extent. All three will have a significant impact upon quality, style and flexibility of domestic TV sets.

In North America quality is greatly limited by the NTSC system. HDTV has the potential for significantly improving definition and quality. Digital TV will give domestic sets the capability to handle a far wider range of signals and signal formats, and of improving quality through the elimination of noise by signal regeneration.

The third significant technological change in this field is the introduction of the flat solid-state TV screen using multicolour liquid crystal technology. Very small TV sets (pocket size) using this technology are available. Over the next 15 years large size, very thin (about 1 cm thick) TV sets will be available. The set will be hung on the wall like a picture and could change the home viewing environment, since they can be mounted almost anywhere, taken around the house and become much more convenient than existing sets. As a result viewing hours are likely to increase and the number of sets per home may also increase.

2.3.4 Computers

Computers, as network devices, supply and receive data from other network devices. Computers may act as either hosts or terminals. Thus a personal computer supplying data to a mainframe which processes the data is a terminal to the host mainframe. Similarly a home computer retrieving data from a public database is acting as a terminal. Mainframes can be terminals to other computers.

More and more computers will communicate and thus become terminals or hosts. The installed base of 2 million personal computers, still growing rapidly, will be the springboard for this increase in communications.

Although sales of home computers have levelled off, the market still represents an area in which much more communication will occur, increasing the impetus for more switching facilities for residential areas because of the longer call time. In turn, because of the need to time connections to computers for billing purposes, the need for local measured service from the telephone companies will increase.

The principal innovation anticipated in this area, permitting greater utility in computer communications, is software implementing universal standards for machine communication. Computer communications, except under well controlled circumstances, are subject to a number of frustrating vagaries, such as non-apparent parity and baud rate choices, and handshaking conventions. The infrequent user is so, because these telecommunications and data processing technicalities, have to be mastered. The standards have been established but they have not been universally implemented yet.

2.3.5 Data Terminals

Terminals may be computers, as identified above, or simpler devices which unlike computers, are unable to act as host devices. These latter machines are basically data converters from keyboards or other forms of input to analogue or digital signals. The intelligence built into them is associated with telecommunications functions or to the specifics of an application, such as a cash register. Familiar examples are terminals for Electronic Funds Transfer (EFTS), Point of Sale Terminals (POS), and the Automatic Teller Machines (ATMs).

Terminals will become more intelligent, either through use of more software, or software programmed into the hardware of the terminal. More and more specialized terminals are being developed as new applications of computers become viable.

Telex and TWX are ancient technologies. Recent announcements of Telex operator staff reductions point to market changes away from use of this technology. The replacement of TWX and Telex machine usage by Teletex in North America does not appear to be assured. This once large demand for Telex is now being served by direct computer to computer communications and by facsimile transmission.

2.3.6 Scanners

Scanning terminals come in a variety of forms. All involve the scanning of data and its conversion into analogue or digital signals for transmission.

Facsimile devices are one form of scanner that use scanning and photocopying technologies to convert images for transmission and regeneration. The price performance and market situation is such that Facsimile terminals are in great demand and so also are the appropriate circuit switched services to support them at speeds from 2400 baud to 9600 baud. The growth in this market has been promoted by the success of the Group 3 CCITT FAX standards.

In the retail sector in particular, use of magnetic card scanners is increasing as a means of credit authorization directly from magnetic stripe bank or credit cards. Bar code scanners are in common use in the larger grocery stores using the Universal Product Code (UPC).

2.4 POWER

Mains power supplies, diesel generators and lead battery technologies are the main sources of power supply and back-up for the telephone system and for broadcast services. No great changes in these technologies are expected. Significant developments are anticipated in the areas of stand-alone power generation specifically in solar energy conversion, batteries and mains power converters. Superconductivity may radically change our approaches to power distribution and power packaging, if recent announcements of superconductive effects at close to normal

temperatures produce commercial results. This is not however expected in the near future.

Solar conversion is used in conjunction with battery storage for operation of equipment remote from regular power supplies. Significant advances in this field are expected, reducing the costs of remote power generation and permitting both more portable operation and greater remote power delivery to be achieved.

Standard alkaline batteries have become a universal consumer item but their power storage is limited. Nickel Cadmium batteries are rechargeable but have limited power capacity.

Major advances in battery technologies are anticipated that will enable subscriber equipment to be independently powered. Independence from local mains power supplies removes the need for powering from phone company central offices. This latter, enables optical fibre cabling to subscriber premises to be installed, which with a separate requirement to provide power as currently, would not be as economically attractive.

Simultaneously there will be reductions in the sizes of power packs. This will be a driver of compact portable telecommunications devices increasing the range, reliability and sensitivity of "vest-pocket" communications devices.

Finally in the power field, innovations in the transformer field are expected. All electrical devices that depend in some way on electronics require power converters or transformers to change mains alternating voltages into DC power signals. These are heavy and expensive components. Technical innovations are expected that will reduce the size and complexity of these devices, enabling even more compact, yet functionally rich devices, to be produced over the time of this study.

2.5 STANDARDS

Standards are not normally considered as a "technology." Technology in the conventional wisdom embodies a significant material component. Yet standards clearly belong within the dictionary definition of technology as "the terminology of a subject."

Standards development has, in a sense, become an industry in its own right. Without standards, few technologies would be marketable, since confidence in their widespread acceptance and usability would not exist. For example, without the CCITT standard X.25 the various packet switching services in over 90 countries would not have been developed and sold successfully. Similarly, the CCITT standards for integrated services have assisted in the justification of the development of the ISDN technologies and services.

There is no evidence that standards generation is over; the industry is thriving. Standards will be continually developed to support and define services. There is a risk in standards of their becoming hindrances to the introduction of further innovations. They need to be continually reviewed to ensure that they promote, rather than hinder the development and acceptance of future innovations.

Emerging standards will continue to influence the evolution of telecommunications. The standards for HDTV, the emerging standards in the field of multi-media representation on compact discs and the wide introduction of SS7 (signalling system 7) will all influence the character and kind of future services.

New services will either require new standards or the revision of existing standards. The Hyper-publication service described in Chapter 3 is one such service. The Open Systems Interconnection model (OSI) will be a driver of new standards in the communications area. OSI provides the paradigm for the development of tomorrow's standards.

Similar efforts in the computing field (the Open Systems Foundation, OSF) will lead to greater commonality of operating systems, programming languages and data base capabilities. Evidence in the adoption of POSIX as a UNIX standard for example, and efforts to adopt SQL conventions as a database access standard, indicate that the development of standards in both telecommunications and computers is far from complete. The development of the OSF conventions will improve the ease with which communications can be achieved and thus encourage the increase of communications traffic.

3 SERVICES

Building on the definitions of technologies that influence the nature of telecommunications in the previous chapter, this chapter presents the generic set of telecommunications services that are provided in Canada and that can be provided in the timeframe of this study. Each service is presented in terms of its use of technologies and in terms of the applications that it supports.

A distinction is made between carriage services and content services. Carriage services provide the basic service of transmission across a network, the communication of a signal between the users of a network or between the supplier and the consumer. A further distinction is made between backbone carriage services and value-added carriage services. Content services generate the signals carried by a carriage service.

3.1 BACKBONE CARRIAGE SERVICES

Three groups of services are discussed, Voice, Data and Programmed (radio and TV).

3.1.1 Voice Services

The public switched network provides the national and international telephone service. It is available throughout the country and subject to significant regulation from national and provincial regulators.

The backbone services of the switched network are provided using all distribution technologies identified in Chapter 2. They provide basic real-time services in which any terminal (telephone) can communicate with any other on the network.

There is reliance on system-wide standards that provide for consistent signalling for control purposes and consistent performance across a multitude of differing equipments. The capital investment in telephone company plant is considerable and represents major inertia in the implementation of service changes.

From a user's perspective, there is a large variety of pricing options presented by the telephone operating companies enabling various strategies for self-regulation of telecommunications expense to be used, such as:

- off-peak hours variation
- high volume usage e.g. WATS
- business and residential use
- geographic areas due to different regulators

With the growth in implementation of ISDN the distinction between voice and data will cease to be made in carriage technology. The integration of both voice and data carriage services (effectively) onto a single cable to the subscriber enables the supply of backbone data services, such as automatic number identification to called party (ANI), to be made as well as the present voice services.

