# **Interorganizational Emergency Medical Services: Case Study of Rural Wireless Deployment and Management**

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**Abstract**

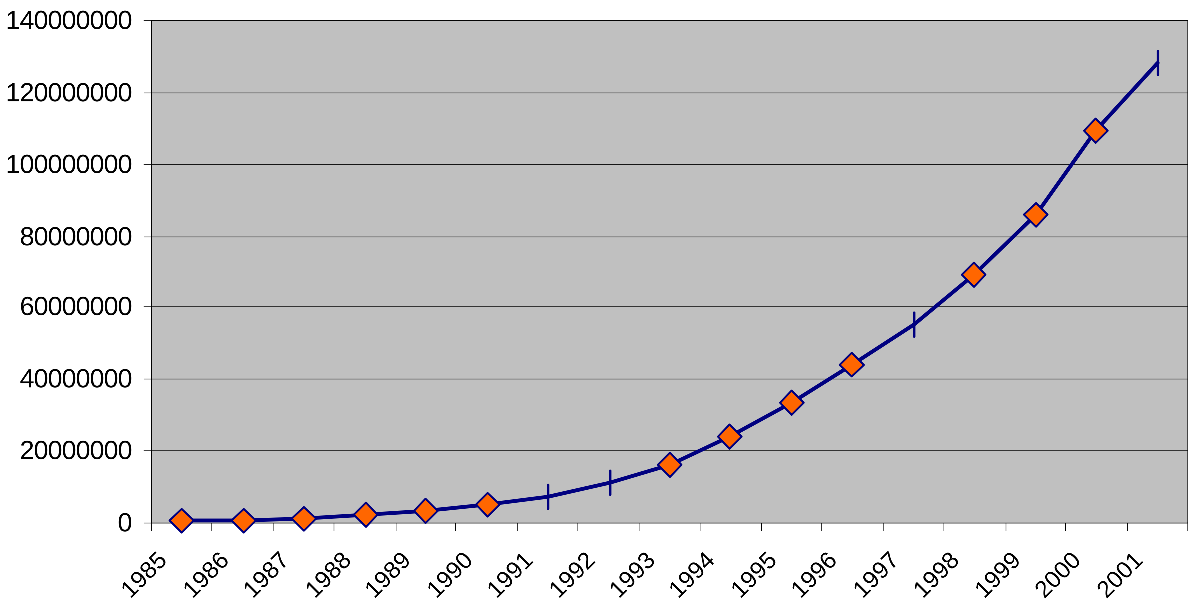
Over the last decade, use of mobile communications for emergency services (e.g. 911) has grown exponentially. This rise of mobile networks has increased reliance on new private and public partnerships and Interorganizational Systems (IOS) to deliver time critical services. This case study explores how rural Minnesota is grappling with this rise in emergency mobile communications. Using concepts of Interorganizational Systems (IOS) and the National ITS Architecture, researchers build a framework for investigation of emergency response and management systems (ERS/EMS) in Minnesota. This framework allowed the identification of technology, institutional, and policy issues. These technical and non-technical dimensions were further examined through a series of in-depth interviews with practitioners and stakeholders throughout the state, as supplemented by review and analysis of key evaluations of and reports on candidate ERS/EMS systems. Key technology concerns include slow systems upgrades, protracted integration of wireless communications to existing infrastructures, and competing (and expensive) standards for deployments. These issues were intertwined with organizational aspects, such as the complexities in developing coordinated and cooperative relationships among agencies in ERS/EMS and staffing and training challenges in rural areas. Underlying these constraints was the need for an integrating management and policy-framework, including a more strategic approach to devising and funding new systems. Recommendations are made on the need to 1) access adequacy of rural wireless coverage, 2) integrate emergency management system elements into local and statewide planning and funding decisions, 3) execute a comprehensive socio-technical approach to EMS/ITS management in small communities, and 4) provide cross-training and inter-organization team building.

**Keywords: Wireless Networks, Emergency Management, mobile communications, E-911 policy**

## Introduction

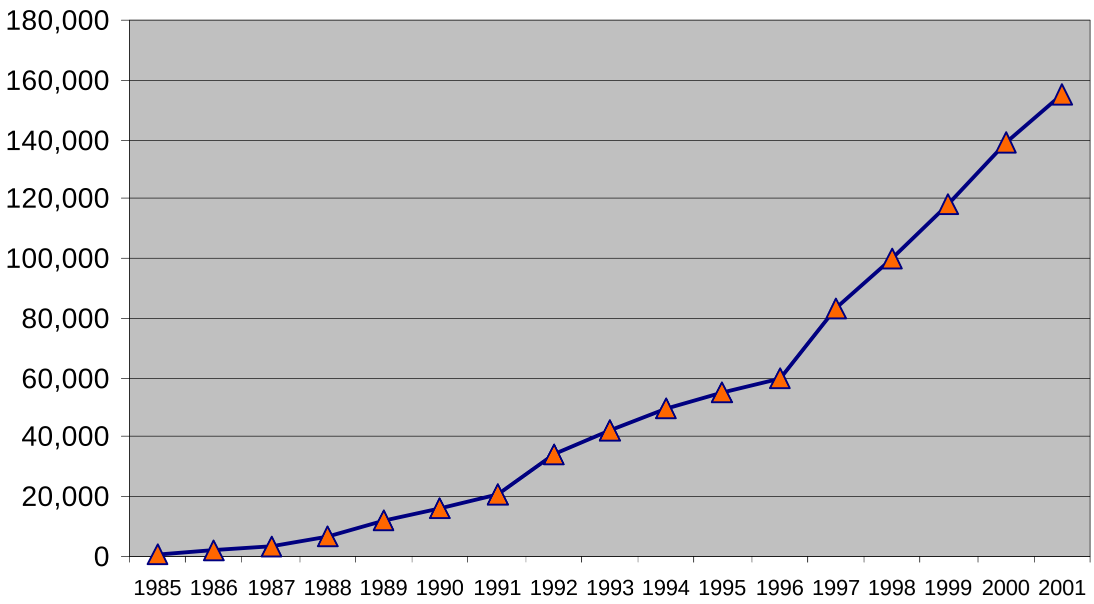
Wireless networks are quickly becoming the networks of choice because they provide the flexibility required for an increasingly mobile population (Varshney & Vetter, 2000). While market research has consistently suggested mobile users value the use of cell phones for safety services (NHTSA, 1997), the data over the last decade shows that this "perceived" benefit is rapidly translating into exponential demand for services—a demand that may only grow given increased sensitivity to security and protection. As such, this rapidly growing use of cell phones is placing a heavy burden on emergency response agencies. The advent of private sector telecommunications and cellular service has played a pivotal role in bringing the safety information network online. Wireless phones have rapidly become one of our greatest tools in improving emergency response time and saving lives. A wireless 911 phone call can shave valuable minutes from the time other-wise required for a caller to find a conventional phone to access emergency medical services. In the past ten years, wireless phone use has grown exponentially. There are more than 120 million wireless users making about 155,000 emergency calls a day across the United States (see Figures 1 and 2). For the same period, Emergency Medical Services notification times for fatal crashes have dropped an average of 30 percent (see Figure 3), as a caller does not have to depend on a conventional phone line for communications access. The steady increase in wireless subscribership and increased burden placed on EMS agencies has created a need to integrate new technologies with the existing emergency response infrastructure. In addition, there is a need to integrate organizations within the infrastructure through private-private and public-private partnerships and thus create cross-organizational synergies for institutionalizing ERS/EMS.

