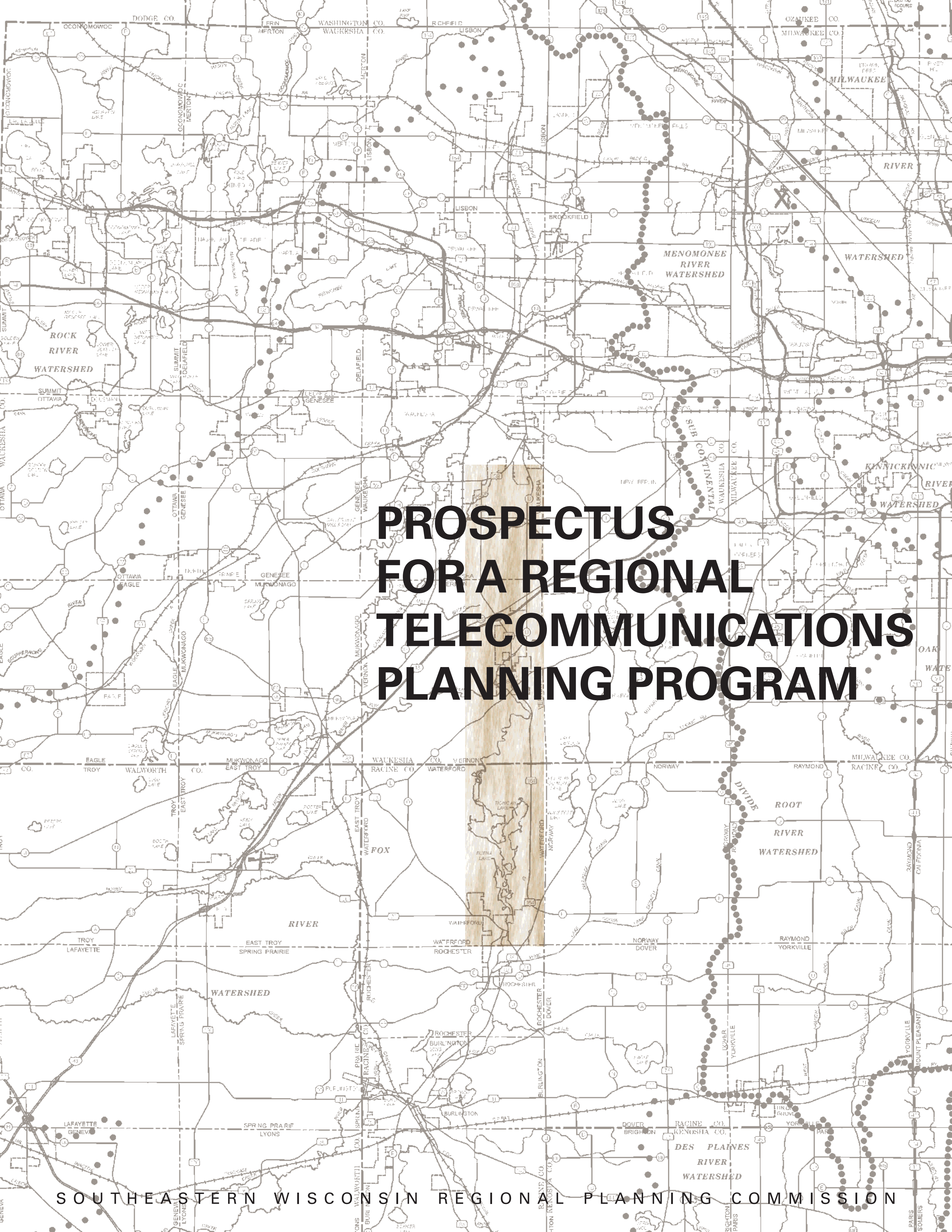

PROSPECTUS FOR A REGIONAL TELECOMMUNICATIONS PLANNING PROGRAM

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

Special acknowledgment is due SEWRPC Executive Director Emeritus Kurt W. Bauer, PE, RLS, AICP, and SEWRPC Telecommunications Systems Engineer Consultant Kenneth J. Schlager, PE, for their contributions to the preparation of this report.

PROSPECTUS FOR A
REGIONAL TELECOMMUNICATIONS
PLANNING PROGRAM

Prepared by the

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Chapter I

INTRODUCTION AND BACKGROUND

INTRODUCTION

Telecommunication networks provide the infrastructure for information interchange in all advanced societies. Such networks are vital for the efficient production and distribution of goods and services in a modern economy. Telecommunication exchanges also serve to establish the social and political fabric of modern day life. Recent and continuing advances in communications technology have allowed for information transfer at rates considered infeasible even a decade ago. Although originally developed for voice communication only, telecommunication networks now transmit data, video, and multimedia forms of information.

Varying rates of deployment of new communications technologies in different areas of the United States and in the rest of the world have produced one aspect of the so-called "digital divide,"[1] placing areas with outmoded telecommunication technologies at a competitive disadvantage in national and global commerce. Such disadvantaged areas are also prevented from introducing communications-based advances in fields such as telemedicine, public safety, education, environmental monitoring, and transporttation that have major impacts on the quality of life. For all of the above reasons, telecommunications planning should be an important concern of elected and appointed public officials in a metropolitan region such as Southeastern Wisconsin.

One mode of telecommunications, terrestrial wireless communications, is advancing more rapidly than other modes such as traditional wireline and satellite wireless communications. Although the first commercial cellular wireless network did not become operable until 1983, wireless telephony is rapidly becoming the predominant form of local and long distance voice communication in the United States and elsewhere. Some countries in Europe and Asia, in fact, have higher rates of wireless telephone usage than does the United States. With the advent of the third generation (3G) of wireless communication technology, wireless is expected to become important in data and video as well as voice transmission. Because wireless telecommunication is based on a set of prominent antennae and connecting infrastructure, the location of the antennae and the associated supporting equipment can have important impacts on land use and on perceived property values in local communities. The coming third generation of wireless telecommunications may be expected to require a much larger number of antenna sites with smaller cellular coverage. This projected large increase in antenna site requirements contributes to a need for areawide planning of the future antenna site network. Without such planning, haphazard location of the

[1]*The term "digital divide" is commonly used to refer to the differences between households, businesses and other organizations that, for whatever reasons, have access to personal computers and the Internet and those that do not. It can also be used to distinguish between areas that are underserved in that the areas do not have high speed data service available. Such underserved—or disadvantaged—areas may exist in urban, as well as, rural areas.*

future multitude of wireless antenna sites may disrupt community land use planning and create excessive and needless conflict in local communities in the Region.

THE REGIONAL PLANNING COMMISSION

The Southeastern Wisconsin Regional Planning Commission is the official areawide planning agency for the seven-county Southeastern Wisconsin Region. The Region is comprised of the counties of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha. The Commission is charged with the responsibility for the collection, analysis, and dissemination of basic planning and engineering data on a uniform, areawide basis; for the preparation of a framework of long range plans for the physical development of the Region; and for the promotion of intergovernmental cooperation and coordination in the adoption and implementation of such long range plans.

Section 66.0309 of the *Wisconsin Statutes* specifically charges the Commission with the function and duty of "making and adopting a master plan for the physical development of the Region." The permissible scope and content of this plan, as outlined in the enabling legislation, extends to all phases of regional development, implicitly emphasizing, however, the preparation of plans for the use of land and for the supporting transportation, utility, and other public infrastructure facilities. The work of the Commission is intended to assist the responsible Federal, State, county, and local units and agencies of government in the making of decisions concerning the development of the Region. The work of the Commission emphasizes close cooperation between the various levels, units, and agencies of government responsible for the development and maintenance of land uses and for the design, construction, operation, and maintenance of the supporting infrastructure facilities. In the pursuit of its statutory responsibilities, the Commission has, to date, prepared and adopted a number of elements of a comprehensive plan for the development of the seven-county Region, including a land use plan, a park and open space plan, a natural areas management plan, a transportation system plan, a series of seven watershed plans for the major natural watersheds lying within the Region, a water quality management plan, and a sanitary sewerage system plan.

Telecommunication networks have not traditionally been explicitly considered in the Commission's planning for the physical development of the Region. Although telecommunication networks form a critical part of the current regional infrastructure, telecommunications planning was considered the responsibility of the private sector. When the Commission was organized in 1960, telecommuni-cations was primarily a voice medium with some data traffic between large business enterprises. The wireline network within the Region was owned and managed by a number of regulated public utilities, including the Wisconsin Telephone Company, a subsidiary of the American Telephone and Telegraph Company, and a few independent telephone companies. Together, the major telephone companies and the AT&T were known as the Bell System. In that era, the role of government—Federal and State—was limited to utility regulation. Network planning usually was ably performed by the regulated privately held utilities. Following the breakup of the Bell System and the AT&T and with the subsequent rapid advances in communications technology, telecom-munications, while becoming increasingly important in the local, national, and global economies, also became increasingly chaotic. The Federal Telecommunications Act of 1996, intended to further encourage local competition, has led to a "network of networks" largely beyond the regulatory purview of any level of government.

Recognizing the need to understand the current status and future trends in regional telecommunications, the Commission, in April 2002, requested the preparation of a document that would brief the Commissioners and the Commission staff on the status of regional telecommunications in the seven-county Southeastern Wisconsin Region.[2] The document was further intended to identify existing problems and possible roles for the Commission in addressing the issues involved. The preparation of the document was guided by a telecommunications panel formed by the Commission. The panel consisted of representatives of the various elements of the regional telecommunications community, including the primary service provider, SBC, and various members with other areas of expertise. This panel

[2]"Regional Telecommunications in Southeastern Wisconsin—Status, Problems, Roles," *prepared for Southeastern Wisconsin Regional Planning Commission by K. J. Schlager, Ph.D., P.E., September, 2002.*

reviewed the document and unanimously approved its major recommendation, the preparation of a prospectus for a regional telecommunications planning program. The panel also recommended that the Commission include in that program a detailed study of future wireless communications infrastructure needs in the Region, with particular emphasis on antenna site location; and that the Commission prepare a telecommunications planning guide for local units of government. On December 4, 2002, the Commission authorized the preparation of the recommended prospectus, embracing both regional telecommunications planning in general and wireless communication infrastructure planning in particular.

ADVISORY COMMITTEE STRUCTURE

The long-established practice of the Commission has been to prepare prospectuses for the conduct of major regional planning programs with the assistance of an appropriately structured advisory committee. The membership of such committees was to be drawn, as appropriate, to include knowledgeable and concerned representatives of the constituent counties and municipalities; of concerned State and Federal agencies; of the academic community; and of concerned private businesses and industries. Accordingly, an Advisory Committee on Regional Telecommunications Planning was created by the Commission to guide the preparation of the recommended Prospectus. The Committee consists of the following members:

Kurt W. Bauer .... Committee Chairman, SEWRPC Executive Director Emeritus
William R. Drew ....Committee Vice-Chairman, Vice-Chairman SEWRPC, and Executive Director, Milwaukee County Research Park
Kenneth Brown..............................District Manager, Nextel Communications, Inc.
Roger Caron .... President, Racine Area Manufacturers and Commerce
Bob Chernow.............................Chairman, Regional Telecommunications Commission
Randy Cicatello ....Vice President-Engineering, Time Warner Cable
Charles L. Colman .... President, The Colman Group, Inc.
David L. DeAngelis .... Village Manager, Village of Elm Grove
Ralph E. Evans, III ....Manager, New Business Development, Evans Associates
Brahim Gaddour.........................Director of Network Operations, Time Warner Telecom of Wisconsin
Barry Gatz ....Network Supervisor, CenturyTel
Nicholas Harteau..................Director of Technology, CoreComm, Inc.
Michael E. Klasen ....Director of Regulatory Affairs, SBC
J. Michael Long.............................. Attorney-at-Law, Murn and Martin, SC
Jody McCann ....Director of Technology Research, Wisconsin Department of Administration, BadgerNet
George E. Melcher .... Director of Planning and Development, Kenosha County
Paul E. Mueller ....Administrator, Washington County Planning and Parks Department
William T. Parch .... Radio Frequency Engineer, Cingular Wireless, Inc.
Mariano A. Schifalacqua....................Commissioner, Department of Public Works, City of Milwaukee
Mark Schoeppel ....Vice President, Global IT Infrastructure, Johnson Controls, Inc.
Paul R. Schumacher .... Program Manager, Tricounty Business Partnerships
Michael Ulicki............................. Vice President and Chief Technology Officer, Norlight Telecommunications
Darryl Winston..................Director of Data Services, City of Milwaukee Police Department
Gustav W. Wirth, Jr. ......Chairman, Ozaukee County Board of Supervisors; SEWRPC Commissioner

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Chapter II

PURPOSE OF THE PROSPECTUS

The purpose of this prospectus is to explore and establish the need for, and recommend the means by which, a technically sound and feasible regional telecommunications planning program can be established for the Southeastern Wisconsin Region. The prospectus is intended to provide the information required to permit the various levels, units, and agencies of government, and the telecommunications service industry to consider the benefits and costs of such a program and to determine the desirability of its execution.

To this end, the prospectus is intended to accomplish the following:

1. To provide information on the current state of telecommunications facilities and services within the Region, on the telecommunications regulatory climate within the Region, and on best practices concerning the provision of telecommunications facilities and services.

2. To establish and document the need for a telecommunications planning program in Southeastern Wisconsin, including, among other needs, the need for the preparation of a framework plan for wireless communications infrastructure and attendant model regulatory guidelines and ordinances;

3. To specify the scope and content of the work required to carry out in a technically sound manner such planning program;

4. To recommend the most effective means for establishing, organizing, and accomplishing the required planning program;

5. To recommend a practical time sequence and schedule for the required work;

6. To provide sufficient cost data to permit the preparation of an initial budget for the work required; and

7. To suggest a means for funding and a possible allocation of costs among the various levels, units, and agencies of government and private agencies concerned.

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Chapter III

HISTORICAL BACKGROUND AND NEED FOR REGIONAL TELECOMMUNICATIONS PLANNING

INTRODUCTION

Southeastern Wisconsin is a highly urbanized and rapidly urbanizing Region. The seven counties comprising the Region have an area of about 2,689 square miles and a resident population of about 1.9 million persons. About 36 percent of the population of the State resides within the Region, which comprises only 5 percent of the area of the State. The Region provides about 38 percent of all of the jobs within the State, and contains about 37 percent of all the tangible wealth of the State as measured by equalized real property valuation.

The economy of the Region is in transition from a base dependent primarily on the manufacturing sector to one dependent on the service sector. During the 1980 through 2000 time period, employment in the manufacturing sector declined from about 35 percent to about 22 percent of the total employment within the Region. Over this same period, employment in the service sector rose from about 19 percent to about 30 percent of the total employment within the Region. If the definition of the service sector is broadened to include wholesale trade, retail trade, government, and finance, the change is even more dramatic, with services now accounting for about 69 percent of all employment within the Region. Service-based organizations are typically more communications-intensive than manufacturing organizations, so that with the growing movement to a service-based economy there is an ever-increasing need for advanced communication facilities and services.

At the same time, there is a need to preserve a vibrant and growing manufacturing sector within the regional economy. Manufacturing jobs typically pay better than service jobs, and the Milwaukee area once had a worldwide reputation for high-skill based manufacturing. Manufacturing is also becoming communication network intensive, so that an advanced regional telecommunications system is necessary to keep the local manufacturing base competitive in a global economy. Good telecommunications facilities and services are important to the practice of "just in time" manufacturing in which the delivery of raw materials and parts for use in assembly and other manufacturing procedures are integrated into the manufacturing operations and the need for warehousing of raw materials and parts minimized. Current manufacturing technology is moving communication networks down from the office level to the machine level on the plant floor. The machines concerned, although diverse in purpose and function, have one thing in common: the need to be monitored and controlled in some way through an effective and efficient telecommunications system. Manufacturing plants also need to be tightly linked with both their suppliers and their customers. Scattered nationwide and worldwide, these suppliers and customers are effectively reached only through a good telecommunication network. Whether for the emerging service or the established manufacturing sectors, then, communication networks constitute an important element of the regional economy.

Although the seven-county Region is highly urbanized, agriculture is still a very important economic activity within the Region. Currently, about 1,395 square miles, or 52 percent of the total area of the Region, remains in rural, primarily agricultural, uses. The adopted regional land use plan foresees only a relatively small decline in the area devoted to agricultural and other rural uses within the Region by the year 2020. With some notable exceptions, rural areas tend to be underserved by high speed telecommunication services in the current competitive environment. It is, therefore, essential that special provision be made so that businesses—particularly including farms—and residents appropriately located in the rural areas of the Region are provided with adequate communication services. Such universal service rarely occurs without either some government regulation or subsidy.

HISTORICAL BACKGROUND

Some knowledge of national and regional telecommunications history is necessary to any understanding of the need for a regional public telecommunications planning effort within Southeastern Wisconsin. A more detailed historical background is contained in the previously referenced Commission document on regional telecommunications. Coverage here will be limited to recent salient events in telecommunications that impact the current situation in the Region.

Prior to 1984, telecommunications in the United States was a regulated industry dominated by the American Telephone and Telegraph Company (AT&T). The AT&T and its subsidiary companies—known collectively as the Bell System—dominated telecommunication service in the urban areas of the country, while independent telephone companies generally served small town and rural America also as regulated monopolies. With the breakup of the Bell System in 1984, the entire structure of the telecommunications industry was changed. The provision of long distance telephone service quickly became subject to a competitive marketplace with multiple service providers. The local telecommunications markets retained their regulated characteristics until the Federal Telecommunications Act of 1996, which introduced competition in the form of what are known as Competitive Local Exchange Carriers as alternative service providers to the former Bell System operating companies. The Federal Telecommunications Act of 1996 initiated a spate of capital investment in telecommunication networks producing a rapid expansion of the industry from 1997 to 2000, followed by the financial collapse of the industry in 2001. The industry is hopeful for a return to normal growth in 2003.

During this period of deregulation of telephone service, a series of technological innovations and market transformations took place that changed the basic costs, operational characteristics, and monopolistic character of the industry. These included:

1. Shift From Voice to Data Traffic
   Telecommunication network traffic underwent a transition from original domination by voice traffic to domination by data traffic. The historic utilization of the system was over 90 percent voice traffic. Currently, the utilization is over 80 percent data traffic. More recently, traditional voice traffic is being provided as an overlay to data traffic, the underlying data traffic structure providing the conduit for the voice service.

2. Creation and Growth of the Internet
   Created in the late 1960s as a research-oriented communications network for the U.S. Department of Defense, the Internet has become a global network interconnecting computers throughout the world. Based on the packet data transmission concept, the Internet was originally used only for data communication. Technological advances now also allow for voice, and multimedia, such as video and imagery, communication.

3. Creation and Growth of Wireless Communications Networks
   The first cellular wireless network in the United States was established in Chicago in 1983. Since then, wireless communication has rapidly grown to become the leading vehicle for voice communication. Fixed antenna wireless access networks are becoming an important means of Internet access. The use of wireless systems to connect residences may over time make the traditional wireline connections obsolete.

4. Introduction of Fiber Optic Transmission Technology
   Wireline transmission has been copper wire based since the original invention of the telephone. Introduced in 1970, fiber optic cable has developed into the dominant means of high rate data transmission (broadband service)

in telecommunications systems, with transmission rates many times that of equal size copper wire coaxial cables.

5. Development and Growth of Digital Broadband Cable Networks
   Although originally designed as one-way analog broadcast networks, cable networks have been converted and upgraded to two-way networks, and are the current leader in the provision of broadband services particularly to the residential market. Cable networks in some areas of the United States are also providing integrated voice service as well as data and video services.

6. Satellite Communications
   One-way satellite-based broadcast networks have also been converted to two-way broadband data service networks. Satellite networks are particularly important in rural areas where other broadband wireline and wireless infrastructures are typically not available.

CURRENT TELECOMMUNICATIONS SERVICE PROVIDERS

In 2003, three large and three small wireline carriers—known as Incumbent Local Exchange Carriers (ILECs) served the seven-county Southeastern Wisconsin Region. SBC, headquartered in San Antonio, Texas, one of the surviving regional Bell operating companies—and a descendant of the original Wisconsin Telephone Company—provided telecommunication services to the most urbanized areas of the Region. Verizon, another surviving Bell operating company, headquartered in New York, serviced the more rural areas located along the northern and southern fringes of the Region. CenturyTel, headquartered in Louisiana, serviced the rapidly urbanizing areas of western Waukesha County. Telephone and Data Systems, Inc., headquartered in Chicago, has an incumbent franchise to serve parts of Racine and Waukesha Counties. Two local incumbent carriers operate in the Elkhorn and Sharon areas of Walworth County. These service areas are shown on Map 1.