The established common carriers do not make extensive use of satellite communications. This is caused by the regulatory situation which prevents them from owning satellite facilities. Since such expenditures have to be expensed rather than capitalised there is little incentive to use satellites. Thus there has been the establishment of specialty satellite "common carriers."

New backbone delivery services have been created in recent years with the introduction of cellular telephone services. The performance of cellular telephones is very comparable with that of normal voice service, while digital mobile networks, given appropriate protocols and architecture, can give error rates of the same low order as optical fibre links. A potential constraint on cellular services is spectrum availability. New techniques to reduce bandwidth requirements and initiatives to reallocate the spectrum should overcome this problem.

Another approach, allowing more mobile users to be served, is the introduction of mobile satellite technology. MSAT, using a different part of the spectrum from other satellites, offers universal mobile communications capabilities. Many authorities expect cellular telephone systems to be the first step towards universal mobile networks, perhaps based on MSAT, where a "vest pocket" voice/data set (telephone) can be used from anywhere in the world to connect anywhere else in the world via international public switched networks.

Private switched networks are established to meet specific organizational constraints. The technology may be packaged somewhat differently from public services but essentially the same technologies are used. The distinctions are in economics, market demand and specific performance characteristics, such as response time or security.

The common carriers may supply telecommunications facilities for private network use. These may include dedicated point-to-point non-switched circuits. These facilities are made available under different pricing structures for the exclusive use of a single organization. Such services may be considered separate from switched services for regulatory considerations though they rely on the same technologies and physical facilities.

3.1.2 Data Services

Having indicated that the distinction between voice and data will be blurred in time, we have nevertheless singled out data services as a separate group of services in this report. The integration that is possible using ISDN will provide integrated carriage from a subscriber's equipment; and it will make the communication of data much easier, but there will still be distinct data services.

Data services may be of many different kinds. From a technology perspective different services may use similar technologies. Data services may be switched or non-switched; they may be for public access, or they may be for private access; and they may address data communications over a larger or smaller geographic area. This latter distinction is perhaps the most significant. We have chosen in the following paragraphs to present data services from the perspectives of wide-area networks, metropolitan networks and local area networks.

a) Wide-area networks

Data transmission uses the identical technologies applied to voice communications. Unlike voice which can, within reason, accept signal degradation, data transmission cannot tolerate such noise. Thus data transmission requires a much more controlled environment in which sequencing and redundancy checking is incorporated, in order to provide a reliable cross network service.

Controllers, or nodes in a data network, are added to a communications network just to service the requirements of data. In a public network the nodes are common carrier owned. In a private network the user organization is responsible for the reliability controls on its own data and building the necessary facilities into computer mainframes or front-ends.

A decision to be made relates to the type of data switching required for national networks either packet- switching, or circuit-switching. In a packet-switching network a single physical connection to the network is made. The individual packets of data presented for transmission across the network identify their destinations. The network provides recovery from any transmission errors encountered and mediates the speeds of the communicating equipment. Datapac is an example of a packet-switched service in Canada.

In a circuit-switched network the network supplies a circuit over which the user can only send data to the terminating equipment identified when the circuit was established. In a circuit-switched service the user is typically responsible for error recovery. DataLink is an example of a circuit-switched data service.

b) Metropolitan networks

A metropolitan network addresses the needs of organizations spread through several buildings within a radius of a few tens of miles. Typically these may be within a city or

metropolitan core.

The service supplied through a metropolitan network may be made available in a private sense to a single corporate user or it may be shared between several city-centre organizations. The service provides an economic approach to data (and voice) communications within such communities at speeds and performance levels not usually available from other sources.

Metropolitan networks are not common today. The concept is introduced as an example of the kind of service that will become possible when cable companies or telephone companies (or even others when regulation of carriers is reduced) react constructively to address the business market with optical fibre networks.

c) Local area networks

A Local Area Network or LAN is defined as an in-building communication system. It is usually designed to link personal computers together to allow file transfer and message communications between these systems.

A large number of different LAN technologies exist. They range from industry standard EtherNet systems using co-axial cable through to simple low-speed twisted pair connections. LANs typically provide a connection between several microcomputers and shared resources, such as large disk storage and printers.

Some LANs have up to 10 Mb bandwidth transfer capability to allow rapid simultaneous exchange of files between systems. In many, there is a pooling concept employed to share a large disk drive or high speed or high quality printer between the different systems. Some LANs are narrow in their bandwidth capabilities, with speeds below 64 Kbps, and are provided as a twisted pair facility from a PBX or personal computer. Some LANs support up to 100 personal computer systems and as such are direct competitors of mini-computer systems.

3.1.3 Programmed

Programmed services either use the ether for broadcasting their signal or are provided over cable network systems. Land-line facilities are used in the course of signal preparation, usually leased line when regular and frequent usage is anticipated.

Most areas of Canada are covered by at least 2 broadcast TV stations and several radio stations. In those areas reached by cable systems - close to 70% of all Canadian homes - many more TV channels are typically available. Radio, although provided on many cable TV services, is mainly broadcast since it is often received by mobile receivers such as in cars or Walkman etc.

It is also possible to receive a large number of TV channels from satellites. There are seventeen U.S. satellites, two Canadian satellites, and one Mexican satellite operating in C band (4/6 GHz), and five U.S. and two Canadian satellites operating in the Ku (12/14 GHz) band. Each of these satellites can accommodate the broadcasting of up to 24 channels. With duplication and many idle channels there is a total of about 100 TV channels that can be received, many of which are scrambled. The channels include Pay TV channels, Network feeds, specialized professional channels (e.g. American Law Network; Hospital Satellite Network; Food Business Network, etc.) and TV superchannels.

Although these satellite transmitted channels may be received by domestic Television Receive Only (TVRO) installations, only a very limited number are designated for this "Direct to Home" service. These are almost invariably scrambled and sold on subscription by organizations such as Canadian Satellite Communication Inc. (Cancom). Indeed in Canada, owners of TVRO's are by regulation, only permitted to receive signals from Canadian satellites and only Cancom is licenced to provide "Direct to Home" service, primarily to remote areas. However this regulation is difficult, if not impossible, to police and enforce.

The very large number of TVRO's in Canada and the United States frequently makes people assume that these earth stations operate with Direct Broadcast Services satellites (DBS). Currently in North America this is not so.

Communications satellites, and the frequencies allocated to them, are in one of three

categories agreed to by the International Telecommunication Union (ITU). These are fixed satellite service (FSS); mobile satellite service (MSS); and direct broadcast satellite service (DBS). All Canadian, U.S. and Mexican domestic (non-military) communications satellites operating now are in the FSS category.

DBS satellites have been proposed (and indeed licenses issued by the FCC) in the U.S. but have not become operational. This was primarily due to high costs and the fact that improvements in satellite receiver technology have driven down the costs of TVRO's operating with the comparatively low power FSS satellites. As a result the viability of the high power DBS concept is in question.

In Europe there are two DBS satellites in operation, one French and one based in Luxembourg, the latter servicing many European countries. A German DBS was launched in 1988 but failed to become operational.

During the next 15 years it is considered unlikely that the DBS concept will be reintroduced into North America. In Europe and Japan its use will be limited.

3.2 VALUE-ADDED CARRIAGE SERVICES

These services add value to the basic function of communication in real time, with speed mediation, protocol conversion, data conversion, intermediate storage for non-real time (e.g. voice, mail) and additional functions above basic transmission and switching.

3.2.1 Voice

Many functions have been built into PBX, key stations and local office switching processors. These include:

Call forwarding
Last number re-dial
Automatic message routing
Usage and cost statistics

Network value-added services have also been added particularly Voice-mail which allows store and forward of messages. The use of these services is expected to grow and to continue as computer-related applications use these technologies in conjunction with voice-text and text-voice conversion when they become available. Applications such as voice initiated ordering from computer retail systems and computer initiated calls with standardized or personalized messages to people will become more common.