*Figure 1.* **Wireless Phone Subscriber Growth in the U.S.**



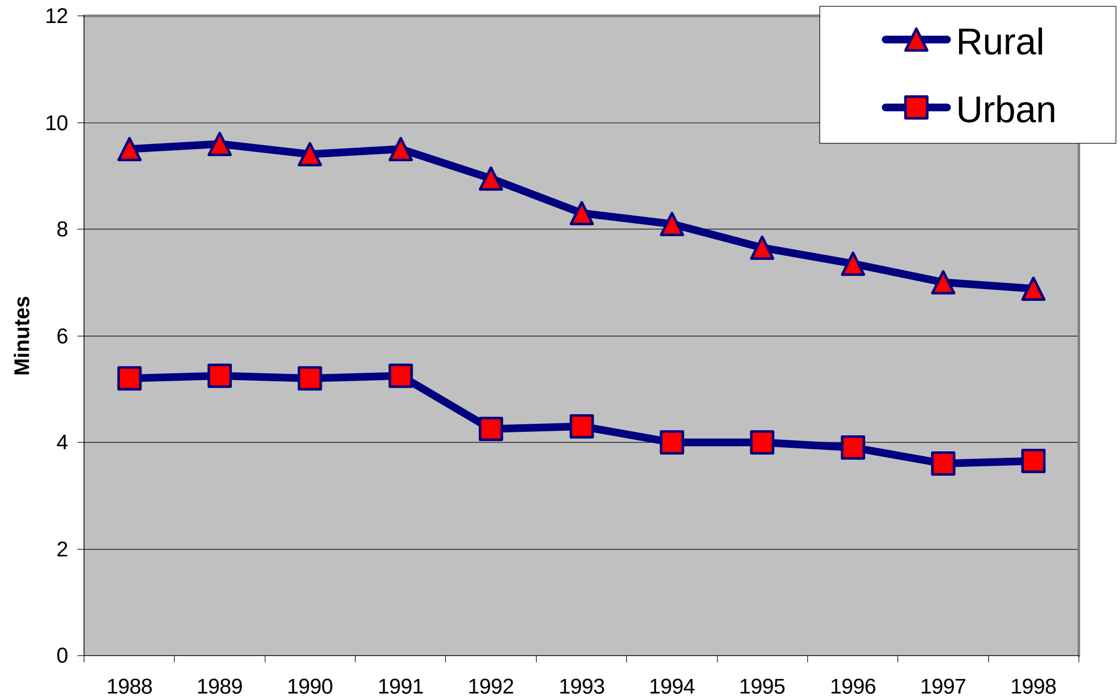

*Note.* From Cellular Telecommunications Industry Association (CTIA) web site retrieved July 10, 2002 from http://www.wow-com.com/industry/stats/e911/.

*Figure 2***.** **Estimated Number of Wireless Emergency Calls Per Day in the U.S**




*Note.* From Cellular Telecommunications Industry Association (CTIA) web site retrieved July 10, 2002 from http://www.wow-com.com/industry/stats/e911/.

*Figure 3.* **Time of Fatal Crash to EMS Notification, U.S. Averages (in minutes)**




*Note.* From National Center for Statistics and Analysis (NCSA), National Highway Transportation Safety Administration, U.S. Department of Transportation. (n.d.). Retrieved July 21, 2002 from National Center for Statistics and Analysis via Fatality Analysis Reporting System (FARS) Web-Based Encyclopedia [electronic database]: http://www-fars.nhtsa.dot.gov

One illustration of these needs is in the U.S. Federal Communications Commissions (FCC) mandatory requirement for wireless communications services such as cellular telephone, wideband (broadband) personal communications services (PCS), and geographic area specialized mobile radio (SMR) to provide automatic location identification (ALI) of a wireless 9-1-1 (E-911) phone call to an appropriate Public Service Answering Point (PSAP). Both the private carriers and public agencies will need to work closely together to accomplish this difficult requirement. Although the technical requirements for building these systems are clear, the management and policy requirements remain dim. For example, technology is developing rapidly in this area. Among the alternatives to provide E-911 are standalone, satellite-based (GPS), and terrestrial systems (e.g. triangulation, angle of arrival) (Zhao, 2002, p. 109). With the current rate of technological change, selecting the one best solution, or combination of solutions, for long term system investment is a daunting task for system administrators and designers.

