MEMORANDUM REPORT NO. 164

POTENTIAL PUBLIC ENTERPRISE TELECOMMUNICATIONS NETWORKS FOR SOUTHEASTERN WISCONSIN

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Chapter I

INTRODUCTION

INTRODUCTION

The Southeastern Wisconsin Regional Planning Commission is charged by law 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, extend to all phases of regional development, implicitly emphasizing, however, the preparation of spatial designs for the use of land and for supporting transportation and other utility facilities, including telecommunications facilities.

The scope and complexity of areawide development problems prohibit the making and adopting of an entire comprehensive development plan at one time. The Commission has, therefore, determined to proceed with the preparation of individual plan elements which together can form the required comprehensive plan. Each element is intended to deal with an identified areawide developmental or environmental problem. The individual elements are coordinated by being related to an areawide land use plan. Thus, the land use plan comprises the most basic regional plan element, an element on which all other elements are based.

Because regional telecommunications planning comprises an integral part of a broader regional planning program, an understanding of the need for, and objectives of, regional planning and the manner in which these needs are being met in southeastern Wisconsin is necessary for a full understanding of the telecommunications planning process and of its findings and recommendations as presented in this report. To that end, this chapter describes the need for, and status of, the regional planning effort within the Southeastern Wisconsin Region.

NEED FOR REGIONAL PLANNING

Regional planning may be defined as comprehensive planning for a geographic area larger than a county but smaller than a state, united by economic interest, geography, and common areawide developmental and environmental problems. The need for such planning has arisen from certain important social and economic changes which, while national phenomena, have had far-reaching impacts on the problems facing local government. These changes include growth and redistribution of population and attendant urban development; changes in agricultural and industrial productivity, income levels, and leisure time; generation of mass recreational needs and pursuits; intensive use and consumption of natural resources; development of private water supply and sewage disposal systems; development of extensive electric power and communications networks; and development of limited-access highways and mass automotive transportation. Through the effects of these changes, entire regions like southeastern Wisconsin are being subjected to the widespread diffusion of urban development and are thereby becoming large, mixed rural and urban socio-economic complexes. This urban diffusion, in turn, creates serious and complex areawide developmental and environmental problems.

The areawide problems which necessitate a regional planning effort in southeastern Wisconsin all have their source in the changes in population size, composition, and distribution and in the attendant urban diffusion occurring within the Region. These areawide problems include, among others: drainage and flooding; air and water pollution; increased demand for park and outdoor recreation facilities, sewerage and water supply facilities, and housing; traffic congestion; a growing demand for high speed, broadband telecommunications; and, underlying all of the foregoing problems, rapidly changing land use development. These problems are all truly regional in scope, transcending both the geographic boundaries and the fiscal capabilities of the local municipal units of government comprising the Region, and can be properly addressed only within the context of a continuing, cooperative, areawide, comprehensive regional planning effort.

THE REGIONAL PLANNING COMMISSION

The Southeastern Wisconsin Regional Planning Commission was created in August 1960, pursuant to the provisions of Section 66.0303 of the Wisconsin Statutes, to serve and assist the local, state, and federal units of government in solving areawide problems and in planning for the more orderly and more economic development of southeastern Wisconsin. The Commission's role is entirely advisory, and participation by local units of government in its work is on a voluntary, cooperative basis. The Commission is composed of 21 citizen members, three from each county in the Region. One Commissioner from each county is appointed to the Commission by the county board, one by the Governor from a list certified to him by the county board, and one by the Governor on his own motion.

The powers, duties, and functions of the Commission and the qualifications of the Commissioners are carefully set forth in the enabling legislation. The Commission is authorized to employ a staff and to appoint advisory committees to assist it in the execution of its responsibilities. Basic funding to support Commission operations is provided by the member counties, with the budget apportioned among the seven counties on the basis of relative equalized property valuation. The Commission is authorized to request and accept aid in any form from all levels and agencies of government to accomplish its objectives, and is authorized to deal directly with the state and federal governments for this purpose. The organizational structure of the Commission and its relationship to the constituent units and agencies of government comprising or operating within the Region is shown in Figure 1.

THE REGIONAL PLANNING CONCEPT IN SOUTHEASTERN WISCONSIN

Regional planning, as conceived by the Commission, is not a substitute for, but a supplement to, local, state, and federal planning. Its objective is to assist the various levels and units of government in finding cooperative solutions to areawide developmental and environmental problems which cannot be properly resolved within the framework of a single municipality or county. As such, regional planning has three principal functions:

1. Inventory: the collection, analysis, and dissemination of basic planning and engineering data on a uniform, areawide basis so that, in light of such data, the various levels and agencies of government and private investors operating within the Region can better make decisions concerning community development.

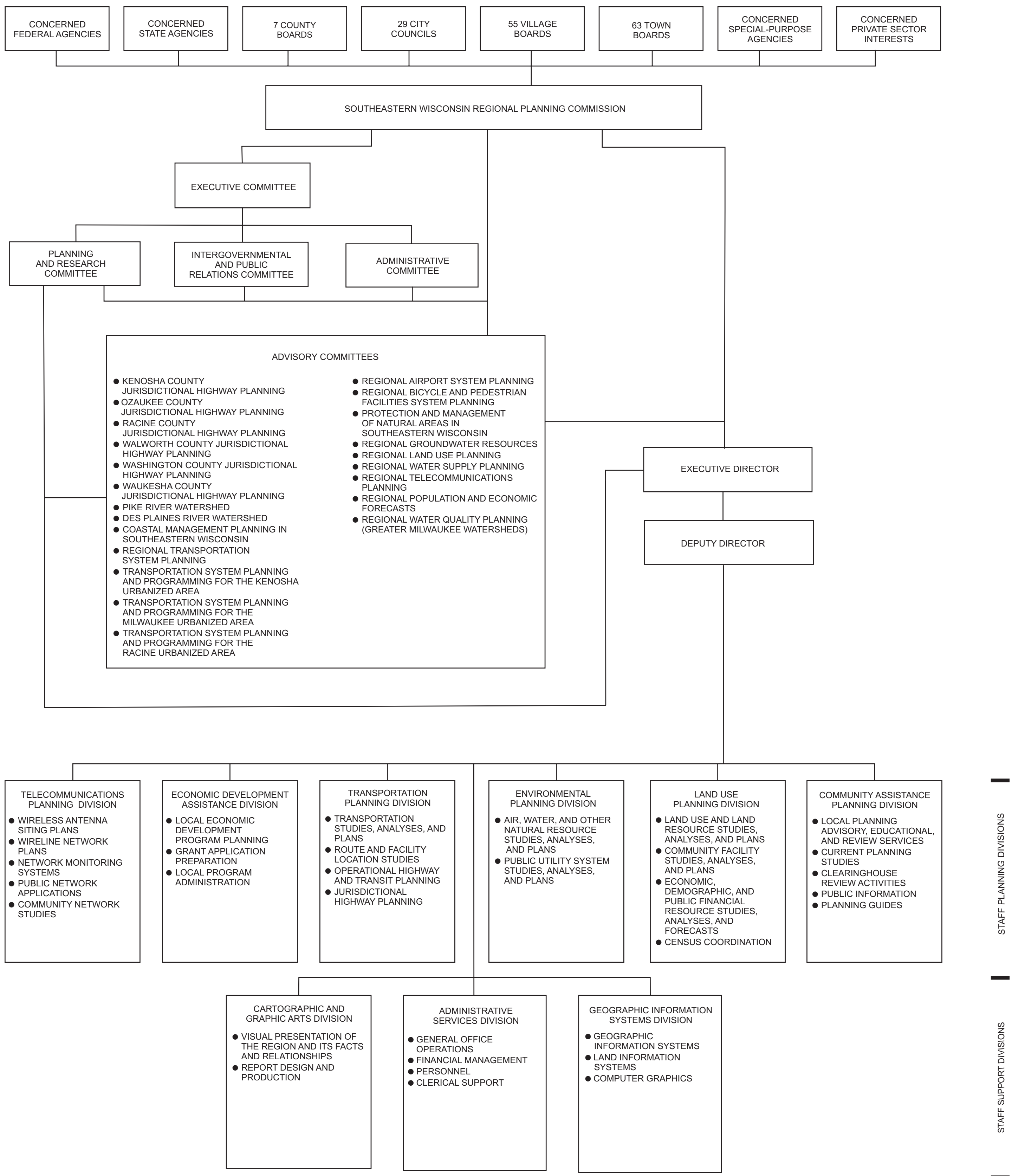
2. Plan design: the preparation of a framework of long-range plans for the physical development of the Region, these plans being limited to functional elements having areawide significance.

3. Plan implementation: promotion of plan implementation by providing a center to coordinate the planning and plan implementation activities of the various levels and agencies of government in the Region and by providing the introduction of information on areawide problems, recommended solutions to these problems, and alternatives thereto, as part of the existing decision-making process.

The work of the Commission, therefore, is seen as a continuing planning process providing outputs of value to the making of development decisions by public and private agencies and to the preparation of plans and plan implementation programs at the local, state, and federal levels. It emphasizes close cooperation between the governmental agencies and private enterprises responsible for the development and maintenance of land uses in the

Figure 1

SEWRPC ORGANIZATIONAL STRUCTURE: 2005



Region and for the design, construction, operation, and maintenance of the supporting public and private facilities. All Commission work programs are intended to be carried out within the context of a continuing overall planning program which provides for periodic reevaluation of the plans produced and for the extension of planning information and advice necessary to convert the plans into action programs at the local, regional, state, and federal levels.

THE REGION

The Southeastern Wisconsin Planning Region, as shown on Map 1, is comprised of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha Counties. Exclusive of Lake Michigan, these seven counties have a total of 2,689 square miles, or about 5 percent of the total land and inland water area of Wisconsin, and a total resident population of about 1.97 million people. About 36 percent of the population of the State lives in these seven counties. The seven counties provide about 1.19 million jobs, or about 36 percent of the total employment of the State. The Region contains real property valued at about $145.4 billion as measured in equalized valuation, or about 37 percent of all of the tangible wealth of the State, as measured by such valuation. The Region contains 154 local units of government, exclusive of school and other special-purpose districts, and encompasses all or parts of 11 major watersheds.

Geographically the Region is located in a relatively good position with regard to continued growth and development. It is bounded on the east by Lake Michigan, which provides an ample supply of fresh water for both domestic and industrial use, and is an integral part of a major international transportation network. It is bounded on the south by the rapidly expanding northeastern Illinois metropolitan region and on the west and north by the fertile agricultural lands and desirable recreational areas of the rest of the State of Wisconsin. Many of the most important industrial areas and heaviest population concentrations in the Midwest lie within 250 miles of the Region, and over 27.3 million people reside within this radius.

COMMISSION WORK PROGRAMS TO DATE

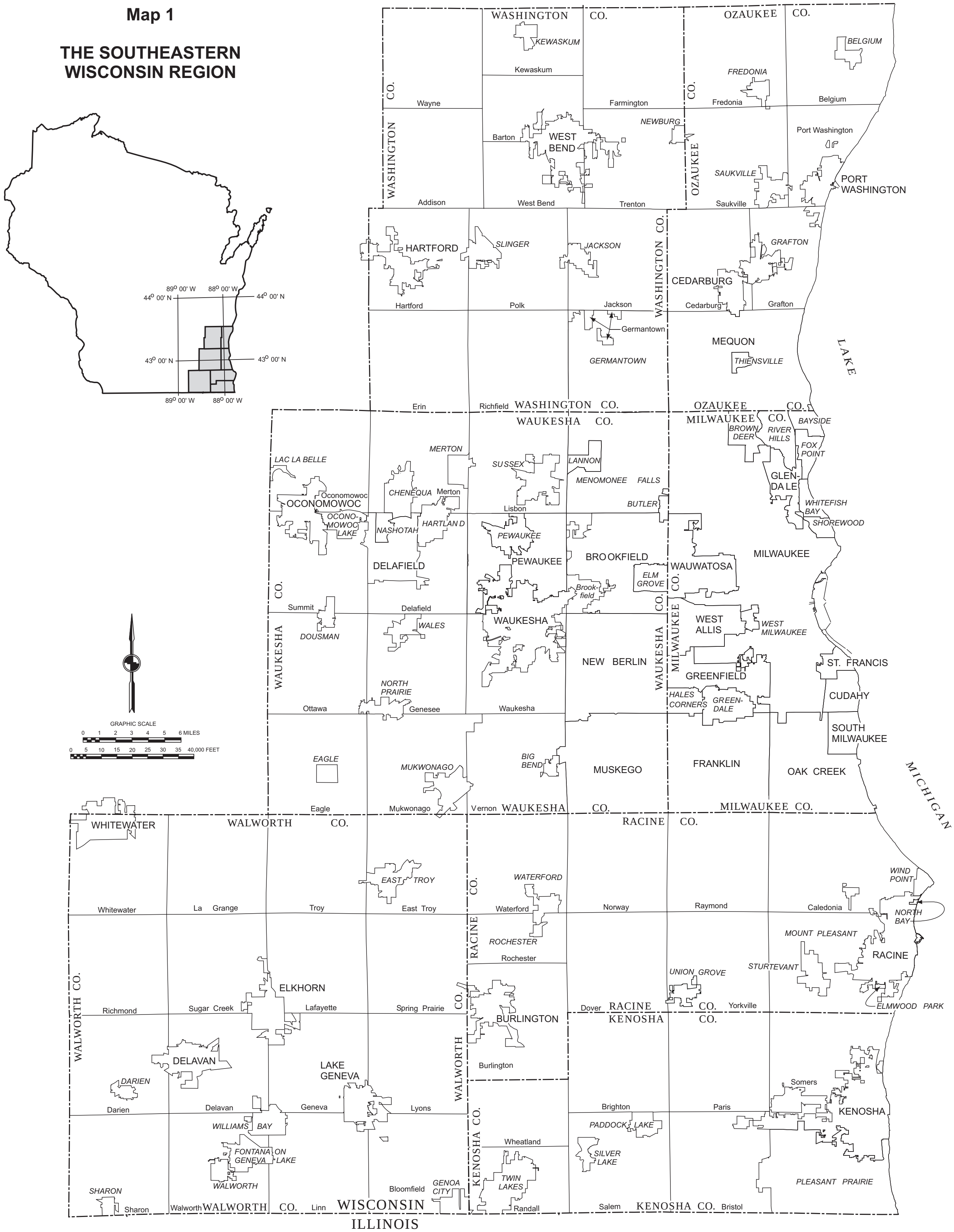
Since its creation in 1960, the Regional Planning Commission has diligently pursued its three basic functions of areawide inventory, plan design, and promotion of plan implementation through intergovernmental cooperation and coordination, although the relative emphasis placed upon these functions has changed somewhat over time. Initially, major emphasis in the Commission's work program was on the inventory function, with increasing attention being placed over the years on the plan design and on the intergovernmental coordination functions.