3.2.2 Data Value-added

Value-added Networks, VANs, are networks which provide functions to the user which are not related to the basic transmission functions. Thus switching and packetizing, for example, are not value-added functions. Electronic mail and electronic directories of users are value-added functions. iNet is an example of a set of value-added network services supplied by Telecom Canada. In general, value-added functions are regarded as those capabilities which are related to a telecommunications service but not to data processing in the terms that are applied by the CRTC to the telephone companies and other common carriers. VAN services are provided by one or more host computers attached to the backbone network providing the transmission service.

Data value-added services have been added to Packet Switched services and provide the following functions:

- electronic mail (store and forward)

- database access (auto dial, log on, etc.)
- data and text manipulation in a common workspace prior to transmission
- coordinated billing for multiple data processing services provided to many individual subscribers
- protocol conversion, not for transmission purposes, but for interworking between dissimilar devices or terminals
- service offerings such as Videotex using the telephone system as a data link to send commands to a service provider computer which transmits the requested information to the subscriber's T.V.
- NABU-like services in which a computer attached to a domestic TV receiver can initiate database displays on the screen and manipulate the information with value added intelligence from the computer.

These services are expected to grow rapidly as more and more businesses become computerized. Electronic Document Interchange, EDI, is another example of new value-added services. The direct computer-to-computer exchange of business documents (invoices & statements, etc.), needs network connections that add-value as well as subscriber computing facilities. EDI is likely to become a universal interbusiness service because of the economies of operation it offers to business in automatic ordering and invoicing.

3.3 CONTENT SERVICES

Content services are defined as those which supply or control the content of the transmissions. Whatever the signal that is to be transmitted the content service has control over it unlike the services previously discussed. Such services (e.g., on-line data processing services) may contribute significant network traffic.

All programmed radio and television signals are supplied, according to this definition, by a content service. Telecommunications technologies, per se, do not influence the structure of this signal. Clearly the existence of telecommunications technologies supports the provision of content services. While there may be many wonderful technologies in use in the preparation of the signal of a content service, these technologies are not necessarily telecommunications technologies. Where they are, they have been addressed in the material above.

Similarly, data services that depend on data processing are considered as content services. Thus EDI (Electronic Document Exchange) is a value added service, in that any processing is external to a communications network, yet the service is heavily dependent on the existence of a reliable communications network which provides more than basic transmission (form design, data capture and data compression). A content service example is the provision of the Chemical Abstracts information via a telecommunications network.

A new service, "Hyper-publication" is identified that will become universally available in the next fifteen years. Hyper-publication is a service that provides information to its subscribers according to predetermined subscriber profiles. Similar services are available today through libraries and through on-line services such as The Source. The difference is that the product of the service is delivered electronically , with electronic notification, on the basis of materials held in a global network of databases and other electronic sources.

Videotex is a generic group of services using a telephone data service and television system, usually cable, to allow the user to access and update databases on computers linked to the TV system. The screens for entering the data and showing retrievals are displayed on the television set and interaction with the databases is achieved, usually, by use of a special key pad, alpha numeric or numeric and functions only. The keypad signals are transmitted to the computer databases on the telephone line circuit. The concept has gained considerable acceptance in Europe but not profitability yet. In the U.S. several large groups are still experimenting with market trials and the

scene in Canada is similar (Bell Canada's Project Alex in Montreal). Standards in the presentation of displays will be an international issue with the Canadian (NAPLPS) being pursued in North America and simpler less costly standards in Europe. This service is one of the opportunities for telephone companies to provide data services to the home market. It is technologically different to Teletext, the broadcast and cable company approach to a similar need which uses the blanking interval in the TV signal as a path for communicating requirements for information display to database computers.

4 FORECASTS

4.1 INTRODUCTION

The forecasts serve to illustrate the effect of the introduction of new technologies and services over the next decade and a half at different times and rates.

It is expected that telecommunications, consisting of telephone and data, television and radio will continue to strengthen its role as the dominant means of communications in our society for social, humanitarian, commercial and industrial purposes. Computer technology will become even more pervasive and will significantly affect all segments of the field.

Digital technology will continue to blur the lines of demarcation between the carriage of voice, data and video signals. The more obvious elements of this trend will be Broadband Integrated Services Digital Networks (B-ISDN), high definition television (HDTV) and the digitizing of many elements of the television signal, and digital radio broadcasting.

In addition to the application technologies mentioned above, advances in distribution technology particularly optical fibre and satellite systems are anticipated. Broadband, very reliable optical fibre point-to-point distribution systems, implemented on a world-wide basis both on land and under the ocean will become common. These fixed, point-to-point very high capacity telecommunications trunks will be complemented by a flexible, world-wide, high-capacity, intelligent satellite communications network. In the next fifteen years a growth in satellite communications will occur to provide fixed links to the very large number of areas where it is not economical to provide optical fibre links; to provide high capacity distribution to areas of temporary interest or importance; and to provide communications and navigational services to shipping, aircraft and land transport on a universal basis. To meet the competition from optical fibre, satellites will have very considerable on-board processing to give voice, data and video switching, beam switching and beam shaping.

These technology-driven trends will exert further pressure on the breakdown of the traditional telecommunications monopolies. In the next decade and a half, private networks including the cabletelevision networks, will perform many traditional telecommunications common carrier functions. Equally the telecommunications carriers using their new broadband capabilities will provide many entertainment and value-added services directly to the home.

In all, the period to the year 2005 will see major changes to the role of telecommunications in our society.

Projections of technologies and services can be presented in several ways. They may be by technology, by media, type of industry or type of service. Our choice is to present the forecasts under 6 major headings:

- Technology Milestones: projections of principal technical events;
- Carriage Services - backbone: changes in backbone carriage services directly or indirectly resulting from technical or market innovations;
- Carriage Services - end-user: changes in end-user or value-added carriage services directly or indirectly resulting from technical or market innovations;
- Content Services: innovations in services arising from technical or market changes;
- User Applications: comments on the introduction or support of new user applications because of the availability of new content or carriage services.

This structure follows that presented through the earlier chapters. Each of the forecasts is summarized in a single table within the text that follows. Each table reflects this 5-topic structure.

Three forecasts have been identified and developed. All of these forecasts assume no major change in regulations or policy direction from the Governments in Canada. The difference between them lies in a sense of economic growth over the fifteen years. They present a forecast

assuming high economic growth (T-1), a forecast based on evolutionary economic growth (T-2), and a forecast based on low economic growth (T-3).

The general relationship between the forecasts is that technical and service introductions are assumed to occur earlier in the high growth forecast and later in the low growth forecast. This is based on our definition of economic growth. The forecasts purport to represent likely innovations in telecommunications on the basis of the overall health of the economy. Thus a high growth forecast is not intended to reflect rapid growth in the telecommunications sector per se, but rather in the Canadian economy as a whole. The opposite is true in our low growth forecast.

However, this is a difficult assumption to sustain in detailed analysis. Rapid growth in the entertainment industry in Hollywood in the 1930's occurred precisely because the rest of the economy was not growing. We are not privileged to any specific negative feed-back effects that may influence the growth of telecommunications over the period of our study. We are disposed to correlate telecommunications growth with the overall health of the economy, commenting where appropriate if converse effects may occur.

(One example is the business choice of corporate network use. This is typically an economic decision in the light of the business health of the corporation. When greater pressure for savings is applied, such as during an economic downturn, then a higher rate of change may be experienced, giving the telecommunications industry an impetus when the rest of the economy may be growing slowly.)

Before presenting the forecasts, it is necessary to provide evidence of a baseline from which all of them evolve. This baseline shows the trends observed to date and general economic factors:

- relatively stable Canadian population growing at about 1% per year;
- comparable overall real growth in the economy at around 2% per year;
- inflation running at about 4%, with national bank rate at about 10%; and
- telecommunications voice traffic and line installations running at about 5-6% per year of the installed base with data traffic increasing at some 15% per year.

4.2 HIGH GROWTH FORECAST - T-1

A strong positive investment climate will show in early introduction of new technologies as allowed by the increased research and larger demand implied by this forecast. The statements below, reflect abnormally high growth rates or service decay because of replacement rather than the assumed greater growth rates which apply to any services not mentioned in this forecast.