Deploying end-to-end E-911 systems will require new and nontraditional partnerships, particularly among wireless carriers, emergency dispatch center administrators (e.g. PSAPs), law enforcement, fire and EMS officials, automotive companies, consumer leaders, technology vendors, and state and local political leaders (Potts, 2000).

The need for local partnerships to implement ERS/EMS aspects of Intelligent Transportation Systems is evident from statistical data from rural areas of the country. According to the U.S. Department of Transportation, more than 56% of fatal automobile crashes in 2001 occurred on rural roads (NCSA, n.d.). The Minnesota Department of Transportation (MnDOT) reports that only 30 percent of miles driven within the state are on rural roads, yet 70 percent of fatal crashes occur on them (MnDOT, 2000). In addition, 50 percent of rural traffic deaths occur before arrival at a hospital. Appropriate medical care during the “golden hour” immediately after injuries is critical to reducing the odds of lethal or disability consequences. Crash victims are often disoriented or unconscious and cannot call for help or assist in their rescue and therefore rely heavily upon coordinated actions from medical, fire, state patrol, telecommunications and other entities.

In this study, researchers focus on implementation of Emergency Response and Management Systems (ERS/EMS) in rural areas of Minnesota for three specific reasons. First, Minnesota has been aggressively pursuing Intelligent Transportation Systems (ITS) initiatives for several years and thus offered a test bed for various research projects, some of which have been conducted very recently. Second, rural areas do not have the technological infrastructure that exists in larger metropolitan areas. This offers the researchers an opportunity to explore specific barriers that may not exist in metropolitan areas. Third, rural areas of the state have often established immature partnerships in relation to ERS/EMS deployment, whereas many metropolitan areas have well-established partnerships. Researchers have an opportunity to explore local implementation of effective ERS/EMS from interorganizational perspectives.

To understand the means of operating effective ERS/EMS infrastructures in Minnesota, this paper will utilize a case-study analysis approach. It will first describe Interorganizational Systems (IOS) theory in order to establish a background for a conceptual framework. It will then describe Emergency Management Systems (EMS) as a subsystem of the Intelligent

Transportation System (ITS) for further background and framework conceptualization. The study will then utilize the conceptual framework for analysis and explore ERS/EMS infrastructures in rural Minnesota from technology, institutional and policy aspects. Based on the analysis and theoretical studies of IOS, the study will develop a conceptual architecture for EMS practices, taking into consideration rural characteristics of the study. Finally, the paper will conclude by discussing implications of this study for planning in rural regions.

## Framework of the Study

### *Interorganizational Systems (IOS)*

There is no doubt that we now live in a "Networked Society", much of which is wireless. The question whether we have learned to manage these networks in effective ways continues to dwell in the minds of researchers. Amin (2001) states that every economic and social function depends upon the secure and reliable operation of energy, telecommunications, transportation, financial, and other infrastructures. As these infrastructures have grown more complex to handle a variety of demands, they have become more interdependent (Amin, 2001). Effective operation of these networks requires the capability to manage many factors that lie beyond the control of one entity. The interconnections that cross organizational boundaries are often referred to as Interorganizational Systems (IOS).

In the broadest sense of the term, IOS help to foster relationships between independent organizations using information technology. Cash and Konsynski (1985, p.134) define IOS as "an automated information system shared by two or more companies." Similarly, Bakos (1991, p. 32) defines IOS as "an information system that links one or more firms to their customers or their suppliers, and facilitates the exchange of products and services." Johnston and Vitale (1988, p. 154) state that "An IOS is built around information technology, i.e. around computer and communications technology that facilitates the creation, storage, transformation, and transmission of information."

While most of the earliest studies conducted on IOS centered on the objective of private sector "competitive advantage" (Bakos, 1991; Johnston & Carrico, 1988; Johnston & Vitale, 1988), some of the recent studies have focused on a cooperative rather than a competitive dimension of IOS implementation between partner organizations (Kumar & van Dissel, 1996; Meier, 1995; Williams, 1997). These studies describe barriers and conflicts related to relationship building between partner organizations and their effect on functionality of IOS. In addition, these studies imply that adoption and implementation of IOS are complex matters due to the difficulty of building cooperative relationships within the system (Oliver, 1990; Premkumar & Ramamurthy, 1995). This is evidenced by a high failure rate of interorganizational relationships (partnerships, joint ventures, etc…) and their representative information systems (Cavaye and Cragg, 1995).

IOS may not simply be a technical system that crosses organizational boundaries. It has become a representation of a more complex system of technical, institutional and relationship building dimensions that cross organizational boundaries. IOS involve the cooperation and commitment of all the participating members. As such, these participants "may have complex economic and business relationships between themselves that result in a number of technical, social, political, and economic factors influencing the adoption of IOS" (Premkumar and Ramamurthy, 1995, p. 303).

The case of ERS/EMS provides an interesting illustration of IOS in that public and private agencies need to interact both technically and organizationally in a time critical fashion to deliver health care services to travelers and other users of mobile communications. Moreover, as it is often the case in complex systems, the rapid growth of wireless emergency systems has "emergent properties" in that there has not been a uniform system for implementing such usage. Rather, it has grown out of the rapid penetration of commercial wireless services throughout the population. In this manner, the case of ERS/EMS also provides an interesting illustration of how ITS and policymakers need to respond to new forms of services that grow out of private industry platforms, but have direct implications for the goals of ITS—that is "providing the intelligent link between travelers, vehicles and infrastructure" (ITSA, n.d.).

***Emergency Management Systems (EMS) and Intelligent Transportation Systems (ITS)***

A broad range of diverse technologies, known collectively as intelligent transportation systems (ITS), includes "information processing, communications, control, and electronics" (ITSA, n.d.). Sensory devices, software programs, cameras, cellular, landline, and satellite telecommunications are among many technologies included to ITS. These technologies provide "the intelligent link between travelers, vehicles, and infrastructure" (ITSA, n.d.). The integration of various advanced technologies into the transportation system has formed several subsystems within ITS and hundreds of smaller divisions within subsystems.