With respect to the inventory function, the Commission's planning program, as conducted since 1961, has resulted in the creation of a data bank containing in a readily usable form the basic planning and engineering information required for sound, areawide planning. The data assembled in the regional data bank include, among others, definitive data on streamflows; floodlands; surface and groundwater quality; woodlands, wetlands, and wildlife habitat; sites having scenic, scientific, cultural, and recreational value; soils; existing and proposed land uses; travel habits and patterns; transportation system capacity and utilization; existing and proposed utility service areas; and the demographic and economic base and structure of the Region. The data base also includes an extensive topographic and cadastral base mapping and horizontal and vertical survey control file.

Some of the data in the regional planning data bank have been assembled through the collation of data collected by other agencies. Data so assembled include data on highway and transit facility capacity, use, and service levels; transportation terminal facility capacity; automobile and truck availability; and population and economic activity levels. Much of the data in the regional data bank, however, have been assembled through original inventory efforts conducted by the Commission itself. Such inventory efforts have ranged from aerial photography, large-scale topographic and cadastral base mapping, and control survey programs; through extensive land use, woodland, wetland, wildlife habitat, potential park site, and public utility system inventories; to massive travel inventory, detailed operational soil survey, and streamflow gaging and water quality monitoring efforts.

Map 1

THE SOUTHEASTERN WISCONSIN REGION



Source: SEWRPC.

The regional planning data bank is supported by an extensive data conversion, filing, and retrieval capability which permits the basic data to be readily manipulated and tabulated by various geographic areas, ranging in size from the Region as a whole down through natural watersheds, counties, and minor civil divisions to planning analysis areas, census enumeration districts and tracts, traffic analysis zones, U.S. Public Land Survey sections and quarter-sections, and, for certain data, urban blocks and block faces. Of increasing importance in the regional planning data bank is the Commission's automated geographic information systems capability. A key regional map file consists of land use data which have been digitized, allowing for automated map reproduction and related data analysis functions. The Commission's planning data bank provides valuable points of departure for all Commission work efforts and is, moreover, available for use by the constituent agencies and units of government and the private sector.

With respect to the plan design function, the Commission has placed great emphasis upon the development of a comprehensive plan for the physical development of the Region in the belief that such a plan is essential if land use development is to be properly coordinated with development of supporting transportation, telecommunications, utility, and community facility systems; if the development of each of these individual functional systems is to be coordinated with the development of each of the others; and if serious and costly developmental and environmental problems are to be avoided and a safer, more healthful and attractive, as well as more efficient regional settlement pattern is to be achieved. Under the Commission's approach, the preparation, adoption, and use of the comprehensive plan are considered to be the primary objective of the planning process; and all planning and plan implementation efforts are related to the comprehensive plan.

Telecommunication networks have become a vital resource in the physical development of metropolitan regions. Business firms, local units of government, educational facilities, and individual households all depend on communications in the conduct of their daily lives and high speed—broadband—communications for data and video as well as voice communications is becoming an integral part of a modern society.

The comprehensive plan not only provides an official framework for coordinating and guiding growth and development within a multijurisdictional urbanizing region, but also provides a good conceptual basis for the application of systems engineering skills to the growing problems of such a region. The comprehensive regional plan also provides the essential framework for more detailed physical development planning at the county, community, and neighborhood levels.

As previously noted, because the scope and complexity of areawide development problems prohibit the preparation of an entire comprehensive plan at one time, the Commission has determined to proceed with the preparation of individual plan elements which together comprise the required comprehensive plan. By the end of 2003, the adopted regional plan consisted of 23 individual plan elements. Four of these elements are land use related: the regional land use plan, the regional housing plan, the regional library facilities and services plan, and the regional park and open space plan. Seven of the plan elements relate to transportation. These consist of the regional transportation plan including highway and transit elements, the regional airport system plan, the transportation systems management plan, the elderly and handicapped transportation plan, and detailed transit development plans for the Kenosha and Racine urbanized areas and for the City of Waukesha. Eleven of the adopted plan elements fall within the broad functional area of environmental planning. These consist of the regional water quality management plan, the regional wastewater sludge management plan, the regional air quality attainment and maintenance plan, and comprehensive watershed development plans for the Des Plaines, Fox, Kinnickinnic, Menomonee, Milwaukee, Pike, and Root Rivers, and the Oak Creek, watersheds. The final two plan elements consist of comprehensive community development plans for the Kenosha and Racine urbanized areas.

The telecommunications planning program is new to the Commission with the initial planning studies beginning in 2004. The program initiation was in recognition of the vital role of telecommunications in the regional economy. In form, it most closely resembles transportation planning, with both relating to infrastructure networks. It differs, however, in the rapid pace of technological change and the role of private carriers in plan implementation.

The Commission also carries on an active community assistance planning program, in which functional guidance and advice on planning problems are provided to local units of government and regional planning studies are interpreted locally so that the findings and recommendations of these studies may be incorporated into local development plans and plan implementation programs. Seven local planning guides have been prepared under this program to provide information helpful in the preparation of local plans and plan implementation ordinances. The subjects of these guides are land subdivision control, official mapping, zoning, organization of local planning agencies, floodland and shoreland development, and the use of soils data in development planning and control. Telecommunications planning services will also be extended to local units of government as part of the Commission's community assistance program. Beyond the questions related to antenna structure siting, some communities may require assistance in assessing telecommunications service levels and needs.

TELECOMMUNICATIONS—DEFINITION AND IMPORTANCE

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 help weave the social and political fabric of modern day life and help to achieve needed economic development. 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—including special distance learning for public safety personnel, environmental monitoring, and transportation 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.

A class of telecommunications networks of particular interest in a regional telecommunications planning program are public networks, or more specifically, public enterprise networks. For the purposes of this, the functions served may be public or quasi-public, the latter including non-profit organizations. The word enterprise is used to avoid confusion with public telephone and cable networks operated by private carriers. The term public enterprise networks, as used in this memorandum, refers to telecommunications networks serving functions generally considered to be in the public domain, such as public safety, public health, transportation, and general purpose county and municipal government. These functions may also include emerging public functions, such as homeland security, the provision of pre-hospital emergency medical services, and the development of at distance learning applications to meeting the continuing training requirements for public safety personnel such as fire fighters and emergency medical technicians.

In identifying the public telecommunications network service initiatives to be considered, precise definitions of the scope of the initiatives concerned is important. Broad, general designations, such as "telemedicine", lack required precision and do not allow for meaningful identification of implementation projects, budgets, or schedules. More precise definitions would include narrower telemedical sub-categories, such as pre-hospital emergency medicine, home healthcare, and public health monitoring. The key definitional issues concern whether the initiative relates to an existing or emerging public function and whether successful implementation of a network would address a pressing public need.

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[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.*

The objectives of the initial public networks planning work element include evaluations of the needs for the current and potential public enterprise networks, together with evaluation of the likelihood of successful implementation of the various networks considered. Such successful implementation is usually dependent on the availability of adequate personnel and financial resources reinforced by strong public and private interest. The end result of the identification and evaluation effort will be definitions of, and recommendations for proceeding with, the next stage of planning for each of the networks considered. These definitions and recommendations are thus intended to constitute potential next step planning projects.

ADVISORY COMMITTEE

The long-established practice of the Commission has been to conduct major regional planning programs with the assistance of appropriately structured advisory committees. The membership of such committees is 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 plans. The Committee consists of the following members:

Kurt W. Bauer, Chairman ....Executive Director Emeritus, SEWRPC
William R. Drew ....Vice Chairman, SEWRPC, and Executive Director, Milwaukee County Research Park
Kenneth Brown... RF Engineer, Nextel Communications, Inc.
Roger Caron .... President, Racine Area Manufactures and Commerce
Bob Chernow .... Chairman, Regional Telecommunications Commission
David L. DeAngelis ....Village Manager, Village of Elm Grove
Michael Falaschi ....President, Wisconsin Internet
Brahim Gaddour ....Director of Network Operations, Time Warner Telecom of Wisconsin
Barry Gatz ....Network Supervisor, CenturyTel
Michael E. Klasen ....Director of Regulatory Affairs, SBC
J. Michael Long ....Attorney at Law, Murn and Martin, SC
Jeff Mantes ....Commissioner of Public Works, City of Milwaukee
Jody McCann ....Network Domain Manager, Wisconsin Department of Administration, BadgerNet
George E. Melcher .... Director, Office of Planning and Development, Kenosha County
Paul E. Mueller .... Administrator, Washington County Planning and Parks Department
Steven L. Ritt .... Attorney at Law, Michael Best & Friedrich
James W. Romlein ....Managing Director, MVLabs, LLC
Bennett Schliesman .... Director, Kenosha County Emergency Management/Homeland Security
Dale R. Shaver .... Director, Waukesha County Department of Parks and Land Use
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. ....SEWRPC Commissioner

PROSPECTUS

On December 4, 2002 the Commission authorized the preparation of a Prospectus for a Regional Telecommunications Planning Program. During the following year the Commission staff, under the guidance of a predecessor Advisory Committee, prepared a prospectus for a regional telecommunications planning program. This prospectus described in some detail the need for, and the major work elements of, such a planning program. In December 2003, the Commission approved the initiation of a regional telecommunications planning program based on this prospectus. The prospectus envisions the regional telecommunication plan to be comprised of two elements: a wireless antenna siting and related infrastructure plan; and an overall telecommunications network plan. In addition, the prospectus calls for a technical report presenting the findings of an inventory of the existing regional telecommunications system and system performance; and a report intended to identify potential public enterprise networks that could be considered in detail in subsequent, more focused planning efforts.

TECHNICAL STUDY DESIGN MEMORANDUM No. 4: PUBLIC ENTERPRISE NETWORKS

In 2004, a series of six technical study design memoranda were prepared to further define the content of the regional telecommunications planning program. One of these design memoranda, No. 4, described a selection and implementation process for the development of public enterprise networks in the Region. The memorandum also highlighted particular types of public networks that warrant serious consideration by local units of government in the Region. This report on public enterprise networks will provide needed information on these potential public sector telecommunications network applications.

THE PUBLIC ENTERPRISE TELECOMMUNICATIONS NETWORK PROPOSALS

As already noted, within the context of the regional telecommunications planning program, the term public enterprise telecommunications networks refers to telecommunications networks that perform public functions in such areas as public safety, public health, and transportation. These functions all represent public sector applications of telecommunications networks. They may or may not require new network infrastructure. Some public networks can operate as applications on existing privately owned physical networks. Others may require augmentation of existing physical networks—public or private—and still others may require new network infrastructure.

SCHEME OF PRESENTATION

The findings and recommendations of the potential public enterprise telecommunication networks identification process are documented in this report. Following this introduction, Chapter II sets forth the basic concepts underlying public enterprise networks planning, and outlines the major steps in the process. Chapter III describes the applications development process for public enterprise telecommunication networks with a section on the steps involved and the need for the support of county and local governments in the Region. A series of public enterprise network candidates are then described in sufficient detail to serve as a basis for developing awareness of their potential contributions to the Region and for mobilizing support for their potential implementation. These include public safety, public health, transportation, and public utility networks, but the functions addressed are not exclusive. Other functions, such as general purpose county and municipal government could be added as interest may dictate. Chapter IV describes the procedures used in the planning and design of public networks. Chapter V concludes with a summary of the findings and recommendations.