4.2.1 Technology Milestones

Most of the technology milestones identified relate to electronics and associated technologies. Their impacts on telecommunications lie in the greater capacities and capabilities they bring to switching and to communicating devices.

In the immediate near-term erasable optical disks will be available in considerable numbers and facsimile devices will appear as common microcomputer peripherals. The use of higher capacity disks reduces the growth of the market for on-line databases with personal access to the same data stored locally and updated periodically. Facsimile devices are already available as peripherals. Their evolution as common peripheral devices provides evidence of the integration of communications and computing capabilities and will promote the development of laser print quality facsimile copy.

The major changes up to 1995, will be in processor capacity. The impact of higher chip density will be evidenced in the availability of "nano-chip" PCs and standard product mega-processor mainframes.

Forecast T-1: High Economic Growth

	up to 1990	1991 - 1995	1996 - 2000	2001 - 2005
TECHNOLOGY MILESTONES Electronics Distribution Terminals Power Standards	Read-Write optical discs Home FAX/Copiers introduced FAX as peripheral common	Nano-chip PCs Mega-processors standard Mega-processor PCs Stand-alone VRUs common Battery compactness breakthrough HDTV & NTSC compatible Car phones standard ISDN-2 in development	Automatic translation "Instant" databases Picturephone re-emergence	ISDN-2 adopted by CCITT Photonic Switching Superconductivity practical
CARRIAGE SERVICES Backbone	Business - fibre to premises Cellular universal	ISDN common: Centrex B-ISDN available leakywire building standard MSAT operational Reduced need for physical business mail	ISDN common: business Home fibre installations common Decay of traditional data services as ISDN grows	ISDN common: home Minimal postal delivery service for business customers
CARRIAGE SERVICES Value-added	Text to voice messaging FAX universal EDI widespread	Voice to text messaging Metro-LANs common Integrated multi-media services Voice Mail to the home	Transparent multi-network data services	
CONTENT SERVICES	Public Voice Mail: business Hyper-publication takes off	HDTV by satellite Home data services introduced ISDN related services Digital FM radio services	HDTV by cable Hyper-publication general	Broadcast HDTV Home data services general
USER APPLICATIONS	Rapid increase in intercorporate communications	Business HDTV introduced Business TV in general use Non-business cellular growth Mobile data growth	Home HDTV Digital Radio Video phone re-introduction Increase in DB use Voice & text in native language	Home video phones common Home office installations common

Several unrelated developments are anticipated in this time-frame:

- the installation of car phones is expected to become standard on all cars;
- breakthroughs in the power/size ratio and life of rechargeable batteries;
- resolution of HDTV and NTSC compatibility; and
- introduction of inexpensive (and therefore appropriate for residential use) integrated copier-facsimile machines.

Over the next five years, processor development will result in commonly available "mega-processor" PCs or transputers. Parallel developments will take full advantage of this computing power in making automatic "small machine" translation and stand-alone "voice recognition units" available. The VRUs will support a general speaker, and because of the translation capabilities, will in time be available for many languages and dialects.

In the last five years of the century software to take advantage of the new transputers will be available. This will include continuous speech recognition, permitting automatic real-time translation; and elegant data base creation and manipulation tools.

A major event early in the next century will be the ready availability of optical switching. Deliveries of a new generation of telephone plant using photo-electrical switching will begin, simultaneously with the introduction of new general communications standards.

4.2.2 Carriage Services - backbone

4.2.2.1 Basic Voice Telephone Systems

The growth in this service is expected to maintain its well established rate driven by population growth and general wealth of the population.

It is expected that all interexchange circuits still in copper, will be replaced by the end of the study period. New local loops will be installed using optical fibre from 1995 onwards. Existing copper wire plant will gradually be replaced when cost effective during maintenance and repair activities. This process will be rapidly accelerated as training of Telco staff in copper connections is reduced.

There will be rapid growth in the installation of fibre links, particularly into business premises, largely in parallel with the penetration of ISDN for business use and the advent of Broadband ISDN. Towards the end of the period, ISDN will be provided to the home and will similarly parallel the introduction of optical fibre for residential local loops.

ISDN is considered here independently of how the service is delivered. ISDN is predicted to be successful in business before achieving much presence in the residential market. In this high growth forecast most of the ISDN capacity will be consumed by large corporations. Small, single location operations, for whom private networks are inappropriate will take advantage gradually of public ISDN services.

An interesting corollary of the greater use of backbone network services for data, facsimile and EDI etc., will be the eroded demand for physical mail delivery services. A significant trend, accelerated in the high growth forecast, is the complete machine manipulation of all paper business material. With information creation, manipulation and storage on the computer, then direct machine-to-machine transmission offers great utility.

4.2.2.2 Mobile Voice Services

Use of cellular services will become very common, in part promoted by battery technology innovations, and in part by the further miniaturization of electronics components. In addition, the advent of mobile satellite technology in the 1991-1995 period, with omnidirectional mobile receivers, will significantly change the way remote communications are conducted and stimulate its growth. Substitution of private radio systems will occur particularly in land and marine applications.

4.2.2.3 Basic Data Transmission Services

Demand for higher bandwidth data services will accelerate. Large corporate networks using T1[2] and T3 carriers will become very common, while the general business user will become an extensive user of backbone network services for applications such as electronic mail and electronic data interchange (EDI).

In urban areas with a high density of businesses, Metropolitan networks will become common.

4.2.2.4 Mobile Data Services

Mobile data is considered to be an area of high growth in all forecasts. Recent advances have reduced the cost of interfaces between microcomputers and radio networks. There will be rapid expansion of in-vehicle, interactive data devices, for a variety of different applications.

4.2.2.5 Broadcast Television

There will be an accelerated trend towards distribution of TV signals primarily over cable systems. Factors dictating this trend are the need for more specialized services, non-renewable spectrum, high penetration of cabletelevision in cities and the expense of UHF tuners in the receivers.

At the same time there will be an increase in satellite broadcasting of TV signals. The variety of signals from satellite is already considerable, many subject to scrambling. Satellite distribution to cable headends will increase providing wider geographic distribution of signals (cf. the new YTV channel) and greater variety on cable systems.

4.2.2.6 Cabletelevision

Expansion into the business sector will occur rapidly after 1989 when optical fibre cable distribution plant begins to be installed. Linkage to the ISDN standard will be available shortly thereafter and these services will be installed in a significant number of all new office buildings by the end of the period.

The major change to optical fibre distribution is likely to be primarily restricted to major population areas. Systems outside these areas are likely to maintain their co-axial distribution technology for at least 15 years.

4.2.2.7 Multi-Media Services

VSAT based services will grow substantially and quickly in this forecast. Several organizations are committed to the use of high volume, high bandwidth services for transmitting video, sound, data and voice. These services are particularly valuable to multi-nationals and other organizations wishing to transmit to multiple locations and others such as large retail chains. Banks and other large organizations will make use of these services. It is likely that these businesses will present this information to consumers in their homes. Large corporations will make greater use of TV for internal education.

4.2.3 Carriage Services - Value-added

4.2.3.1 Value-added Voice Services

Significant strides will be made in the provision of voice messaging systems. Large volumes of traffic in text-to-voice and voice-to-text services will occur with the introduction of automatic voice recognition equipment, as well as greater demand for convenient communications.

2 Not to be confused with the terms T-1 and T-3 used to designate the forecasts nor with the regulatory term "common carrier." See the glossary for an explanation of the terms T1 and T3 carriers.

4.2.3.2 Value-added Data Services

Electronic mail becomes a pervasive tool in business. Significant benefit is gained in many large corporations with E-mail services today. Demand from the public market over the period of the forecast increases. Services, such as Envoy-100, become very commonly used. At the end of the forecast period E-mail services are in use by 25% of the residential market.

4.2.3.3 Facsimile

Facsimile is rapidly becoming a universal capability. This high growth forecast predicts a continuing role for facsimile, particularly in situations where a legal record and interfaces with the public are required. However, it is not expected that facsimile will grow substantially in use for business communication after 1993; it may even decay rapidly from that time as computer generated images are transferred from computer to computer saving the intermediate paper step in medium and large organizations. Continued rapid growth of facsimile will occur in small business and later in the home.