In addition to the ILECs, a number of Competitive Local Exchange Carriers (CLECs) operate telecommunications networks within the Region, including: AT&T, McLeod USA, TDS Metrocom, Time Warner Telecom, Winstar, and MCI/Worldcom. Although nine CLECs were officially active within the Region in 2001, some restricted service to business or large institutional customers. MCI/Worldcom and TDS Metrocom, the latter an affiliate of Telephone and Data Systems, Inc., have aggressively pursued the residential telecommunications market. Competition, however, has also come from cable companies which offer broadband voice, data, and video services. In many areas of the United States, including Milwaukee, cable companies have penetrated the residential two-way telecommunications market.

The wireless service provider market is, like the wireline carrier market, highly competitive. In the 1980s, only two wireless service providers were authorized within the Region—SBC, now Cingular Wireless, and Cellular One, now U.S. Cellular. After 1996, all wireless companies were free to compete, so that there are now seven major wireless service providers operating within the Region: AT&T Wireless, Cingular Wireless, Nextel Communications, Sprint PCS, T-Mobile, U.S. Cellular, Verizon Wireless, and Voicestream.

Cingular, Nextel, and U.S. Cellular compete using similar wireless technologies in the 800 to 900 megahertz (MHz) frequency band. AT&T Wireless, Sprint, T-Mobile, Verizon, and Voicestream Wireless operate at a higher frequency band range—1,800 to 1,900 MHz. Generally speaking, this higher frequency range requires more cell sites to cover the same geographic area.

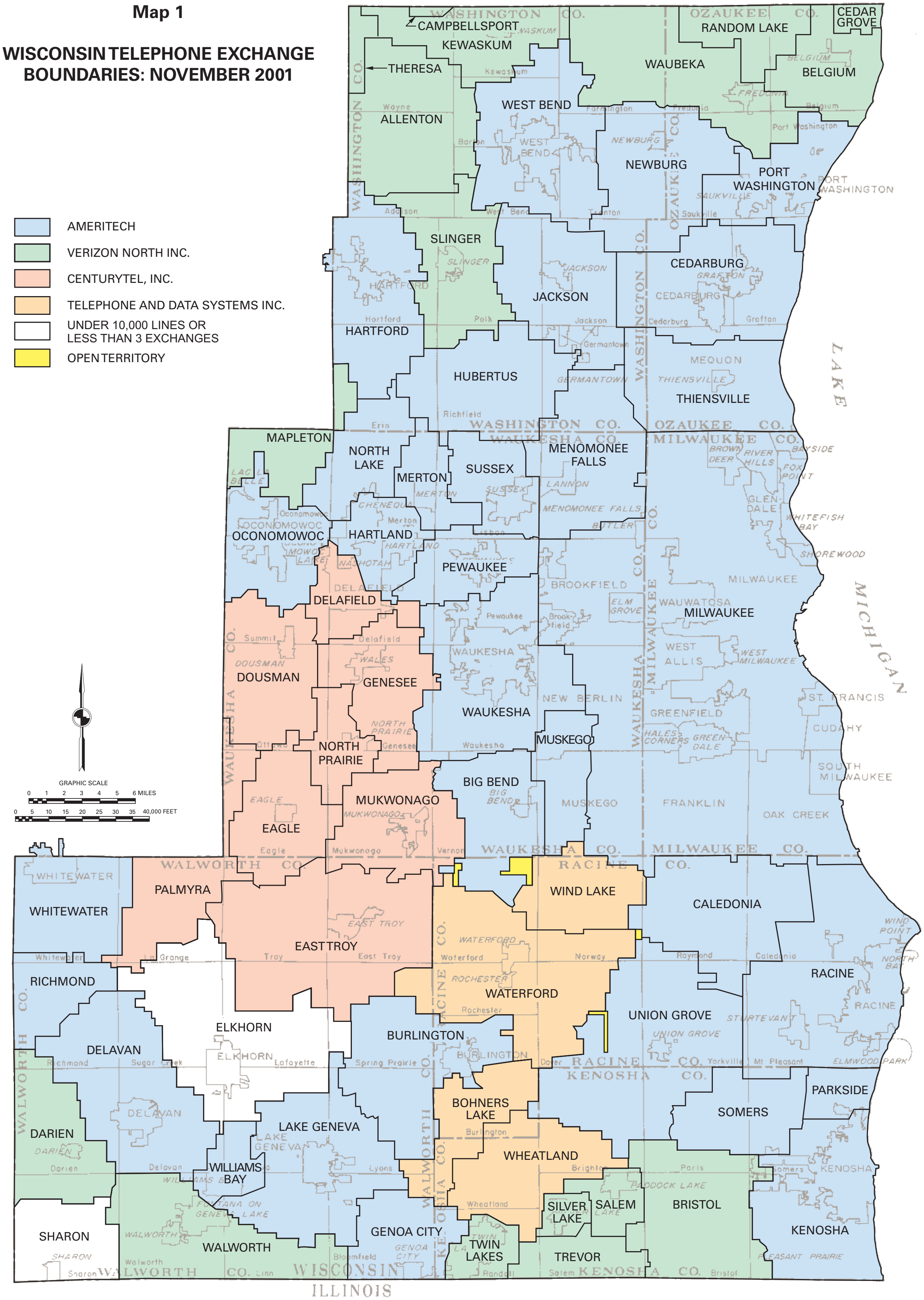
Two major satellite-based wireless service providers operate in the Region: Direct TV (Hughes) and Norstar Satellite.

Although satellite wireless service is typically higher in price, these wireless carriers have been able to compete well in outlying areas for the provision of broadband services. It is important to note that one of the previously listed CLECs, Winstar Communications, provides a different kind of wireless service based on fixed, rather than mobile, users employing Microwave, Multipoint Distribution System (MMDS) technology. While this approach has had only minor impact to date, it could become an important alternative in the future, particularly in the offering of broadband services.

A second fixed antenna wireless technology, however, has already had a major impact on data communications. This technology based on the Institute of

Map 1

WISCONSIN TELEPHONE EXCHANGE BOUNDARIES: NOVEMBER 2001



Source: Wisconsin Department of Administration Office of Land Information Services and SEWRPC.

Electrical and Electronic Engineers (IEEE) Standard 802.11, is known as WiFi. WiFi permits a user to connect to the Internet through a small antenna located in such public gathering places as airports, hotels, and parks. It is also being installed in home locations. Although limited in range, this technology allows users to readily transfer data to the Internet from personal laptop computers. Traveling businessmen make use of free WiFi service, so that it provides an alternative to conventional wireless service. Extensions of WiFi may eventually threaten the franchises of a whole range of wireless and wireline service providers. An example is Seattle Wireless, a community-organized and limited network, offering broadband service based on WiFi. The network is created by the informal action of interested volunteers. Recently, there have also been other forms of fixed wireless technologies beyond MMDS deployed within the planning area, such as the Motorola, Inc., a Canopy system.

A number of interchange carriers serve the Region. These carriers connect regional core networks with national and global networks. Some of these carriers, such as AT&T and MCI Worldcom, also function as CLECs. Norlight Communications is a strong, independent interchange carrier in the Region.

Another class of service organizations related to Internet communications is the Internet Service Provider (ISP). These providers connect users to the Internet and also convert messages into packets of data using the Internet Protocol (IP). Each packet has address information attached to it, and once on a link of the Internet, it is passed through various routing points until it reaches its destination. ISPs also perform other service functions such as E-mail and the World Wide Web. ISPs vary in size from global organizations, such as AOL and Earthlink, to more regional servers, such as CoreComm, which is predominant in Southeastern Wisconsin. ISPs are vital to the operation of the Internet, but traditional service providers, such as SBC and CenturyTel, also perform the ISP function.

BROADCAST SERVICE PROVIDERS

Broadcast services are not generally considered as part of telecommunications. Under both the 1934 and 1996 Federal Communications Act, broadcast and telecommunications are treated separately. For that reason, and because the two industries differ in other significant ways, broadcast communications will not be considered directly in the regional telecommunications planning process proposed in this Prospectus. Broadcast communications will be considered indirectly, however, since all aspects of national and regional communications are merging. It is already possible to listen to broadcast radio over the Internet. With broadband capability, television broadcasts can also be received over the Internet. Ultimately, commercial radio and television broadcasts may merge with the Internet. In the proposed planning process, radio and television broadcasting will be considered to the extent that such commercial broadcasting may constitute a potential source of telecommunications traffic. In that sense, commercial broadcast communications will constitute an element of the proposed regional telecommunications plan. No effort will be made, however, to explore the complexities of Federal Communications Commission (FCC) broadcast communication regulations.

TELECOMMUNICATION SERVICES

Although there are many telecommunication service providers, there are only a few basic types of communication services. These are: 1) Voice Transmission Services; including: "Plain Old Telephone Service" (POTS); cellular wireless; satellite wireless; packet-based telephone networks (ATM-Frame Relay); and Internet voice services; 2) Data Transmission Services, including: the Internet; ATM-Frame Relay, and third generation (3G) cellular wireless networks; 3) Multimedia Services, including: video, imaging, streaming video, data, and voice; and 4) Broadcast Services, including: AM/FM terrestrial radio, satellite radio and television, terrestrial television, and cable television.

Comprehension of telecommunications services is facilitated by an understanding of the "layer" concept in modern telecommunications technology. Although other reference models are used, the most popular is the Open System Interconnection (OSI) reference model. This seven-layered model features three lower layers—physical, data link, and network—that are concerned with the routing of data from one piece of equipment to another. The upper four layers relate to the actual dialog for a particular application.[1]

[1]*Telecommunications is a complex, multi-layered process ranging from electrical interconnection interfaces at the physical layer to standards for e-mail transmission and reception at the applications layer. In the early days of data communications, each computer company developed its own set of protocols, interfaces, and standards. As a result, communication between different manufacturers' equipment was difficult, if not possible. To foster universal data communications and to minimize redundancy and confusion, the International Standards Organization (ISO) in 1983 established the Open Systems Interconnection (OSI) model. Although other protocol models have been developed and are in use, the OSI model is still the recognized standard. OSI is a seven layer model.*

The first three layers—physical, link, and network—are concerned with routing of data from one piece of equipment to another. The last four layers are concerned with the actual dialog for a particular application. In an application such as e-mail, the user interacts with the highest layer, the application layer. More specifically, the layers are characterized as follows:

1. *Physical Layer*
   - *Hardware and its physical and electrical connections*
   - *Responsible for converting raw data into electrical, or optical, signals and transmitting these signals over a physical medium, such as a coaxial cable or an optical fiber cable*
2. *Data Link Layer*
   - *Controls access to the line*
   - *Detects and corrects transmission errors*
3. *Network Layer*
   - *Routes packets of data from origin to destination*
   - *Controls congestion*
4. *Transport Layer*
   - *Fragments messages into packets*
   - *Reassembles packets into messages*
   - *Provides end-to-end message control*
5. *Session Layer*
   - *Establishes connection between users*
   - *Manages transfer of data between them*

It is important to appreciate that different communications technologies can make use of the same physical layer—e.g., fiber optic wireline—while employing different protocols at higher layer levels. The Internet protocol is defined at the network and transport layers while transmitting over greatly different physical media.

All of the telecommunication service providers compete to varying degrees with respect to all of the above services, and do so with increasing overlap between telecommunications and broadcast services. Cable service providers, basically a form of broadcast service, now offer broadband, multi-media voice and data, as well as video services. At the same time, telephone companies with very high speed transmission capabilities will be able to offer, for example, motion picture entertainment services, in direct competition with the cable networks.

Service providers and services are all based on networks. From the standpoint of regional telecommunications planning, it is conceptually more useful to concentrate on the networks and the services the networks provide than on competing service providers. If the required network infrastructure is provided, then market competition should ensure the availability of service.

TELECOMMUNICATIONS NETWORKS

Regional common carrier telecommunication networks may be classified by function into three categories: core networks, access networks, and broadcast networks.

Core networks receive data, or other media, from access networks and transport these data to other access networks within the Region or on to national trunk lines to other regions of the United States or foreign countries. By technology, core networks may be further classified into: 1) circuit-switched networks, and 2) packet-switched networks, including

(footnote continued)

6. *Presentation Layer*
   - *Performs character set conversions*
   - *Performs data compression, reformatting and encryption*
7. *Application Layer*
   - *Deals with specific application such as e-mail, credit transaction, stock prices, or airline reservations*

ATM/Frame Relay Telenet routing and switching, and Internet routing and switching.

Circuit-switched networks constitute the traditional form of both voice and data communications. In circuit-switched networks, a dedicated circuit is assigned for the duration of a call. Packet-switched networks send voice or data signals in small digital packets with destination addresses over shared circuits. In the Telenet-based ATM/Frame Relay version of packet-switching, packets are kept intact over a single circuit path. In the Internet version, packets may be broken up into sub-packets (datagrams) and follow different circuit routes to the same destination. In recent years, most core networks have shifted from copper wire coaxial cable to fiber optic cable. This shift has occurred because of the large bandwidth capabilities of optical transmission systems. Core networks are transitioning from the Synchronous Optical Network/ Synchronous Digital Hierarchy (SONET/SDH) protocol to Ethernet, which will allow for data transmission at very high rates. Ethernet, which evolved from Local Area Networks (LANS), may become one of the more important core network technologies in the near future.

Access networks connect end users to the core networks using various technologies including:

1. Mobile Wireless
2. Fixed Wireless
    a. Microwave, Multipoint Distribution Services (MMDS), and
    b. WiFi
3. Satellite Wireless
4. Cable Wireline - Cable Modem
5. Twisted Pair Wireline
    a. Plain Old Telephone Services (POTs), and
    b. Digital Subscriber Line (DSL)
6. Fiber Wireline
    a. To the neighborhood, and
    b. To the home
7. Enterprise Networks - Private networks that access regional and national core networks
8. Power Line Networks

Currently, access networks are the limiting factor in modern telecommunications, particularly as related to what has become known as the "last mile problem." The "last mile problem" refers to providing broadband connections to residences and small businesses. Core networks currently have a significant degree of unused capacity, so that expansion of user access is vital for a return to profitable growth in the telecommunications industry.

The predominant means of access for most network users—and particularly for residences and small businesses—continues to be the twisted pair of copper wires. Second in importance, especially for voice communications, are cellular wireless networks. A major source of network traffic are the enterprise networks. Large business corporations, major educational institutions, and governmental organizations have their own private networks that link various parts of the enterprises concerned locally as well as throughout the nation and the world. Although these networks typically bypass the local public switched telephone network, they do eventually feed into the regional and national core networks.

Enterprise networks are another result of the 1984 breakup of The Bell System. Prior to the 1984 breakup, enterprises would contract with AT&T, or with independent service providers, for telecommunication services, even if, in the case of large enterprises, the enterprises were global in scope. After the breakup, these enterprises were forced to develop their own telecommunication systems using for technical resources a combination of internal staff and consultants. The end result has been the emergence of a separate market for telecommunications equipment in the enterprise sector. As a major contributor to regional network traffic, enterprise networks may be expected to be a significant concern in regional telecommunications planning.

Broadcast networks are, as already noted, one of the three types of common carrier telecommunications networks. Broadcast networks, do not function as access networks, since, by definition, broadcast networks are "point to multi-point" networks.

Current Status of Broadband Networks

Currently, of particular interest in the telecommunications industry is the growth of high speed broadband services. Prior to the year 2000, the growth of broadband services in the United States was extremely disappointing, with only about 2.7 million households out of a total of over 60 million households having high speed Internet connections.

This slow response is cited as one of the causes of the severe decline in the telecommunication equipment industries that began early in the year 2000. During the 1990s, the capacity of the national long distance communication network was significantly increased through the installation of high capacity fiber optic cables. Supporting growth in access networks linking end users to this fiber optic network, however, never occurred. The resultant surplus of long-distance capacity currently still plagues the industry. Order levels for new telecommunication equipment remain at record lows awaiting the long anticipated rise in broadband usage.

During this same time period, however, the demand for high speed broadband connections turned sharply upward. Two factors drove this remarkable turnaround:

1. On the demand side, users became aware of the need for faster Internet service as a result of applications such as music transfer, network-based gaming and Web usage requiring use of large data files. Dial-up connections running at 56 kilobytes per second (kbps) require six minutes to download a one-megabyte file that a high speed interconnection, for example, could download in six seconds.

2. On the supply side, many companies began to aggressively market broadband services in the form of cable modems and other technologies. Competition from satellite television caused the cable companies to upgrade their networks. These upgraded optic cable networks, in addition to providing improved television service, also had the capability to offer broadband Internet connections at higher speeds for non-residential services. This rapid growth in cable broadband caused the regional successors to the original Bell Telephone System companies and their competitors to lower prices and aggressively promote xDSL broadband service offerings. The end result has been a dramatic rise in high-speed Internet connections nationally, from 2.7 million in December 1999 to 16.2 million in June 2002, with cable modems capturing about 57 percent of the market. Predictions now envision one-half of all households in the United States—or approximately 42 million households—as broadband subscribers by the year 2006.

The current status of broadband services in the Milwaukee area is reflected in Table 1. The primary regional alternatives are xDSL and cable modem. Secondary alternatives include satellite and fixed wireless services. It is important to note that upload speeds of cable and satellite services are significantly lower than the download speeds. This discrepancy hampers some applications such as teleconferencing where comparable two-way transmission speeds are essential. Moreover, xDSL service is available only in areas within two to three miles of central office locations. Cable modem transmission rates also vary with the number of subscribers on a particular branch network. The most promising long-term broadband service currently appears to be fixed wireless which provides equivalent transmission rates in both directions and is rapidly deployable with relatively low infrastructure costs. Although the Motorola Canopy fixed wireless technology is cited in the table, there are a number of other current and emerging technologies including optical communications.

The rise in high-speed Internet connections would seem to restore the balance between excess long-haul fiber optic cable network capacity and broadband subscriber usage. Such a restoration, however, is not a current reality. With the recent addition of dense wave-length division multiplexing (DWDM), the information carrying capacity of fiber optic networks has increased enormously. At least 10 terabits per second of capacity has been demonstrated as of early year 2002. This capacity would provide an allocation of 10 megabits per second each to one million subscribers on a single fiber optic cable backbone. The imbalance between access and core networks remains. Current xDSL technology allows for access rates from 128 kilobytes per second to 2.3 megabytes per second. Modems can provide access at rates as high as 30 megabytes per second, but multiple subscribers must share a cable, and simultaneous subscriber usage drastically reduces the data rates available to each subscriber.

A current access method with the long run potential to restore the core network-access network imbalance is fixed wireless technology which provides access rates as high as 6 megabytes per second without the multiple user degradation of cable networks.

Table 1

MILWAUKEE AREA HIGH SPEED SERVICE PROVIDERS: JUNE 2002

Item	Digital Subscriber Lines (the technology uses basic phone lines to transmit data at high speeds; customers typically must be within a few miles of a phone company's central office to get service; DSL is resold through several local, smaller internet service providers as well as large telecommunications companies)			Cable Modem (the technology uses the coaxial TV cable to connect users to the Internet; cable TV service does not interfere with cable modem Internet service; subscribers can watch cable TV and access the Internet via cable modem at the same time; speed can be affected by the number of subscribers in a neighborhood)				Satellite Service (uses consumer satellite dishes to receive and transmit information to the Internet at high speeds)		Fixed Wireless (uses dish on consumer's house to link to Internet via radio towers)
	TDS Metrocom	SBC	Earthlink	Time Warner Road Runner	Earthlink	Max.Inter.Net	AOL Broadband	DirecTV's DirecWay	Starband	Canopy Fixed Wireless
Cost	$35 to $50 a month	$35 to $50 a month	$50 a month	$45 a month	$42 a month	$45 to $55 a month	Up to $55 a month	$60 a month. $579 up front for equipment	$50 a month for a three-year contract	$40 a month
Speed	256 to 768 kilobits per second	384 to 768 kilobits per second	Speeds vary	Speeds vary but can range up to three megabits per second	Download speeds up to two megabits per second and upload speeds up to 384 kilobits per second	Speeds vary	Speeds vary	Download speeds are about 400 kilobits per second and upload speeds are 128 to 256 kilobits per second	Download speeds of up to 500 kilobits per second and upload speeds around 150 kilobits per second	Up to six megabits per second
Number of Connections Nationally	5,101,493			9,172,895				220,588		

Source: Milwaukee Journal-Sentinel *and Federal Communications Commission.*

Fixed wireless technology in combination with the fiber to the neighborhood (FTTN) could comprise a major component of the future broadband networks serving the Southeastern Wisconsin Region.

Special mention is appropriate for the last of the above-listed network categories: power-line networks. Power lines, as the name implies, are used primarily for transmitting electric energy. Since power lines currently extend to virtually every building site within an area, they offer a potential alternative in providing universal broadband services. To date, however, power-line based telecommunications networks have been limited to short distance applications, such as networking in the home. In fact, home networking technology based upon power line use is now in its second generation with speeds competitive with wireless Wi-Fi technology. A number of domestic and foreign companies now offer home power line network products. Extending the technology to longer distances, however, faces formidable obstacles because of line noise, numerous interference sources, high attenuation levels and widely varying line impedance conditions. This extended distance version of power line communication currently remains in the research and development stage.