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Chapter II

BASIC PLANNING CONCEPTS

INTRODUCTION

In developing proposals for identifying potential public enterprise networks within the Region, the Regional Planning Commission deviated from its normal planning process which is oriented to specific types of infrastructure. These proposals present the needs for specific classes of potential public enterprise networks, and then presents the characteristics, resource requirements, potential development project schedules, and potential interests concerned with these networks. Based on this information, this document then suggests the means for organizing application task forces to implement the development of each type of network.

PUBLIC ENTERPRISE NETWORK—DEFINITION AND SCOPE

A general definition of public enterprise networks was provided in Chapter I. Here this definition is extended to present the nature and scope of these networks and how they may be expected to impact the Region now and in the future. Until recently, both wireline and wireless communication networks have provided a secondary, supportive role to local governments in the Region. With the advent of broadband communications, the role of communications in governmental operations of all kinds may be expected to become of primary concern. The availability of multimedia communications in public safety, public health, transportation, and general government services may transform the way in which these functions are carried out, enhancing their cost effectiveness.

PLANNING PROCESS

The purpose of this report is to initiate the public enterprise network planning process by presenting an applications development procedure aimed at defining the needs for, and characteristics of, various potential public enterprise networks. This information can provide the foundation for obtaining the support of appropriate county and local officials that will be needed to gain the resources required for network development. An example of such an effort is presently underway in the field of the public safety networks. At the request of cognizant county officials, a preliminary broadband wireless network design layout for the public safety function complete with antenna site locations based on WiMAX technology was prepared by the Commission for Ozaukee County. A preliminary infrastructure cost estimate was also prepared. This preliminary network design was then presented to the telecommunications manager of Ozaukee County for consideration. That initial presentation has created sufficient interest so that Ozaukee County is including plans for the development of a broadband WiMAX high speed data network as part of a county public safety communications system upgrade for 2006. This experience would indicate that county and local government interest in broadband public enterprise communication network is most likely to occur from concrete preliminary network designs rather than from just generalized descriptions of technology. After such interest is forthcoming, planning for specific public enterprise networks may then proceed with the assistance of a modified version of the regional planning process. That process may be described as follows:

1. <u>Formulation of Objectives and Standards</u>

A set of objectives and standards have been prepared and approved for general purpose future broadband wireless networks in the Region.[1] These objectives and standards can serve as general guidelines for the development of any telecommunications network within the Region, including public enterprise networks. Some of these objectives are applicable to any telecommunications network, including the objectives relating to performance, redundancy, and infrastructure cost minimization. The applicability of some of the objectives will vary with the network application. Similarly, the standards supporting the universal class of objectives are applicable to any network, including availability, throughput, response time, and accuracy. Unique applications with specific objectives may require additional standards.

2. <u>Facilities and Services Inventory</u>

The telecommunication facilities and services inventory data for a potential public enterprise network will typically be available through the public agencies concerned. Public wireless and wireline infrastructure inventories will also be collected as part of the general regional telecommunications planning effort. Performance monitoring for service quality is a different matter. Service quality must be measured both before and after a new communications system is installed, or a major upgrade is performed. A performance inventory may require special field measurements for each network.

3. <u>Analyses and Forecasts</u>

Analyses and forecasts of public enterprise networks planning will be specialized in nature. For example, the analyses and forecasts required for public safety network planning may emphasize new and emerging police, fire, and emergency medical service functions as well as spatial coverage and capacity needs based on the number of users. Transportation network analyses and forecasts may be dominated by potential new applications of broadband telecommunications technology. Analyses and forecasts for such network planning would also be greatly influenced by regional transportation system plans. Planning of telemedical networks for home health care may require special analyses and forecasts of home health care functions and growth trends in the industry. Overall, it is clear that the planning for each public enterprise network sector will have its own unique set of analyses and forecasts.

4. <u>Plan Design</u>

For wireless public enterprise networks, a common set of planning techniques and procedures have been developed that can apply to any public or private enterprise wireless communications network. These include an inventory of existing and potential antenna sites to serve as site candidates for new network plan design. The required inventory data should be available from the regional wireless and antenna location and related infrastructure plan. Radio propagation modeling studies may be required to determine the coverage and capacity of proposed networks. Optimal antenna site location studies may be required utilizing mathematical programming models that determine the minimal number of antenna sites required to provide needed coverage, capacity, and levels of quality of service. Finally, the techniques will have to include methods for infrastructure design and costing, including means for detailing of components, and estimation of costs involved in building the needed wireless infrastructure.

The foregoing planning techniques and design procedures may be applied to any wireless communications network. Public wireless networks will differ primarily in the characteristics of the application. For some applications in public safety, videoconferencing may require broadband data rate capability. Other applications, such as environmental monitoring, may be served at slower data rates but require low power, low cost field modules for remote data collection. Whatever the application, the planning techniques and design procedures will have to be applied in developing cost effective network designs.

[1] *These objectives and standards are set forth in the Chapter III, “Objectives and Standards”, of A Wireless Antenna Siting and Related Infrastructure Plan for Southeastern Wisconsin, SEWRPC Planning Report No. 51”.*

Wireline plan design techniques and procedures are not as well structured as the wireless plan design techniques and procedures. There are, however, wireline equivalents to each of the above wireless plan design techniques and procedures. These will be documented in the comprehensive regional wireline and wireless telecommunications network plan report. These techniques and procedures are not pertinent to planning for the potential public enterprise network candidates presented in this report because of the current existence of large public sector core fiber networks in Southeastern Wisconsin. The large capacity of these core fiber networks, particularly the Wisconsin Department of Transportation, the City of Milwaukee, and the Biocatt network serving Kenosha and Racine Counties, make it unlikely that there will be a need to deploy new core fiber networks in the foreseeable future. New fiber network deployments in the public sector may be expected to take the form of extensions of, or augmentations to, these current core fiber optic networks. Most of the new public enterprise telecommunications network candidates presented in this report that will require new infrastructure will be wireless in nature, with wireline fiber links required only to provide additional access points for wireless networks.

5. Plan Test and Evaluation

Two primary means exist for plan test and evaluation—system simulation modeling and prototype network experimentation. Simulation modeling may also be used as a design tool to verify the performance of network design plans, modifying these plans in an iterative fashion until the plan achieves desired performance standards. Such modeling is useful for evaluating the basic capacity of a network given specified bandwidth resources and estimated traffic loadings. For new communications technologies, however, simulation modeling may have to be supplemented with prototype network experimentation. In the application of new technologies, potential problem areas may be expected to be related to component and network characteristics that are either poorly defined or unknown. For this reason, prototype mini-networks may have to be used to determine the operational characteristics of the new technology. Fortunately, the evaluation capabilities of prototype mini-networks are complementary to those of systems simulation studies. Basic equipment function and operating procedures are best established through prototype mini-network experimentation, while the determination of network capacity and potential network "bottlenecks" are the domain of computer system simulation. Thus, simulation and field experimentation can together provide a comprehensive evaluation of new plan designs.

6. Plan Selection and Implementation

Plan selection and implementation of public enterprise networks differ significantly from communications networks for commercial and general public usage. Plan selection and implementation would take place in a more highly technical setting with representatives of the concerned public agencies working in conjunction with Commission staff and special advisory committees to select the best plan from among the alternatives considered.

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Chapter III

POTENTIAL APPLICATIONS

INTRODUCTION

This chapter presents a procedure for defining and characterizing a public enterprise network application in terms of the need for the network, a description of the network, and a description of the resource requirements for its implementation. A series of public enterprise networks are described in sufficient detail to allow for their presentation to potential sponsors, such as specific governmental agencies, with the authority, responsibility and resources necessary for moving toward implementation.

APPLICATIONS DEVELOPMENT

The first step in public enterprise network development is to establish the need for advanced telecommunications technology. Phrased differently, how would some form of advanced telecommunications, such as broadband wireless or remote monitoring, assist in better performance of public sector functions? The more specific and quantitative the need rationale, the more compelling will be the justification for the deployment. Provision for universal interoperability between jurisdictions and agencies may alone justify a new broadband public safety network. Significant savings in health care costs may justify a home health care network. Optimizing the performance of a metropolitan freeway network may justify a centralized freeway management system.

For each of the potential public sector applications presented below the following information will be provided:

1. Need for the application
   - current situation of the application
   - applicable telecommunications technology
   - potential benefits of new telecommunications technology
   - urgency and visibility of the application

2. Description of the application
   - narrative description
   - previous examples of the application

3. Resource requirements
   - personnel, SEWRPC
   - personnel, other
   - equipment and materials

4. Schedule and budget
   - project duration
   - preliminary estimated cost

5. Stakeholder identification
   - local governments
   - nongovernmental organizations
   - concerned citizens

6. Application task force
   - SEWRPC representative
   - local government representative
   - other technical/professional personnel

7. Proposal preparation

APPLICATION NO. 1

Public Safety—Emergency Response Networks

Need For Application

Current public safety communications networks within the Region operate in various VHF and UHF bands primarily in either the 150 MHz band, or the 800 MHz band. These networks provide voice communications and offer relatively slow data transmission capabilities. There is a need for broadband communications technology for high speed data transfer and video services. Such a broadband addition to the system would provide police, fire, and emergency medical service capabilities not possible with current networks. Many counties and other local units of government within the Region are currently in the process of upgrading their public safety networks that are generally 10 to 20 years old and are based upon technology that is 30 to 50 years old. Most plan to continue with the same basic technologies but with upgraded equipment and features. Some plan to switch from conventional to trunk networks in which frequency channels are dynamically shared between different public agencies. Upgrades of these systems are generally quite expensive—involving multi-millions of dollars—since they are based on equipment designs proprietary to individual manufacturers. There is now an opportunity for all public safety agencies to reevaluate their needs, and to consider the potential application of broadband communications technology in their future operations.

The applicable technology for adding high speed data transfer and video services to public safety networks is the new WiMAX technology scheduled for release soon. The first version of this technology—meeting IEEE Standard 802.16d—provides for communications from fixed sites only. A later version scheduled for release by 2006—meeting IEEE Standard 802.16e—will have the mobile capability needed for high speed public safety data-video networks.

Significant benefits may be expected from the data transfer rates possible with the new WiMAX technology. Average data transmission rates with current networks are less than 20 kilobits per second (20 kb/s) as compared to WiMAX data rates exceeding 20 megabits per second (20 Mb/s) up to 100 Mb/s and even beyond. Application of this technology may be expected to improve services and reduce costs. As an example, one current service used by law enforcement agencies, license plate based vehicle identification, now utilizes special T1 leased lines from every community in southeastern Wisconsin to Department of Transportation (WisDOT) facilities in Madison. The monthly cost of this special network could be significantly reduced while providing more rapid response times. Such services could also make use of the underutilized WisDOT fiber network that covers most of the Region and extends along IH 94 to Madison. The provision of Emergency Medical Services (EMS) could also benefit from video contact with emergency physicians at the hospital during an EMS incident. Many of the new uses of high speed data transmission and video service will develop only when the public safety users of the network become fully aware of the capabilities of the new technology.

A second related technology that could have major advantages for public safety interoperability in the Region is the new Internet protocol, known as Session Initiation Protocol (SIP). SIP-based software, currently commercially available, would allow for Internet based voice, data and video communications between both existing VHF-UHF systems and new broadband wireless networks as well as wireline networks all under SIP server control. A SIP based communications system would provide other interoperability and information exchanging features such as: data file sharing, instant messaging, presence indication and management, white boarding, web collaboration, application sharing, videoconferencing—point-to-point and point to multipoint—and web-page co-browsing. Together these features allow the provision of a level of communications in a public safety network previously beyond the reach of traditional public safety networks.

Resource Requirements, Budget and Schedule

Many of the benefits of new WiMAX based broadband wireless public safety networks are enhanced by region-wide implementation. For this reason, the resource requirements estimated here assume a regional implementation. Individual counties, or groups of counties, could gain many of the benefits without such a region-wide deployment.

A regional WiMAX/SIP broadband public safety network deployment project would require the following resources:

1. A selected broadband wireless communications manufacturer-partner. The WiMAX manufacturer should be part of the original project team;

2. A selected SIP server software partner;

3. An advisory committee comprised of representatives of the users in the participating county or group of counties involved;

4. Identification of an installation-startup service company,-if this service is not provided by the manufacturer; and,

5. An approved budget to support the project.

It is important to understand that both technologies involved in the recommended future direction for the improvement of public safety networks are standards based technologies. WiMAX is based on IEEE Standard 802.16 which is the standard for metropolitan area wireless networks. SIP is the Session Initiation Protocol established by a working group of the Internet Engineering Task Force (IETF). Standards-based technologies differ from proprietary technologies in that they are based upon equipment specifications adopted industry wide.

Once adapted, the companies in the industry manufacture to the standard and compete in the marketplace. Standards-based technologies in recent years in the telecommunications industry have led to higher quality at lower prices than proprietary equipment unique to each company. Recent examples are the Ethernet Standard (IEEE 802.3) and the WiFi Standard (IEEE 802.11). Ethernet is becoming the industry standard for fiber optic networks because of its superior performance at lower cost. The Internet itself in the form of the TCP/IP protocol is a standard that has replaced a multitude of proprietary protocols previously used in Lucent, Nortel Networks, IBM and other manufacturers equipment.