In the home an integrated facsimile/copier device is likely to have great appeal particularly by 1995 when packaged at a price around $500.00. The technology will enable items of domestic interest to be transmitted -- menus, recipes, shopping lists, etc. -- and become as universal in the home as the device is becoming in business.

4.2.4 Content Services

4.2.4.1 Data Services

There will continue to be a proliferation of data content services (on-line databases), but significant changes will occur in the areas of Videotex and Hyper-publications.

Videotex, based on the federal government's promotion of Telidon, has received a boost from the Minitel program in France and recently Bell's Alex test program in Montreal. In the high growth forecast, Alex becomes respectable and rapidly accepted for both domestic and business locations. Alex provides the lead-in for telephone companies to domestic data services that grow substantially in the middle 90s.

Hyper-publication, the system mediated distribution of relevant information to subscribers, will take-off early in the next 15 years and will become a universally used "library" service before the end of the century.

4.2.4.2 Broadcast Television

The early introduction of HDTV will be in closed circuit applications. National distribution of quality video signals for corporate promotions, legal and medical applications will take advantage of HDTV.

Significant penetration by HDTV will occur following resolution of the standards issues by about 1994 and will grow more rapidly such that few NTSC signals will be available after 2002. In parallel a steep decline in the price of HDTV sets will make the technology attractive to consumers.

4.2.4.3 Broadcast radio services

Broadcast radio is a mature technology. Threats of change are presented in the quality of signals available from compact disc not currently available on air. In the high growth forecast, digital FM radio broadcasting is introduced in 1993, as a response to satisfy a growing public interest in high quality signals. AM radio stays stable throughout the period.

4.2.5 User Applications

In the high growth forecast, conditions of economic growth will depend on rapid telecommunications. Accordingly, this forecast predicts a rapid increase in telecommunications traffic, particularly within the business community. Intercorporate and intracorporate communications will

grow, supporting the growth in backbone network services, as well as growth of private networks. Mobile service demand is likely to increase significantly, stimulating rapid evolution of MSAT services.

Digital television for both business and domestic use will be available well before the end of the century encouraged by a keener demand for quality in a high growth economy. The emphasis on television as a communications medium, will also stimulate new interest in the picture phone concept which will become common as a domestic device in the forecast period.

High growth will also strongly stimulate the computer industry. With greater power in microcomputers and their derivatives greater diversity of machine applications will be developed. Optical disk publication will play a large role in the expanding economy though the demand for current information will enable database services to maintain a good market share. Interest in Hyper-publication will arise early in the decade of the nineties.

4.3 EVOLUTIONARY FORECAST - T-2

4.3.1 Technology Milestones

The evolutionary forecast does not propose the advent of new technologies at a dramatically slower rate than in the high growth forecast. The forecasts of computing enhancements fall in much the same timeframe though all introductions may be somewhat later in each of the five-year periods.

In the near term, erasable optical disks will be available in considerable numbers and facsimile peripheral devices will appear as increasingly common microcomputer peripherals. Optical disks will slightly reduce the demand for telecommunications services as database services can be provided locally. Facsimile peripheral devices will encourage the adoption of laser quality facsimile printing.

The major changes up to 1995, are still in processor capacity. "Nano-chip" PCs and standard product mega-processor mainframes will be typical new products. Mega-processor PCs would not be available until after 1995.

Developments anticipated in this time-frame are:

- the installation of car phones is expected to become a standard feature on all cars;
- breakthroughs in the power/size ratio of rechargeable batteries;
- resolution of HDTV and NTSC compatibility; and
- introduction of inexpensive (and therefore appropriate for residential use) integrated copier-facsimile machines.

Towards the end of the century the next generation of ISDN standards are likely to be in development. Unlike the high growth forecast, the introduction of these standards will not occur until after 2005.

Finally, towards the end of the period, developments in software and computing technology will result in intuitive programming which will make the preparation of user databases very easy. Software generation tools will be available to the general public that will enable the average computer user to create and manipulate complex (in todays terms) databases, trivially. Such tools will allow extensive use of telecommunications for information searches. Technological and social changes are expected to lead to the resurrection of the picture phone anticipated on the evolutionary scale early in the 21st century.

4.3.2 Carriage Services - backbone

4.3.2.1 Basic Voice Telephone Service

The evolution in this service is expected to maintain its well established growth rate caused primarily by population growth. New technology will continue to limit price increases but will not

Forecast T-2: Evolutionary Growth

	up to 1990	1991 - 1995	1996 - 2000	2001 - 2005
TECHNOLOGY MILESTONES Electronics Distribution Terminals Power Standards	Read-Write Optical discs FAX as peripheral	Nano-chip PCs Mega-processor standard Car phones standard Battery compactness breakthrough HDTV & NTSC compatible Home FAX/copier	Mega-processor PCs Automatic translation Stand-alone VRUs common ISDN-2 in development	"Instant" databases Picturephone re-emergence
CARRIAGE SERVICES Backbone	Cellular widespread	ISDN common: Centrex Cellular universal MSAT operational Business - fibre	B-ISDN available Leaky-wire standard Electronic communications reduces need for business mail	ISDN common: business Home fibre installations common Home ISDN growth Decay of traditional data services as ISDN grows
CARRIAGE SERVICES Value-added	FAX universal	Text to voice messaging Integrated multi-media services EDI widespread	Voice to text messaging Metro-LANs common	Transparent multi-network data services
CONTENT SERVICES	Public Voice Mail: business	Home data services common Hyper-publication takes off ISDN related services	HDTV by satellite Voice Mail to the home Hyper-publication general Digital FM Radio services	HDTV by cable
USER APPLICATIONS	Moderate increase in inter-corporate communications	Business HDTV introduced Non-business cellular growth Mobile data growth	Home HDTV Business TV in general use	Increase in DB use Voice & text in native language

allow any dramatic changes. Rather, ISDN (1991) and satellite systems will provide the basis for enhanced services and better coverage in remote areas.

ISDN will not grow as extensively as in the high growth forecast. This slower growth will be at the expense of private ISDN systems. Growth in public ISDN services will predominate though it is still anticipated to be slower than in forecast T-1.

4.3.2.2 Mobile Voice Services

The high growth of mobile telephone service, as implemented with the cellular transmission techniques, will continue through the forecast period. Any possible market saturation will be offset by the introduction of very small terminals such as "vest pocket devices." This growth will produce an increase in the consumption of local and interexchange public voice services. Conventional radio communication to marine and aviation sectors will continue their present growth rates. Mobile satellite networks will provide greater coverage and lower prices but the change starting in the mid 1990s will be slow as the MSAT-based service will not be compatible technically with existing terrestrial networks.

4.3.2.3 Basic Data Transmission Services

Continued growth in data traffic is expected but at a relatively stable rate of 15%-20% for both the publicly provided services and the private networks which the larger corporations are using in increasing numbers. (It is recognized that many new data services are growing at a much higher rate but a proportion of that growth is migration from existing services). Both of these services address the needs of business in which data communications are an essential every day activity, so speed and reliability are the key factors. Both T1 speeds of 1.544 Mbits/sec of today and T3 speeds of 45 M bits/sec will be generally available by the end of the period. While prices may not rise much, relative to inflation, the corporate user will pay more for the increased performance offered by the technology.

4.3.2.4 Mobile Data Services

The growth in these services both cellular based and conventional radio is expected to be high throughout the forecast period. Both depend on the provision of reliable public or private data networks and low cost rugged portable terminals and power supplies. All these technologies are in place and rapid growth up to the mid 1990's is predicted. The general availability of ISDN and portable terminals for both voice and data will stimulate demand to continue the growth rate from 1995 to 2005.

4.3.2.5 Broadcast TV Services

A trend to distribute TV services solely over cable TV rather than using electromagnetic spectrum is expected over the forecast period as cable strengthens its position as the preferred distribution medium because of spectrum limitations and multiple channel availability on the cable.