NEED FOR REGIONAL TELECOMMUNICATIONS PLANNING

Accordingly, seven factors contribute to the need for the conduct of a regional telecommunications planning program and the preparation of a regional telecommunications plan:

1. The lack of comprehensive information on the state of telecommunications in the Region;
2. The increasing need for advanced telecommunication networks to support the economic development of the Region;
3. The need to address the provision of adequate broadband telecommunication service within the Region;
4. The need to address differences in the provision of adequate telecommunication services in rural and other underserved areas of the Region;
5. The need to develop special purpose public telecommunications networks within the Region

for applications such as telemedicine, public safety, transportation, environmental monitoring, and education;

6. The need to assist local units of government in telecommunications network development; and

7. The need to develop a well-conceived antenna siting and related infrastructure plan for wireless communications in the Region.

The Need to Determine the Status of Telecommunications in the Region

The aforegoing description of telecommunications in Southeastern Wisconsin indicates the complexity of the current environment, and the potential confusion of users, created by the number of competing service providers, the kinds of providers, the kinds of services, and the changing technologies concerned. Dealing with this complexity and confusion is further aggravated by the fact that no organization or agency—private or public—is fully cognizant of the current state of the system. Prior to the Bell System breakup, the Wisconsin Public Service Commission (PSC) was fully informed concerning both the infrastructure and the service quality of the regional telecommunications system. Today, the PSC is no longer in possession of such information. Based on current statutes and regulations, the PSC information base is limited to data relating to the wireline ILECs.

The CLECs report on infrastructure condition to the PSC on a largely voluntary basis. The ILECs are not fully covered since they are able to create subsidiaries for their more advanced networks that are not required to report to the PSC. Wireless service providers and networks are not covered at all. Inter-exchange carriers also are not required to report. PSC network service quality information is reported in the form of subscriber complaints. There is no on-going monitoring of service quality aside from the complaint channel, and there is currently no comprehensive regional telecommunication infrastructure or service quality database. All of the report requirements and requirement exemptions noted severely restrict the value of the PSC database.

Privately-owned service providers are undoubtedly knowledgeable about the infrastructure and quality of service provided by their own networks, but typically are not knowledgeable about the status of rival networks. The need, or desire, for proprietary and competitive secrecy generally prevents the sharing of information among service providers. Given the importance of telecommunications to the regional economy, comprehensive knowledge of the total existing system is a prerequisite for any meaningful participation of local governments, of concerned businesses and industries, and of concerned citizens in the planning and development of telecommunications facilities and services within the Region. In the competitive environment created by the Telecommunications Act of 1996, a responsible public agency may be in the best position to inventory in a comprehensive manner the configuration of the telecommunications facilities and the quality of service provided by those facilities within the Region.

The Need to Support Economic Development

Modern economies are heavily dependent on telecommunication networks. Most of the growing service industries, such as banking; business and consumer services; financial services; gaming; health care; insurance; legal services; public and private education and training; hospitality and recreation; real estate; and wholesale and retail trade are essentially information oriented. The productivity of such industries is strongly correlated with the quality of communication networks and services in an area. Given the efficiency of modern communication facilities, it is also possible for industries to perform certain functions geographically far removed from the core establishments and ultimate users of the services. Accounting and engineering services for American industries, for example, are now being performed in India and other foreign countries. Insurance claims and customer service functions are also moving overseas. For these reasons, service industry development requires a modern telecommunications system within the Region that is on the right side of the "digital divide" between growing and declining economic regions.

Manufacturing industries are also being restructured and now may require network services down to the individual machine and operator level. Materials, parts, and product flows are precisely timed based on instantaneous communications. The manufacturing sector of the economy is in severe decline within Southeastern Wisconsin. Beyond primary plant closings and job losses, there has been a lack of investment in, and a decline in the number of, associated trained personnel, particularly in the machine tool industry. Improved telecommunications facilities and services, by significantly increasing the efficiency of manufacturing operations through plant-wide telecommunications down to the individual machine level, could assist in bringing about a renaissance of the manufacturing sector within the Region.

The Need to Identify the Best Means of Providing Broadband Telecommunication Service within the Region

A major problem to be faced in any consideration of the economic implications of telecommunications relates to the provision of broadband services. Currently, broadband service access is dominated by the cable modem from the cable service industry, and digital subscriber lines (xDSL) from telephone companies and Internet service providers. Neither of these two service offerings, however, appears to provide a good long term solution to the problem because both are limited in bandwidth expansion capability. Long term, broadband communications may be expected to feature two technologies: fiber optic wireline and wireless service. The future mix of these two technologies in access networks is difficult to forecast. Fiber optic transmission offers the ultimate in bandwidth, but is costly to deploy. Wireless transmission is relatively easy to deploy and relatively low in cost, but the finite nature of the radio spectrum may impose future limits. Currently, however, spectral limitations are not apparent. The success and explosive growth of WiFi would point to the dominance of fixed wireless at least in the short term. The need to deal with the uncertainties involved in the provision of broadband services provides one rationale for regional telecommunications planning.

The Need to Ensure Availability of Telecommunication Services in Rural Areas and Other Underserved Areas

Underserved areas exist in densely populated urban neighborhoods, as well as in rural areas of the Region. For example, xDSL service is not available to subscribers who are located at distances beyond three miles of a telephone network central office. Also, some low income areas are underserved for lack of sufficient market potential for high speed data services. Closing the "digital divide" in these underserved urban areas presents challenges equal to, or greater than, those found in some rural areas of the Region.

Under the former regulated utility arrangement, service providers were required to provide universal telephone service. With the current regulatory structure, a requirement still exists to provide universal "plain old telephone service," but no requirements exist requiring the universal provision of high-speed broadband services. Telecommunication providers will typically service some rural and some urban areas with networks of reduced capability. Regional telecommunications planning, in cooperation with regional service providers, should ensure that the entire Region is on the high side of the "digital divide."

The Need to Develop Special Purpose Public Networks

Recent advances in broadband and wireless communications offer opportunities for the development of a new category of public infrastructure in the form of special purpose telecommunication networks. These networks are specifically developed to meet important public needs, but generally are not economically attractive for development by private enterprise. Examples of such needed public networks include: telemedical systems; public safety, including police and fire protection systems; environmental monitoring systems; transportation-related systems; and industrial services systems.

Telemedical networks have the potential to improve the quality and reduce the costs of health care. Health care in all of its manifestations has become one of the largest industries in the United States and in the Region. Health care costs have recently severely escalated to levels beyond the ability of many businesses and individuals to pay, and are becoming of great concern to businesses and industries, labor unions, and government. An important factor in the rising costs of health care concern the relationship between hospital and home health care. Home health care, although costly, is usually more cost effective than hospital care. Home health care could be more efficiently, effectively, and safely provided if the need for home visits by health care professionals can be minimized. Recent clinical experiments indicate that home care costs can be reduced using broadband technology in which visual observations and diagnostics can be performed remotely. A telemedical network in the Region through which home care patients could be connected to professional health care providers could be developed using temporary transportable wireless home connections to regionally deployed access points.

A telemedical network could also be used in the provision of emergency medical services in which emergency vehicles at the scene of an accident would have the capability of providing visual data and voice communication with hospital emergency centers. This would improve the quality of health care, since life or death decisions, and decisions that may lead to permanent disabilities in accident victims, often must be made at accident sites.

Finally, a telemedical network within the Region could be used in other medical applications, such as connecting general practitioners, clinics, and operating rooms to specialty centers for ready consultations; and facilitating the ready transfer of medical images and records. Such an improved special purpose telecommunications could contribute significantly to a reduction in health care costs, and to an improved quality of care.

The potential applications for public networks in the provision of public safety services are manifold. A special public wireless voice network for police, fire, and public works organizations, known as 800 Trunking, already exists within parts of Southeastern Wisconsin. Mobile broadband police networks presently exist in some cities in California and with the State Police agency in Virginia. Fixed broadband video networks have been deployed in high crime areas of British cities. Such networks have also been applied to discourage violent crime in public schools. Given the recent emphasis on homeland defense in the United States, public safety networks may be expected to assume increased importance in the near future.

Of particular note in this respect within the planning area is the City of Milwaukee's Community Safety Wide-Area Network (CSWAN) that interconnects all City police and fire stations and all major City Department of Public Works facilities. This network is based on SONET-DWDM technologies of high data rate capacity. Such a network could provide the potential core network infrastructure for future public access networks in home healthcare telemedicine, in K-12 education, and other public network applications.

A major area of research in telecommunications is related to environmental monitoring. A truly adequate environmental monitoring network requires the deployment of sensing devices for measuring ambient air and water quality in large numbers across wide areas. The network of ambient air and water quality sensors can be supplemented by a network of sensors monitoring air and water pollution discharges. Such networks could contribute significantly to developing and maintaining air and surface and groundwater quality within Southeastern Wisconsin.

Transportation telecommunications networks are related to the broader field of Intelligent Transportation Systems (ITS). The ability to locate and communicate with highway vehicles opens up the possibility of optimal routing of vehicles on metropolitan freeways and major arterials. Such routing and traffic flow control could reduce congestion by making more efficient use of the current transportation network, thereby improving the safety, reliability, and efficiency of the current transportation networks.

Primary work in education networks has demonstrated the cost effectiveness of "remote learning" at all levels of education. Such remote learning has become important in primary and secondary, as well as higher and adult, education. Remote learning has also demonstrated value in the tutoring of students in cooperation with parents, particularly low-income and disadvantaged situations.

The Need to Assist Local Units of Government

The provision of planning, engineering, and management assistance to local governments has been a major element of the Regional Planning Commission operations since the inception of the Commission in 1960. Local governments now, and increasingly in the future, will require assistance in determining the direction of telecommunications development within their communities. The Commission should provide such assistance in the form of municipal telecommunications assessment and related studies.

Local communities within the Region, such as the City of West Bend, have already embarked on plans for the provision of advanced broadband communications to their businesses and residents. Other Wisconsin communities, such as the City of Sun Prairie, already have municipally owned, fixed broadband wireless systems operating within their boundaries. Given the confusing multitude of choices made available by advancing communications technology, objective guidance from the Commission could help to prevent costly mistakes in telecommunication network deployments by local communities within the Region. Furthermore, proactive support in the form of local planning guides and model ordinances could be prepared by the Commission to assist local communities in considering telecommunications development policies and programs.

The Need to Develop a Regional Wireless Antennae and Related Infrastructure Plan

The most rapid expansion of telecommunications networks in the last few years has taken place in wireless technology. Cellular mobile wireless communications is fast becoming the predominant mode of voice communication. After a rapid conversion from first generation (1G) analog to second generation (2G) digital transmission systems in the last decade, the mobile wireless industry is in the initial stages of another transformation to multimedia—voice, data, and video—third generation (3G) technology. The required network structures may be expected to visibly impact local communities in the Region through the siting of radio frequency antennae and their supporting infrastructures. The siting of antenna create political and land use, as well as, technical issues that must be addressed at the county and local level of government.

With the movement toward third generation (3G) networks, and with the growing demand for service in the high frequency ranges, there will be even more antenna sites required, each with smaller areas of coverage. Although promises of less obtrusive antenna structures have been made by some industry representatives, the move to higher frequencies with subsequent higher absorption by woodland and other foliage and building structures does not support these promises. In the more distant future, fourth generation mesh networks using small, low elevation antenna may become a reality, but it will be difficult or impossible to skip a technical generation and ignore the needs of present cellular wireless systems.

Coupled with the needs of mobile wireless is the impact of fixed wireless systems. While most of the publicity for fixed wireless networks has been on very short range WiFi communications in homes and public places, networks based on the IEEE 802.11 Standard have been put in place in Seattle, San Francisco, New York City, and Boston that span metropolitan areas. These community networks provide broadband access at a lower cost than charged by traditional service providers. Fixed wireless may also be expected to be an important part of needed public networks within the Region.

The dynamic nature of wireless communications in its fixed and mobile manifestations requires direction from a public planning effort if the full potential of such telecommunications facilities and services is to be achieved. The efforts of county and local units of government within the Region to cope with the wireless infrastructure demands of competing service providers would greatly benefit from a coordinated, areawide approach through the preparation of a regional plan.

SUMMARY

The telecommunications industry nationally and within the Region is in a state of transition from a regulated monopoly to a competitive free market environment. Forces unleashed by rapidly advancing technology coupled with the deregulation resulting from the Federal Telecommunications Act of 1996 have created over capacity in the existing network and a depressed market in the industry. The breakup of the Bell System has also fragmented the original national and regional telephone network into a "network of networks," in which no public agency or private organization is fully cognizant of the state of the system or the direction in which it is moving. A need exists for a governmental planning agency, such as the Regional Planning Commission, to determine the status of the current system, ascertain the telecommunication needs of the Region, and develop an on-going planning process to satisfy those needs.

Accordingly, seven factors contribute to the need for the preparation of a telecommunications system plan for the Region at this time:

1. The lack of comprehensive information on the state of telecommunications in the Region;
2. The increasing need for advanced telecommunication networks to support the economic development of the Region;
3. The need to address the provision of adequate broadband telecommunication service within the Region;

4. The need to address differences in the provision of adequate telecommunication services in rural and other underserved areas of the Region;

5. The need to develop special purpose public telecommunications networks within the Region for applications such as telemedicine, public safety, transportation, environmental monitoring, and education;

6. The need to assist local units of government in telecommunications network development; and

7. The need to develop a well-conceived antenna siting and related infrastructure plan for wireless communications in the Region.

Chapter IV

MAJOR ELEMENTS OF A REGIONAL TELECOMMUNICATIONS PLANNING PROGRAM

INTRODUCTION

This chapter sets forth the major work elements of a proposed regional telecommunications planning program for the Southeastern Wisconsin Region. The chapter is intended to establish the general scope and content of a planning program required to produce a telecommunications system plan for the Southeastern Wisconsin Region. The major elements of the planning program are presented in sufficient detail to permit the development of cost estimates for budgeting purposes; to establish a practical time sequence and schedule for the work; and to recommend an organizational structure for the conduct of the work.

The scope and content of the proposed planning program are based upon the following assumptions:

1. The primary purpose of the planning program will be the development of a technically sound and practical plan to guide the evolution of telecommunication facilities and services, and to specify the infrastructure framework needed for new wireless and wireline communication services. The planning program would also coordinate the development of telecommunication networks within the Region with the development envisioned in the adopted regional land use plan.

2. The telecommunications system plan produced by the program should be in sufficient detail to provide a sound basis for implementation by regional wireline and wireless service providers. To this end, the plan should recommend regional area core network requirements along with the regionwide access networks to provide needed broadband services to all governmental, business, and institutional organizations, as well as to residences within the Region. In the case of terrestrial wireless networks, the plan should specify preferred antenna sites and related supporting infrastructure locations consistent with land use and environmental as well as communication needs. The plan should recommend any needed revisions to the present telecommunications infrastructure, particularly for mobile and fixed wireless communications.

3. The plan should specifically address the need for a system to monitor the quality of service provided by all telecommunication networks within the Region. The need for such a monitoring system is in recognition of the complex “network of networks” characteristic of free market telecommunications and the attendant difficulties in detecting and correcting service quality problems.

4. The plan should evaluate the advantages and disadvantages of the available broadband communications technologies for network access service within the urban, suburban, and rural areas of the Region. These technologies include, but are not limited to: twisted pair wireline

enhancements—xDSL; coaxial cable enhancements—cable modems; mobile terrestrial wireless, fixed terrestrial wireless, satellite wireless, and optical fiber cable—to the neighborhood (FTTN) and to the home (FTTH). The former would require wireless connection from individual structures to an antenna linked to a core optical fiber cable. The latter would bring optical fiber cable into individual structures. Cable modems and xDSL are the predominant short-term broadband technologies. These technologies, however, may be expected to be replaced within the next five to seven years by fixed terrestrial wireless and optical fiber cable which have much higher transmission rate potentials. The recommended plan should seek to determine the most cost-effective combination of these technologies for the various urban, suburban, and rural areas of the Region.

5. Special consideration in the plan should be devoted to the need for, and provision of, public telecommunication networks in the areas of: public administration, public safety and security, telemedicine, transportation, environmental, and education. Such networks typically require public investment on a regional scale and their development can be facilitated through comprehensive regional planning.

6. More detailed planning is required for terrestrial wireless communication networks in order to identify the most cost effective and implementable antennae site configuration within the Region. Such detailed planning efforts should include:

    a. A recommended set of antenna sites for both mobile and fixed wireless communication networks for the range of licensed and unlicensed frequency bands;

    b. A reconciliation of the needs of the various wireless generational technologies (1G, 2G, 2.5G, 3G, 4G);

    c. Consideration of the role of fixed wireless technologies in providing general broadband services and public networks;

    d. The preparation of a model antenna site location ordinance as part of a telecommunications planning guide for local units of government within the Region.

7. The task of preparing, adopting, and implementing a regional telecommunications system plan will require close and continuing coordination among communications service providers, the Wisconsin Public Service Commission (PSC), business and institutional enterprises, and the various levels, units, and agencies of government concerned. Toward this end, the plan should address the regulatory and economic, as well as technical, issues involved in plan implementation.

8. Full use will be made of all existing information on the current telecommunications infrastructure of the Region. Such information will include surveys, studies, reports, and other data from private service providers as well as State and Federal regulatory agencies. Additional data collection activity will be considered only as necessary to develop data essential to plan preparation not available in existing databanks. Provision should be made for continual updating of the data as part of a regional network monitoring system.

9. Current state-of-the-art techniques will be used in the preparation of the regional telecommunication plan. Such techniques will be particularly important in the development of the regional network monitoring system and in the preparation of the regional wireless antenna site and supporting infrastructure plan elements.

10. Providers will support the inventory data collection phase of the telecommunications planning process by providing information on network infrastructure.

STUDY DESIGN

The pioneering nature of the proposed regional telecommunications planning program requires that the study design include the preparation of a series of detailed staff memoranda setting forth the methods and procedures to be followed in accomplishing certain elements of the planning process. While the methods and procedures for some of the work elements will be adequately described in this prospectus, others, because of their complex technical nature, must be described in more detail in study design memoranda.

The work elements that will require the preparation of technical study design memoranda include at least the following:

1. **Current Infrastructure Inventory**
   The scope and content of a comprehensive inventory of the existing telecommunications infrastructure within the Region will need to be specified, together with the means for conducting the inventory and organizing and presenting the findings. The memorandum should specify in detail the data to be collected, the means to be used for collection, and the attendant analyses to be made of the collected data. The memorandum should also address how security would be maintained for sensitive data.

2. **Network Monitoring System Design**
   While network monitoring systems are commonly employed in both enterprise and service provider networks, the adaptation of such systems to a public monitoring effort represents a new endeavor. A preliminary description of a proposed monitoring system, together with a design methodology, will be featured in this technical memorandum.

3. **Telecommunication Services Forecasting**
   A memorandum providing background information on telecommunication services forecasting and analysis, and setting forth a proposed procedure for such forecasting and analysis of existing and probable future spatial demand, will be necessary. Special attention will need to be given in the memorandum to public networks.

4. **Wireless Network System Design**
   Special wireless network simulation models will have to be employed in antenna site and infrastructure planning. The complexity of these models necessitates a memorandum describing the models and the proposed use of the models in the planning effort.

5. **Regional Network Design**
   This major program work element seeks to formulate a comprehensive integrated Regional telecommunications network. The complexity of the design process s involved necessitates a memorandum describing the process in detail.

6. **Public Networks**
   A memorandum describing the characteristics and attendant requirements of the various possible public networks will be required to assist in the planning process.

These technical memoranda would augment the contents of this prospectus, and help to provide a sound technical basis for the conduct of a regional telecommunications planning program.

FORMULATION OF OBJECTIVES AND STANDARDS

The formulation of a set of telecommunication system service objectives is an essential task which will have to be accomplished before alternative plans can be prepared and a recommended plan selected. The objectives must be related in a demonstrable way to alternative regional telecommunications plans and related system development proposals through a set of quantifiable standards. Only if the objectives are clearly related through the standards to telecommunication service quality and development, and subject to objective test, can a choice be made from among alternative plans in order to select that plan which best meets the agreed-upon objectives.

In scope, the telecommunications plan and system development objectives and standards may be expected to range from general objectives relating to the growth of the regional economy to detailed standards related to the types and quality of service to be provided in urban, suburban, and rural areas of the Region.

Formulation of the necessary objectives and standards will have to be preceded by appropriate studies. The objectives and standards should reflect good current planning and engineering practice and be consistent with published standards in the telecommunications industry.