Emergency Response and Management Systems (ERS/EMS) is one of the most distributed subsystems of ITS. The ERS/EMS subsystem includes many different organizations, services, and technologies. First responder services, such as law enforcement, fire, and state patrol, health care facilities, state departments of transportation, wireless and wire line telecommunications service providers, emergency response call centers and some private organizations compose the complex EMS infrastructure.

According to the Minnesota Guidestar Program there is a need to integrate new technologies with the existing emergency response infrastructure (Minnesota Guidestar, n.d.). In addition, there is a need to integrate organizations within the infrastructure through private-private and public-private partnerships and thus create cross-organizational synergies for institutionalizing ERS/EMS.

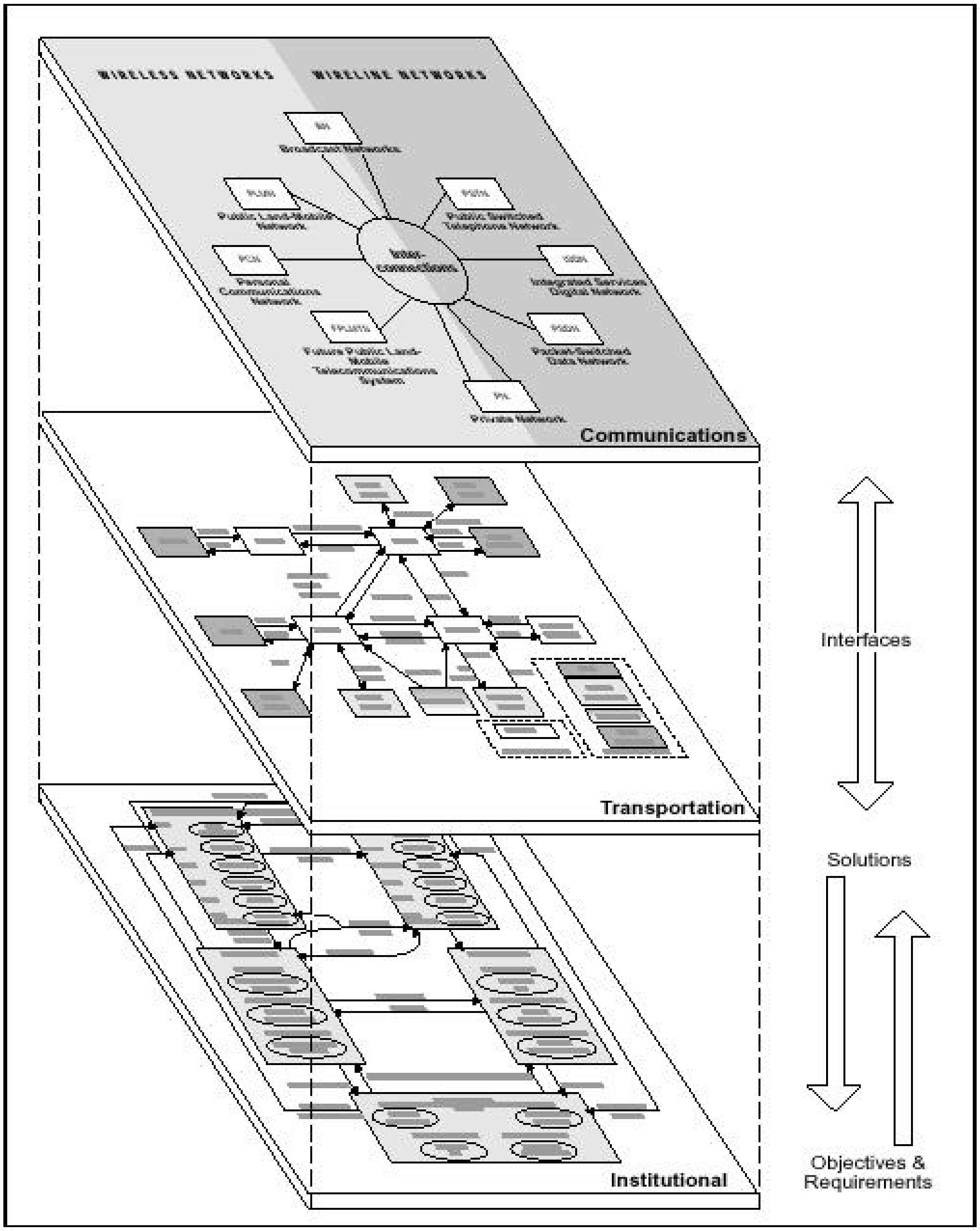
### *National ITS Architecture*

In this study, the National ITS Architecture is applied as a framework to analyze current functionality of ERS/EMS in rural areas of Minnesota. The National ITS Architecture was developed by the U.S. Department of Transportation in collaboration with the Intelligent Transportation Society of America (ITS America) as a framework to define the interactions between the transportation and telecommunication domains to create and offer ITS services throughout the nation. The purpose for applying the National ITS Architecture in this study is that its design helps "to mitigate the complexity involved in dealing with numerous complex entities" (Lockheed Martin, 1997, p. 1-1). One of its basic concepts relates to the "decoupling of the transportation and telecommunication domains into two, fairly independent, yet tightly coupled 'layers'" (Lockheed Martin, 1997, p. 1-1). In addition, the architecture focuses on connecting separate, yet partnered entities and is therefore relevant in the study of interorganizational aspects of ERS/EMS formation in rural Minnesota.