At the same time HDTV will be available on video cassette, video disc and specialty cable channels in five years. Broadcasters will respond with HDTV on satellite based services in 1995 when similarly equipped TV sets become available. Virtually all broadcast TV will be HDTV by 2005.

Conversion to digital transmission of TV will start in 2000 and not be complete by the end of the period.

4.3.2.6 Cabletelevision Services

When optical fibre links are installed two-way facilities will become standard. With interconnection between cabletelevision companies the business market can be approached aggressively. It is expected that this expansion into "non-programmed" services will help the cable companies to obtain a better return on their investment in fibre optic links. These services, primarily data transmission, will compete head-on with the public services provided by common carriers and the

private networks developed by corporations. The main technological problem for the cable companies will be the provision of ISDN-like connections to other organizations.

The volume of traffic, number of channels and locations served will all increase as HDTV, flat screens and the decay of broadcast TV become significant factors from 2000 onwards.

4.3.2.7 Multi-Media Services

There are specific services today that by the end of the period will be integrated with basic services to provide a consistent level of service. In particular the use of VSAT based services will grow substantially. Canadian Tire, Hudson's Bay and the federal government have announced that they will use this service for high volume transmission of data to multiple locations across the country. Hudson's Bay has proposed to extend the concept further with the use of this service to transmit special TV shows to its retail outlets. Banks and other large organizations can be expected to follow. It is likely that these businesses will seek to find a way to present this information to consumers in their homes. Large corporations will make greater use of TV for internal education.

4.3.3 Carriage Services - Value-added

4.3.3.1 Value-added Voice Services

These services are available in the form of voice stock quotations, voice mail and computer driven voice output for reservation systems. They will continue to grow in use and functionality until the mid 1990s by which time many large corporations will be using private systems. However, growth with the more numerous small companies will continue and receive boosts with introduction of text to voice translation by 1993 and voice to text by the year 2000.

4.3.3.2 Value-added Data Services

These services will generate much of the increased demand for the basic services and address the frequent access of multiple and different types of systems. Ease-of-access and use are the critical factors in this market. It is expected that all businesses except the very small will use these value-added services for data as the need for intercorporate communications intensifies. Large corporations will continue to extend and enhance the value of their private networks still relying on public services for lower volume links in these networks. Packaged functionality can be obtained now e.g. iNET, and this type of offering will become more common. In addition many of these large organizations are building additional functions into their systems to address ease-of-use and accessibility issues.

4.3.3.3 Facsimile

Facsimile is receiving remarkable acceptance. It is expected to continue to flourish in this forecast. Despite wide availability of electronic mail and EDI, facsimile will continue to be used extensively over the forecast period with a trend to its replacement by other EDI late in the period.

In 1993, the integrated facsimile-copier will be introduced for home usage providing to the home user the flexibility of instant paper transfer enjoyed by business users.

4.3.4 Content Services

4.3.4.1 Data

The evolutionary forecast shows data services growing similarly to the high growth forecast. The significant changes in terms of Videotex and Hyper-publication will occur in a slightly later time frame. Videotex will not be as popular a service though it will generate its own following. Residential data services will be introduced but keener competition from personal computers and services available directly from them will take market share from Videotex services.

4.3.4.2 Television

As for the broadcast TV services, HDTV is expected to be distributed by cable companies by 1998, probably received at the head-end by satellite from Pay TV companies. This will require significant upgrading of the networks and will be completed concurrently with the conversion from co-axial to optical fibre trunks. By the end of the period, NTSC services will still be widespread though HDTV services will be common in urban areas.

The early introduction of "pay-per-view" services will encourage special event programming. The provision of two-way communication for these purposes will promote network use, for example, for automatic meter reading in a subscriber's home for the three utilities.

4.3.4.3 Broadcast Radio Services

These services are divided into those provided by the public broadcast organizations and by the private licensees who obtain revenue from advertising rather than from taxpayer funds.

Radio broadcasting of AM has continued without change for many years and will continue to do so throughout the period. FM broadcasting is limited in spectrum so growth is also limited.

However, FM is expected to change to digital transmission (not just for signal preparation as now) in order to equal the higher sound quality available from compact discs. This forecast predicts the stable situation continuing until 1995 but with lessening profits when the migration to digital services starts. This is expected to be complete in 5 years by which time the levels of use will have returned to those of the present day.

4.3.5 User Applications

In the evolutionary forecast, with steady growth in the consumption of telecommunications services there is a steady increase in the number and variety of user applications of telecommunications. The forecast suggests that there will be evolution in business situations of the use of television in general with an emphasis, as it becomes available, on digital television. The higher quality of HDTV will commend itself to direct marketing campaigns and internal training courses delivered within national corporations from central sites.

There is no evidence of a saturation in the usage of microcomputers. These devices will continue to be used extensively with increasing interest in telecommunications as a standard feature. Interest will continue to grow in access to remote data bases, which services such as Hyper-publication, will further stimulate. Counter effects caused by local data storage, optical disks etc., will not be significant in terms of telecommunications traffic reductions.

Late in the forecast period, with the ready availability of voice to text and associated automatic translation facilities, linguistic barriers will begin to soften. Intrapersonal communication will be possible in real-time in one's own language or dialect.

4.4 LOW GROWTH FORECAST - T-3

As with the other forecasts, only significant downturns or increases will be referred to. Otherwise a later rate of introduction and lower level of demand are assumed compared to the Evolutionary forecast.

4.4.1 Technology Milestones

The rapid introduction of optical disks and greater penetration by facsimile devices will not occur in this forecast. Optical disks are expected to have greater difficulty in meeting production quality and cost constraints such that smaller magnetic disks continue to be the media of choice. Database services will not be affected as much. Facsimile is judged to be a fad, that will develop its market niche, but will not become universal.

Forecast T-3: Low Economic Growth

	up to 1990	1991 - 1995	1996 - 2000	2001 - 2005
TECHNOLOGY MILESTONES Electronics Distribution Terminals Power Standards	FAX as peripheral	Nano chip PCs Read-Write optical discs common Battery compactness breakthrough	Mega-processors standard Car phones standard HDTV & NTSC compatible Home FAX/copier	Mega-processor PCs Stand-alone VRUs common Automatic translation "Instant" databases ISDN-2 under consideration
CARRIAGE SERVICES Backbone		Business - fibre Cellular universal	ISDN common: Centrex MSAT operational	In-building leaky wire standard B-ISDN available Reduced physical business mail
CARRIAGE SERVICES Value-added	FAX universal		Text to voice messaging Integrated multi-media services	Voice to text messaging Metro-LANs common
CONTENT SERVICES		Public Voice Mail: business	Hyper-publication takes off EDI widespread Home data services ISDN services widespread	HDTV by satellite Voice Mail to the home Hyper-publication general Digital FM Radio
USER APPLICATIONS	Slow increase in corporate communications		Business HDTV introduced Non-business cellular growth Mobile data growth	Home HDTV Business TV in general use Increase in DB use

Major changes in the area of processor capacity are anticipated. "Nano-chip" PCs and standard product mega-processor mainframes will result though not before 1995. The advent of services dependent on such new technologies will accordingly be after 2000 or even not occur: the attractiveness of Hyper-publication for example, will not become apparent until early in the next century.

It is expected that the installation of car phones will become a complete standard feature at the turn of the century. Simultaneously voice recognition technology will allow "hands-free" use of car telephones.

Breakthroughs in battery technology will occur by 1995 because there are many other electronics devices (non-telecommunications) that will benefit from this technology inspite of this being the low growth forecast.

The "mega-processor" PC will be available early in the 21st century.

In the low growth forecast certain technical changes, anticipated in the other forecasts, do not occur. The impetus for their development is not sufficient in this economy over the 15 year timeframe. Bio-electronics are not predicted to make any serious progress. The picture phone will not make its re-appearance. ISDN will have struggled to achieve major usage by business and will not have significantly penetrated the residential market.

4.4.2 Carriage Services - backbone

4.4.2.1 Basic Public Voice Telephone System

ISDN will be available in 1995 and will only be introduced gradually. Competitive private systems based on U.S. developed equipment will allow more of the larger corporations to use private networks.