INVENTORY

Introduction

Security and competitive disclosure concerns of wireline and wireless service providers necessitate a modification of the typical infrastructure inventory conducted under regional planning programs. Traditionally, the first step in public works planning is the conduct of a detailed inventory of the existing infrastructure facilities of interest and of the current quality of service or performance of these facilities. Examples would include a detailed inventory of the existing arterial street and highway network or of the sanitary sewerage system. Because the current regional telecommunications system is really a "network of networks," with each network owned and operated by competing service providers, there is an understandable reluctance on the part of each service provider to reveal the network infrastructure to the other competitive providers. This reluctance is compounded by security issues resulting from the terrorist threat following the September 11, 2001, tragedies. Accordingly, and in deference to the preferences of service providers and the current competitive market environment, the inventory data to be collected under the proposed regional telecommunications planning program will be limited under each of the following four categories:

1. Facility Provider Inventory
2. Circuit Provider Inventory
3. Service Provider Inventory
4. Public Domain Data

The facility provider inventory will focus on the fiber optic cable network and collect information on points of presence (POPs), transmission specifications, interface capabilities, and approximate capacity and routing of the cables. The circuit facility provider inventory will be limited to a list of buildings with current entrance facilities and capabilities. The service provider inventory will be generally limited to description of service areas on a geographic basis. A notable exception, however, would be business dial and business Internet service providers who would be asked to provide data on points of presence access for business user connections. The conduct of these three inventories will require the cooperation of the service providers.

The fourth category of inventory data will relate to network information currently in the public domain and, therefore, readily available from public or private sources. Examples would include:

1. Data available from the U.S. Federal Communications Commission (FCC);
2. Data available from the Public Service Commission of Wisconsin;
3. Antenna site location data available from private databanks; and
4. Antenna site characteristics available from private databanks.

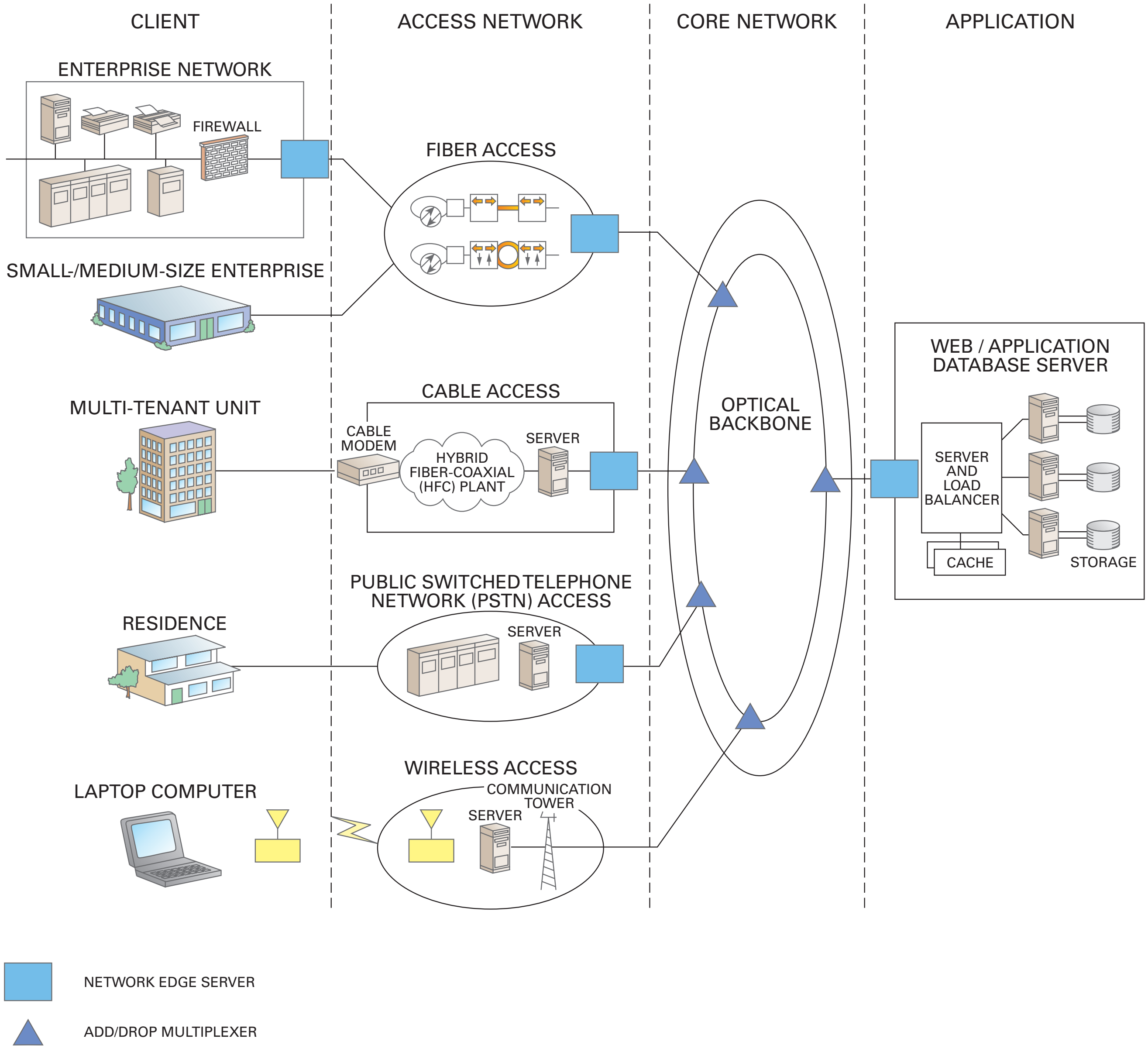
The acquisition of definitive knowledge of the current infrastructure will still represent the first step in the telecommunications planning process. Although the telecommunications network infrastructure information to be collected will be limited for the reasons already noted, the limitations need not fundamentally interfere with a sound regional telecommunications planning process. An inventory of the existing infrastructure and service areas coupled with information on the quality of service provided by the various regional networks must still provide the foundation for the preparation of alternative regional telecommunications plans, and the selection of a recommended plan from among those alternatives.

Wireline communication networks are made up of a collection of nodes and interconnecting links. The nodes are typically switching-routing centers for either circuit or packet-switched networks. The links currently consist of either coaxial copper cable or fiber optic cable lines. Wireless network infrastructure features a set of base station antenna sites connected to a base station controller, which is, in turn, connected to a mobile switching center. The mobile switching center then connects to the landline public—common carrier—switched telephone network.

An idealized illustration of the emerging Regional telecommunications network is shown in Figure 1. The various classes of end users or clients are shown on the left side of the diagram. These end users connect to the core network through various access networks as shown. All of the access networks link to the core network, which is also called an optical backbone. There are, in fact, a number of "core networks" within the Region. The core network in the diagram represents a virtual composite of the multiple Regional core networks. On the right side of the diagram are application providers, such as ISPs that serve as intermediaries directing Internet traffic along the path to the appropriate destination.

Figure 1

THE EMERGING TELECOMMUNICATIONS NETWORK



Source: Bell Labs and SEWRPC.

The network service quality inventory will be limited to end user measurements of quality of service expressed in such measures as transmission rates and file transfer times. This quality of service inventory will be carried out by a network monitoring system which will provide measurement of network service quality on a continuing basis. The dynamic nature and changing patterns of telecommunication networks require such a monitoring system to maintain and expand the level and quality of telecommunications services.

Wireline Service Provider Network Infrastructure Inventory

The infrastructure of the set of networks operated by the wireline service providers may be generally classified as follows: circuit-switched networks; packet-switched networks; cable and satellite networks, including cable telephony and cable modem service; and the Internet. Although the wireline service provider network infrastructure inventory elements are presented below by type of network, each element of the inventory reflects, as noted below, one or more of the four inventory categories set forth above.

Circuit-Switched Networks

Circuit-switched networks provide traditional voice and data services over a connected circuit. Designated as "plain old telephone service" (POTS), these were the sole telecommunications networks prior to the invention of packet switching in the 1970s. Such networks consist of a set of central office switching centers connected to subscribers by twisted wire pair local loops. These central offices are also connected to other higher level central offices in the Local Access and Transport Area (LATA) through coaxial copper or fiber optic cables. Interexchange carriers connect LATA networks to national and international networks also through either copper or fiber optic cable.

The following data will be required for the circuit-switched network inventory:

1. Residential dial coverage and capabilities on a detailed geographic basis (service provider);

2. Business and organizational dial capabilities and point of presence (service provider);

3. Central office (CO) locations (Public Service Commission of Wisconsin) (public domain data); and

4. Building locations and capabilities (circuit provider).

Most of these data will have to be provided by the service providers themselves with supplemental information from public (FCC and WIPSC) and private databanks as required.

Packet-Switched Networks

Packet-switched networks are used primarily for data transmission, although broadband versions also carry video and other multimedia. Voice transmission of good quality can also be carried over Asynchronus Transfer Mode (ATM) packet networks. There are two types of packet-switched networks: dedicated circuit packets and datagram packets. Dedicated circuit packet networks are characteristic of protocols such as ATM, while datagram packets are used primarily on the Internet.

The following data will be required for packet-switched networks:

1. Facility Providers
   a. Points of Presence
   b. Interface capabilities
   c. Approximate link routing
   d. Capabilities
   e. Approximate capacity

2. Circuit Providers
   a. Building locations
   b. Capabilities
   c. DSL by central office availability and capability as wholesale provider

3. Service Providers
   a. Digital broadband cable by coverage and capabilities
   b. DSL by central office availability and capability as retail provider

Again, most of these data will have to be provided by the service providers with supplementary information from public and private databanks.

Cable Networks and Satellite Networks

Cable networks, like cellular and personal communication system (PCS) wireless networks, are access networks. Cable networks collect and transmit voice-data-video information from subscribers into the core circuit-switched or packet-switched networks. Cable networks do not comprise an independent, comprehensive telecommunications network on either a regional or national level. Cable access networks have become important alternatives both for voice telephony and broadband data and multimedia services. Cable networks have the advantage of integrated service for broadcast television, voice telephony, and broadband data transmission, all with one cable connection. For this reason, cable networks form an important segment of the inventory. While the PSC has no jurisdiction over cable networks, the FCC and local units of government do have jurisdiction.

Cable networks are networks that fan out in a tree-like architecture, from national trunk lines to neighborhoods and to certain commercial establishments located throughout urban, and some rural, areas. Although originally designed for one-way broadcast communications, many of these networks have now been converted using a hybrid coax-fiber optic cable (HFC) architecture to two-way networks providing both voice telephony and broadband multimedia services. The extensive coverage of these networks precludes any attempt at a comprehensive link-by-link network mapping. Rather, cable networks will be addressed primarily as data sources for and as core networks. For this reason, inventory data requirements for cable networks will be limited to the following: coverage areas by cable telephony services and by high-speed Internet access services; and access points to the core networks by circuit-switched network for cable telephony, and by packet-switched network for high-speed Internet access services.

Satellite networks will be inventoried with respect to the general availability and types of services provided. The services will be monitored for quality, as detailed later in this chapter.

The Internet

The Internet is not a network in the same physical sense as are the telephone networks. The Internet is a higher level layer—network layer and transport layer—network utilizing other lower level physical and link layer networks to send packets of data, voice, or multimedia. The Internet is, basically, a non-physical network utilizing a multitude of physical facilities. As a nonphysical network, it has no network infrastructure in the normal sense of the term. It does have a partial infrastructure in the form of Internet Service Providers (ISPs). ISPs receive messages from computer users, check them for valid addressing, and then multiplex them onto a high speed data link connected to a point-of-presence in the core network. ISPs also provide special services such as Email, World Wide Web, and Instant Messaging.

The Internet infrastructure inventory would collect for each Internet service provider the following data:

1. Residential Internet
   a. Geographic coverage by local calling area; and
   b. Type of access
      i. Dial up
      ii. Broadband

2. Business Internet
   a. Point of presence locations, and capabilities

Wireless Network Infrastructure

Wireless communication infrastructure functions as a major source for voice traffic and a potential source for data and video traffic. As an access network, the wireless network infrastructure consists of a set of antenna sites and their associated base station controllers and mobile switching centers. The mobile switching center is the point of entry into the public switched telephone network (PSTN). For some of the regional wireless service providers, this switching center may not even be located within the Region. In addition to its general utility as a basis for regional telecommunications planning, the wireless infrastructure inventory is also intended to serve as the foundation for a detailed wireless antenna site and related infrastructure study. While the antenna study will require more information than would be appropriate for a more limited planning inventory, the antenna study infrastructure database can be aggregated to the needs of the planning inventory. Because of the dual purpose of this inventory, it falls under both the facility and service provider inventories categories.

The following inventory data will be required for the wireless network infrastructure: current antenna site locations by geographic coordinates by class as mobile or fixed, by frequency, and by type as cellular, Personal Communication System (PCS), Microwave Multi-point Distribution System (MMDS); base-station controller site locations by geographic coordinates; class as mobile or fixed, by frequency, and by type as cellular, PCS, MMDS; and mobile switching center locations by geographic coordinates, by class as mobile or fixed, by frequency, and by type as cellular, PCS, or MMDS. Antenna heights and topographic elevations are also key data required for the proposed antenna site study.

The antenna site data required should be available from the Wireless Application Corporation of Bellevue, Washington; and would include all existing wireless antenna sites and the application data of the site owner. It will not detail other wireless users of each site. Such data may be available from the local units of government concerned.

Enterprise Network Infrastructure

To the extent that enterprise networks reach beyond individual buildings, the enterprise network infrastructure should be included in the regional telecommunication inventory under the facility provider category. No attempt will be made to cover Local

Area Networks (LANs) confined to one building or a small campus. Enterprise networks embrace institutional as well as business organizations. Examples of institutional networks include academic institutions, churches, and nonprofit organizations, such as the American Automobile Association (AAA). The inventory of such networks is important in that these networks are major sources of traffic for the Regional core network.

Enterprise networks, to the extent that they use regional core networks to transport voice, data, or multimedia, comprise yet another set of access networks. Therefore, the enterprise networks can, for inventory purposes, be treated in the same way as the cable networks, except that coverage areas are not relevant. The access points to the core networks, however, are important items of information. If there are no access points—points of presence—within the Region, then the enterprise network will not be inventoried. If there are access points, then incoming cable information at each access point should include: cable type as coaxial or fiber optic, and cable capacity as T/DS level or OC level.

Public Networks

The inventory data required for physical wireline networks will be the same as for the private wireline networks. The Milwaukee CSWAN and WisDOT fiber networks with their potential for public network backbone application will be inventoried as facility providers in the context previously presented. Public networks based primarily on leased line facilities, such as the Badger Net, will be inventoried as service providers.

The inventory data required for the wireless networks, such as for the "800 Trunk" networks, will be the same as for the private service provider wireless networks.

A particularly interesting public core network is the Touch America fiber optic cable network located along the primary interstate highway corridor (IH 94) in the State. This 400 mile network stretches from the Minnesota border through Madison and Milwaukee to the Illinois border near Kenosha. It provides 36 strands of fiber in the conduit cable. The network was installed by Touch America, Inc., an outgrowth of the Montana Power Company, headquartered in Butte, Montana. This broadband facility was constructed under an agreement between Touch America, Inc., and the Wisconsin Department of Transportation WisDOT). In return for permitting the use of freeway rights-of-way, WisDOT may utilize its portion of the network for State governmental purposes. Such a facility, particularly in combination with the Milwaukee CSWAN network, offers a potentially powerful core net for public networks in Southeastern Wisconsin. Public network applications that could benefit from use of Touch America and CSWAN networks include Intelligent Transportation Systems (ITS) networks providing system-based ramp metering control and vehicular routing; telemedical and educational networks. In conjunction with fixed wireless access networks, Touch America and CSWAN could serve as core networks for home healthcare and educational networks.

Broadcast Networks

No attempt will be made to inventory radio or television broadcast networks in the Region. The only aspect of broadcast networks proposed for consideration in the planning program relates to broadcasting as a traffic source on existing and future telecommunication networks. It is now possible to listen to radio programs through the Internet. Broadband connections allow for television broadcasts over the Internet. While the real-time quality of service of these programs is still not up to terrestrial, cable, or satellite standards, these quality differences may be expected to disappear over time, so that broadcasting will emerge as another traffic source on the Internet. Such a transformation could have major traffic load implications for the Internet in the Region. Such traffic implications, however, have little or nothing to do with the current broadcast infrastructure whether terrestrial, cable, or satellite. The implications of future broadcast traffic are best considered under the network traffic and quality of service inventory.

Antenna Site Sharing with Broadcast Networks

Broadcast networks also interact with telecommunications networks in the area of antenna site sharing. Some broadcast providers permit utilization of their antenna sites by wireless telecommunication providers. A review of nationwide data available for Wireless Applications Corp. of Bellevue, Washington, indicates that such site sharing can be particularly useful in high density urban areas. In such areas, the number of shared broadcast sites may comprise a small percentage of total wireless antennae sites, but the shared sites can be of critical importance in achieving public acceptance of antennae locations.

Monitoring
In deference to the security and competitive secrecy concerns of the service providers, network traffic would not be inventoried. Similarly, the security—that is, vulnerability—monitoring of the network would not be inventoried. The quality of service inventory and the network monitoring system are, in effect, identical since end user performance monitoring represents the most efficient and objective method of collecting service quality data.

In the absence of a network traffic inventory, the ability of the monitoring system to provide data for the development of a source-destination traffic matrix is eliminated. Such a traffic matrix is vital to the spatial forecasting function of the forecasting stage of regional telecommunications planning. This deficiency, however, can be overcome with the cooperation of service providers, since the databases of these providers contain all of the information needed to develop such a traffic matrix. The data provided would be in the form of a normalized matrix detailing the relative amounts of traffic between various categories of land uses together with the aggregate call volumes concerned.

In telecommunications, network monitoring is considered an important component of a more encompassing function-network management. Network management, according to the International Standards Organization/Fault-Configuration-Accounting-Performance-Security Management (ISO/FCAPS) model, is defined to include the following functions: fault management; configuration management; accounting management; performance management; and security.

Four of these five functions are of interest only to organizations that develop and operate networks such as service providers and enterprise network operators. One of these functions—performance management—is, however, of direct interest to a broader audience and ideally would be addressed in a regional telecommunication planning program. The major purpose of regional telecommunications planning is to ensure the availability of a communications network that satisfies the socioeconomic needs of the planning area. Performance monitoring provides a measure of the quality of service provided by an existing telecommunications network.

Network monitoring may be accomplished utilizing the standard Simple Network Monitoring Protocol (SNMP). An SNMP-based monitoring system has two primary components: a management station and agents. The management station may consist of either a desktop or laptop computer (PC) equipped with network monitoring software. Agents, as managed objects, include infrastructure equipment such as switches, routers, servers, and desktop or laptop computers used to collect data. Agents also include software applications such as Lotus Notes or Microsoft Mail. Therefore, an agent, as a managed object, is not necessarily a piece of hardware but rather a network function. The data collected by an SNMP-based monitoring system is defined in a Management Information Base (MIB). This MIB varies with each agent depending on the function involved.

Among the important network parameters that can be monitored include:

1. Availability
   - dial tone vs. busy signal
   - dropped calls on a wireless network
   - dead zones on a wireless network

2. Response Time
   - turnaround time on a data message

3. Throughput
   - transmission rates on a data network
   - download/upload time for a standard file on a data or multimedia file on a data network

4. Accuracy
   - voice quality on a circuit-switched or packet-switched network
   - uncorrected error rate on a data/multimedia network

Because the specifications for a public telecommunication monitoring system will differ somewhat from that of an individual service provider or enterprise network monitoring system, it is unlikely that the system software can be purchased as a total integrated package. Rather, it is more likely that individual components of the system—hardware as well as software—may be purchased, while other components must be developed internally. The system would be developed using the SNMP. Since SNMP is Internet oriented, some adaptation may be necessary for other packet network structures such as ATM and Frame Relay. Separate measures, procedures, and software will also be required for circuit-switched networks both wireline and wireless. Since circuit-switched wireline service quality is generally quite high, monitoring emphasis would be on wireless service quality.

Traditional network monitoring emphasizes packet transmission quality measures, such as access response time, connection transmission rate, and file transfer download time. Circuit-switched measures will need to be specified, such as blocked calls (busy signal), and for wireless: noisy line, dropped calls, and no coverage (dead) zones.

Complete network coverage would also entail service quality monitoring of cable access networks and satellite access networks. Such monitoring would be facilitated by the fact that both of these networks are accessible through the PSTN. Cable network monitoring could be carried out at two primary locations in the cable network: at end user location to determine quality of service; or at POP access points.

Network Monitoring System Design

Since the quality-of-service inventory is based on network monitoring, the design and operation of such a monitoring system becomes an integral part of the inventory work element. Although this system design requires knowledge of network technology and operating procedures, it differs from the network designs that are part of the primary planning process in that it does not affect the basic network infrastructure.

The network monitoring system design should represent an integration of software modules to perform the following two functions: quality-of-service monitoring at wireless subscriber locations, and such monitoring at wireline subscriber locations.