The framework is used for constructing interview questions, determining the scope of the document analysis, analyzing findings, and developing an architecture for effective ERS/EMS, taking into consideration the specific case of rural Minnesota. The National ITS Architecture includes the following three layers (see Figure 4):

1. **Transportation Layer -** This is the physical ITS infrastructure. This layer identifies key players and establishes a common terminology for existing and future ITS subsystems. The Architecture encompasses essentially (1) travelers; (2) vehicles; (3) management centers, and (4) roadside appliances.
2. **Communications Layer -** This information infrastructure connects the technological elements of the transportation layer. The Architecture carefully lays out (1) what types of information and communication support various ITS services; (2) data sharing and use by physical entities (subsystems); and (3) sets of standards to facilitate data sharing and use.
3. **Institutional Layer –** This layer determines the socioeconomic infrastructure of organizations (agencies of all governmental levels, public and private entities) and their social roles, reflecting jurisdictional boundaries. The institutional layer includes developing local policy, financing ITS, and creating partnerships to guide ITS development. (Lockheed Martin, 1999, p. 1-1 - 1-2)

*Figure 4.* **National Intelligent Transportation System Architecture**




**Note.** From "National ITS architecture documents: Communications document," by Lockheed Martin Federal Systems and Odetics ITS Division, 1997, January, Prepared for the Federal Highway Administration, U.S. Department of Transportation, p. 11.

## Methodology

Researchers deployed two research techniques in order to explore challenges to establishing effective ERS/EMS policy in Minnesota. The methodology included expert interviews as the primary tool and evaluation synthesis of existing technical and policy document reviews on ERS/EMS test projects in Minnesota as the secondary one. One of the most commonly given reasons for choosing a case study design is that “the thing to be described is so complex that the data collection has to probe deeply beyond the boundaries of a sample survey” (GAO, 1991, p. 43). Specifically, in this study, a single embedded case-study design methodology was used to ask “What” the interorganizational challenges are to effective Emergency Management Systems. According to Yin (1988), when a “What” research question is asked, and an exploratory study is conducted, an embedded case-study design is appropriate. In single case study designs, “information is acquired about a single individual, entity, or process” (GAO, 1991, p. 45). This case study examines Emergency Management Systems within a single entity, the state of Minnesota. In addition, Yin (1988) states that an embedded single case study has subunits of study within the single entity. As such, this case study examines individual organizations within EMS in two rural towns within the state of Minnesota. The two data gathering techniques used in this study are discussed further below.

### *Interviews*

The principle data used in this case study were in-depth interviews with representatives of multiple organizations that participate in public-private and private-private ERS/EMS partnerships. Kerlinger (1986) stated that open-ended interviews could be used to gain in-depth exploration into ideas and relationships not initially considered. An open-ended-item technique was used to provide a framework for the study to place minimal restrictions on the single or multiple interviewees within each organization. In Spring 2001, a preliminary set of group interviews were conducted on the general subject of wireless infrastructure and implications for access and safety in rural areas.

After further refinement of the study objectives, a second round of in-depth interviews were carried out in Fall 2001. Representatives from six public and private organizations (see Appendix A) in rural Minnesota provided their responses to open ended questions, which reflected technical, institutional, and policy aspects of wireless technology integration into

ERS/EMS. Organizations included Virginia County State Patrol, Virginia Country Fire Department, Minnesota Department of Transportation Office of Electronic Communications, Duluth Economic Development Association, Rochester Police Department, Mayo Medical Transport, and the City of Rochester mayor's office. Results from the second round of interviews were documented for later synthesis.

In Spring 2002, a third round of in-depth interviews were conducted on the general subject of transportation safety, particularly public access into the IOS. In this round, expert representatives (see Appendix A) from seven public and private organizations presented their opinions and views on institutional, technology and policy issues. The organizations included the Rhode Island E-911 Board, Public X-Y Mapping Project, AK Associates, MnDOT, Mayo Clinic, Minnesota Department of Administration, and the Metropolitan 911 Board (see Appendix A).

***Evaluation Synthesis***

A second data gathering technique included the "use of available data" (GAO, 1991, p. 61) and provided a supplement to the expert interviews. A series of research and project reports relative to ERS/EMS in Minnesota were reviewed (see Appendix B for full listing). In recent years, Minnesota has implemented ERS/EMS and ITS test projects, including ARTIC, MayDay Plus, DiVert, and others. Generally, these projects aimed at integration of advanced wireless technologies into transportation and communication infrastructures. Several central reports included:

- 800 MHz Statewide Report – This report presented a study and assessment of the current and future wireless communication requirements, needs and concerns of the local units of government and major user groups, including the state of Minnesota, the Emergency Medical Services community and school districts.
- 9-1-1 Dispatching: A Best Practices Review Summary– This summary provided assessment of safety dispatching in many counties of Minnesota. It also identified best practices in improvement of service delivery and intended to help communities in learning about effective methods of PSAP regulation.
- Mayday Plus Operational Test — This report described results of testing and establishing an emergency detection and response infrastructure in Southeastern

Minnesota. Specifically, it evaluated use of Mayday Plus system that allowed a direct voice and data link from the vehicle to emergency dispatchers.

- Advanced Rural Transportation Information and Coordination (ARTIC) Operational Test Evaluation Report – This report presented results of a one-year test of ARTIC in Northeastern Minnesota. The objective of ARTIC was combination of resources and streamlining dispatching operations for four transportation agencies: District 1 of MnDOT, Minnesota State Patrol (MSP) District 3100, City of Virginia Dial-a-Ride, and Arrowhead Transit Services.