ISDN is a new service with serious public perception difficulties: these may result in its meeting a slow growth forecast rather than meeting the goals established above in the evolutionary forecast.

Part of the difficulty with ISDN is properly identifying the need for the primary rate services of 2B + D. This has been reflected in the cynical misreading of the initials as "Innovations subscribers don't need" and "I still don't know" what ISDN means! Certainly multiple PBX networks will benefit from ISDN and so will subscribers with data communication needs that may be met simultaneously with voice using ISDN. But for regular subscribers ISDN represents a quantum leap in the capacity of their telephone links, as yet with no clearly identified use.

It is considered very unlikely in the low growth forecast that optical fibre residential cabling will be in place before 2010.

4.4.2.2 Mobile Voice Services

Cellular will follow a moderate growth path. Market saturation in the absence of convenient "vest-pocket" devices will occur since such devices will be delayed in their appearance until late in the nineties.

A softening of the market will lead to postponement of the MSAT launch date. The introduction of the MSAT service will occur in 1996.

4.4.2.3 Basic Data Transmission Services

While volumes will not warrant the adoption of EDI early in the time frame, traffic on data networks will grow at 10-15% per year. Network access speeds will grow into the T1 range for many corporate users but major expansion into new data networks supporting greatly increased speeds is not seen in this forecast.

4.4.2.4 Mobile Data Services

Mobile Data is expected to show a strong growth even in this low growth forecast. Again the availability of economic terminal-to-network interfaces and the availability of portable com-

puters and terminals will generate a demand for mobile data services.

4.4.2.5 Broadcast Television

Pressures to place broadcast signals directly on cable will be small. By the end of the period there will be more channels available on cable systems than currently; but remote reception will still be dependent largely on terrestrial broadcast signals. Satellite will be available but only to those willing to acquire the still expensive receivers.

4.4.2.6 Cabletelevision Services

The larger cable companies are already installing optical fibre to business premises. While cable companies will be able to move into "non-programmed" services early in the period, the growth of these services will be low. The smaller companies will delay their introduction of optical fibre for cable services to subscriber premises and will miss the opportunity. In fact the latter will come too late to be competitive with broadband ISDN and will falter and be withdrawn by 2005. Use of the cable as a collection means for utility meter reading will not occur in this forecast.

4.4.2.7 Multi-Media Services

High volume and high bandwidth services using VSAT will gradually come into use as the spread of TV through the business community for presentation, training and customer awareness. Retail chains, banks and other large corporations with multiple locations will evaluate these services and quite a number will be implemented at the end of the forecast period.

4.4.3 Carriage Services - Value-added

4.4.3.1 Value-Added Voice Services

Much greater use of private services will occur as larger corporations, concerned with cutting visible costs immediately, will judge it more economic to use private services. Their alternative will be to wait for full interconnection when ISDN is available, a solution that provides a smooth path for voice and data across corporations.

4.4.3.2 Value-Added Data Services

The delay in ISDN introduction will encourage a faster growth in private line services and similarly affect the investment available for Value-added Data services on the public networks thus delaying their enhancement and thus further stimulating the private systems which provide both basic and value added functions.

4.4.3.3 Facsimile

Facsimile will continue in use in business markets until the end of forecast period. Transmission of paper documents enjoys a very strong market in the low growth forecast. Alternative electronic communications will not be as economically attractive, which, coupled with failure to solve the security issues surrounding authentication by electronic means, will further the growth of the facsimile market.

This growth will extend into the residential market. With the economies of the business market driving it, the residential FAX/copier will be very attractively priced.

4.4.4 Content Services

4.4.4.1 Data

Data services will continue to enjoy a good market in the low growth forecast. Competition from read only optical disks (CD-ROM) will not materialize in a significant way.

The low growth forecast does not predict Hyper-publication being successful early. The

benefits of the service will not be appreciated. Hyper-publication services falter until 1997 and do not become widely used until early in the twenty-first century.

Videotex will fail to gain a major hold. Quality and performance perceptions combine to depress demand for Alex services which further hinders growth in the number of service vendors willing to offer their services on Alex, and Alex-like services.

4.4.4.2 Broadcast Television

These services will continue their current growth trends since the competitive cabletelevision services will be delayed by lack of demand and thus investment. HDTV will not be available on all broadcast channels in 2005 and conversion to digital transmission will have only just started at that time. Where HDTV is available it is a slow-moving technology because of higher TV set costs.

4.4.4.3 Broadcast radio services

The slow-down in acceptance of new technologies such as compact discs will delay the competitive investment in digital transmission of FM radio until well after 2000.

4.4.5 User Applications

Many of the user applications discussed in the other forecasts will arise much later in the low growth forecast. A long-term situation of low economic growth would discourage innovation in communications practices. Thus, the low growth forecast does not foresee major usage of HDTV till late in the period, early in the twenty-first century. Resurgence of interest in picture phones does not occur in this forecast. Growth in mobile data usage does not begin until after 1995. Use of portable voice recognition units does not occur since the dependent technologies do not emerge.

In practice, a period of low economic growth is unlikely to extend for the full fifteen years. While there may be periods of recession such periods often stimulate change that in turn leads to rapid economic growth.

5 CONCLUSIONS

This technology review, has examined the technologies of communication and has provided forecasts of likely changes over the next fifteen years. The forecasts are based on the collective experience and knowledge of the project team and the industry participants whom we consulted.

It is the consensus, arrived through the process of interviewing and analysis, that the technologies themselves are not the driving forces that will shape our telecommunications future. Technologies may enable changes in our communications infrastructure to be implemented but it is the market through the support of innovations and the regulator in permitting or denying services, that together will have the greater influence.

This study has not examined needs in detail. Users' needs will determine the patterns of future telecommunications services. Estimates of need have been made in order to project possible innovations, and the extension of existing trends.

The main points to note as a result of the study are:

- steady growth of basic voice, data, TV services;
- greater integration of voice and data communications;
- increasing difficulty of differentiating between telecommunications and data processing;
- increasing migration to digital services from analogue;
- parallel evolution of new computer services and local processing capabilities, netting to moderate growth in telecommunications demand;
- cable and telephone company competition for delivery of services to both residential and business markets;
- greater use of portable, un-wired, telecommunications devices;
- lack of consensus on comparable market share of public or private services;
- with Free Trade, more likely to see high growth economy, than low-growth; and
- no comment on penetration of Canadian markets by US organizations.

The principal thrust of the forecasts presumes the continued need for basic services. With steady growth in population, and in particular, the steady growth of urban population, a consistent growth in demand for standard voice telephone services, and for programmed video services will occur. No decline or dramatic growth in these services is foreseen. The forecasts project the continued use of existing technologies with enhancements as economically viable to meet this steady growth.

The digital evolution in telephony will continue. Already we use a national network that is largely digital for telephone service. With the anticipated growth in the penetration of digital services to the subscriber's premises a full national digital service will be available. Such a service will blur the distinction between voice and data services, such that a single network connection will provide access to both voice and data. There will be greater standardization in data interfaces and communications software packages making data communications as easy as voice communications are today.

The innovations that are forecast will assist in the integration of computing and communications. The integration that has occurred in the transmission of signals will be carried over into the computing devices and the services they are used to access. With greater capacity for computing more will be achieved, both at the user's device and in remote network accessible hosts.

There is also a parallel trend that will mitigate, to some extent, the growth in data communications. With the availability of more power in individual work stations and the availability of vast amounts of portable published machine-readable material, the need for universal access to public data services will not grow quickly. The expectation is that competing technologies will

moderate the growth rate of these data services.

Two service examples quoted in the forecasts, Hyper-publication and data services to the home, have been discussed in previous forecasts. They have yet to materialize in a significant way. The forecasts see both of these service groups being major innovations over the next fifteen years.

The pending launch of new satellites for mobile telephony represents the next major innovation in telecommunications to be introduced. MSAT with full two-way point-to-point communications will permit the introduction of individual communications devices, unfettered by base station requirements. Significant improvements in battery technologies are anticipated that will not only encourage the miniaturization of personal communications devices (the vest pocket phone) but will also enable reliable residential telephone service using un-powered optical fibre to be provided.