Quality of service monitoring is a reasonably straightforward function to implement. A number of remote agents are selected for monitoring by the central management station. These agents, as previously indicated, may be hardware devices, such as a personal computer or an application, such as a file transfer. The variable of interest, such as file download time, will be defined in the remote MIB. The central management station retrieves a particular parameter, such as file download time using a "get" operation under the SNMP protocol. The agent then responds to the management station with a transmission of the requested parameter back to the management station. To retrieve all of the data, the management station employs a "get-next" operation. Other SNMP operations allow for setting the value of a variable at an agent—"set a trap"—so that an agent can inform the management station of an important event, such as an equipment failure. Traps are typically employed in the network fault management function rather than in performance monitoring, so they would find little use in a regional network monitoring system.

It is important to understand that SNMP and its various operations only establish the framework for network monitoring. Specific computer programs written in a language such as C or Visual Basic are required to activate a network monitoring system. Some of the utility programs for SNMP application are available at no cost as downloads from the Internet. Others are offered as commercial products. Program code specific to the regional monitoring system, however, must be developed internally.

Quality of service monitoring would be carried out by a network management station (NMS) located at the Regional Planning Commission offices in conjunction with an estimated 200 remote agents. These agents are proposed to be sampled on different dates over a period of six months. The remote agents would be either desktop computers of selected public agencies or private organizations or portable laptop computers supplied by the Regional Planning Commission. The only requirement for these computers would be that they support the SNMP protocol. Most Windows-based desktop computers support SNMP. Remote site desktop computers would be selected based on such SNMP support. Laptop computers used by Commission personnel would include SNMP support and an IEEE 802.11 (WiFi) connection. This WiFi capability would allow for wireless broadband connection at sites supporting WiFi communications.

Remote sites for wireline data transmission monitoring would be selected by the following site categories:

1. Dial-up telephone sites;
2. T1 line or faster direct line sites;
3. xDSL sites; and
4. Cable modem sites

Site measurements would be performed at multiple sites in each of the seven counties, including both rural as well as urban areas. Measurements would also be carried out during known overload periods to determine the degree of degradation during these periods. For dial-up sites, measurements would be made to include different ISPs to determine the effect of ISP service capabilities on overall network performance. The total number of site measurements would be determined by a statistically-sound experimental design. Preliminary estimates indicate the need for about 200 initial site measurements distributed throughout the Region and among the aforelisted four site categories.

The quality of service measurements would include:

1. Availability
   - for "dial-up" sites

2. Throughput
   - connection speed (transmission rate)
   - download time for 5 MB file

Security Monitoring
As previously stated, a security monitoring function is not proposed as a part of the planning effort.

Regulatory Inventory
Federal communications laws and regulations have a major impact on infrastructure development in telecommunications. The current "networks of networks" is a major byproduct of the Federal Telecommunications Act of 1996. This act facilitated and encouraged competition at the local level. The regional telecommunications planning process must be aware of the changing regulatory environment at the Federal, State and local levels. This regulatory environment results not only from Federal and State statutes, but also from the numerous rulings of the FCC and the PSC. As this prospectus was being prepared, a major FCC ruling drastically altered the UNE access rights of CLECs in the Region. This ruling of February 20, 2003, essentially maintained the rights of low cost UNE access for narrowband circuit-switched voice telephony and reduced it for Digital Subscriber Line (xDSL) and other broadband services. Such a ruling should encourage incumbent local exchange carrier companies—such as the former Bell System companies—to invest in facilities needed to provide advanced broadband packet-switched services. While State and local regulations have generally less impact than Federal regulations, local units of government can have a major influence on the location of wireless antenna sites and related infrastructure. Local governments also have right-of-way jurisdiction, important in the deployment of wireline cable infrastructure. The regional telecommunications planning process must be accompanied by a cognizance of applicable Federal, State, and local regulations that influence the development and operation of the regional telecommunications system.

An inventory and analysis of the legal framework governing the planning and development of telecommunication facilities will be required. The wide range of complexity of governmental regulation of telecommunications in the United States, particularly at the Federal level, however, will require that the inventory and analysis be focused on those aspects of regulation that may be expected to directly impact the regional telecommunication planning and development processes. Accordingly, the inventory should include, at a minimum, the statutes, administrative rulings, and case law relating to the location of wireless antenna sites, the provision of satellite service facilities, and the regulations affecting the laying of coaxial or fiber optic cable and the construction of related facilities in and along local, county, and State streets and highways and other public rights-of-way and lands. The inventory and analysis should identify any Federal or State regulations that may serve to discourage private investment telecommunications facilities that may be required to implement a regional telecommunications network plan. It is anticipated that a competent law firm would be retained to conduct the required inventory and analysis.

A summary of the inventory element of the proposed planning process is provided in Table 2.

ANALYSES AND FORECASTS

Inventories provide factual information about historic and current situations. Analyses and forecasts prepared utilizing inventory information are necessary to provide estimates of future needs. With respect to telecommunications, these future needs must be determined from a combination of demographic, economic, technological, and regulatory forecasts. Telecommunication differs from other regional infrastructures such as transportation and sanitary sewerage and water supply in its rapidly changing technology. In the last two decades, the life cycle of most telecommunications technologies has been about five to seven years. In wireless communications, the fourth generation (4G) of technology is in development before the third generation (3G) has been put in place.

Table 2

SUMMARY OF PROPOSED REGIONAL TELECOMMUNICATIONS INVENTORY

Network Types	Provider Types			Public Domain
	Facility	Circuit	Service	
Circuit-switched	- -	Building locations Capabilities	Residential Coverage Capabilities Business Points of presence Capabilities	Central office locations
Packet-switched	Points of presence Interface Link routing Capabilities Approximate capacity	Building locations Capabilities Digital subscriber line by central office	Digital cable Coverage Capabilities Digital subscriber line coverage	- -
Cable	Points of presence Interface Link routing Capabilities Approximate capacity	- -	Internet coverage Telephony coverage Access points	- -
Satellite wireless	- -	- -	Internet coverage	- -
Internet	- -	- -	Residential Coverage Dial-up Broadband Business Capabilities Points of presence	- -
Terrestrial wireless	- -	- -	- -	Antenna sites Locations, heights Mobile or fixed Frequency Type
Enterprise	- -	- -	Internet coverage Telephony coverage Access points	- -
Public	Network diagrams	- -	- -	- -
Broadcast	- -	- -	Access points Digital cable	- -

Source: SEWRPC.

The Internet has had a dramatic effect on all aspects of telecommunications in the United States and worldwide. For this reason, analysis of technological trends will play a major role in determining future telecommunication needs within the Region. At the same time, there are aggregate trends in the needs for voice, data, and multimedia communications. While voice communications once dominated the telecommunications networks, data transmission now accounts for over 80 percent of all network traffic, and network growth is dominated by data and multimedia traffic. It may be possible to correlate network traffic generation with land use allowing for the determination of future needs on a spatial basis throughout the Region. Estimates of future telecommunications needs will then depend on trend analysis of voice, data, and multimedia traffic modified by analyses of advancing telecommunications technology. Technological changes may be expected to be manifested in the form of a series of "modal splits" between wireline versus wireless services, and telnet versus Internet networks.

Aggregate Telecommunications Forecasting

A significant collection of databases exists recording historical trends in voice, data, and multimedia communications. Government agencies such as the FCC and the PSC of Wisconsin publish voluminous reports replete with data summaries recording past operations. These reports are supplemented by reports published by trade associations such as the Telecommunications Industry Associations (TIA). An example of such reporting is the UNE Fact Report 2002 previously referenced, which contains extensive data on telecommunications media operations.

Analyses of these data are facilitated by extensive software offerings in forecasting and estimation techniques. These techniques allow for nonlinear as well as linear extrapolation of current trends, so that aggregate telecommunications forecasting at either the national or regional level should not be difficult.

Spatial Telecommunications Forecasting

Forecasting future telecommunications traffic on a spatial basis will require correlating telecommunications traffic data with land use data. Voice, data, and multimedia traffic data will be correlated to land use areas, and regression formulas developed. These formulas will all include a growth factor parameter based on the aggregate media forecasts that will scale the spatial forecast depending on the target year. Generating future traffic forecasts by geographic areas, utilizing planned land use data, will, in conjunction with the source-destination traffic matrix, allow for simulated loading of alternative future telecommunications networks. These forecasts will form a critical input to the Regional telecommunications planning process.

Modal Splits in Telecommunications Forecasting

Advances in telecommunications technology require forecasts allocating future voice, data, and multimedia traffic between the various telecommunications technologies. These allocations may be termed as "modal splits" in parallel with a concept derived from transportation planning where the forecast future personal travel demand is allocated between the automobile and transit modes of travel. Modal splits in telecommunication are more complex since there are multiple technologies competing for various media services. A major modal split example relates to voice traffic—still the primary revenue source in the telecommunications industry. One form of modal split to be considered involves the relative volumes of wireline versus wireless services. This competition represents competition at the access network level since both utilize the same circuit-switched network. Nonetheless, this modal split has major implications for design of a regional telecommunications system. Another form of modal split to be considered involves all forms of communications media and the split between the public-switched telephone network (PSTN or Telnet) and the Internet. This split also has major implications for the design of a regional telecommunications system. Yet another form of modal split concerns the core network primarily and involves a technology emerging from local area computer networks—the Ethernet. The low infrastructure costs and very high transmission rates of the Ethernet portend eventual replacement of the current core network with Ethernet-based technology. These three forms of modal splits will each be incorporated into the forecasts prepared for use in the planning effort.

Wireline-Wireless Modal Split

An important aspect of telecommunications traffic forecasting relates to the wireline-wireless modal split. In the year 1996, wireline voice traffic was about three times the level of wireless voice traffic. In the year 2003, the modal split is estimated to be about equal, and wireless voice traffic may be expected to exceed wireline traffic in the near future. Forecasting this modal split will be important not only in consideration of any future wireless and wireline access infrastructure, but also as consideration of Regional core networks, since some of the wireless voice traffic bypasses the Regional core network and directly enters the Chicago area core network. Forecasts of this modal split will require in-depth analysis of both the technical and market forces involved. Simple extrapolation of statistical trends may be expected to lead to projecting the complete disappearance of wireline access voice traffic. Such disappearance is unlikely, but estimating the future residual market share of wireline voice traffic will represent an important challenge.

Internet and Ethernet Modal Split

Forecast of telecommunication traffic for future networks also requires an estimation of two more modal splits: telnet versus Internet, and telnet versus Ethernet. In this respect, it is important to understand that the Internet is not a physical layer system. Rather, the Internet operates as a "network of networks" to transfer data between computers located all over the world. In operation, the Internet uses a variety of physical facilities to transmit its packet messages. The heart of the Internet is the transport control protocol-Internet protocol (TCP/IP), which operates at Layers 3 and 4 of the Open System Interconnection (OSI) Reference Model. Layer 3 consists of the network level routing packets, and Layer 4 consists of the transport layer end-to-end message control. Internet traffic is directed by ISPs that route messages from users to the proper destination.

Although the Internet is not a physical network, a modal split related to it will be required for network control and revenue purposes. Internet data traffic partially bypasses the public telephone network. With a dialup service, the user must use PSTN facilities to reach the ISP. From there on, however, the switching network of the PSTN is irrelevant since the message is routed through a series of networks until it reaches its destination. In broadband service, particularly with cable service, the PSTN may be bypassed completely even in its initial origin and final destination.

Until now, the Internet has carried almost exclusively data traffic with a growing portion of multimedia traffic—such as graphics, sound, images, and video. Despite rapid growth in Internet data traffic, the PSTN has also experienced rapid non-Internet data growth mostly from enterprise networks. Voice traffic over the Internet, or Voice Over Internet Protocol, (VoIP) has not yet been an issue because of quality problems. In the future, however, the Internet may be expected to be useful to transmit all forms of media, including voice traffic, which is the "cash cow" of the incumbent local exchange carrier companies—such as the former Bell System companies and the independent local telephone companies. Loss of voice revenue would have a major financial impact on all utilities that make up the PSTN. To reiterate, technical, market, and regulatory analysis, rather than simple trending, will be necessary in determining the probable range of this modal split in telecommunications forecasting.

The Ethernet protocol operates at Layer 2, the data link layer, of the OSI Reference Model. It controls access to the line and detects and corrects transmission errors. Ethernet originated in small computer networks called Local Area Networks (LANs). It was originally defined under Institute of Electrical and Electronic Engineers (IEEE) Standard 802.3. It has since expanded, however, to higher speeds for application on core networks at speeds as high as 100 gigabits per second. At these speeds, it outperforms other protocols such as the Asynchronus Transfer Mode (ATM), the current dominant telephone company protocol. Moreover, the Ethernet does not require the complex switching and multiplexing equipment of an ATM-based network. Central office equipment is reduced to a simple router and line terminal equipment. With such a cost-performance advantage, Ethernet may be expected to penetrate core network markets. Unlike the wireline-wireless and the Internet modal splits, which emphasize access networks, Ethernet will apply to the Regional core network. Recognition of this reality must be incorporated into the modal split within the Regional core network. Once more, technical, market, and regulatory factors must be considered in this modal split.

Regional Traffic Matrix

Having aggregate network traffic by media class and land use response functions, it will be possible to evaluate the adequacy of the current and proposed future networks to serve these traffic requirements. Modal split ratios will also assist in determining the preferred network paths of various forms of transmission traffic. Required, however, will be a source-destination traffic matrix that designates the destinaion preferences of traffic originating from various land use categories. As previously discussed, data to generate such a matrix is available from service provider records. Also available from such records are data indicating both intra-LATA calls and inter-LATA (long distance) calls. Random sampling studies may be used to estimate such Regional traffic matrices to any desired degree of accuracy.

The normalized Regional Traffic Matrix (RTM), in conjunction with land use traffic generation, provides the input for evaluating the adequacy of current and proposed network systems. These data are then used in a network simulation model system evaluation.

Regional Telecommunications Network Simulation Model

Network simulation models have been employed in regional transportation system planning programs for over 40 years. Such models allow for the evaluation of alternative roadway network plans as part of the system design, test, and evaluation process. These models were developed with Federal and State support over a number of years, often by planning agencies, such as the Regional Planning Commission. Prior to the breakup of the Bell System, the Systems Engineering department of the Bell Telephone Laboratories utilized simulation modeling in the design of telecommunications networks. Unfortunately, these Bell Labs models were oriented toward circuit-switched networks, which form an important, but declining, portion of current-day telecommunications networks.

A number of general purpose simulation modeling software packages are available in the commercial marketplace. One of these software packages, Visual Slam, is particularly well suited to communication network simulation modeling. Developed over a 20 year period by Professor Alan Pritsker of Purdue University, the product is now supported by Frontstep Corporation in West Lafayette, Indiana. The modeling program allows for both discrete and continuous simulation and allows for user program inputs using Visual Basic or C languages to reflect network management algorithms. Employing the Visual Slam Simulation model, it will be possible to evaluate Regional telecommunications networks at varying levels of detail. Simulation modeling may be used to investigate both incremental changes in current networks and to evaluate future network designs.

PLAN DESIGN, TEST, AND EVALUATION

Three types of network design plans are recommended as parts of the proposed Regional Telecommunications Planning Program:

1. Wireless Antenna Site
   and Related Infrastructure Design
   - to determine the best set of preferred sites for 3G and 4G cellular wireless systems
   - also includes plans for fixed wireless antenna sites
   - would require site data from Wireless Applications Corp. for seven-county area
   - would utilize EDX Signal Planning Tool Software
   - would require GIS Canopy map data for seven-county area
   - would analyze combinations of new and existing antenna sites for fiber-to-the-neighborhood alternative plan.
2. Special Public Networks - Needs
   Analysis and Network Design
   - needs analysis to determine potential cost-effectiveness of public networks
   - for public administration, telemedicine, education, public safety and security, environmental
   - monitoring and transportation
   - would encompass both logical and physical network design
   - carried out in conjunction with advisory committees of disciplines involved
3. Future Needs-Based
   Telecommunications Network Design
   - involves preparation of a set of alternative plans to meet future Regional telecommunications requirements
   - requires information on the current Regional network infrastructure
   - requires forecasts of future traffic by land use and a Regional traffic matrix
   - will utilize Visual Slam Simulation modeling software to evaluate proposed alternative plans
   - will involve the preparation of alternative plans with emphases on alternative network access technologies and topologies.

Each of these three network design plans differs in form and content. Only the third design, however, represents a comprehensive Regional plan element in the tradition of regional planning. It provides for a set of alternative Regional communication networks designed to serve the forecast telecommunication traffic for the target year of the plan. Such a plan resembles other plan elements prepared by the Commission in transportation, land use, and water quality management. The alternative plans produced would undergo the same testing, evaluation, selection, and adoption process as applied in previous planning programs. Because antenna sites designated in the study may be used in one or more of the regional telecommunications plans, coordination between the planning efforts entailed in each of the three proposed plan elements will be essential.

The other two planning efforts for wireless antenna site location and special public networks represent preliminary engineering-level designs for subsidiary components of a future telecommunications network. The end product of the antenna site design study would be a set of screened sites suitable for incorporation in the network designs of service providers, enterprises, or public networks. This design effort is described first since it is independent of the comprehensive Regional network in that it does not produce or recommend any final wireless network. This siting plan was specifically requested by the original industry advisory panel that reviewed the aforereferenced Commission document on the status of regional telecommunications in Southeastern Wisconsin.

The second category of design, specialized public networks, may produce specific network designs in areas such as transportation, public safety, telemedicine, education, and the environment. These specialized networks should be integrated into the overall Regional network. These networks may require a special equipment infrastructure, or may operate as virtual networks within the framework of existing service provider infrastructure. The end product of these design efforts would be a functional or logical design with implementation dependent on acceptance by the agency or agencies concerned.

Since a number of possible public networks are candidates for development, a needs analysis would be required to screen and rank public networks in terms of potential benefits and costs.

Wireless Antenna Site and Related Infrastructure Design

The primary objective of the wireless infrastructure design plan is to determine a set of preferred antenna sites and the supporting infrastructure for the provision of quality wireless communications within the Region, while recognizing the differing requirements of the various technologies operating or expected to operate within the Region. These sites, to be cost effective, must provide extensive coverage consistent with the network topology involved. Cellular networks supporting mobile subscribers are organized into cellular patterns with the cell dimensions dependent upon the operating frequency, transmitter power, surrounding terrain characteristics, and the potential number of subscribers. Antenna sites for noncellular wireless networks typically serving fixed location subscribers are also influenced by these same parameters, but without the constraints imposed by the cellular patterns.

The plan should minimize the number of sites required to provide the desired quality level of service. Collocation and multi-use of existing sites would be emphasized with a view to minimizing both infrastructure investment costs and developmental and environmental impact on regional communities. During the rapid development of wireless telecommunication facilities in the 1990s there was a rush by wireless service providers to market with a tendency to deploy antenna sites without extensive consideration of comprehensive coverage, costs, or local developmental and environmental impacts. The results in most areas of the United States was an excessive number of sites that still do not provide comprehensive coverage of the service areas concerned. Thus, the primary objective of the proposed antenna site plan would be to select a set of candidate antenna sites that can provide comprehensive coverage within the Region using a minimum number of shared, multi-use sites.

There are two basic approaches to evaluating the suitability of a wireless antenna site location: One involves the conduct of field measurements of receiver signal levels to verify the extent and quality of antenna coverage by field measurement of receiver signal levels. The other involves the use of wireless system planning models to verify the extent and quality of coverage based on radio wave propagation modeling.

Sound communication engineering practice typically involves a combination of the two approaches. Site location by field measurement alone is a very expensive process even for a single antenna location. For multiple site locations, particularly for an area as large as Southeastern Wisconsin, field measurement verification of a large number of potential sites becomes impractical on the basis of the costs involved.

Radio wave propagation modeling, in contrast, allows for relatively low cost coverage and interference evaluation of a large number of potential antenna sites. Radio wave propagation models, like all mathematical models, are only approximations of actual situations. Model-based coverage studies must be statistically verified based on sampled field measurements. These same field measurements may also be used to enhance modeling performance by "fine tuning" propagation models based on specific terrain characteristics. Accordingly, a combination of propagation modeling and field measurements is proposed to be used for the wireless antenna site plan design.

A specific propagation and network modeling planning tool is proposed to be used in the plan design effort. The EDX SIGNALPRO family of propagation modeling programs provides an extensive set of propagation models, both physical and empirical, for determining antenna coverage based on propagation and interference considerations. Additional program modules allow for the detailed design of cellular/PCS and fixed broadband networks. The proposed antenna site planning program will be limited to the determination of a preferred set of antenna site locations consistent with radio frequency propagation and interference avoidance requirements and the availability of access points to wireline networks. Detailed network design, whether for cellular/PCS or fixed broadband networks, will be left to individual service providers. Such detailed network design entails consideration of technical and business factors beyond the proper responsibility of a public planning agency. Only in support of specialized public networks would such network design efforts be appropriate. It is important, however, that the siting information satisfy the data requirements of the regional telecommunications network planning work element.