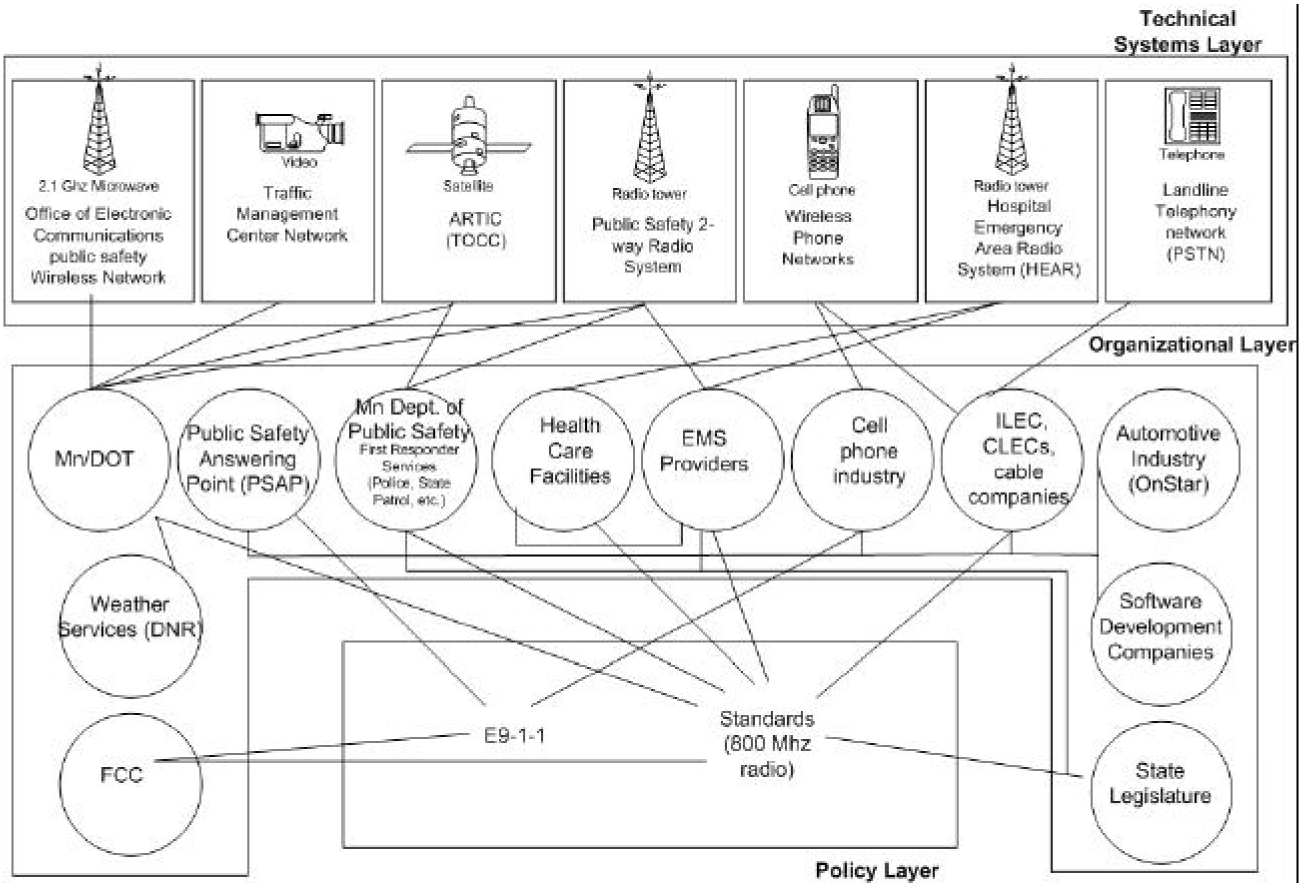
These sources and other related evaluations of ITS and ERS/EMS nationally helped inform the context for the Minnesota case study and provided specific data on selected implementation trends and challenges.

## Findings

Both the interviews and reports served to identify major difficulties and achievements in establishing well-functioning and efficient ERS/EMS in Minnesota (see Figure 5). As a point of departure, it is important to note that Minnesota has established a strong record of demonstration and implementation for ITS generally. For example, Minnesota Guidestar, the state's ITS program, has carried out a number of projects to provide traveler information, promote transit ridership, and improve traffic control and incident management. Consequently, the Minnesota ITS program has deployed several ITS features (e.g. ramp meter controls) at a rate greater than the national average and continues to take a leadership role in testing rural deployments.

With regard to ERS/EMS specifically, results of expert interviews and document surveys revealed several critical issues. Experts discussed problems of unreliable technology in serving the public during emergency responses. Document surveys revealed difficulties such as establishing interagency cooperation, which was the key to successful implementation of ITS technologies. In interviews, experts discussed policy issues such as a lack of timely technology upgrades due to insufficient funding. Experts also raised issues related to a lack of policy incentives to provide full cell phone coverage in rural areas. As the discussion topics were qualified as technology, organizational, and policy issues, researchers organized the structure for analysis accordingly.

*Figure 5*. **An Interorganizational Architecture for Emergency Management Systems in Minnesota**




### *Technology issues*

A complex characteristic of ERS/EMS can be explained by its composition. ERS/EMS is comprised of many organizations and services that greatly rely upon technology to perform the vital liaison function for coordinating actions within the IOS. While there is no doubt that the technology exists to create state-of-the-art ERS/EMS, major barriers exist to implementing and managing them.

The challenge of deploying new ERS/EMS services was seen in the design of Minnesota's Mayday Plus demonstration. Automated location devices increased the effectiveness of medical and road assistance, while collision severity notification systems transmitted requests for additional help and special medical instructions to emergency room or trauma center personnel at the Mayo Clinic in Rochester, Minnesota. The technology is advanced and effective while the costs are prohibitive for a wide scale deployment.

Not surprisingly, several interviewees noted that technological provision remained one of the essential issues in creating effective interorganizational ERS/EMS in Minnesota, especially in rural areas. Interviewees explained benefits to newly implemented technologies, including enhanced efficiency among call dispatchers and state patrol officers in arriving to accident locations (D. Gustafsson, personal communication, Fall 2001). Although Minnesota partnerships widely deployed special software, radio, cellular, Geographic Positioning Systems (GPS), Automatic Vehicle Location (AVL) and other advanced types of technologies; experts concluded that the ERS/EMS infrastructure demanded additional resources. Systems need to be added, upgraded, and integrated with existing transportation information systems. Yet, there is often a paucity of local funds in rural areas to do so.