The message services, TWX and Telex, will be confined to oblivion. The power of message systems using standard microcomputers will render these services obsolete. Similarly it is forecast that variants of Videotex will also flounder, except in the High Growth forecast, as the capabilities of microcomputers in power and functionality reduce the demand for such presentation and database access tools.

There are two notable omissions in the forecasts: any distinction between the use of public and private services and the integration of telephone company services with those of the cable companies. This reflects, in part the lack of consensus in our discussions and more importantly the fact that such occurrences are independent of technical capabilities. Decisions on the use of public or private facilities are either based on economics or service needs; as are any decisions on the establishment of such services. Similarly, while some trials of integrated telephony and video services have been undertaken, the introduction of integrated facilities is purely a matter of regulation.

Some observers felt that the realization of technology potential depends critically on the regulators. The regulator may allow or disallow technical innovations with little or no regard for the merits of the technology. A reduced level of regulatory intervention would dramatically change the impact of new technologies on telecommunications services. Forecast T-1, with stronger telecommunications growth would reflect reduced regulation better than forecasts T-2 or T-3.

Finally, the forecasts presume above all else, a stable world and Canadian environment. The most certain thing about the future is its uncertainty. Yet these forecasts presume a reasonably stable progression from the current into the near future. Confidence in the forecasts can be based on recognition of human needs to communicate and belief that such needs are fundamental and will not change. Technology will influence how that communication occurs but will not detract from its occurrence.

GLOSSARY

Alex	Name of a Videotex service introduced on a trial basis by Bell Canada in Montréal in late 1988.
ANI	Automatic number identification. A telephone system feature that provides the caller's number to a called party.
Anik	The name of Telesat Canada's series of fixed service geosynchronous satellites. Anik is the Inuit word for brother or friend.
Cancom	Canadian Satellite Communications Inc. The licensee for satellite broadcast signals to rural and remote areas of Canada and for VSAT and other satellite and audio services.
CCITT	CCITT is an acronym for the french name of one of three International Telecommunications Union (ITU) committees based in Geneva: Comité Consultatif International de Télégraphie et Téléphonie. It is responsible for the preparation and adoption of recommendations according to which the world's telephone and telegraph systems operate.
CD-ROM	Compact Disc Read Only Memory. Computer form of audio compact discs.
CMOS	Complementary Metal Oxide Semiconductor. The principal fabrication technology for integrated circuits, or computer chips.
CRTC	The Canadian Radio-Television and Telecommunications Commission. The agency responsible for regulating the broadcast industries in Canada and the federally incorporated telecommunications common carriers.
DBS	Direct Broadcast Satellite. A high powered broadcast satellite service that can provide wide area reception with relatively small antennas.
downlinks	Refers to the downward communications link from satellite to the ground. cf. uplink.
EDI	Electronic Document Interchange.
FAX	Common abbreviation for facsimile, a page transmission service using scanners and copiers.
FCC	Federal Communications Commission. U.S. regulatory body responsible for U.S. telecommunications services regulation.
FSS	Fixed Satellite Service.
GHz	GigaHerz (Abbrev.) 1 GHz = one thousand million cycles per second.
gigabyte	one thousand million bytes.

HDTV	High Definition Television. One of several schemes for the presentation of a higher quality colour TV image than presented by NTSC, PAL and SECAM TV standards.
Head Ends	The term used to describe the receiving and channel processing centre for a cable distribution network.
iNET	A Bell Canada service based on Datapac, that provides Intelligent Network functions.
ISDN	Integrated Services Digital Network. A fundamental feature of ISDN is the use of "out-of-band" signalling, signalling that is transmitted independently and simultaneously with communications traffic.
ISDN-2	Nominal title used in this report to indicate the successor to ISDN standards.
ITU	International Telecommunications Union. An agency of the United Nations.
Kb	Kilobyte. 1 Kb = 1024 bytes (accurately), a thousand bytes (colloquially). Also used as an abbreviation for Kilo-baud.
Kbps	Kilobits per second. A measure of transmission speed.
LAN	Local Area Network. A term used to describe the dedicated networks used to link computers and peripherals together within a relatively confined area. The area is usually an office, but may be as large as a building or a campus.
Mb	Megabyte. 1 Mb = 1,048,576 bytes (accurately, 1024 x 1024), one million bytes (colloquially, and more usually).
Mbps	Million bits per second. Another measure of higher transmission speed. If one were dealing with computer mainframe channel speeds, one would talk of Mbps and mean Megabytes, not megabits.
MICS	Microwave integrated circuits.
Mips	Millions of instructions per second. An inaccurate but comparative measure of the power of a computer.
MSAT	Telesat Canada's proposed mobile satellite.
MSS	Mobile Satellite Station.
multiplexed	A technique whereby several signals share a single transmission medium. The signals may be time multiplexed, or frequency multiplexed.
NABU	A company that pioneered use of cable TV channels for computer program distribution.
nano	A thousand-millionth.

NAPLPS	North American Presentation Level Protocol Standard. A standard for Videotex, developed for the North American market. Based on the federal government's development of Telidon.
Neural Networks	An approach to artificial intelligence that models in computer structures the structure of brain neuron s. The approach offers interesting potential in signal processing of many varieties, including speech recognition.
NTSC	National Television Systems Committee. Responsible for the definition of the television picture standard used in North America, Japan and some other countries.
OSF	Open Systems Foundation. A grouping of major computer industry companies to promote the adoption of microcomputer standards.
OSI	Open Systems Interconnection. A model of communicating processes established for use in the definition of inter machine protocols.
PAL/SECAM	Phase Alternation Line system/Séquentiel Couleur à Mémoire. Colour television picture standards.
PCs	Personal Computers
photonic	Relating to photons. Used with respect to optical switching technologies.
POSIX	A specification that has been proposed for Open UNIX systems.
SQL	Structured Query Language. A set of conventions adopted by IBM for a common database query language.
SS7	Signalling System number 7. A set of inter-office signalling protocols defined for use "out-of-band" for digital signalling of call progress in a digital telephone network.
superchannel	The name given to several TV channels satellite broadcast to North America.
telco(s)	An abbreviation used to refer, collectively, to the telephone companies.
telecom(s)	An abbreviation for telecommunications.
Telesat Canada	A private company, incorporated by act of parliament (the Telesat Act) to implement and operate domestic satellite service in Canada.
Teletex	A defined standard for document exchange, extending TWX and Telex capabilities.
Teletext	Generic name for a service that uses the blanking interval of a TV picture for the broadcast of text. CEEFAX in the U.K. is one such service.
Telidon	The development by the Canadian government, of a set of graphic display conventions and associated data communications protocols.
Transputer	Term used in this paper to refer to a multiple CPU computing machine,

	where multiple is several tens if not hundreds of processors.
TVRO	Television Receive Only.
T1 Carrier	A designation of a transmission circuit, referring to its capacity. T1 Carrier has a bandwidth of 1.544 Mbps and T3 Carriers operate at 45 Mbps.
UNIX	A computer operating system developed by Bell Labs (AT&T). Increasingly subject to presentation as a possible universal piece of systems software, for use on all microcomputers.
uplinks	The communications path from a ground station to a satellite. The frequency used on the uplink path differs from that of the downlink path.
VCR	Video Cassette Recorder.
VHCM	Very High Capacity Microwave. Used for short-distance video signal transmissions.
Videotex	Generic name for text and image retrieval services using simple graphics and data terminals. Telidon was an early videotex protocol, and Alex is a videotex service.
VRU	Voice Recognition Unit.
VSAT	Very Small Aperture Terminal. Refers to a satellite system using a star network such that a single large high-power (and expensive) satellite hub feeds a multiplicity of small low-power (and inexpensive) terminals. Can operate in any appropriate satellite frequency band.
2B+D	Shorthand designation of the "circuit" capability provided by a Basic Rate ISDN channel. The typical basic interface provides two 2 "B" channels for voice or data, plus a signalling "D" channel. A "B" channel provides 64 Kbps capacity while a "D" channel provides 16 Kbps.

LITERATURE

The following material was reviewed in the course of the technology assessment component of the work in preparation of this report.

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