The following information is required for application of the EDX SIGNALPRO design model:

1. An automated geographic information system (GIS) database providing either topographic terrain elevation, canopy, or vector building data inputs. Canopy data with 1 arc-second (30 meter) horizontal accuracy and 10 meter vertical accuracy are proposed to be used for the study.

2. A selected physical or empirical propagation model.

3. A set of radio frequency (rf) transmitter/receiver parameters.

4. A quality of service objective to be used in determining antenna site coverage areas such as:

   a. Received power or signal level
   b. Signal/noise ratio
   c. Percent service availability

The type of GIS database required depends on the area being studied. In rural areas, topographic terrain elevation data are usually sufficient. In urban and urbanizing areas, such as much of Southeastern Wisconsin, a Canopy GIS database will be required. Canopy GIS data conceptually represent the surface level formed by a "net" incorporating the tops of both structural and natural terrain. This net forms a composite "canopy" overlaying the terrain and may be represented in a manner similar to the manner in which the terrain itself is represented by a topographic map. Vector GIS data are required only in areas with dense concentrations of high rise buildings, such as exist in the central business district of Milwaukee. Vector GIS data represent tops of the building structures in a more precise fashion than do canopy GIS data. The use of a Canopy database should be adequate for most areas in Southeastern Wisconsin. A canopy database provides building as well as terrain elevation data, but with lower resolution than vector databases. The cost of a canopy database is also much lower, with cost rates as low as $0.25 per square mile, or less than $700 for the seven-county regional planning area. Vector data for the central area of Milwaukee County may be expected to cost about $8,000.

A wide assortment of physical and empirical propagation models is available for use in the EDX SIGNALPRO program package. Guidelines are also provided for propagation model selection under varying areal conditions. Empirical models are based on past experimentation with radio wave propagation in various terrain environments. These models do not require a specific GIS database, but only a class description of the surrounding terrain. The models provide only a first approximation of antenna site coverage to assist in determining the required transmitter power, antenna configuration, and receiver sensitivity. Physical models actually combine GIS spatial elevation input data with the physical free-space, diffraction, reflection, absorption, and other loss characteristics of radio waves to determine signal levels at specific geographic locations. Various physical models will be tested in the proposed antenna site study to determine the one best suited to Southeastern Wisconsin. Comparison of model results with selected field measurements will provide the basis for this selection. Transmitter, antenna, and receiver equipment characteristics will be selected based on the current state-of-the-art in the various wireless communications technologies.

Received power, or signal level, is the most common quality of service objective used in radio propagation modeling studies. Other criteria, such as signal-noise value, or percent service availability, however, provide more comprehensive measures. The signal-to-noise parameter is commonly expressed as the C/(I+N) function that measures the ratio of the carrier C signal to expected interference (I) and noise (N). All of these factors and terms are expressed in either volts or in decibels. The percent service availability is a more user-oriented measure that also incorporates path loss, interference, noise, and receiver sensitivity. It is anticipated that multiple objectives measures will be employed in the study.

The design procedure requires the availability of a set of candidate antenna sites. Therefore, the proposed design process would begin with an inventory of existing wireless antenna sites, and then augment this collection with additional site candidates obtained by a computer search of the canopy GIS. Site candidate selection would be based on the relative height of a potential site in comparison with the surrounding terrain. Candidate sites would then be screened for compatibility with the existing land use pattern and regional, county, and local land use plans; and for availability prior to modeling studies of the remaining site candidates.

Area coverage studies would be carried out in the following frequency bands to provide potential antenna sites for the following wireless services:

1. 2G, 2.5G, and 3G cellular voice and data transmission services in the 800-900 MHz and 1,900 MHz bands;
2. Fixed wireless services in the 2400-2500 MHz band;
3. Fixed wireless services in the 5200-5900 MHz band;
4. Fixed wireless services in the higher frequency SHF and EHF radio bands (above 20 GHz); and
5. Free-space optical wireless service bands.

The output of the area coverage studies would be a set of site candidates for each of the above-listed frequency bands. The final step of the antenna site planning process would be a series of areawide optimization studies to identify a preferred set of sites that minimize infrastructure development costs through multi-use of existing sites and collocation of antennas for multi-band wireless services. A mathematical programming model would be used to carry out this selection process.

The end result of the antenna site design study will be a set of recommended antenna sites for each of the above wireless services. Site location and coverage data will be provided in both geographic coordinate and graphic map display form. Service providers may then select from these potential sites in carrying out their network designs.

Future Needs-Based Telecommunications Network Design

The preparation of the proposed wireless antenna site and related infrastructure plan and the specialized public network plans require quite detailed and specific planning processes. While the planning efforts concerned are pioneering in nature, they are able to utilize well-accepted design tools previously employed in related communication applications. The EDX SIGNALPRO modeling tools offer both a structure and a methodology for wireless systems engineering in both applications.

Such a design structure and engineering methodology does not exist for regional comprehensive telecommunications planning. However, a design framework and methodology employed in enterprise communications network design provides guidelines and methods for the formulation of an equivalent structure and methodology for regional telecommunications planning. Descriptions of this structure and methodology are available in published text.[1] The described design process for enterprise networks provides a parallel to the design process for regional networks. The process begins with a review of network goals and constraints, followed by an inventory of the existing internetwork (a network of networks), and the traffic flows in this internetwork. It then proceeds with a logical network design that precedes the physical network design. This logical network is designed to meet the needs of projected enterprise communication needs and demands. Logical network design relates to the topology of the network, the interconnection of subsidiary networks, and the development of strategies for network security and management. Only after the logical network design is completed does the physical network design involving the selection of technologies and equipment begin. The physical network design is then followed by a testing, optimizing, and documenting process.

[1] *See, for example,* "Top Down Network Design," *Priscilla Oppenheimer, Cisco Press, 1999.*

The parallels between enterprise network design and regional network design are quite apparent. This similarity exists because the needs of a large enterprise and a geographic region are very much the same; that is, the provision of a network to meet identified needs. This viewpoint contrasts sharply with that of the post-1996 telecommunications service provider. In the current competitive situation, even the well- established CLECs are not able to provide a top-down network system design approach to the future needs of the Regional telecommunications system. Future system infrastructure is greatly distorted by the UNE provisions of the FCC rulings, which recently reaffirmed the rights of CLECs to low-cost usage of the SBC infrastructure for narrowband applications. The FCC goal of maintaining local competition distorts investment patterns by discouraging investment by either ILECs or CLECs. Even if such UNE regulation were removed, it would still be very difficult for any service provider in the current competition environment to support a systems engineering approach to future network design. The pressure to maintain and grow profitably in the short term tends to override all other considerations for any service provider. The top-down network system design approach advocated here for Regional telecommunications networks has a longer term functional focus.

The top-down network system design approach currently practiced in enterprise networks does provide a relevant template for the Regional telecommunication planning process. There are important differences, however, in the implementation of this planning process. Enterprises typically have complete freedom and control in the implementation of their network design. A Regional network design, with the possible exception of special purpose public networks, is only advisory in nature and must be implemented by private service providers. This aspect of implementation, however, does not change the basic planning process. With adaptation, top-down network design provides a good structure for the Regional telecommunications planning process.

This approach to regional telecommunications network design is possible with the data provided by the minimal infrastructure and traffic inventory previously described. Core network infrastructure data of the kind required here would be limited to facilities provider data. Circuit provider and service provider data have been limited to access points (points of presence) and capabilities. Nevertheless, facilities providers with their excess capacity provide a basic core network for the regional network design. Where link gaps exist in the regional core network, virtual core links would be used to complete the network design. Design emphasis would be located on the access network. Such a focus is appropriate since it is widely accepted that access networks, particularly the "last mile" connection to homes and smaller business organizations, are the limiting factor in extension of broadband services.

Along with structure and process, the other major need of Regional telecommunications planning relates to tools. Telecommunications networks are complex entities. Evaluation of such networks implies some form of computer simulation modeling. Such models have been employed in the design of transportation networks for over forty years. Much effort has been devoted to the development of these transportation networks models. Arterial street and highway construction, however, is a relatively slowly evolving technology, particularly in comparison with communications technology. Telecommunications network planning requires a more flexible form of simulation modeling. A number of commercially available network oriented simulation program packages are available. The best of these would appear to be the Visual SLAM general purpose simulation system originally developed at Purdue University. This simulation model allows for either continuous or discrete simulation at whatever level of detail required.

It allows for user-developed subroutines in the Visual Basic language to simulate switching, multiplexing, routing, or other operations in a communications network. Beginning with the current Regional traffic matrix as input, the modeling will permit evaluation of the adequacy of the current network infrastructure. Employing forecasts of future traffic matrices, alternative telecommunications networks can be evaluated in terms of cost-performance, security, and general ability to satisfy the socioeconomic needs of the Region.

In the proposed telecommunications planning process, two types of networks will be evaluated both individually and as an integrated system: access networks, and core networks.

Access network evaluation is particularly important in the provision for universal broadband services. Such provision is currently important in telecommunications network development with emphasis on the "last mile" problem, which problem is generally viewed as the major impediment to network growth and usage. All of the current and known future access alternatives are proposed to be evaluated alone and in combination in the study, including:

1. Twisted pair xDSL;
2. Cable modems;
3. Fixed wireless;
   a. Radio frequency
   b. Free-space optics
4. Mobile wireless;
5. Satellite wireless; and
6. Optical fiber
   a. to the neighborhood (FTTN)
   b. to the curb (FTTC)
   c. to the home (FTTH)

Some of the combinations of interest would include FTTN and fixed wireless to the home or business with either radio frequency or free-space optical (FSO) links. These access network alternatives would also be evaluated in various land use settings from rural agricultural to high density residential, and commercial and industrial areas.

Core network plan design will make use of the current core network as furnished by facilities providers supplemented by virtual links as required. New technologies, such as the latest version of Ethernet, supplemented by auxiliary technologies, such as label switching, will be evaluated in formulating the network design.

With the shift in emphasis to access networks, more detailed evaluation of various alternative plans involving fixed wireless will be possible. Examples include the design of neighborhood wireless networks using SHF/EHF bands or free-space optics.

The end result of this planning process will be a set of alternative network plans with emphasis on a variety of access network technologies and topologies. Examples of such regional network plans could include:

1. Extrapolation of Current and Expected Trends – the "do-nothing" alternative;
2. Fiber to the Home (FTTH) service, in urban and urbanizing areas, with fixed wireless or satellite service in rural areas;
3. Fiber to the Neighborhood (FTTN) service with fixed radio wireless (UHF or SHF or EHF) or free-space optical links to subscribers (UHF or SHF or EHF); and
4. Universal satellite wireless.

Special Public Networks

The inventory element of the telecommunications planning process will provide information on the current status of public networks in the Region. Beginning with this inventory, the technical and operational status of existing public networks will be evaluated along with the need for upgrading current networks and establishing new networks in areas of public need. An example of a potential network upgrade is the 800 Trunk System used in the counties of the Region for voice communications. The need to improve this network to better accommodate data and multimedia communications would be investigated. Such a needs analysis approach would be applied to all public networks in the Region. Maximal use would be made of documented experiences with such public networks in other regions of the United States and other countries. Interviews with public officials in the Region would also be scheduled to determine the level of interest in each type of network. The end result of needs analysis would be a set of needs for each candidate public network with supporting rationale.

Needs analysis will be followed by an economic analysis of public network candidates that survive needs analysis screening. This economic analysis would determine both the estimated capital costs for network development, construction, and installation, together with the estimated operating costs of the proposed network. The economic analysis would also investigate and document potential Federal, State, and private funding sources for the proposed public network.

The proposed tasks are summarized in Table 3.

PLAN SELECTION AND ADOPTION

Following public informational meetings and hearings on the alternative plans considered, one plan would be selected as the recommended plan to be used to guide

Table 3

SUMMARY OF PROPOSED REGIONAL TELECOMMUNICATIONS PLANNING PROCESS

Inputs	Planning Task	Outputs
Historical data	Aggregate forecasts	Regional voice, data and multimedia forecasts
Land use/traffic data	Spatial forecasts	Spatial traffic generation
Historical data	Modal splits	Wireline vs. wireless traffic Telnet vs. Internet traffic
Traffic matrix Spatial traffic generation	Virtual network traffic forecasting using network simulation model	Virtual network traffic forecasts
Canopy database Current antenna sites and characteristics Wireless technology forecasts	Wireless antenna site network design Radio propagation modeling Integer programming modeling Field measurements	Proposed antenna site locations
Spatial forecasts Modal splits Network traffic forecasts Antenna site infrastructure Current facility providers Infrastructure Circuit/service providers Coverage Access points	Regional access/core network design	Alternative regional telecommunications network plans
Public network Needs and requirements Current public network Infrastructure Performance Evaluation	Public network analysis and screening	Recommended public network Development initiatives

Source: SEWRPC.

the short and long range development of regional telecommunications systems within Southeastern Wisconsin. The recommended plan may consist of one of the alternative plans considered, or may be a composite of the best features of two or more of these alternative plans. The recommended plan should include both the overall Regional Telecommunications Network Plan and the subsidiary plans relating to wireless infrastructure and special public networks.

The overall Regional network plan should clearly define the assumed virtual core network required to support the Regional access networks. This virtual core network will be a combination of the actual known network links of facilities providers and the assumed links of circuit and service providers based on the original inventory. Access networks will be defined in terms of technical specifications, geographic coverage, capacity, costs, and capabilities. Each type of access network, however, will be specified in detail for a selected area in order to confirm the credibility of the access network design. It is highly likely that multiple types of access networks would be featured in the final plan. Recommendations, if any, for on-going network monitoring systems should also be included in the selected plan. A special emphasis in all alternative plans would relate to provision of broadband data and multimedia services. Rural as well as urban areas should have provision for such services. Broadband capabilities will be featured in all of the alternative plans with special emphasis on their ability to service all of the people in the Region.

The wireless antenna location and related infrastructure plan would designate recommended antenna sites and related wireline access point connections throughout the seven-county Region. Both mixed and fixed wireless sites will be designated for the four frequency bands—800-900 MHz, 1900 MHz, 2400 MHz, and 5200-5900 MHz. There would be no alternate plans as such, but the site plans would be open to public review and subsequent modification, as may be found necessary. Additional site location studies will extend to higher frequency SHF and EHF bands (above 20 GHz) and free-space optical bands in order to support the overall regional telecommunications planning element.

Public network plans would be presented in terms of perceived needs, benefits versus costs and potential funding sources for each type of public network. Recommended public networks will then proceed to the individual prospectus stage for detailed design and funding support.

The recommended overall telecommunications system plan should be based upon careful analyses of the capacity, performance, and security of existing networks; probable future demands for various telecommunication media; Federal, State, and local regulatory constraints; and the organizational structures and management policies of existing service providers. The various networks should constitute, at least in an actual or virtual sense, an integrated Regional telecommunications network capable of servicing the communication needs of the Region at an advanced level competitive with similar metropolitan regions in the United States and elsewhere in the global economy.

PLAN IMPLEMENTATION RECOMMENDATIONS

Upon agreement on an overall Regional telecommunications system plan and supporting economic justification data, recommendations should be made with respect to the organizational and financial arrangements under which the recommended plan and its component subsystems can be implemented. The potential roles of competitive ILEC-CLEC wireline service providers, wireless service providers, public agencies, and local units of government should be specifically defined. The fiscal implications of the recommended plan should be determined, and the economic viability of the plan, with respect to service providers, confirmed. Needs for Federal and State financial assistance for the plan should be identified. Recommended capital improvement programs for both service provider and special public networks and related financial programs for plan implementation should be outlined. Impacts of the recommended plan on wireline and wireless subscriber costs should be determined. Any necessary legislative, regulatory, and administrative measures required for plan implementation should be addressed. The possibility of utilizing private service providers to install and/or operate public networks should be investigated. However, access to public rights-of-way for the construction of capital assets by any telecommunications service provider shall not be made contingent upon, nor given priority, based upon conformance with a recommended Commission telecommunications plan.

PLANNING REPORT

A planning report should be prepared and published setting forth a clear graphic and written description of the inventory findings, the analyses and forecasts, the alternative plans considered and the recommended plan. The reasons for the selection of the recommended plans from among the alternatives should be clearly set forth, and the required plan implementation measures specified. An environmental assessment of the recommended plans should be included in the planning report.

The planning report should provide an adequate basis for the adoption of the recommended plan by private service providers and the Federal, State, county and local units and agencies of government concerned. To this end, the report should provide clear statements with respect to:

1. The purpose of the regional telecommunications planning program and of the resultant report as an instrument for public policy determination.

2. The existing and potential telecommunications problems of the Region as revealed by the inventories, analyses, and forecasts prepared under the planning program with particular emphasis on those areas and user groups of the Region which currently, or in the future, may experience inadequate or too costly communications services inconsistent with economic development or quality of life standards.

3. The alternative means available for addressing the telecommunication problems of the Region.

4. The evaluation of the benefits and costs broadly defined of the alternative means considered for adequately providing both short term and long term telecommunication services for the Region; and

5. The critical decisions that need to be made in the light of the identified telecommunication problems and the interrelationship of those problems to the long term socioeconomic development of the Region.

Particular attention should be focused in the report on those aspects of the recommended plan relating to the development of an advanced integrated core network and the provision of broadband communication services to all areas and potential users based on advanced and cost effective access networks throughout the Region.

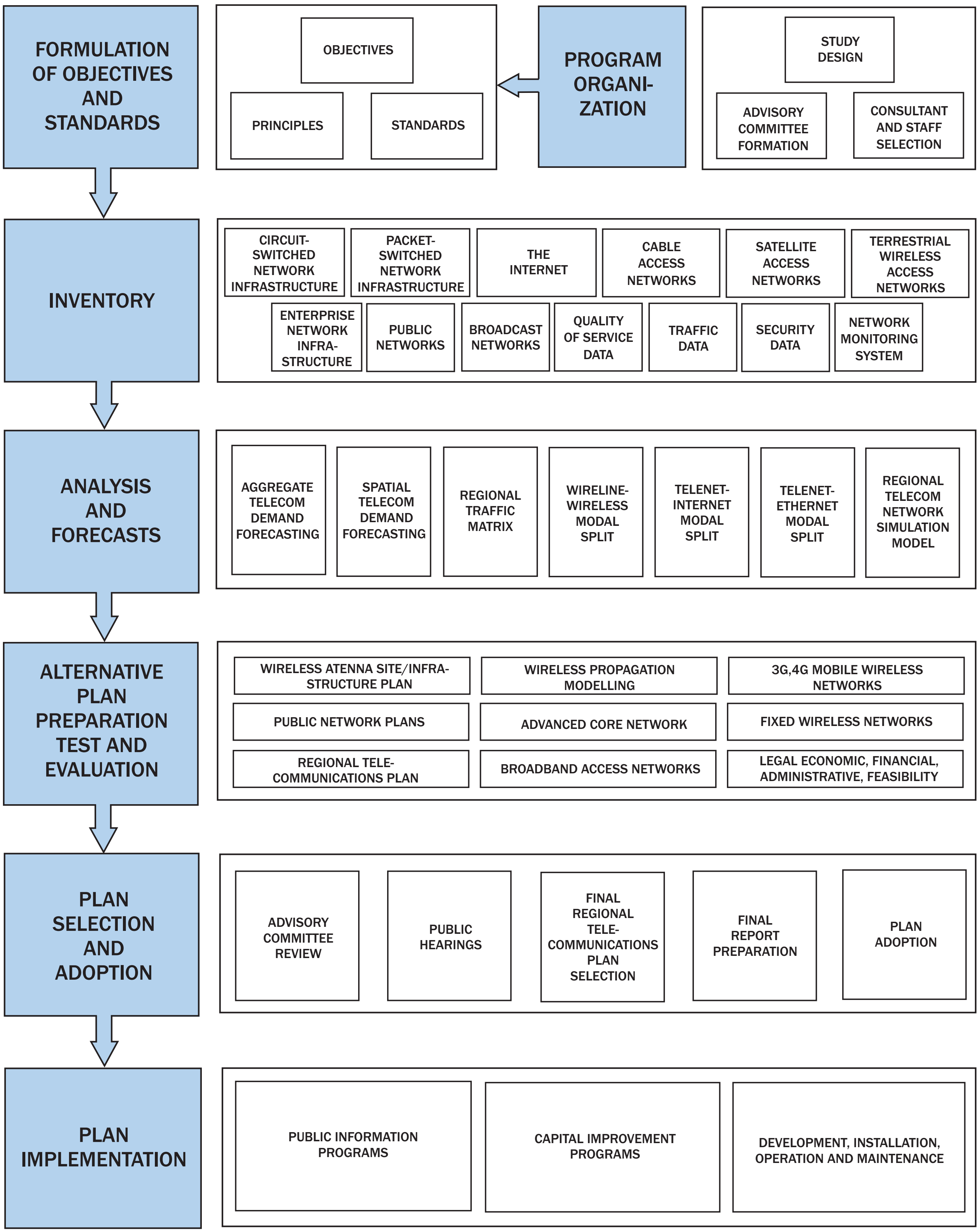
The major work elements comprising the recommended regional telecommunications system planning program are summarized in Figure 2.