Interviewees and document reports showed that in recent years the Minnesota ERS/EMS significantly increased reliability on cellular telephone usage. The Minnesota State Patrol answered 650,000 cellular 9-1-1 calls annually (or 1,780 daily), and numbers of cellular 9-1-1 calls have increased 15 to 20 percent each year (To & Choudhry, 2000). Many of these calls originate from rural areas of the state, where access to wire line telephone service is not always easily available. Several interviewees also discussed insufficiencies in developing wireless infrastructure in rural areas, including a limited coverage area and improper call routing to the correct Public Service Answering Point (PSAP) (Terry A., Hogan M., Lyden G., Gustafson D., & Jonassen M., personal communications, Fall 2001; Beutelspacher J., Pollig N., and Moody M. personal communications, Spring 2002). This doubtless creates time delays and other difficulties related to immediate response to emergency calls and the location of their related accident sites. As one expert noted, local specialists rely upon their "general sense of the area and can generally locate the victim without specific directions" (Gustafson D., personal communications, Fall 2001).

Some interviewees described synergies created between organizations by sharing technological resources and associated costs similar to the findings of the ARTIC test project. The ARTIC evaluation report states that there was a "Tremendous positive impact in system efficiency with the integration of [partner] communications" systems (Mn/DOT, 2000). However, most experts explained that a lack of funds contributed to slowing the process of implementing new technology and integrating systems with partner organizations.

The pivotal unit for dealing with emergency calls is the Public Service Answering Point (PSAP). There are 119 PSAPs in the state of Minnesota. About 40 percent of PSAPs are compliant to Phase 0 and Phase 1 standards of TEA-21 legislation, which has required a dialable number and location of the nearest cell tower base station to accompany each 911 call (Beutelspacher J., Pollig N., and Moody M., Personal Communications, Spring 2002). Only a few PSAPs have upgraded their equipment to accept data with latitudinal and longitudinal dimensions in compliance with Phase 2 rules. Obviously, geographical dimensions are critical in responding to emergency calls from rural areas. Due to high costs associated with technological upgrades, the process of implementing FCC's regulation is going relatively slow. According to revised FCC rules on wireless E-911, PSAPs should have started accepting location information by October 1, 2001. This deadline was also effective for service carriers, the majority of which have filed for time extensions with the FCC.

Interviewees gave several additional examples relating to the need to upgrade systems. Regarding PSAPs functions, experts mentioned that nationally 80 percent of PSAPs do not have full data backup capabilities, which causes a high percentage of calls to be lost. In addition, as the number of emergency calls from cellular telephones has increased, wireless trunks are often busy, leaving wire line trunks available (Kraus, A., personal communications, Spring 2002). Upgrading data backup capabilities, adding wireless trunks to PSAPs, and upgrading technology to include acceptance of both wireless and wire line calls rather than retrofitting existing wire line systems were among some of the related recommendations from interviewees. Another issue was that PSAP decision-makers are often not aware of new, lower cost technical solutions. They often rely on vendors, who push high cost, long-term solutions.

***Organizational issues***

Interviews and document reviews described several benefits to partnership creation and their associated IOSs. Several explained that resource sharing enabled partnership organizations to save time and money. They explained that in order to establish a well functioning ERS/EMS through the use of advanced technologies, coordinated relationships between individual member organizations of the system must be established. Because these relationships have a horizontal structure, system efficiency depends on the organized, clearly defined and conscientious actions of each member agency. Several expert opinions and evaluations of ITS test projects indicated that there was a need to further enhance "knowledge of inter and intra organizational roles and responsibilities" in Minnesota ERS/EMS partnerships.

Partnerships that consist of public and private organizations encounter both barriers and synergies to creating effective ERS/EMS. An expert from the Mayo Clinic described the situation when the clinic purchased Gold Cross Ambulance Service (GCAS), its previous partner (Canfield C., personal communicatons, Fall 2001). The Mayo Clinic purchased the ambulance service due to GCAS's low funding, which inhibited its ability to adopt new technology for its vehicles and "keep up" with the hospital. Another expert from Virginia Fire Department stated that the local hospital, the main private partner in the Virginia emergency response partnership, was slowing the process to adopt new technology for emergency response purposes (Gustafson D, personal communications, Fall 2001). These two examples demonstrate the unbalanced nature of partnerships and the uneven distribution of opportunities for member agencies. MnDOT's representative confirmed that a partnership heavily evoked issues of financing arrangements (including technology and costs incurred from participation in the partnership).

There was no common theme in terms of the best structure, distribution of roles, responsibilities and burdens for maintaining effective ERS/EMS partnerships. Perspectives on partnership roles and responsibilities varies in each organization and in some cases, this causes discrepancies in ERS/EMS performance. Several interviewees explained that this major barrier stemmed from a lack of trust between partnership organizations, especially as relates to public-private partnerships. An expert from MnDOT's Communications Technology Office (CTO) pointed out that government agencies could not always rely on private companies to cooperate for emergency purposes. Recognizing a strong potential in using cellular technology in emergencies, the CTO proposed the solution that the government agency receive a priority access service during a large-scale emergency. This, however, would lower consumer cell phone call completion rates and pose undesired risks to the private cellular carriers. Another proposed solution is to bypass using private cellular systems for emergency response purposes and instead utilize the 800 MHz radio frequency band for 2-way radio State Agency purposes (Mn/DOT, 2001).

Other institutional barriers included lack of proper training and resistance of an agency's personnel to learn new technologies. For instance, Rochester Police Department (Rochester, Minnesota) reported a long learning curve in training officers to transition to technologically advanced operations. The Mayo Clinic interviews supported similar patterns of adjustment to new technologies. The Mayo Clinic's Medical Transport reported employee's resistance to incorporate new devices into the workplace, stating that the employee's feared becoming heavily reliant upon machines in the event of emergency accidents.

***Policy issues***

Research demonstrated that federal, state and local policy had a critical role in determining incentives and terms for ERS/EMS functionality. One of the most significant steps in improving conditions for ERS/EMS functionality was elaboration of coherent policy decisions at all levels. Interview and document survey results indicated a need for greater interaction between government agencies of all jurisdictions to encourage rapid implementation of advanced technological products into the emergency response infrastructure.