In the early stages of introducing a standards-based technology, however, it is necessary to select and work with a manufacturer-partner. The alternative is to wait until the standards-based equipment is in full production following the traditional system specification and request for proposal (RFP) route. Such an approach, however, is incompatible with the needed planning. By the time the standard-based equipment reaches full production the opportunity for advanced planning is past since equipment deployment will already be occurring at a rapid rate. There seems little choice but to work with the standard through a selected manufacturer in the early stages to provide for a suitable time horizon for planning. During plan implementation, however, the choice to purchase equipment from a competing manufacturer will still remain an option since all suppliers will be producing to the same specifications.

The project schedule and budget will depend on the size and characteristics of the county, or group of counties, involved and the attendant public safety organizations. Project time duration from initial funding approval to installation and start-up is estimated at about one year. Firm budgets and schedules will require the preparation of a prospectus that completely defines the project scope and work requirements. The estimated infrastructure costs for a county in Southeastern Wisconsin may be expected to range from $500,000 to $1,000,000 depending on the size of the county. This cost range is based upon a system that supports communication with patrol cars equipped with laptop computers and vehicular transceivers. If the network must support patrol officers on foot equipped only with hand-held transceivers, then costs may be expected to be at least double given the need for a denser network with more antenna sites.

The Commission recommends a staged approach to advanced broadband wireless public safety networks beginning with the high-speed data network application. This application is least sensitive to transmission delays and represents an application most suitable for early deployment of a new technology. Voice communications would be the logical next application but only after an extensive analysis of the network for VoIP prior to its actual implementation on the network. The quality of voice communications in a packet-switched system is very sensitive to latency time (transmission delay) and lost data. These two parameters can be measured on a network prior to VoIP implementation allowing for network improvements before installation of the VoIP application avoiding most of the trial and error frustrations of premature voice communications installations. The final media application will be video, particularly if it is interactive video, since video is the most demanding of all broadband applications. Noninteractive video or store-and-forward video could be implemented earlier as part of the high speed data application. The staged-implementation approach will produce a better system and with less frustration for all concerned.

Stakeholder Identification and Application Task Force
The seven regional counties along with the municipalities are the natural stakeholders in any advanced public safety communications systems. The counties must provide the leadership to achieve major change at the county and municipal levels. An application task force in addition to county telecommunications representatives should include county officials, manufacturer’s representatives, and technical and executive representatives from the Commission.

Proposal Preparation
The Commission is prepared to develop a public safety broadband wireless communications WiMAX/SIP proposal for any county or municipality seeking Federal or other funding support for broadband wireless public safety networks. This proposal would include a preliminary network design with antenna site locations and predicted aerial coverage based on radio propagation modeling. The costs, work tasks and project schedule for network deployment would also be provided in some detail.

APPLICATION NO. 2A

Centralized Freeway Traffic Control

Need for Application
Traffic congestion, particularly freeway congestion, is a major growing problem in the Southeastern Wisconsin Region, the United States, and throughout the developed and developing world. Demand for highway travel by Americans continues to increase particularly in metropolitan areas such as southeastern Wisconsin. Construction of new highway capacity to accommodate this growth in travel has not kept pace with demand.

The growing problem of traffic congestion is reflected by Commission data. From 1972 to 1991, the miles of freeway within the Region carrying volumes exceeding their design capacity, and therefore experiencing congestion, increased from 9 miles to 46 miles as traffic grew over that period by nearly 65 percent. From 1991 to 2001, the miles of freeway carrying traffic volumes exceeding design capacity increased by another 39 percent to 64 miles. The same trend has been exhibited by the surface arterial system. From 1972 to 1991, the miles of surface arterials carrying traffic volumes exceeding their design capacity and experiencing traffic congestion increased from 151 miles to 227 miles. This level of congestion remained from 1991 to 2001.

Commission studies indicate that, absent effective action congestion may be expected to increase further within the Region. To address this growing problem, the Commission design year 2035 transportation system plan currently under preparation proposes—among other actions—the development of a centralized freeway traffic control system within the Region. A centralized freeway traffic control system would have as an objective the optimization of ramp metering operational control based on operating conditions over the entire total regional freeway network, while providing for equitable delays at all metered on-ramps, and no extension of queues at ramp meters onto connecting surface arterials. Currently, ramp metering control is either fixed in a "pre-timed" mode, or with vehicle release rates based upon immediately adjacent freeway system traffic volume and congestion. Centralized freeway control would have as its primary objective minimizing travel time for all freeway users.

Previous Planning Efforts

In November 1988, the Commission published SEWRPC Planning Report No. 39, *A Freeway Traffic Management System for the Milwaukee Area*. This report called for the development of a centralized freeway traffic control system. The control center was to include a computer that would operate in real time with pre-established programmed control routines. Although ramp meters have been installed and are operating at the on-ramps of key interchanges, and a central freeway traffic management center in Milwaukee has been in service since June 1994, implementation of a real time, pre-established, programmed central control system has never materialized. Recent conversations with Donald J. Schell, systems engineer for District 2 of the Wisconsin Department of Transportation (WisDOT), indicate that qualified personnel to develop such a freeway traffic control system have never become available within WisDOT. A Transportation Research Board publication indicates that Wisconsin is not alone in this failure to implement a centralized traffic control option.[1]

When a national strategic plan for Intelligent Transportation Systems (ITS) was developed in June, 1992 by ITS America—an organization of private industry, universities, and local, state, and federal government established to promote ITS development and deployment, one of the primary goals was to develop an automated system that could collect real time data from the transportation infrastructure and vehicles, and then, through intelligent algorithms, make automatic changes in network operations so as to improve traffic flows and provide a higher level of service for travelers. The gathering of real time data has become a reality, but the needed algorithms are still practically nonexistent. Localized control of ramp metering is now commonplace, but there have been no intelligent algorithms developed that have demonstrated significant improvements in freeway traffic flow or reductions in average travel times. This application presents an entirely different approach to developing the missing "intelligent algorithms" that could represent a major breakthrough in the development of intelligent transportation systems.

The existing Wisconsin DOT telecommunications infrastructure in Southeastern Wisconsin is extremely well suited for an initiative in centralized freeway control. An extensive broadband fiber optic communications network is already in place in parallel with the freeway network throughout the Region. A significant opportunity exists for SEWRPC and WisDOT to provide leadership in this area.

[1] *Transportation Record No. 1886, Transportation Research Board, National Academy of Sciences, Washington, D.C., 2004.*

The technologies involved in the centralized freeway control application are three:

1. Instrumentation technology to measure the speed, volume, and density of freeway traffic on a real time basis. Such measurement can be accomplished using current—embedded magnetic loop, microwave, and video—technologies, or advanced measurement technologies, such as active and passive infrared detection.

2. Communications technology, such as the fiber optic cable network paralleling much of the freeway network in the region, augmented where necessary by wireless access networks.

3. Adaptive control technology to generate ramp meter control rates based on operational conditions over the entire freeway system based on real-time freeway monitoring and simulation inputs to an adaptive control algorithm. The proposed adaptive control approach is more fully described in a SEWRPC staff memorandum entitled "*Adaptive Control Approach to Freeway Network Management*", February 18, 2005.

Implementation of centralized freeway traffic control as herein proposed may be expected to result in optimal utilization of a limited resource, mainly, freeway network capacity.

Resource Requirements, Budget and Schedule

This application would be developed in a two-phase sequence:

Phase I–Feasibility Study

A feasibility study would develop the system specifications; the two freeway simulation models required (reference and network operations); and would provide adaptive control experimentation using the two simulation models. The feasibility study would also provide a plan for the next stage of application. The cost of the feasibility study is estimated at $197,000. The study would require twelve calendar months to complete.

Phase II–System Deployment

System deployment would include integration of the reference and network operation models; the freeway command, communications, and control system; and actual deployment of the system. Deployment would also include the sequential improvement of the system based on operational experience; and installation of the system for permanent operation. The cost of this phase is estimated to total $750,000. The initial deployment would require 24 calendar months.

Stakeholder Identification and Application Task Force

The Wisconsin Department of Transportation (WisDOT) District 2 is the primary stakeholder and major task force member for this application. In Phase I, the composition of the application task force could be limited to WisDOT, Federal Highway Administration and SEWRPC representatives. In Phase II, the task force composition should be broadened to include law enforcement, county, municipal, and academic representatives.

Proposal Preparation

A draft of a preliminary proposal for the development of a centralized freeway traffic control system within the planning region has already been prepared.[2] This proposal could be further extended in terms of work tasks and time durations in the form of a detailed master schedule. Otherwise, the referenced proposal is adequate for submission to WisDOT.

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[2] *See SEWRPC Staff Memorandum "An Adaptive Control Approach to Freeway Network Management", February 18, 2005.*

Table 1

**OPEN SYSTEMS INTERCONNECTION (OSI) MODEL
(TELECOM VERSUS TRANSPORTATION)**

Layer	Telecom Function	Telecom	Transportation
Physical	Physical Transmission	Cables, Airwaves	Roads
Data Link	Access Control	Media Access Control (MAC)	Ramp Metering
Network	Routing	Packet Routing	Vehicular Routing
Transport	Origin-Destination Packet Control	Message Control	Origin-Destination Trip Control
Session	Managing Connections	Session Control	Not Applicable
Presentation	Information Presentation	Data Compression, Encryption, Data Conversion	Not Applicable
Application	Application Execution	Email, Web Search, File Transfer	Residential Trips, Commercial Trips

Source: SEWRPC.

APPLICATION NO. 2B

Areawide Traffic Routing

Need for Application

Congestion is not limited to the regional freeway system, but extends onto the attendant surface arterial system. Just as the previously presented centralized freeway traffic control application would be intended to achieve optimal usage of the regional freeway network, so would areawide traffic routing extend this optimality to the entire regional arterial street and highway network. The continuing inability of highway capacity to keep pace with traffic demand has stimulated the search for new approaches to traffic management. The costs and political issues associated with freeway and arterial street capacity expansion virtually guarantee the continuation of this mismatch between ever growing travel demand and lagging growth of transportation network capacity. This mismatch also guarantees the continuing growth of traffic congestion.

Region-wide traffic routing would provide for optimal use of the entire regional freeway-highway-arterial network by providing a “dynamic map of the state of the network in terms of travel time on each of the major links along with the location of major accidents and other incidents, affecting traffic flow. The availability of such a map on a timely basis (15 minute intervals) will allow motor vehicles with “telematic” (GPS and route selection) capabilities to select the minimal time routes to their destinations. Telematic vehicles already have this minimum time route selection capability based on static network information. The timely availability of a dynamic network map would allow for optimal routing of all telematic vehicles. Such optimal routing would result in optimal use of the transportation network resource.

The layer concept of the Open Systems Interconnection Model (OSI Model) used in telecommunication networks can be applied to transportation networks as shown in Table 1. The lowest layer in both kinds of networks is the physical infrastructure—in telecommunications this layer represents a copper cable network, a fiber cable network, or the wireless airways. In highway transportation, the physical layer would represent the road network. The next layer in telecommunication, as indicated in Table 1, represents control of network access. A parallel in the transportation domain would represent ramp metering control of the freeway network—the subject of the first installed transportation system application previously presented.

It is the third layer of the OSI model that directly addresses the regionwide traffic control problem. In telecommunications, the network layer represents the routing of packets through the network. In a similar way, the model can represent vehicles routed through the road network. Extensive research efforts have been directed toward optimal routing in telecommunications networks. This experience can be applied to highway networks. In fact, this experience has already been applied at the vehicle level by the automobile manufacturers in the field of "telematics technology". Global positioning system (GPS) based navigation systems are now fairly common in higher priced motor vehicles. General Motors "On Star" voice navigation system, and the voice or data based navigation systems of other manufacturers, feature minimum-time and minimum-distance routing algorithms. The minimum time routing algorithms are based on the speed limits of the various network links and do not allow for current reflection of traffic conditions or incidents such as accidents. To provide for a traffic-based dynamic routing system within the Region, a means must be found to furnish telematic equipped motor vehicles with current—"real time"—information on the operational state of the regional transportation network. A proposed system to furnish real-time information to telematic equipped vehicles on a region-wide basis is described in the following section.

Proposed Dynamic Vehicular Routing System

The proposed vehicular routing system would include the following components:

1. Network instrumentation to determine the average travel time on a given network link based on speed measurements of current link traffic and adjustments for delays at signalized and other intersections;

2. Communications to transmit speed data back to a central operations center using either WiFi, (IEEE 802.11) or ZigBee (IEEE 802.15.4) technology through a mesh network topology; since both ZigBee and most versions of WiFi utilize the crowded 2.40 to 2.48 GHz band, interference could become a major issue in sensor network operation for the Phase I feasibility study described below, thus potential problems would be explored in detail. Other unlicensed bands, such as the new WRC band, in the 5.470 to 5.725 GHz band are worthy of exploration in this respect.

3. Information processing to convert multiple speed and delay measurements into average travel time on each network link;

4. Broadcast communications to broadcast the state of the network to all telematic equipped vehicles in terms of link travel times and incidents—such as accidents—affecting minimal time routing. Initially this communication would be provided through existing cellular/PCS or telematic networks; but eventually through a standard Region-wide WiMAX or through the WiFi or ZigBee data collection network.

5. Telematic equipped motor vehicles. Vehicles operating within the Region equipped with suitable data communications and navigation equipment would then be provided with minimum time routing information on a "real time" basis.