TIME SCHEDULE

An estimated time schedule for the accomplishment of the major elements of the proposed telecommunications planning program is provided in Figure 3. This schedule is subject to revision upon the preparation of any needed detailed study design memoranda as work on the planning program proceeds.

Figure 2

MAJOR PHASES OF THE REGIONAL TELECOMMUNICATIONS PLANNING PROGRAM

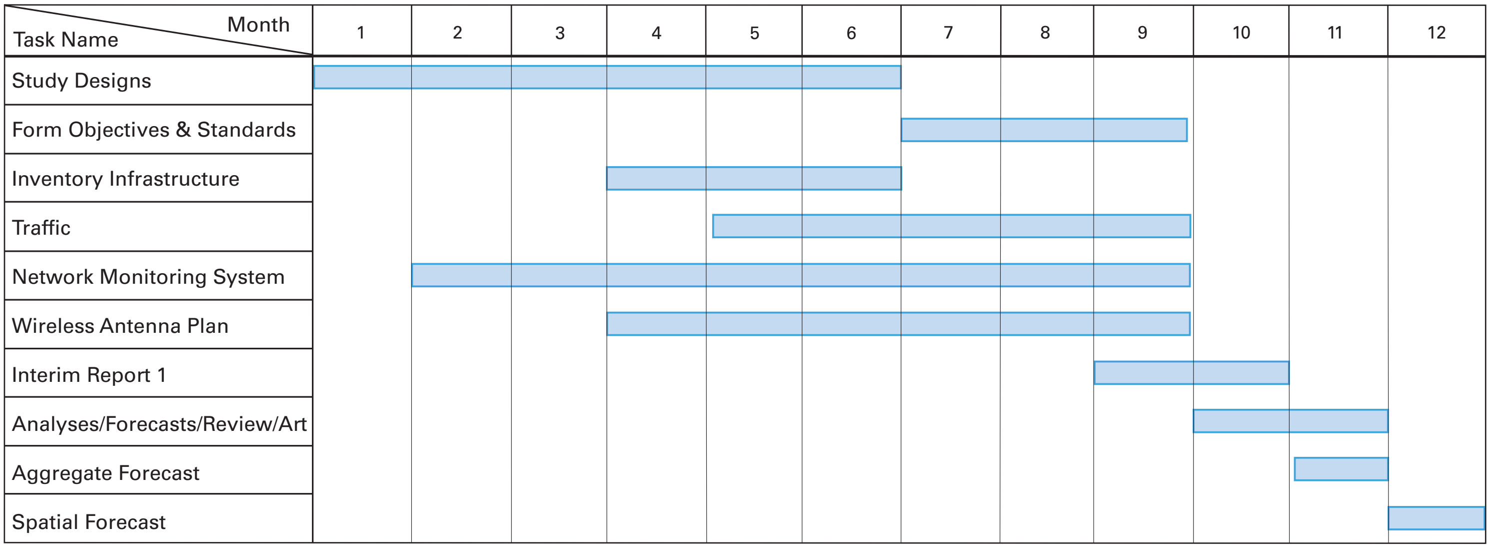


Source: SEWRPC.

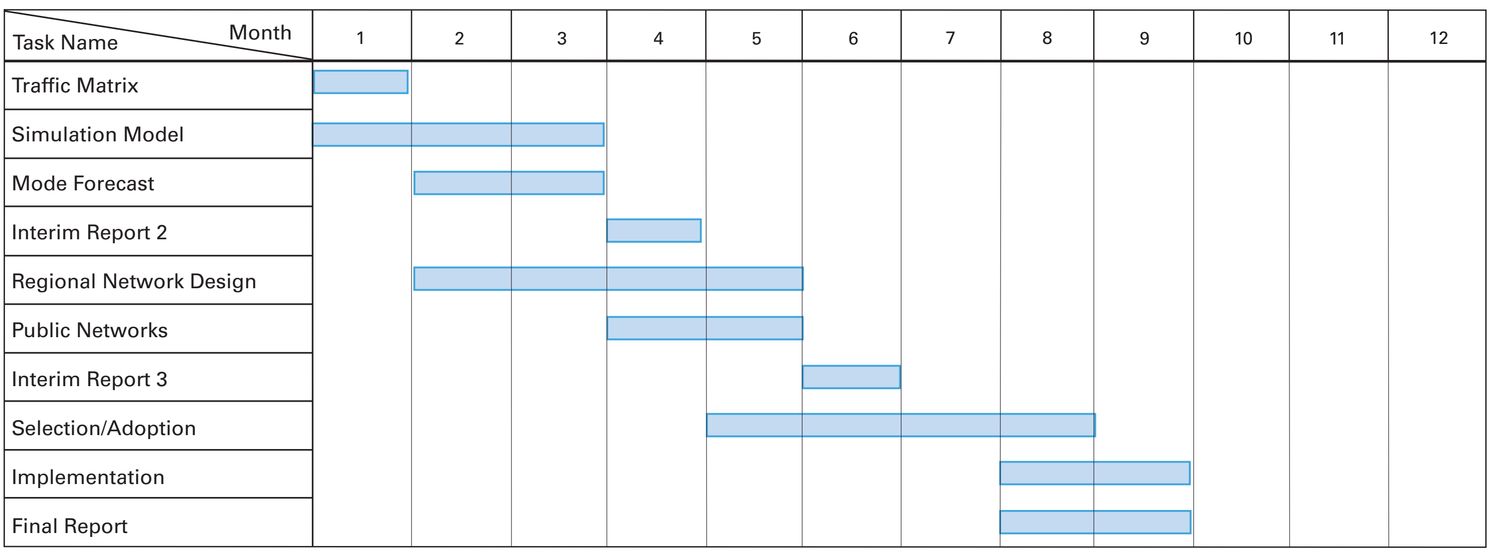
Figure 3

MAJOR WORK ELEMENTS-TELECOMMUNICATIONS PLANNING PROGRAM FOR THE SOUTHEASTERN WISCONSIN REGION

PROJECT SCHEDULE: YEAR ONE



PROJECT SCHEDULE: YEAR TWO



Source: SEWRPC.

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Chapter V

ORGANIZATION FOR THE CONDUCT OF A REGIONAL TELECOMMUNICATIONS PLANNING PROGRAM

INTRODUCTION

The proper conduct of the proposed planning program will require the assumption by a public agency of responsibility for the administration of the study; a means of providing the technical skills required; and the identification of a public and private enterprise coordinating mechanism to guide the conduct of the study in a collegial manner. Alternative approaches to fulfilling the administrative direction, technical staffing, and intergovernmental coordination required were explored. After careful consideration, the following organization for the study was recommended.

ADMINISTRATIVE DIRECTION

It is recommended that the Southeastern Wisconsin Regional Planning Commission assume responsibility for the administrative direction of the study. The Commission has a long record of successful administration of major planning and engineering studies for its constituent counties and local units of government and is a neutral, disinterested party with respect to the provision of telecommunication facilities and services within the Region.

TECHNICAL STAFFING

It is important to recognize that regional telecommunications planning, as proposed here, represents a pioneering endeavor. Such regional telecommunications planning was undoubtedly carried out by the old Bell System companies. Such planning, however, related only to the circuit-switched system which is of decreasing importance in the current packet-switched oriented, multi-media network environment. The socioeconomic environment of the original Bell System was also quite different and less obviously linked to the growth and development of a regional economy.

The conduct of the proposed regional telecommunications planning program will require a combination of Regional Planning Commission staff and consultant services. The Commission maintains a core staff of full time, professional, technical, administrative, and clerical personnel supplemented by additional temporary staff and consultants, as may required by the various Commission work programs. The Commission staff includes personnel experienced in transportation, environmental, and land use planning; in municipal planning and zoning; and in economic development; as well as in the provision of such support services as cartographic and graphic arts and geographic information system technology. The Commission staff expertise does not, however, currently include telecommunications planning and systems engineering skills.

It is, therefore, recommended that a Telecommunications Planning Division be created within the Commission staff structure. The Division would consist of a Telecommunications Planner and an experienced Resident Systems Engineer, the former employed on a full-time basis and the latter on a part-time basis by the Commission. Assistance in land use planning, including the provision of existing and forecast demographic and economic activity levels and land use patterns, as well as other technical and administrative support, would be provided to the Division as necessary by existing Commission staff. The Commission would retain a telecommunications consulting firm and a legal firm to assist the Division in the conduct of the proposed planning effort.

It is recommended that the Resident Systems Engineer act as project manager. As such, the Resident Systems Engineer would be responsible for study design, including the preparation of the six technical memoranda identified in Chapter IV. These memoranda are intended to describe in greater detail the methods and procedures to be followed in establishing and carrying out certain particularly complex elements of the planning process. It is further recommended that the Commission staff be responsible for the formulation of the necessary system development Objectives and Standards. More specifically, the formulation should involve, as necessary, the Land Use and Economic Development Division staffs of the Regional Planning Commission, as well as the staff of the proposed Telecommunications Planning Division.

With respect to inventory operations, the Commission Geographic Information Systems and Cartographic and Graphic Arts Divisions would be responsible for the necessary geographic information system, mapping, and publication services required. The Commission Land Use Division would be responsible for the provision of the necessary existing and forecast population, employment, and land use data. The proposed Telecommunications Planning Division would be responsible for the collection of the necessary telecommunications infrastructure and traffic data and for the establishment and operation of the proposed network monitoring system. The proposed Telecommunications Planning Division would, with the assistance of the Land Use and Economic Development Divisions, be responsible for the necessary review and summary of the state-of-the-art information; the preparation of the aggregate spatial and modal split forecasts; and the development and application of the network simulation model. The proposed Telecommunications Planning Division would be responsible for plan design, including the wireless antenna site and related infrastructure plan design, regional telecommunications network plan design, and special public networks investigation and design.

The proposed Telecommunications Planning Division would be responsible for alternative plan evaluation and for plan selection and adoption. The Division would also be responsible for the formulation of plan implementation recommendations including, with the assistance of the Commission Community Assistance Planning Division, as appropriate and timely, the preparation of a planning guide and local model ordinance relating to telecommunications system development within the Region.

Finally, the Commission Cartographic and Graphic Arts Division would be responsible for the publication of the envisioned planning report. The writing of the report itself, however, would be the responsibility of the proposed Telecommunications Planning Division. Importantly, the services of a telecommunications consulting firm would be retained to assist in the development of the wireless antenna site and related infrastructure system plan and for the conduct of field measurement studies of potential wireless antenna sites that may be required for the formulation of the plan. A legal firm would be retained to conduct the necessary legal studies and to report the findings and recommendations of those studies in a written report to the Commission staff.

COMMITTEE STRUCTURE

It is recommended that a Technical Advisory Committee be created to guide the conduct of the proposed planning effort. The Committee would have an important role in guiding the development of the detailed study design for the planning effort; the selection of inventory and analytical techniques to be utilized in the study; the formulation of objectives and supporting standards; the design, test, and evaluation of alternative plans; the selection of a recommended plan; and the formulation of implementation measures. The Committee would be responsible for reviewing preliminary drafts of the technical memoranda and of the various chapters of the required planning report as those drafts are produced. The Committee would also assist in familiarizing the political, business, and industrial leadership within the Region with the planning work as it progresses, and in fostering an understanding of the basic objectives of the planning effort, the structure of a recommended plan and of alternatives thereto, and of the necessary implementation measures.

The membership of the Technical Advisory Committee should be carefully selected by the Commission to include staff representatives of wireline and wireless service providers—both incumbent and competitive; Internet service providers; cable service providers; industrial network operators; regulatory legal experts; county and local planners and engineers, and representatives of economic development organizations operating within the Region. The Wisconsin Department of Administration should be represented on the Committee.

The Technical Advisory Committee guiding the preparation of this Prospectus could be retained as the required Technical Advisory Committee, reconstituted, as may be necessary or desirable, to include all of the major interests that are involved in telecommunications systems planning, engineering, construction, operation and maintenance within the Region.

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Chapter VI

BUDGET

COST ESTIMATE

Estimated study costs are set forth in Table 4 and are based upon the scope of work, time schedule, and study organization recommended in this Prospectus. Study costs are estimated to total $715,000. In any consideration of this cost estimate, it must be recognized that a precise estimate of the costs of some of the proposed work elements cannot be made in the absence of a detailed study design. This is particularly true with regard to such work elements as the development of a network monitoring system and the design of alternative means for providing universal access to broadband telecommunications service. There are a significant number of unknown factors affecting such work elements that could raise or lower program costs. Some of these factors relate to the quality of information available upon which to base the planning effort. These factors can be clarified and addressed only as the work proceeds. Consequently, the cost estimates presented in Table 4 must be considered tentative with respect to the allocation of the total cost among the various work elements. Changes in this allocation must be expected as the work proceeds. The overall study cost, however, should not vary greatly from that estimated.

Table 4

REGIONAL TELECOMMUNICATIONS PLAN COST ESTIMATE

Work Element	Cost
Study Design	$ 24,000
Formulation of Objections and Standards	12,667
Inventory and Network Monitoring System	143,000
Analyses/Forecasts	72,000
Plan, Design, Test and Evaluation	
Antenna Site Plan	129,135
Regional Network Plan	65,196
Public Networks Plan	50,668
Plan Selection and Adoption	25,334
Plan Implementation	8,000
Other Support Labor	48,000
Publication of Report	50,000
Subtotal	$628,000
Travel Contingencies and Miscellaneous Expenses	$ 87,000
Total	$715,000

COST ALLOCATION

The Advisory Committee guiding the preparation of this Prospectus deliberated at some length upon the issue of study cost allocation. In its deliberations, the Committee noted that the Governor's current initiative to create jobs in Wisconsin specifically includes a proposal to promote the universal deployment of broadband telecommunications services as a critical economic development measure.[1] The Committee also noted that in a recent project proposal, the President of the Milwaukee Public Policy Forum proposed a program that would lead to, among other outcomes,

[1]*See page 23 of* "Grow Wisconsin—Governor Jim Doyle's Plan to Create Jobs," *Office of the Governor, September 2003.*

the preparation of a regional plan for the development of the telecommunications infrastructure of the Southeastern Wisconsin Region.[2] This proposal was reinforced in a series of articles published in the *Milwaukee Journal-Sentinel* on Sunday, October 12, 2003, in which articles representatives of the Public Policy Forum and the Greater Milwaukee Committee outlined a number of initiatives to promote the economic development of the greater Milwaukee area, including universal broadband telecommunications access.

The Committee also considered that the Wisconsin Public Service Commission, the primary State utility regulatory agency, would have an interest in the data to be collected under the proposed planning program and in the recommended plan elements to be produced by that program, even though that Commission had declined to participate as a member of the Advisory Committee ostensibly to avoid possible future conflicts of interest in that Commission's consideration of regulatory issues. The Committee also considered that the counties comprising the Southeastern Wisconsin Region would have an interest in the preparation of a telecommunications plan that would promote the sound social and economic development of the Region as a whole.

Accordingly, the Committee directed the Commission staff to explore sources of funding in addition to the Commission's constituent counties; including specifically, private foundations; other private sector organizations; Federal agencies, such as the U.S. Department of Agriculture; and State agencies. Accordingly, Commission staff took the following actions:

- The Annenberg Foundation
  In accordance with the Committee's directive, the Commission staff contacted representatives of the Annenberg Foundation, headquartered in Davids, Pennsylvania. That Foundation has, as its primary mission, the advancement of the public well-being through improved communiation, with emphasis on the furtherance of public education and other community activities dependent upon good communications. The Foundation grants approximately $175 million per year, with grant awards ranging from approximately $52,000 to $800,000 per project.

  A grant application to the Foundation must be preceded by a letter of inquiry, no more than two pages in length, in which the essence of a proposed grant application is described. All letters of inquiry are answered within no more than six weeks of receipt. Based on Commission staff telephone conversations with Foundation officials, a letter of inquiry was submitted by the Commission on November 3, 2003. Upon the advice of Foundation officials, the letter of inquiry focused on that element of the overall planning program that would be directed at the creation of potential public telecommunications networks in areas such as education, telemedicine, areawide intergovernmental cooperation, and environmental monitoring. Even if eventually approved, the Foundation grant could not be expected to exceed about $100,000, or about 14 percent of the total estimated cost of the proposed planning program.

- Regional Economic Partnership
  In accordance with the Advisory Committee's directive, the Commission staff briefed the members of the Regional Economic Partnership, an organization comprised of representatives of the economic development agencies of each of the seven counties of Southeastern Wisconsin, the City of Milwaukee, the Milwaukee Metropolitan Association of Commerce, and WE Energies Corporation, on the potential regional telecommunications planning program under consideration by the Commission and its Advisory Committee. While the partnership members expressed interest in, and support for, the proposed planning program, the Partnership determined that its very limited resources, provided primarily by the county boards concerned, would preclude any direct funding of that program by the Partnership.

- Public Policy Forum and Greater Milwaukee Committee
  Given the aforereferenced initiatives, and in accordance with the Advisory Committee's directive, the Commission staff provided to the President of the Public Policy Forum and to the staff Director of the Greater Milwaukee

[2] *See Page 7 of* "A Project Proposal: Our Region, Our Future: An Action Plan to Promote Economic Growth and Quality of Life in Southeastern Wisconsin," *submitted by Jeffrey C. Browne, President of the Public Policy Forum, Undated.*

Committee a copy of the draft regional telecommunications planning program prospectus with the request that representatives of those two agencies caucus and determine whether or not there might be some potential private sector funding available in partial support of the proposed planning program. As of November 15, 2003, no response to that request had been received.

- State Government
In accordance with the Committee's directive, the Commission staff contacted Mr. Jody McCann, Director of Technology Research, Wisconsin Department of Administration, and a member of the Advisory Committee, to request his assistance in exploring the potential for State funding of the proposed planning program. Mr. McCann indicated that he had already raised this issue with his superiors in the Department of Administration with the request that the Secretary of the Department respond to the proposal; and, as that Secretary might find desirable, contact the Secretaries of other State departments that might have a potential interest in the program. On November 7, 2003, the Commission staff was advised in a telephone communication from Mr. McCann that while the Wisconsin Department of Administration was in support of the conduct of the proposed planning program, given the present State financial crisis, the Department of Administration had no funding available for the proposed planning effort. Officials of the Wisconsin Department of Commerce, however, indicated that significant funding might be available through that Department utilizing Federal monies potentially available through the Department; and that this potential should and would be further explored.

- Federal Agency Funding
Commission staff determined that obtaining potential funding from such agencies as the U.S. Department of Agriculture, the U.S. Department of Transportation, and the newly formed Department of Homeland Security in a timely manner was impractical given, except for the U.S. Department of Agriculture, present lack of specific Federal grant programs in this area.

With respect to the U.S. Department of Agriculture, grants in support of telecommunications improvements are available only to rural areas.

Based upon considerations of the results of the staff investigations undertaken in response to the Committee's directive, and upon considerations relating to practicality as well as equity, the Committee recommended that the Regional Planning Commission fund the proposed telecommunications planning program as part of its normal ongoing regional planning program. This would require an annual appropriation over a three-year period of about $238,000. This would also mean that the costs of conducting the program would be borne by the seven constituent counties in the Region on the basis of equalized property valuation in the same way as those counties support the other regional planning efforts.

In this respect, it should be noted, however, that it has been the practice of the Commission to consult with the county executives and county boards of the constituent counties before proceeding with a major planning program. In its consultations, the issue of cost allocation is carefully considered. Based upon the results of those consultations, the Commission makes a determination as to whether to include a proposed new planning initiative in its regular work program, or to conduct the initiative as a special planning effort. Under the former determination, by State law the cost of the new planning initiative is allocated to the seven constituent counties on the basis of equalized real property valuation. Under the latter determination, the cost of the initiative may be allocated on the basis of equalized real property valuation, or may be allocated on some other basis agreed upon between the Commission and the constituent county executives and county boards. In either case, efforts should be continued to obtain private foundation or State funding in partial support of the program. If successful, such efforts would proportionally reduce the costs to the regional taxpayers, and enhance the potential for approval of the program by the constituent counties. Federal and State grants or foundation funds, if available, may be used to reduce the cost to the counties concerned.

The interest in, and the positive stance of, the Wisconsin Department of Commerce in support of regional telecommunications planning, and the availability of Federal funding to the Department, makes State financial assistance for the proposed planning program a possibility.

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Chapter VII

CONCLUSIONS AND RECOMMENDATIONS

INTRODUCTION

Telecommunication networks provide the infrastructure for information exchange in all advanced societies. Such networks are vital for the efficient production and distribution of goods and services in a modern economy. Telecommunication exchanges also serve to establish the social and political fabric of modern day life. Recent and continuing advances in communications technology have allowed for information transfer at rates considered not feasible even a decade ago. Although originally developed for voice communication only, telecommunication networks now transmit data, video, and multimedia forms of information.