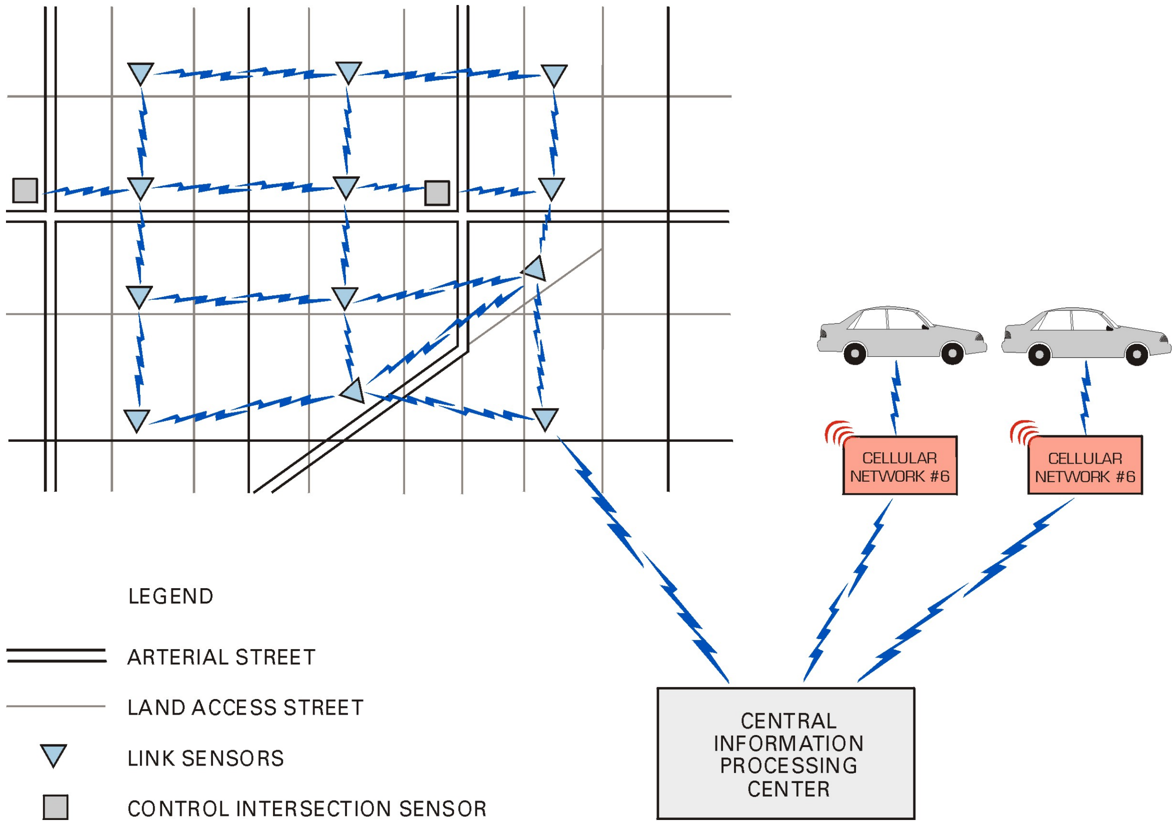
A pictorial view of the proposed dynamic vehicular routing system is shown in Figure 2. As the number of telematic equipped vehicles operating within the Region increases, the system would move toward an optimal allocation of road network capacity.

Instrumentation Subsystem

Average travel time on any roadway link would be determined by multiple vehicular speed measurements in a specified reporting time interval, as for example, 15 minutes. Current devices used for measurement of vehicular speeds on roadways are probably too expensive for deployment on the mass scale required for this purpose. Such devices include inductive loop measurement and radar/lidar instrumentation. An alternative, relatively low-cost instrumentation has been developed and has demonstrated accurate vehicular speed measurement capability in tests at the University of Michigan Transportation Research Institute (UMTRI) under a Federal Highway Administration sponsored research program. Based upon an evaluation of a wide variety of technologies for vehicular speed measurement—including active infrared, magnetometer, passive infrared, passive acoustic,

Figure 2

BLOCK DIAGRAM AREAWIDE TRAFFIC ROUTING SYSTEM



Source: SEWRPC.

ultrasonic and microwave—active infrared was identified as the preferred technology based upon accuracy and cost.[3] Because active infrared optical speed measurement instruments are assembled from standard light emitting diodes and silicon photodetectors that are produced in great volume for other applications, the cost is quite low making the required link speed measurements financially feasible.

Each installation would consist of a pair of infrared detectors operating at 880 nanometers in the infrared spectral region. Vehicular speeds are computed from the detection time intervals. A pair of detectors—even in single quantities—costs only $172. In the volume required, much lower costs are likely. An extensive testing program at UMTRI found active infrared optical measurements providing a standard deviation error of 3.11 mph for a vehicle moving at 48.26 mph, an error of 6.47 percent. This error was less than the errors found for both passive infrared or magnetometer, the other two technologies tested.

[3] *See: " Work Zone Safety ITS," Sullivan, J. M. et al, University of Michigan Transportation Institute, February, 2005.*

The installation costs of active infrared instrumentation are also lower than those of magnetic instrumentation since they can be mounted on posts located on the side of the roadway without the need for more expensive pavement installations. Typically, active infrared sensor pair instruments would be spaced about 300-600 feet apart along the network link. This spacing distance is a function of the communications technology employed, and the need for accurate travel time data on all arterial network links. The regional speed measurement network then would consist of hundreds of infrared instruments spaced along the arterial network of the Region. Travel times on network links also depend on delays encountered at signalized and other road intersections. These delays will add to the travel time implied by infrared speed measurements previously described. These same infrared sensors could be used to measure intersectional delays by detecting nonmoving traffic at each intersection and then recording the time until traffic movement is resumed. The basic infrared sensor would be the same except that traffic time delay rather than traffic speed would be measured.

Communications Subsystem

Speed data collected by multiple infrared instruments would be transmitted to a central information processing center through a mesh wireless communication network utilizing either WiFi (IEEE 802.11) or ZigBee (IEEE 802.15.4) technology. ZigBee technology is preferred because of its low power requirements and its sensor network orientation. ZigBee communications modules operating in the 2.4 GHz band are commercially available complete with transceivers, and a small microprocessor equipped with the software necessary to implement a mesh network infrastructure. The ZigBee communications module would be mounted with the infrared detector pair along with a battery power supply perhaps augmented by a small solar cell to extend the life of the batteries to a year or more.

The multiple speed measurement stations and attendant mesh wireless communications network throughout the Region would transmit vehicular speed measurements on a continuous, “real time” basis to a central information processing center which would convert the speed measurements into average travel times on each of the arterial network links.

Central Information Processing

Speed data acquired from the highway arterial links throughout the planning area would be received at a Central Information Processing Center where the speed data would be classified by link, time-weighted averages computed (smoothing), and converted into real time average travel times on each link. The system design issues concerned relate to the architecture of the central computer subsystem and whether a single large server-computer or a series of small server-computers would be more appropriate. Redundancy and reliability considerations would favor a bank of small servers with switch-over backup provisions. A further issue relates to the use of digital signal processing as an accessory computing module. The great bulk of the computing would be of a signal processing nature-rapid smoothing of thousands—or millions—of speed measurements each second. Digital signal processors are far more efficient for these computations than traditional desk top or server-computers. The server-computer or bank of server-computers would still be needed for classification of incoming data and general communications functions, but the digital signal processor module cards integrated with each server-computer would do the bulk of the computing for determining link travel times. Considering these special communication-computing requirements, the central information processing center design would feature a special server-computer, or set of server-computers, with each of the server processor modules integrated with a digital signal processor (DSP) module. Such DSP modules are commercially available over a wide range of specifications. Selection of the proper size server-computer with its appropriate DSP module would be based on a system study which would define the data rate requirements for input from the sensor network and output—broadcast to vehicles—for the central server-computer bank.

Broadcast Communications

The final component of the system is the broadcast network that would update the link-by-link dynamic operational state of the arterial network on a continuing basis, with a new data set at a specified time interval. The time interval used would be selected based upon the findings of The Phase I study. To realize system usage at an early date, the initial broadcast network should make use of existing cellular/PCS service provider networks. Some wireless carriers already have joint working arrangements with automotive navigation systems such as the General Motors OnStar. The information processing center could operate as a major subscriber for each wireless carrier sending out network updates on a pre-scheduled basis. Since the same data message would be sent to each carrier, additional carriers would not represent a major load on the system. At some time in the future, it may be advisable to have a standard broadcast network such as WiMAX for all vehicle users. To wait for such a specialized network, however, would significantly delay the deployment of the system.

Vehicular Routing Subsystem

The control actions of the system would take place in the vehicle subsystems. Having received the dynamic map containing updated link travel times, the on-board vehicle telematic computer would determine the minimum time path route to the selected destination. As the number of vehicles equipped with route determination telematics increases over time, minimal time routing may be expected to result in improved loading of the regional arterial system, the extent of the improvement being dependent, in part, upon driver response to the data provided.

Resource Requirements, Budget and Schedule

This application would be developed in a three-phase sequence.

Phase I–Feasibility Study

> The feasibility study would consist of the preparation of the system specifications to define the link-by-link network, the data transmission and data volume requirements; and to identify the measurement, communication, computer and accessory equipment required for system deployment. The study would result in a Phase II plan. The feasibility study is estimated to cost approximately $220,000 and require 12 calendar months to complete.

Phase II–Experimental subnetwork deployment

> A selected arterial corridor subnetwork would be deployed with instrumentation, communications, information processing and broadcast communications equipment sufficient to verify the basic systems design. This deployment and experimental test program is estimated to cost approximately $350,000 and require 12 calendar months to complete. A typical arterial corridor subnetwork would be represented by IH 94 West, W. Bluemound Road (USH 18) and W. Greenfield Avenue (STH 59).

Phase III–System deployment

> System deployment would consist of the preparation of final network drawings; procurement of system components in a staged fashion with elemental testing of incremental component combinations; and data acquisition system deployment starting with deployment of the sensor network on a link-by-link and subarea by subarea basis culminating ultimately in final dynamic network generation. The deployment would also include broadcast communications installation and test, and comprehensive system test/evaluation. System deployment is estimated to cost about $20 million and would be staged over a number of years.

Although there are potentially 292 miles of freeways and 3,308 miles of arterials in the Region, the proposed system would be limited to the freeway network plus the arterials located in the Milwaukee urbanized area. This area includes about 1,400 miles of arterial facilities. The estimated cost of the complete system would be $20 million, however, the deployment would be staged over 5 years with an estimated annual cost of about $4 million per year.

Stakeholder Identification and Application Task Force

The Wisconsin Department of Transportation (WisDOT) District 2 is also the major stakeholder and task force member for this application. In Phase I, the composition of the task force could be limited to WisDOT, Federal Highway Administration and SEWRPC representatives, and a representative from the University of Michigan Transportation Research Institute. In Phase II, the task force composition would be broadened to include county, municipal, and academic representatives.

Proposal Preparation

A more detailed proposal for the areawide traffic control system would be prepared at the request of WisDOT with a more accurate description of the work entailed and of the estimated final cost of a deployed system.

APPLICATION NO. 3A

Broadband Telemedical Home Health Care

Need for Application

Historically home health care has always represented an alternative approach to patient care. This approach received renewed attention in the early 1980's when the central medical figure of home health care system became the visiting nurse. Medicare, however, did not reimburse physicians for home care until January 1995 and then only with severe restrictions.

Thus, the clinic, hospital and nursing home have been the dominant centers of health care in the United States since World War II. Prior to World War II, the home was the center of long-term medical care, but rapid changes in medical technology and substantial Federal subsidies in the postwar period shifted the center of medical care to the hospital. The aging population coupled with new communications technology has now stimulated further interest in home health care. With the proportion of the American population over 65 growing every year, the current Medicare-Medicaid reimbursement structure may be in jeopardy. Home health care offers a partial potential answer to the escalating and economically debilitating costs of health care in the United States. Recent State budget initiatives would for the first time offer a Medicaid reimbursed alternative to permit patients in nursing homes to transfer to their homes for health care service. A recent analysis of Wisconsin nursing home patients, by the Wisconsin Department of Health and Family Services indicated that about 31 percent of these patients would qualify for this home health care alternative. Such a transfer would represent a cost savings to Medicaid of about 75 percent for the State of Wisconsin, or about $255 million per year.[4] With the aging population and imminent transfers of patients from nursing home care to home care, a significant burden will be placed on the present home health care delivery system. This demand, coupled with the shortage of trained nurses, may be expected to make telemedical home health care increasingly attractive.

Broadband telecommunications has the potential to increase the cost effectiveness of home health care, particularly in rural areas. The costs of home health care are primarily related to the cost of the home visits by medical staff. Therefore, minimizing the number of home visits should reduce the costs of home health care. It should be possible to reduce the number of visits if the patient can be monitored through high quality videoconferencing now available with 10 to 20 megabits per second type broadband service, and with computerized control based on the new Session Initiation Protocol (SIP). Currently, Medicare pays home care providers a fixed amount of money for a two-month period regardless of the number of visits, so that visit minimization may have a significant impact on home health care costs. The introduction of telemedical home health care should result in major productivity enhancements and cost reductions.

The economic case for telelmedical home health care may prove compelling, but equally important are the personal preferences of patients. A number of surveys indicate that most, if not all, patients prefer a home setting for health care over the nursing home or hospital alternatives. The combination of economic justification and social preference further serve to make the need for broadband telemedical home health care in Southeastern Wisconsin evident.

Description of Application

The broadband telemedical home health care application differs from the previously presented public enterprise communications network applications in that it does not necessarily require new infrastructure. The proposed application will require:

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[4] Wisconsin Medicaid Program, *Wisconsin Department of Health and Family Services, May, 2005.*

A broadband connection between home care location and the home health care operations center providing a data transfer rate of about 3.8 megabits per second. Lower data transfer rates can be evaluated to determine a minimal acceptable bandwidth.

1. A Session Initiation Protocol (SIP) Server to create a collaborative environment similar to that in a hospital, physician's office or nursing home through a multimedia—combined voice, video and data—telecommunications link. The telecommunications link should be available for "anytime-anywhere" communication between patients and health care providers to provide rapid response communications between the home health care provider and the remote patient.

The physical realization of the proposed initial broadband telemedical configuration will be a remote digital camera and associated broadband modem-router or transceiver-router at the home location and a multimedia/SIP-based server at a designated operations center along with an appropriate video display for the ER physician.

Other features such as remote patient monitoring could be added, but the above two elements comprise the foundation of the broadband approach. The basic objective and operating concept is to create a remote environment in which videoconferencing will allow for "virtual visits" on a frequent basis in reducing the number of home visits required.

Resource Requirements, Budget and Schedule
The application would be developed in a three-phase sequence:

Phase I–Feasibility Study

The feasibility study would develop the system specifications based on a needs assessment and requirements analysis; would provide a preliminary design for a video conferencing subsystem for home health care application; and would provide a preliminary design for a SIP-based multimedia communications and resource management subsystem. The feasibility study would also provide a plan for the succeeding stage of the application. The feasibility study is estimated to cost $80,000, and require six calendar months to complete.

Phase II–Prototype Development

A pilot system would be installed involving a home health care operations center and three to five home care sites. The pilot system would be intended to verify the capabilities of high quality, computer-managed video-conferencing and related patient monitoring functions. This experimental deployment is estimated to cost approximately $120,000 and would require six calendar months to complete.

Phase III–System Deployment

System deployment would involve a county-wide, all home patient servicing telemedical home health care operation. The system would be incrementally deployed starting from the pilot system and gradually expanding to full county coverage. Costs and scheduling estimation of a full-scale system are possible only after completion of the Phase I feasibility study.

Stakeholder Identification and Application Task Force
A county health department offering home health care services would be the logical partner for the application. Changes in Medicare-Medicaid reimbursement policies should add incentive to this application. Other task force members could include physicians or nursing professionals specializing in home health care at the Medical College of Wisconsin, University of Wisconsin-Milwaukee or Marquette University.

Proposal Preparation
A more detailed proposal containing more technical information could be prepared if an interested organization would so request.

APPLICATION NO. 3B

Pre-Hospital Emergency Medical Services

Need for Application

Emergency medical service (EMS) organizations perform pre-hospital emergency health care services in all seven counties of the Region. Typically, these organizations are affiliated with the local fire department. Many EMS personnel are local volunteers. The level of training of these volunteers varies greatly.

Emergency medical services play a key role in most emergency medical situations. They are typically the first responders, and their actions can literally determine the life or death progress of the emergency patient. Prior to the Vietnam War, EMS services were focused primarily on transportation to hospitals with few, if any, medical interventions. Military experience in Vietnam, however, developed a number of pre-hospital medical procedures that significantly changed the EMS practices throughout the United States. Ambulance personnel were trained to perform various potentially life-saving medical protocols at the scene of accidents, or other emergency situation locations, as well as en route to hospital emergency care facilities.

Emergency medical technicians (EMTs) receive training at different skill levels ranging from EMT-basic at the low end to paramedic at the high end. Even the best trained EMT, however, is frequently faced with emergency medical situations beyond his or her knowledge and skills. The great majority of EMTs in most jurisdictions are trained only at the basic level and could significantly benefit from on-site communications with hospital emergency room staffs based on broadband-based videoconferencing. The objective is to provide high quality multimedia—video, voice and data—communications so as to create a dynamic "presence" environment such that the remote patients, in effect, appear to be in the same room as the emergency medical physician. The system would allow EMTs in some extreme circumstances to contact special emergency medical facilities called trauma centers that are able to handle the more trauma-related medical emergencies. The system would utilize the communication management capabilities of a multimedia Session Initiation Protocol (SIP) server computer to connect the remote EMS team to the required medical resource—medical professional or data file—anytime, anywhere, and with a "seconds range" response time. The end objective of all pre-hospital emergency medical services is to improve survival rates. In a characteristic medical emergency, cardiac arrest, the national survival rate for an emergency incident is only one in seven. Broadband teleconferencing will, in effect, bring the medical expertise of the hospital emergency room staffs to the scene of an accident or other medical emergency. By so doing, significant improvements in survival rates may be expected. Such improvements serve to justify broadband based pre-hospital emergency medical services.

Description of Application

Pre-hospital emergency medical services operate using public safety wireless communications networks. The proposed application then must take place in a county or municipality that has deployed a broadband wireless network based on the IEEE 802.16 standard. The only county in the Region currently scheduled for such a deployment is Ozaukee County. Based on such a network, the application's deployment requirements are similar to those of home health care with the added need for mobility:

1. A broadband connection between EMS location and the hospital emergency room staffs providing a data transfer rate of about 3.8 megabits per second. Lower data transfer rates can be evaluated to determine a minimally acceptable bandwidth.

2. A Session Initiation Protocol (SIP) Server to create a collaborative environment similar to that in the emergency medical center through a multimedia—combined voice, video and data—telecommunications link. The telecommunications link should be available for "anytime-anywhere" communication between the remote ambulance or other site and health care providers to ensure rapid response communications between EMTs present at the scene and physicians in the hospital emergency rooms.

The physical realization of the proposed initial broadband telemedical configuration would be a remote digital camera and associated broadband modem-router or transceiver-router in the ambulance vehicle and a multimedia-SIP based server at the hospital along with an appropriate video display for use by the emergency room physician.

Other features such as remote patient monitoring could be added, but the above two elements comprise the foundation of the broadband approach. The basic objective and operating concept is to create a remote environment in which a hospital emergency room physician can provide on-site guidance to EMTs in an emergency medical situation. A secondary objective is to allow for seamless collaborative communication between the ambulance and the hospital emergency room.

Resource Requirements, Budget and Schedule

The application would be developed in a three-phase sequence:

Phase I–Feasibility Study

The feasibility study would provide the system specifications based on needs assessment and requirements analyses; would design a video conferencing subsystem for emergency medical application and a SIP-based multimedia communications and resource management subsystem. The feasibility study would produce a Phase II plan. The cost of the feasibility study is estimated at approximately $80,000 and would require six calendar months to complete.

Phase II–Prototype Deployment

The system designed under the feasibility study would be installed in a cooperating hospital emergency room and in a single ambulance to verify the functional operation of the system and to correct any deficiencies and provide enhancements as may be required. The cost of this experimental deployment is estimated at approximately $120,000 and would require six calendar months to complete.

Phase III–System Deployment

System deployment would provide broadband emergency medical communications throughout a selected municipal service area. Such deployment would be preceded by a training program for hospital emergency room staff and EMT personnel. The cost of a full-scale deployment will depend upon the number of ambulance vehicles to be served. Operations center equipment and training is estimated to cost about $150,000.

Stakeholder Identification and Application Task Force

A municipal EMS unit and a hospital emergency medicine department would be the logical partners for this application. Task force members could include emergency medical specialists at the Medical College of Wisconsin and EMT training personnel at the Waukesha County Technical College.

Proposal Preparation

A more detailed proposal containing more technical information could be prepared by the Commission if an interested organization would so request.

APPLICATION NO. No. 4

Homeland Security Monitoring

Need for Application

Of these three threats to homeland security, the use of “dirty bombs” represents one of the most potentially destructive forms of terrorist attack. Although weapons grade nuclear materials are heavily guarded, a plausible scenario involves terrorists detonating a simple radiological dispersion device (RDD) capable of broadcasting nonfissile, but highly radioactive particles over a densely populated area. In most cases, a motor vehicle would have to be used to transport the device to the target destination. A widespread sensor network located along freeways and major arterials could provide an early warning of the presence of such a threat and also serve as a deterrent based on the known existence of such a sensor network. Radiation monitoring for homeland security could justify a regionwide sensor network in its own right but could also serve as the foundation for other homeland security monitoring applications.

An important recent development in communications technology is a growing interest in low power, low cost sensor networks. This interest is now centered on a new IEEE Standard 802.15.4 and its industrial counterpart, the ZigBee Alliance. ZigBee technology was previously referenced in Application 2B, Areawide Traffic Routing. In that application, low power ZigBee communications modules were proposed to be used to transmit traffic speed information to a central location for traffic routing purposes. These same low power ZigBee modules could be used to communicate sensory data on matters related to homeland security to a central location for recording, analysis, and action. Heretofore, most homeland security funds distributed to states and lower level jurisdictions have supported needs for expanded and interoperable telecommunications facilities. There is, however, a growing awareness that widespread sensor networks could play a major role in early warning systems anticipating and then responding to a terrorist attack. Potential homeland security related sensor network applications would include instrumentation for detecting nuclear, biological, and chemical attacks.

Description of Application

The structure of a homeland security sensor network would be similar to the data acquisition portion of the dynamic vehicular routing system previously described in this report. The communications elements of both networks would be identical. They would differ only in the characteristics of the instrumentation employed. The traffic routing systems would employ traffic speed and traffic delay sensing instrumentation. The homeland security monitoring system would employ instruments that measure nuclear radiation. For this reason, the description of the homeland security application will be limited to the instrumentation subsystem.

Instrumentation Subsystem

Radiation instrumentation development would be based on a cooperative effort with the U.S. Department of Energy Los Alamos National Laboratory (LANL). Recent experimental results of a study carried out at LANL were documented in a paper published in the IEEE publication entitled “Computer”.[5] While the radiation sensors employed were not integrated into a ZigBee packaging, they should lend themselves to such integration. Because LANL is a Federal national laboratory with a research and development orientation, they should be a valuable, cooperative, partner for the application. They also should be well-informed on the state-of-the-art in nuclear radiation instrumentation.

Resource Requirements, Budget and Schedule

This application would also be developed in a three phase sequence:

Phase I–Feasibility Study

An initial feasibility study would be required to develop the system specifications; develop preliminary designs of instrument packages for nuclear radiation monitoring; and to develop a preliminary design of the communications network required including a central server computer system. The feasibility study would also produce a Phase II plan. The cost of the feasibility study is estimated at $120,000. The study would require eight months to complete.

Phase II–Pilot Network

A small pilot network would be deployed with instrumentation, communications and central server computer subsystems. The network would be based on prototype instrument packages and standard ZigBee communications modules. The cost of the pilot network is estimated at $300,000. Such a network would require twelve months to deploy and operate on a pilot basis.

[5] *Brennan, S.M. et al, “Radiation Detection with Distributed Sensor Networks” IEEE Computer, August 2004.*

Phase III–System Deployment

System deployment would be scheduled on an incremental basis starting from the Phase II Pilot Network. The cost of a full-scale deployment will depend upon the geographic extent of the network and number of sensors. It is not possible to estimate the cost or schedule of such a deployment prior to the completion of the Phase I Feasibility Study.

Stakeholder Identification and Application Task Force

Given that Federal Homeland Security funding is the most likely financial support source for this application, an alliance with a county or municipal emergency management organization would seem most advantageous. The Los Alamos National Laboratory would be the primary technical partner for both instrumentation and background information on nuclear radiation. The Wisconsin Department of Military Affairs, Division of Emergency Management would also seem a logical task force member.

Proposal Preparation

A more detailed proposal containing more technical information could be prepared by the Commission if an interested organization with funding prospects would so request.

APPLICATION NO. 5A

ZigBee or WiFi5 Sensor Networks for SCADA Applications

Need for Application

The need for supervisory control and data acquisition (SCADA) networks relates to the spatial distribution of facilities in water supply utilities, electric power and natural gas utilities, sewerage utilities, railroads and other critical infrastructure systems. Such networks are typically data acquisition networks on the incoming links and supervisory control networks on the outgoing links. For example, incoming data in a water utility application typically relate to water levels, flows, pressures and water quality indicators. Outgoing controls activate pumps and valves at critical parts of the distribution network. Other utility networks follow a similar pattern with incoming data and outgoing controls dependent on the characteristics of the network. The need for, and utility of, SCADA networks is well established. Their use and the extent of their coverage has been limited only by cost and the availability of the land line telephone infrastructure. The new ZigBee and WiFi5 sensor network technologies are well positioned to remove both of these limitations.