Varying rates of deployment of new communication technologies in different areas of the United States and in the rest of the world have produced one aspect of the so-called "digital divide," placing areas with outmoded telecommunication technologies at a competitive disadvantage in national and global industrial and commercial development. Such disadvantaged areas are also prevented from introducing communications-based advances in fields such as telemedicine, public safety, education, environmental monitoring, and transportation that have major impacts on the quality of life. For these reasons, telecommunications planning should be an important concern of elected and appointed public officials in any metropolitan regions, such as Southeastern Wisconsin.

Accordingly, the Southeastern Wisconsin Regional Planning Commission, which is charged by law with creating and adopting a comprehensive plan for the physical development of the seven-county Southeastern Wisconsin Region, acted on March 20, 2003, to create a Telecommunications Advisory Committee. The Commission charged that Committee with the preparation of a Prospectus on the need and means for telecommunication planning for Southeastern Wisconsin. The prospectus was intended to provide the information required to permit the various levels, units, and agencies of government, and the telecommunication facilities and services providers concerned, to consider the benefits and costs of such a planning program, and to determine the desirability of its execution. The membership of the Committee was drawn to include knowledgeable and concerned representatives of the constituent counties and municipalities, of concerned State agencies, and of concerned private businesses and industries. The full membership of the Committee is listed in Chapter I of this Prospectus.

More specifically, the Prospectus is intended to provide information on the current state of telecommunication facilities and services within the Region; to establish and document the need for a public telecommunication planning program within the Region; to specify the scope and content of the work required to carry out such a planning program; to recommend the most effective means for organizing and accomplishing such a program; to recommend a practical time sequence and schedule for the required work; to provide sufficient cost data to permit an assessment of the value of the attendant benefits of such a program; and to suggest a means for the funding of such a program.

NEED FOR A REGIONAL TELECOMMUNICATIONS PLAN

Based upon a careful examination of the historical background and of the current state of telecommunications facilities and services within the Region, the Advisory Committee concluded that seven factors contribute to the need for the conduct of a regional telecommunications planning program and the preparation of a regional telecommunications plan for Southeastern Wisconsin. These factors are:

1. The lack of comprehensive information on the state of telecommunications facilities and services within the Region.

   In past years, comprehensive information on the Regional telecommunications infrastructure was available from the Public Service Commission of Wisconsin (PSC). The PSC no longer has any jurisdiction over the growth areas of the telecom infrastructure, i.e. the packet-switched wireline network and all wireless networks. Without such information, public planning of any kind is not possible.

   Quality of service information on telecommunication services within the Region is also lacking. Many users of data services are often unaware of the degraded nature of transmission rates provided in some parts of the Region. Remedies for the correction of service deficiencies often take extended time periods with increasing subscriber frustration. At the same time, information on levels of service is rarely publicized. A Regional Network Monitoring System could assist significantly in identifying network deficiencies as well as publicizing service quality levels throughout the Region.

2. The increasing need for advanced telecommunication facilities and services to support the economic development of the Region.

   Currently, primary economic competitors of the Region include countries of East Asia—South Korea, Japan and increasingly China. Manufacturing jobs especially are moving from Southeastern Wisconsin to East Asia. East Asia is reported to be ahead of the United States and the Region in broadband telecommunications services—both in terms of transmission speeds and in lower costs of these services. A regional telecommunications plan would assist Southeastern Wisconsin in recovering and maintaining its competitive position in the global economy by identifying the telecommunications infrastructure required to prosper in the current economic environment.

3. The need to address the universal provision of adequate broadband telecommunication services within the Region.

   A long term public approach to planning for the universal provision of broadband services within the Region is needed. Such an approach requires the evaluation of alternative network configurations and technologies to ascertain what is in the best socioeconomic interests of the people of Southeastern Wisconsin.

4. The need to address differences in the provision of adequate telecommunication services in rural and other underserved areas of the Region.

   Governor Jim Doyle has recently called for the provision of universal broadband communication services to all areas of Wisconsin as part of a needed economic development program. Creative network design innovations are required to make such universal coverage cost-effective in rural and disadvantaged areas in a more effective manner. Such innovations can be evaluated as part of a regional telecommunications planning process.

5. The need to develop special purpose public telecommunication networks within the Region for applications such as telemedicine, public safety, transportation, environmental monitoring, and education.

   Some of the greatest benefits of advanced telecommunications technology can result from the development of special public networks in areas such as emergency telemedicine, home health care telemedicine, air and water pollution monitoring, transportation system management, and education. Many of these public network applications are regional in scope and planning for such would be enhanced by a regional telecommunication planning program.

6. The need to assist local units of government in telecommunication network development.

   Wisconsin municipalities have authority to provide telecommunications services, and court decisions have upheld this authority. As of September 30, 2003, 25 municipalities have been certified by the Wisconsin Public Service Commission to provide competitive telecommunications services. The Village of Jackson, within the Southeastern Wisconsin Region, is currently considering the creation of a broadband telecommunication utility to provide telecommunication facilities and services within the Village. Municipalities choosing this route could significantly benefit from planning assistance at the regional level. All municipalities within the Region will, however, require planning assistance with respect to telecommunication issues, particularly as related to future wireless and broadband communications services. In this respect, it should be noted that Section 66.0295(2)(d) of the *Wisconsin Statutes* requires that local comprehensive plans specifically address telecommunications facilities as an integral part of the utilities and community facilities element of such plans.

7. The need to develop a well-conceived antenna siting and related infrastructure plan for wireless communications in the Region.

   The emerging major role of all forms of mobile and fixed wireless communications in future broadband services highlights the importance of a regional antenna siting and related infrastructure planning effort. Particularly important will be consideration of new radio and free space optical bands beyond VHF and UHF (3GHz) in the SHF (Super High Frequency), EHF (Extremely High Frequency) and near infrared—free space optical—regions. These higher frequency bands are synonymous with broadband capability and offer a potentially powerful and low cost alternative for the local loop—a potential key to resolution of the "last mile" connection problem. The antenna siting plan would also provide the structure for orderly expansion of wireless communications services in the Region.

MAJOR ELEMENTS OF A TELECOMMUNICATIONS PLANNING PROGRAM

Chapter IV of this Prospectus sets forth the major elements of the needed telecommunications planning program. The primary purpose of the needed planning program would be the development of a technically sound and practical plan to guide the evolution of telecommunication facilities and services within the planning Region and to specifically identify the infrastructure framework needed for new wireless and wireline communication services. The planning program would coordinate the development of telecommunication facilities and services within the Region with the land use development envisioned in the adopted regional land use plan. Major work elements would include the formulation of a set of telecommunication system service objectives and standards related to the type and quality of service to be provided in the urban, suburban, and rural subareas of the Region; the conduct of essential inventories to identify the existing wireline and wireless telecommunication facilities and services within the Region; the monitoring of the availability and quality of telecommunication services within the various subareas of the Region; and the identification of the regulatory framework for the provision of such wireless and wireline services. The work would include the preparation of projections and forecasts of telecommunications voice, data, and multimedia traffic on a spatial basis within the Region through correlation of telecommunication traffic and land use data, and the development of a regional source-destination traffic matrix that identifies the destination preferences of traffic originating from various land use categories. The work would result in the preparation of three types of network design plans: a wireless antenna site and related infrastructure plan; a special public networks needs analyses and plan; and a future needs-based telecommunication network design. In the preparation of these plan elements, alternative configurations would be pursued with particular emphasis upon the means for providing adequate universal access to broadband service within the Region.

PROGRAM BUDGET AND COST ALLOCATION

The estimated cost of conducting the needed telecommunications planning program is $715,000. This total cost could be incurred over three calendar years resulting in an average annual funding requirement of about $238,000. At the direction of the Advisory Committee, a number of potential funding sources for the program were explored, including private foundations, other private sector organizations, and State and Federal agencies. Prospects for obtaining such outside funding remained uncertain as the Committee completed work in late fall of 2003. Accordingly, the Committee recommended that the cost of the proposed planning program be borne as part of the normal regional planning effort whereby the seven constituent counties share program costs annually based upon equalized property valuation, all in accordance with State statutory requirements. Should private sector or State funding become available, such funds would reduce the cost burden to be borne by the property taxpayers in Southeastern Wisconsin. The interest in, and the positive stance of, the Wisconsin Department of Commerce in support of regional telecommunications planning, and the availability of Federal funding to that Department, makes State financial assistance for the proposed planning program a distinct possibility.

CONCLUDING RECOMMENDATIONS

The Advisory Committee recommends that a regional telecommunications planning program be established for the Southeastern Wisconsin Region at the earliest possible date; and that the scope, content, time sequence, organization, committee structure, and budget for the needed planning effort all be as recommended in this Prospectus. The proposed planning program would provide, for the first time within the Region, a monitoring network that could be used to identify the quality of telecommunication services within the various subareas of the Region; would provide a needed wireless service antenna and related infrastructure facilities siting plan for the Region; and would set forth alternative universal access to broadband telecommunication facilities and services throughout the seven-county Region.

During a period of very rapid technological and regulatory change in the telecommunications industry, a regional telecommunications planning program will enable Southeastern Wisconsin to strengthen its role in a very competitive global economy. Asian countries have already deployed broadband services to a large majority of their businesses and people, far beyond what is now available in Southeastern Wisconsin. Over the next 10 years, the impacts of telecommunication facilities and services on regional development may be expected to parallel previous historical impacts of railway facilities and services in the 19th century, and of highway and freeway facilities and services in the 20th century. Developing an advanced telecommunications infrastructure will require a thorough ongoing evaluation of multiple technologies and networks to identify the best telecommunication system for Southeastern Wisconsin. Plan implementation will also require a creative approach to financing the construction and operation of this system. Meeting the telecommunications challenge will require timely and effective action by both local governments and private service providers in Southeastern Wisconsin. The alternative, however, is to be left behind in a stagnant economy on the wrong side of the digital divide.

It is also important, in conclusion, to point out some very specific benefits that could result from the proposed regional telecommunications planning program. These include:

1. <u>Knowledge of Current Regional Telecommunications Infrastructure and Service Quality</u>
   The proposed planning effort will provide not only for a current telecommunication inventory, but also for periodic updates of service quality based on the network monitoring system.

2. <u>Alternative Network Designs</u>
   The proposed planning effort will allow for a wide-ranging and open evaluation of alternative telecommunication network infrastructure designs. Such an open evaluation is unlikely to occur without a regional telecommunications planning program.

3. <u>Advanced Broadband Network</u>
   The proposed planning effort will offer the opportunity for a quantum leap forward in

broadband networking, avoiding the incremental "catch up" scenario characteristic of the current system.

4. Public/Private Partnerships
   The proposed planning effort will provide an opportunity for cooperative public/private partnerships in financing and deploying the best telecommunications network for Southeastern Wisconsin.

5. Cost-Saving Benefits
   The proposed planning effort will permit the Region to reap the cost-saving benefits of optimal use of wireline and wireless technologies and facilities.

6. Public Networks
   The proposed planning effort will assist in the creation and expansion of public telecommunications networks such as healthcare, public safety, education, environmental monitoring, and transportation.

At the same time, the absence or extended delays in initiating a regional telecommunications planning program could seriously inhibit the economic development and social welfare of the Region in the following ways:

1. Service Provider Dependence
   In the absence of a public telecommunications planning effort, the Region may be expected to remain dependent upon existing service providers for the development of the telecommunications infrastructure of the Region. These providers are primarily national or global corporations whose interests and priorities may or may not coincide with the socioeconomic interests of Southeastern Wisconsin.

2. Wireless Infrastructure
   In lieu of a regional wireless antenna site and related infrastructure plan, the Region will be subject to the "rush to market" siting of antennae in the coming growth of wireless communications.

3. Public Networks
   In the absence of a regional telecommunications plan, and a proactive program for public network development, the Region may forego opportunities to advance telemedicine, public safety, education, and the quality of the environment and the level of transportation service.

4. Universal Regional Broadband Service
   Without a regional telecommunications plan, it is unlikely that a uniform and advanced level of broadband service will develop within the Region.

5. Low End of Digital Divide and Socioeconomic Stagnation
   While an advanced telecommunications system will not guarantee a vibrant, growing economy, a mediocre system will severely limit the development of the Region in today's information-based economy.

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APPENDIX

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Appendix A

GLOSSARY

Term	Definition
1G	First generation wireless technology: Analog technology, introduced circa 1983.
2G	Second generation wireless technology: Digital technology, introduced circa 1992.
3G	Third generation wireless technology: Broadband, high speed, digital technology, currently being introduced.
4G	Fourth generation wireless technology: Advanced broadband, high speed, digital technology, anticipated to be introduced circa 2007.
ATM	Asynchronous Transfer Mode: ATM service was developed to allow one communication medium (high speed packet data) to provide for voice, data and video service. During the 1990s, ATM became a standard for high-speed digital backbone networks. ATM networks are widely used by large telecommunications service providers to interconnect their network parts (e.g., DSLAMs and Routers). ATM aggregators operate networks that consolidate data traffic from multiple feeders (such as DSL lines and ISP links) to transport different types of media (voice, data and video).
AT&T	American Telephone & Telegraph Company: Prior to 1984, AT&T was the major telephone service provider and equipment manufacturer in the U.S. Broken up by court decree in 1984, the Company became a long distance service provider and eventually spun off its manufacturing arm in a series of divestitures. Today, it is a major long distance and wireless service provider and a CLEC in many areas of the country.
CLEC	Competitive Local Exchange Carriers: The term was coined by the Telecommunications Act of 1996 and refers to an organization that competes with the incumbent, i.e., a former monopoly local phone company.
CO	Central Office: The CO is the location which houses a switch to serve local telephone subscribers.
DSL	Digital Subscriber Line: A generic name for a family of digital lines (also called xDSL) being provided by CLECs and local telephone companies for high speed data services.
DWDM	Dense Wave-Length Division Multiplexing: A version of fiberoptic communication that combines many optical channels on a single fiber to increase the data transmission capacity of the fiber. Dense wave division multiplexing provides a significant increase to wave division multiplexing (WDM) that combines up to four different optical channels (different wavelengths) on a single fiber. As of 2001, DWDM systems provided for 8 to 80 different wavelengths with the capability of transferring over 1 trillion bits of data per second (Tbps).
EHF	Extremely High Frequency: The band of microwave frequencies between the limits of 30 GHz and 300 GHz (wavelengths between 1 cm and 1 mm).
FCC	Federal Communications Commission: The federal organization set up by the Communication Act of 1934 to regulate all interstate (but not intrastate) communications in the U.S.

Term	Definition
FSO	Free Space Optical: FSO refers to wireless telecommunications transmission in the infrared frequency bands in the 800-1600 nanometer range.
FTTC	Fiber to the Curb: A hybrid transmission system which involves fiber optic links to the curb and either twisted pair or coaxial cable to the premises.
FTTH	Fiber to the Home: A transmission system in which optical fiber is carried all the way to the customer's premises.
FTTN	Fiber to the Neighborhood: A hybrid transmission system involving optical fiber from the carrier network to a neighborhood node. The connection from the neighborhood node to individual homes may be wireless or involve legacy twisted pair or coaxial cable.
GIS	Geographic Information System: Computer applications involving the storage and manipulation of maps and related data in electronic format.
HFC	Hybrid Coax-Fiber Optic Cable: An advanced CATV (cable television) transmission system that uses fiber optic cable for the head end and feeder distribution system and coaxial cable for the customer's end connection. HFC are the 2nd generation of CATV systems. They offer high-speed backbone data interconnection lines (the fiber portion) to interconnect end user video and data equipment. Many cable system operators anticipating deregulation and in preparation for competition began to upgrade their systems to HFC systems in the early 1990s. As of late 2000, over 35 percent of the total cable lines in the United States had been converted to HFC technology.
IEEE	Institute of Electrical and Electronic Engineers: Founded in 1884 as the AIEE (American Institute of Electrical Engineers), it later merged (circa 1960s) with the Institute of Radio Engineers (IRE) to become the world's largest technical professional society renamed the IEEE. It sponsors technical symposia, conferences and local meetings and publishes technical papers. In telecommunications, it is best known for the publication of standards such as the 802 series for local area networks.
ILEC	Incumbent Local Expansion Carrier: A telephone carrier (service provider) that was operating a local telephone system prior to the divestiture of the AT&T Bell system. Also specifically defined in the Telecommunications Act of 1996 as a carrier providing local exchange service to a specific area as of the date of the enactment of the Act.
IP	Internet Protocol: The IP is a protocol describing software used on the Internet that routes outgoing messages, recognizes incoming messages, and keeps track of addresses for different nodes.
ISO/FCAPS	International Standards Organization/Fault Configuration Accounting Performance Security: ISO is a voluntary organization chartered by the United Nations in 1947 that develops and publishes international standards in many technical areas. FCAPS is a standard for the management of telecommunications networks. The standard embraces performance management which is the function of the proposed network monitoring system in Southeastern Wisconsin.

Term	Definition
ISP	Internet Service Provider: A company that provides an end user with data communications service that allows them to connect to the Internet. An ISP purchases a high-speed link to the Internet and divides up the data transmission to allow many more users to connect to the Internet.
ITS	Intelligent Transportation System: A technology that employs computers, sensors and communications networks to improve the operation of transportation systems.
LAN	Local Area Network: A LAN is a communications network connecting computers, work stations, printers, file servers and other devices inside a building or campus.
LATA	Local Access Transport Area: An area served by a local telephone company in which it may offer both local and toll services.
MHz	Megahertz: A unit of frequency denoting one million Hertz (Hz) or one million cycles per second.
MIB	Management Information Base: A database of network management information used by CMIP (common management information protocol) and SNMP (simple network management protocol).
MMDS	Microwave Multipoint Distribution System: A method of distributing television signals through microwave from a single transmission point to multiple receiving points.
MPLS	Multiple Protocol Label Switching: MPLS is a widely supported method of speeding up IP-based communications over ATM or Ethernet networks.
NMS	Network Management Station: NMS is a central station in a network monitoring system that talks to remote network management agents to obtain information used in network performance or other monitoring functions.
OC	Optical Carrier: OC is a term used to designate transmission rates in fiber transmission systems using the SONET protocol.
OSI	Open System Interconnection: A reference model developed by the ISO that defines the seven layers used in communication network protocols.
PCS	Personal Communication System: A low-powered, high frequency alternative to traditional wireless cellular communications systems.
POP	Point of Presence: A physical location that allows an interexchange carrier (IXC) to connect to a local exchange company (LEC) within a LATA. The point of presence (POP) equipment is usually located in a building that houses switching and/or transmission equipment for the LEC.
POTS	Plain Old Telephone Service: The basic service supplying standard telephone single line telephones and access to the public switched network.
PSC-WI	Public Service Commission of Wisconsin: The agency that regulates public utilities in Wisconsin.
PSTN	Public-Switched Telephone Network: The local, long distance, and international phone system.

Term	Definition
QoS	Quality of Service: A measure of the quality of telephone service provided to a subscriber. It embraces a wide range of specific definitions depending on the type of service provided.
RF	Radio Frequency: Electromagnetic waves operating between 10 kHz and 30 GHz in either cables or free space.
RTM	Regional Traffic Matrix: A data matrix that defines the origins and destinations of voice, data, or multimedia communications in a geographic region.
SHF	Super High Frequency: The frequencies ranging from 3 GHz to 30 GHz (wave-lengths between 10 cm and 1 cm).
SNMP	Simple Network Management Protocol: A standard communication protocol that is used to setup, test, and manage network equipment. By conforming to this protocol, equipment assemblies that are produced by different manufacturers can be managed by a single program. SNMP protocol can operate via Internet protocol.
SONET/SDH	Synchronous Optical Network/Synchronous Digital Hierarchy: The current leading optical transmission protocols used in North America (SONET) and internationally (SDH).
T/DS	Transmission-Digital Signal: The T and DS define levels of digital transmission speed capabilities of digital lines and trunks. The T-1 line has a signaling speed of 1,544,000 bits per second.
TCP/IP	Transmission Control Protocol/Internet Protocol: TCP/IP is standard set (suite) of protocols that define the transmission of Internet messages. The Transmission Control Protocol (TCP) portion ensures message delivery between two points and the Internet Protocol (IP) defines the routing of physical packets of data.
TIA	Telecommunications Industry Association: An association of telecommunications equipment manufacturers.
UHF	Ultra High Frequency: The frequency range from 300 MHz to 3000 MHz (3 GHz).
UNE	Unbundled Network Element: Network elements owned by ILECs that must be available to CLECs in accordance with the Telecommunications Act of 1996.
VA	Vulnerability Assessment: Methods used to determine the security of a network.
VoIP	Voice Over Internet Protocol: A process of sending voice telephone signals over the Internet. If the telephone signal is in analog form (voice or fax), the signal is first converted to a digital form. Packet routing information is then added to the digital voice signal so it can be routed through the Internet.
WiFi	Wireless Fidelity: A popular term for wireless local area networks operating under IEEE Standard 802.11b in the 2.4 GHz range.