The communication links used in SCADA networks have typically been based on traditional telephone line connections. Such telephone connections are relatively costly in terms of the initial investment required and in continuing operating charges. ZigBee sensor networks, previously described for roadway speed sensing and nuclear radiation monitoring, could find application in advanced SCADA networks. ZigBee sensor networks could significantly reduce the cost of such networks and allow for their extension into areas not previously feasible because of the nonavailability of landline telephone service. ZigBee networks are applicable in networks with links limited to a maximum of about one-quarter mile. Many SCADA systems reconfigured in a wireless topology will have much longer links. To satisfy these longer link networks, a different wireless technology, 802.11a (WiFi5) may have to be employed.

Description of Application

As presently constituted, a SCADA network consists of one or more master terminal units (MTUs) which operators use to monitor and control a large number of remote terminal units (RTUs). Originally developed in the 1960's, such networks were typically interconnected through traditional copper line telephone networks. The MTU is often a general purpose computing platform, like a personal computer, running SCADA management software. The RTUs are generally small dedicated sensors or control modules which are hardened for outdoor use and utility environments. In recent years, SCADA link connections have migrated from copper line to fiber optic networks which offer electromagnetic interference (EMI) immunity. Some networks have even been configured as self-healing fiber ring networks. Using fiber optic technology for SCADA networks, however, restricts the deployment of the systems. Bandwidth requirements for SCADA networks are typically quite modest with 250 kilobits per second, usually more than sufficient for most SCADA systems. The mesh network topologies used in most ZigBee networks also makes more efficient use of available bandwidth. Should there be a need for more bandwidth for video or other high speed data transmission applications, the preferred technology would be 802.11a (WiFi5) which has transmission rate capabilities in the over 5 megabits per second range.

In a typical conversion of an existing SCADA network, the installed instrumentation would stay in place, but communications interconnections would change from a telephone wireline to a wireless ZigBee or WiFi5 module. The design of the new sensor network would require radio propagation modeling to insure that all RTUs are within range of one or more other RTUs for mesh networking. The objective would be to design and build a robust network with multiple alternate paths to the MTU. Development of the initial ZigBee networks would also require proof of concept mini-network demonstrations on a small-scale. Such a pilot demonstration would serve to identify system problems and allow for their resolution prior to a full-scale deployment. It is important to emphasize, in this respect, that ZigBee or WiFi5 are new technologies that may be expected to require a "shakedown" period. It is also important to emphasize, however, that both standards technologies have been developed by representatives from over 100 electronics manufacturing companies. Like the Ethernet and WiFi technologies before it, the ZigBee and WiFi5 technologies are expected to be reliable, robust, and lead to widespread use of sensor networks.

Resource Requirements, Budget and Schedule

This application would also be developed in a three-phase sequence:

Phase I–Feasibility Study

For an existing SCADA system upgrade an initial feasibility study would be required to develop a system specification and to design a mesh network layout that would insure robust multiple pathway alternatives from each RTU to the CTU. The feasibility study would also produce a Phase II plan. The cost of the feasibility study is estimated at $35,000. The study would require six months to complete.

Phase II–Pilot Network

A portion of the existing network would be designated for a pilot demonstration. Existing instrumentation of each RTU would stay in place along with the MTU at the central operations center. Sufficient RTUs would be converted to demonstrate mesh network communications. The cost of the pilot network demonstration is estimated at $25,000-$55,000 depending on the number of RTUs converted. All converted RTUs would be available for use in the Phase III System Deployment.

Phase III–System Deployment

System deployment would be scheduled on an incremental basis starting from Phase II Pilot Network. The cost of a full-scale deployment will depend upon the geographic extent of the network and number of RTUs. It is not possible to estimate the cost or schedule of such a deployment prior to the completion of the Phase I Feasibility Study.

Stakeholder Identification and Application Task Force

A logical project sponsor would be a water or wastewater utility. Since many municipal water utilities have developed SCADA systems, they would form the most likely candidates for conversion to ZigBee wireless technology. The Milwaukee Metropolitan Sewerage District would also be a logical project sponsor.

Proposal Preparation

A more detailed proposal containing more technical information could be prepared by the Commission if an interested organization with funding prospects would so request.

APPLICATION NO. 5B

Environmental Sensor Networks

Need for Application

Water pollution remains a major problem in the Region. Sources of water pollution include both point and non-point sources. Point sources, such as municipal wastewater treatment plant outfalls, are relatively easy to monitor since the source is well defined as to location, as are industrial plants that are potential point sources of toxic wastewaters. Nonpoint sources, in contrast, are extremely difficult to isolate and control because of their wide dispersion and low volumes. While the original sources are usually small in volume, collectively many small sources combine to constitute a major source of water pollution in many areas of the Region. The predominance of nonpoint sources in current day pollution also derives from the tight control exercised over point source pollution sources by Federal and State regulatory agencies. Distributed low power, low cost sensor networks provide a new approach to dealing nonpoint source water pollution control. Unfortunately, the sensor technology to measure the truly critical water pollution parameters such as bacterial contamination (coliform indicator count) and biological oxygen demand (BOD) is not currently available. It is possible to measure other water quality indicators such as temperature, dissolved oxygen and suspended solids.

In contrast to water quality indicators, most air quality indicators are currently measurable by “off the shelf” instrumentation that can be adapted to the ZigBee packaging configuration. Air pollution is also characterized by both point and nonpoint sources. Air pollution is very dependent on weather conditions, so that adverse air pollution situations can occur even with no changes in source outputs. Distributed sensor networks could serve to monitor air pollution in the Region to a greater degree than now possible with the relatively small number of isolated air quality monitoring stations currently in operation within the Region.

The ZigBee and WiFi5 wireless communications technologies previously described in connection with potential applications in transportation and utility monitoring and control could also be applied to environmental sensor networks. Because such environmental sensor networks based on telephone landline connections already exist, it was believed advisable to concentrate in this report on the potential for converting these networks to a wireless infrastructure prior to expanding the number of monitoring locations or introducing new variables for measurement. With this approach the structure of environmental sensor networks would be similar to that described for the SCADA networks.

Following the strategy of first connecting existing water and air quality sensor networks, initial emphasis will be on the following:

1. U.S. Geological Survey, Flow and Water Quality Monitoring Network
   The U.S. Geological Survey in cooperation with the Regional Planning Commission, the Milwaukee Metropolitan Sewerage District, and a number of municipalities operates 32 continuous stream flow monitoring stations within southeastern Wisconsin. At five of those 32 stations selected water quality indicators are also monitored. These may include specific conductance, dissolved oxygen, percent dissolved oxygen saturation, pH and temperature. Supporting air temperature and barometric pressure are also collected at some stations.

   The U.S. Geological Survey also operates a network of 14 ground water level monitoring stations within southeastern Wisconsin some of which utilize electronic recording equipment.

2. Milwaukee Metropolitan Sewerage District Water Quality Monitoring Network
   The Milwaukee Metropolitan Sewerage District (MMSD) operates five continuous water quality monitoring stations within the greater Milwaukee area. The selected water quality indicators monitored include specific conductance, dissolved oxygen, and stream stage.

   The District also monitors flow at 300 locations in the District sewerage system.

3. Wisconsin Department of Natural Resources Air Quality Monitoring Network
   The Wisconsin Department of Natural Resources operates 14 air indicator quality monitoring stations within the Region. Air quality indicators measured include ozone, particulate matter, solar radiation, temperature, wind direction and speed, carbon monoxide, nitrogen oxide, nitrogen dioxide and oxides of nitrogen, air temperature and barometric pressure.

Description of Application
The converted water and air quality networks would function like the inbound data acquisition links of a SCADA network. Existing monitoring stations would function as remote terminal units sending their data to a master terminal unit (MTU) or its equivalent. As in the SCADA networks, the installed instrumentation would stay in place with the interconnection changed from a telephone line to a ZigBee, or WiFi5, module. Existing instrumentation with no communications link would be interfaced to the appropriate wireless communications module.

Resource Requirements, Budget and Schedule
The application would be developed in a three-phase sequence:

Phase I–Feasibility Study

For an existing water or air quality system conversion, an initial feasibility study would be required to develop a system specification and to design a mesh network layout that would insure robust multiple pathway alternatives from each RTU to the CTU. The feasibility study would also produce a Phase II plan. The cost of the feasibility study is estimated at $35,000. The study would require six months to complete.

Phase II–Pilot Network

A portion of the existing network would be designated for a pilot demonstration. Existing instrumentation of each RTU would stay in place. A central master terminal unit (MTU) similar to those used in a SCADA system would be installed as required. Sufficient RTUs would be converted to demonstrate mesh network communications. The cost of the pilot network demonstration is estimated at $25,000 to $55,000 depending on the number of RTUs converted. All converted RTUs would be available for use in the Phase III System Deployment.

Phase III–System Deployment

System deployment would be scheduled on an incremental basis starting from Phase II Pilot Network. The cost of a full-scale deployment will depend upon the geographic extent of the network and number of RTUs. It is not possible to estimate the cost or schedule of such a deployment prior to the completion of the Phase I Feasibility Study.

Stakeholder Identification and Application Task Force
The existing network managers, the U.S. Geological Survey, Milwaukee Metropolitan Sewerage District, and Wisconsin Department of Natural Resources are potential sponsors for this application. The U.S. Environmental Protection Agency should also be involved.

Proposal Preparation
A more detailed proposal containing more technical information could be prepared by the Commission if an interested organization with funding prospects would so request.

APPLICATION NO. 6

Distance Learning For Public Safety Personnel

Need for Application
Distance learning is an important educational application of broadband telecommunications. Although distance learning is possible even at dial-up data transfer speeds, remote quality educational presentations require high

quality video. There also is a need for multi-party connectivity for education/training sessions. Even though a class session may originate from a single primary source, secondary sites such as other fire stations or hospital emergency room facilities may strongly support education/training objectives. The proposed broadband/SIP-based system would have the capability to provide these communications services.

Fire fighters and emergency medical technician (EMT) personnel in the Region's municipalities and towns are required to complete 150 hours each year of continuing education in their respective specialties. Currently such continuing education and training are carried out at various locations such as one of the branches of the State technical college network and University of Wisconsin Extension-System. Such classes typically involve moving fire fighting or EMT personnel with their fire fighting or EMS vehicles to these locations for classes. A potentially cost saving alternative would bring the class to the various Fire-EMS stations using broadband communications networks and the new Session Initiation Protocol (SIP). This approach would allow for the optimal use of educational resources by directing various sources of information and knowledge to the dispersed public safety student groups in their home fire house environments.

Description of Application

This distance learning application would have a structure similar to that of the home health care application with broadband communications and a Session Initiation Protocol(SIP) server computer as the key elements. It differs in the need for a classroom type video display and the potential multiple party conference aspects of the application. These features do not affect the basic design of the application nor should they require any special software programs to implement the application.

Resource Requirement, Budget and Schedule

Phase I–Feasibility Study

A Phase I feasibility study would develop a system specification that would define the communications and network management requirements of the application. The study would also produce a Phase II/III plan. The cost of the feasibility study is estimated at $40,000. It would require six months to complete.

Phase II–Pilot Network

A pilot network involving one education source such as the Milwaukee Area Technical College and a single fire station would be deployed along with two to three alternate secondary sources to verify system operation. The cost of this test experiment would be about $60,000 and require 9 months to complete.

Phase III–System Deployment

System deployment would be incremental in nature adding fire stations and education sources consistent with the ability of staff to train participants in the use of the system. Deployment costs and schedule would be estimated as part of the Phase I feasibility study.

Stakeholders Identification and Application Task Force

The Regional Telecommunications Commission would be a logical partner for this application. This north shore Commission has previously submitted a grant proposal for this application.

Proposal Preparation

A more detailed proposal to obtain funding could be prepared by the Regional Planning Commission in cooperation with the Regional Telecommunications Commission.

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Chapter IV

PUBLIC ENTERPRISE NETWORKS PROGRAM INITIATION STRATEGIES

INTRODUCTION

This chapter sets forth a strategy for creation of the public enterprise networks described in Chapter III. Creation of each network will require the preparation of an implementation plan by a sponsoring agency. The Regional Planning Commission would assist the sponsoring agency in the development of the implementation plan. Identification of such an agency and the pursuit of that plan will be the key to program initiation and network development in the public enterprise area.

APPLICATION NO. 1—PUBLIC SAFETY-EMERGENCY RESPONSE TELECOMMUNICATIONS NETWORKS

Although public safety networks typically serve at least three functions in each jurisdiction—law enforcement, fire and emergency medical services—law enforcement personnel usually control the specification and purchase of the equipment concerned. Therefore, law enforcement agencies are the most logical sponsor of any effort to create a public safety-emergency response telecommunication network involving the new technology. Some jurisdictions may also employ a general government telecommunications specialist who would have to be involved as co-sponsor in the creation of any advanced public safety-emergency response telecommunications networks. Still other jurisdictions may subcontract both the installation and maintenance of their public safety-emergency response telecommunications networks to a third party private company. In such cases this third party organization may also have to be involved in the planning for any new telecommunications system initiatives. Such organizations could include a county wide communication services division, an effective way of providing for telecommunication services of all kinds within a county. In each case, the chief executive—county executive, mayor, village president or town board chairman—should express the desire to proceed with the needed implementation planning and designate the key participants in the public safety-emergency response network planning process.

Currently, many governmental jurisdictions, particularly counties, within the Region are in the process of upgrading their existing wireless radio systems. Most of these systems operate in either the 150 MHz or the 800 MHz band. Upgrades of these systems may involve public expenditures of $5 million to $10 million. With the advent of new technologies such as WiMAX, the question arises whether these expenditures are in the long term public interest. Future broadband networks may be expected to provide voice, video and data services in one network using standards-based equipment. Public safety-emergency response telecommunications networks, however, often involve life or death situations demanding the highest level of network reliability. For this reason, it is recommended that public safety agencies transition in stages to multimedia broadband public safety-emergency response networks. The first stage should emphasize the use of the new broadband network technology as a supplement to current voice networks for high speed data transmission. Data communications networks are usually not as time-sensitive as voice networks. For this reason, they provide a good proving ground to demonstrate system capabilities and to identify and remedy deficiencies prior to expansion into voice and video services. These later services are more time sensitive and more crucial to rapid decision making in the operation of public safety-emergency response agencies.

Advanced public safety-emergency response networks represent a major area of opportunity in the development of public enterprise telecommunications services. The need is well established and generally acknowledged. The current Federal Homeland security initiative has accentuated the need. Even given the potential availability of Federal homeland security funding, the willingness or ability of state, county, and local elected officials to provide necessary local funding may present an obstacle to implementation. Nevertheless, project initiation efforts in the public safety-emergency response networks area should be pursued as having a high priority for development. Any proposed projects should promote needed interagency and intergovernmental coordination in the development of a proposed network as well as the application of available new technologies.

APPLICATIONS NO. 2A AND 2B—TRANSPORTATION NETWORKS

Application 2A, Centralized Freeway Traffic Control, and Application 2B, Areawide Traffic Routing both involve the Wisconsin Department of Transportation as the potential project sponsor. Obtaining support for these projects should involve direct meetings with appropriate personnel from the Department central and district offices.

First priority should be given to the centralized freeway traffic control application (Application 2A). The need for this application was recognized by the Regional Planning Commission as far back as 1988 as described in Chapter III. A Commission staff technical memorandum describing the adaptive control technology proposed to be used in this application was prepared early in 2005. That memorandum could serve as the basis for the needed interagency staff meetings and the preparation of a more detailed proposal.

A project involving Application No. 2B, areawide traffic routing, should also be of interest to the Wisconsin Department of Transportation since it provides a means for more efficient utilization of the existing road network. Because it involves a longer development period with new forms of instrumentation, it would seem prudent to initiate this project with the conduct of the Phase I feasibility study.

APPLICATION NO. 3A—TELEMEDICAL HOME HEALTH CARE APPLICATION

Government-based home health care is generally provided at the County level by a department designated as "health services" or its equivalent. The best candidate project sponsor would be a county having a home health care organization that would recognize the potential benefits of productivity improvement through broadband communication with an emphasis on videoconferencing. The primary challenge in home health care today is to provide high quality home care, with limited resources. There are strong reasons to believe that high quality videoconferencing supported by computer-based resource management can improve the productivity of home health care. Most home health care is funded by Medicare which usually pays a fixed monthly amount for each patient depending on medical condition. If the quality of home health care can be maintained and improved with fewer home visits, then the productivity of the operation is improved. The other major medical payer, Medicaid, is already funding video-conferencing in Wisconsin in recognition of its cost-saving characteristics. It should not, therefore, be difficult to argue the benefits of broadband-based teleconferencing in home health care. To expedite the initiation of a broadband home health care project in the Region, use of current wireline and wireless broadband services should be the first choice. Waiting for future higher speed networks is not necessary since the quality of videoconferencing can be substantial at even the low end of broadband transfer rates.

Having identified a county with interest in the provision of telemedical home health care, a successful program will require the active cooperation of at least two other partners: a telecommunications service provider–wireless or wireline–to furnish the broadband link for a video-conferencing demonstration in Phase I, and a telecommunications equipment manufacturer to provide a SIP server to manage the video-conferencing sessions.

APPLICATION 3B—PRE-HOSPITAL EMERGENCY MEDICAL SERVICES (EMS)

EMS organizations exist in most cities, villages, and towns usually in connection with the local fire department. The first challenge is to fund local EMS organizations interested in broadband wireless communication as a means to improve EMS outcomes. The second challenge is to find a broadband wireless service provider. The requirement for mobility rules out wireline networks. Under the current situation in Southeastern Wisconsin, there are two options for a wireless broadband network: use of a planned county or municipal WiMAX public safety network, or a cooperative arrangement with a commercial wireless service able to provide advanced 3G versions of CDMA or GSM-UMTS technologies.

The first choice would probably result in a faster data transfer technology. It would also help support and justify county or municipal adoption of WiMAX technology. On the negative side, it would probably delay the initiation of any project until a county or municipality proceeds with installation of a high technology public safety network. The second of the above alternatives would provide an earlier start to the program. It would also allow for a greater choice of EMS organizations throughout the Region. The unknown involved would be the true broadband capabilities of the service provider network.

Perhaps the greatest challenge for this application is the source of funding. There is no obvious provider of financial support.

APPLICATION NO. 4—HOMELAND SECURITY MONITORING

Initiating this project should follow two paths—the fastest of which would be an emergency management agency in one of the seven counties of the Region. The second of which would be the Los Alamos National Laboratory (LANL). LANL is needed not only for their technical expertise in nuclear instrumentation, but also for knowledge of potential funding sources. LANL may be able to fund the project itself, or guide the project sponsor and Commission to funding sources known only by them. LANL may also be looking for a metropolitan area in which to demonstrate the first deployment of such a network.

APPLICATION NO. 5A—ZIGBEE OR WIFI5
SENSOR NETWORKS FOR SCADA APPLICATIONS

The adoption of existing supervisory control and data analysis (SCADA) applications may be one of the first public sector applications relatively readily initiated. If a municipal water or wastewater utility is cognizant of its current telephone line charges, the financial returns of converting to wireless service should be apparent.

APPLICATION NO. 5B—ENVIRONMENTAL SENSOR NETWORK

This application initiation involves working with other government agencies such as the U.S. Geological Survey, Wisconsin Department of Natural Resources, and Milwaukee Metropolitan Sewerage Commission. The technical approach and financial returns based on current telephone line charges would be exactly the same as for the SCADA networks. Such similarity is not surprising since these environmental sensor networks are partial SCADA networks featuring the data acquisition side, but not the supervisory control side of a SCADA network. Funding this application may be difficult. Counties and municipalities are usually receptive to making investments with a short payback period. Federal and State agencies may not be as conscious of the cost savings possible.

APPLICATION NO. 6—DISTANCE LEARNING FOR PUBLIC SAFETY PERSONNEL

Distance learning is an important educational application of broadband telecommunications. Although distance learning is possible even at dial-up data transfer speeds, remote quality educational presentations require high quality video. There also is a need for multi-party connectivity for education/training sessions. Even though a class session may originate from a single primary source, secondary sites such as other fire stations or hospital emergency room facilities may strongly support education/training objectives. The proposed broadband/SIP-based system would have the capability to provide these communications services.

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Chapter V

SUMMARY

This memorandum report has described eight potential public enterprise telecommunications networks for southeastern Wisconsin that if made operational could contribute significantly to the improvement of government services while reducing capital infrastructure and operating costs. The potential public networks include:

1. **Public Safety Wireless Communications**
   Public safety wireless communications networks serve important public functions in areas such as law enforcement, fire fighting, and pre-hospital emergency services. Current networks that provide primarily voice communications are in a state of transition from circa 1980s analog technology furnishing voice and slow data transmission to new advanced multimedia broadband communications delivering high speed data transfer, high resolution video, and synchronized multimedia communications. New wireless technologies such as WiMAX offer the opportunity to achieve these with relatively modest infrastructure investment.

2. **Centralized Freeway Control**
   The Regional Planning Commission has long advocated centralized freeway traffic control based on the overall status of the network at a given moment of time. The objective is to minimize travel times for vehicular freeway users. Such centralized freeway control has also been a major goal of the Federal Intelligent Transportation Systems (ITS) initiative. A major void has been a lack of system-wide traffic control algorithms that reflect the complexity of a metropolitan freeway network. A new approach to algorithm development for centralized ramp metering control based on adaptive control technology has become available. A detailed description of the design approach has been prepared and is ready for presentation to the Wisconsin Department of Transportation as a potential project sponsor.

3. **Areawide Traffic Routing**
   Many motor vehicles are now equipped with satellite-based global positioning instrumentation (GPS) and navigation computers that can determine the minimum travel time from a current location to any selected destination. Currently, link travel times are based on posted speed limits. What is lacking is information on the current travel times actually experienced by drivers especially during periods of congested traffic: The proposed system would measure vehicular speeds and intersection delays on all major arterial links using new infrared speed detection devices. An area-wide sensor network would transmit the speed and delay information to a central information system for processing and distribution to area motor vehicles through existing cellular wireless networks. Suitably equipped motor vehicles could then determine their minimal travel time path to any destination in the Region. As the number of Global Positioning System-based and navigation computer-equipped vehicles increase, such minimum time travel will facilitate optimal use of the regional road network. The Wisconsin Department of Transportation would be a logical project sponsor.

4. **Broadband Telemedical Home Health Care**
   As health care costs continue to rise and the population ages, the importance of home health care as an alternative to hospitalization and nursing home care is receiving increased attention. Broadband communications offers potential for improving the efficiency of home health care. Medicare, the primary funds provider for home health care, pays a fixed amount monthly for each home patient. The center of home health care is the nurse visit. If the number of home visits can be reduced using high quality video-conferencing while still improving care quality, then the overall efficiency of home health care will significantly improve. Each nurse will serve more patients, but with more frequent video-conferencing daily contact for better medical outcomes at reduced costs. With the increasing spread of broadband communications services in the Region, the infrastructure is present to establish broadband-based telemedical home health care with interested county health departments and other agencies in the near future.

5. **Pre-Hospital Emergency Medical Services**
   Rescue squad ambulance services have improved significantly particularly since the Vietnam War where it was learned that on-the-scene medical procedures could save lives. Emergency medical technician (EMT) training has also advanced both in scope and quality so that many lives are saved by the rapid and skilled actions of EMTs at the scene of an accident or other medical emergency. Even with these advances, however, there is still a great need for improvement in the outcomes in medical emergencies. Nationally, the odds for saving an emergency patient is cases of stroke or cardiac arrest are still poor. Ambulance-based EMTs could benefit significantly from on-the-scene video-conferencing with the emergency department of the destination hospital. Such conferencing could bring the best medical talent to bear in emergency situations where minutes may have life or death implications. This application could be launched in the near future in cooperation with a regional emergency medical services group in any of a number of municipalities along with a wireless service provider moving into 3G quality video communications.

6. **Homeland Security Monitoring**
   One of the most potentially destructive threats to homeland security would involve the detonation of a simple radiological dispersion device capable of broadcasting nonfissile, but highly radioactive particles over a densely populated area. Such a “dirty bomb” would require transport in a motor vehicle to the target destination. A new sensor network communications technology called ZigBee, (IEEE Standard 802.15.4), could serve as the infrastructure to detect and report the arrival of such vehicles to a metropolitan emergency management center for an action response. Instrumentation developed at the Los Alamos National Laboratory in New Mexico could serve as the sensors for this network. Funding may be available from either the U.S. Department of Energy or the U.S. Department of Homeland Security.

7. **SCADA Networks**
   SCADA—for supervisory control and data acquisition—networks are widely used in water, wastewater, electric power and other utilities to control widely disbursed water, wastewater and electric infrastructure systems. These networks collect operational data and allow for the remote control of pumps, valves, switches and other actuators. SCADA data communications are generally currently based on leased telephone lines. A change to advanced, secure, reliable and robust wireless communications technology may be expected resulting in significant savings on line charges and allow for the low cost expansion of these networks. This application may be one of the most readily implemented public sector applications because of the strong economic justification.

8. **Environmental Sensor Networks**
   The U.S. Geological Survey operates a 32 station stream flow and water quality sensor network in the Region. The Wisconsin Department of Natural Resources similarly operates a 14 station air quality monitoring network. Both of these networks could be converted to advanced wireless

networks at significant savings to the public agencies concerned in the same manner as the utility SCADA networks using the same wireless technologies. These agencies should be asked to determine if they are willing to support and finance such a conversion.

9. **Distance Learning for Public Safety Personnel**
   Fire fighters and emergency medical technician (EMT) personnel in the Region's municipalities and towns are required to complete 150 hours each year of continuing education in their respective specialties. Currently such continuing education and training are carried out at various locations such as one of the branches of the State technical college network and University of Wisconsin-Extension System. Such classes typically involve moving fire fighting or EMT personnel with their fire fighting or EMS vehicles to these locations for classes. A potentially cost saving alternative would bring the class to the various Fire-EMS stations using broadband communications networks and the new Session Initiation Protocol (SIP). This approach would allow for the optimal use of educational resources by directing various sources of information and knowledge to the dispersed public safety student groups in their home fire house environments.

For each of the above potential public enterprise network systems, the need for the application was defined along with a description of the network and how it would operate. Preliminary schedules, budgets and staged project plans were also described in some detail. Potential project sponsors were identified. Initiation of any of the projects will rest with interested project sponsors. The Commission would, on request, assist such sponsors in project implementation.