The Advanced Rural Transportation Information and Coordination (ARTIC) project illustrates the successful use of a network-based approach to establishing the ERS/EMS in northeastern counties of Minnesota (Mn/DOT, 2000). Before deployment of ARTIC, agencies independently developed duplicate record keeping, which stretched scarce resources and degraded the quality of service to the public. Under the ARTIC project, several state and local agencies created an alliance, shared resources, and implemented ITS technology to design well-managed and efficient emergency response systems that served rural roads.

Government policy comprises not only direct participation in creating the efficient ERS/EMS but also determination of a set of incentives to establish and develop ERS/EMSs within the state. As previously mentioned, the federal government has required wireless carriers to implement E-911 service to further improve the quality of emergency services. While taking measures to comply with the federal rules, Minnesota's PSAPs encountered serious barriers. Low funding from budget sources and lack of private investments inhibited their ability to upgrade systems and equipment to support E-911. As a result, implementation was notably repressed and thus required the state's intervention. Considering the successful experience of Rhode Island in gaining funds from a $0.47 telephone surcharge per customer, Minnesota experts supported a similar solution to the issue: allocation of upgrade costs through increasing the statewide telephone charge from 10 to 27 cents per customer. This measure has not yet been approved.

The study results also demonstrated how effective policy could help overcome another major barrier to implementation: a lack of standards. Experts defined standardization of geographical databases in multijurisdictional dimensions as a primary task to establishing ERS/EMS. Experts stated that the lack of a uniform method for describing incident locations has long been a major impediment to rapid and effective emergency response in diverse metropolitan and rural areas. When the Federal Geographic Data Committee adopted the U.S. National Grid (USNG) standard (FGDC-STD-001-2001), the problem of interoperability of location services seemingly disappeared. The USNG corrected discrepancies in map products and provided a countrywide consistent grid reference system as preferred in data applications in emergency response. However, the USNG has not been rapidly incorporated at governmental levels and therefore has not realized the full potential of its advantages. In the study context, implementation of the USNG for uniform geoaddressing would significantly increase the effectiveness of GPS applications in emergency response measures.

Recently, safety and privacy issues in application of wireless technologies to transportation have received much attention from government and the public. Studies indicate that wireless technologies present a number of benefits as well as risks when used in a vehicle. Cell phone users can place emergency calls directly from a vehicle or accident site. This is particularly critical in rural areas. However, distraction created by cell phone use while driving can increase the risk of a crash (NHTSA, 1997). Considering these risks, Minnesota and other states have been involved in discussion about the possibility of imposing a legal ban on cellular phone use while operating a vehicle. Of course, common practice dictates legal authorization to use cellular phones in emergencies. Here, the main concern is whether rural areas would largely remain unsupported by cellular telephone service after introduction of restrictive rules on cellular phone use.

## Implications

This study has raised several policy, organizational and technological issues for ERS/EMS in rural Minnesota as well as rural areas more generally:

### *Technology*

The rise of wireless systems has a prominent effect on ERS/EMS. The rapid growth of wireless technologies and applications in transportation related emergencies detected by citizens and communicated via wireless systems signifies the increasing role of customer-based distributed systems in creating knowledge about service demand and delivery of services (Horan, 2002). The challenge is to devise and deploy new sets of location-specific devices (and call centers) that can in essence keep-up with emergent consumer demand. Advanced technologies further intensify the challenges of using increasingly distributed, complex, and interorganizational systems. At the same time, new technologies solve issues related to cooperated data creation, use and exchange within ITS infrastructures. E-911 provides a strong example of how a strong set of technological standards, or lack thereof, plays an important role in the implementation of an advanced technology in an interorganizational system.

### *Issues of interagency cooperation*

The ERS/EMS partnerships of rural Minnesota present dynamics in building interagency relations under current federal, state and local policies. Their experience revealed a set of new considerations in management of interorganizational systems. For example, Departments of Transportation do not usually consider communications infrastructure to be a core function of their agency, yet they may be in the best position to provide backbone infrastructure services, as the 800 MHz report has suggested. MnDOT is currently one of the major radio users in the state and has the most significant need for radio communications. But, the state will have to construct the infrastructure in order to meet their current and emerging needs. Major interorganizational barriers were generated from varying positions in terms of finance, competencies, trust, and interest in cooperative relations. Concepts such as the self-organizing nature of the enterprise, the role of disequilibria in generating change, and the role of independent agents in affecting change have value in understanding these interorganizational networks.

***Policy***

Ubiquitous emergency management service is costly and raises public policy issues as to who absorbs this burden. The terrorist attacks on September 11, 2001 have heightened general interest in domestic preparedness and provision of emergency services (Howitt, 2001). These services ultimately fall upon a range of public and private service systems similar to ERS/EMS projects in Minnesota. The ERS/EMS study demonstrates that policies on implementation, standards, and sufficient funding can create favorable climate for interagency cooperation and hasten the upgrading of systems to promote regional implementation of the ITS architecture. However, there is widespread concern that regulations such as the E-911 mandate will impose costs on regions that they are not quite prepared to absorb, especially given current governmental shortfalls.

## Recommendations

The following recommendations are offered as steps toward resolving present issues and developing capability to meet future challenges in creating and developing ERS/EMS in State and local governments and in rural and small town areas generally:

- *Access Critical Coverage Gaps and Implications for Service.* The ITS/EMS service is fundamentally dependent on mobile coverage. Yet, adequate coverage in rural areas continues to be problematic. In the case of EMS, the consequence is not just the inconvenience of not being able to place a personal or business phone call, but could be a fatal gap should failed coverage not allow for adequate response.
- *Integrate EMS Planning Into ITS Planning and Funding*. For rural areas the safety aspects of ITS are arguably more important than the mobility elements typically featured in regional ITS architectures and deployment plans. Moreover, the communication and system elements to ITS provide an important cornerstone for EMS management. But in order to receive local funding, such systems need to be integrated into the transportation planning process as this is the means by which state and local funds are often allocated.
- *Develop a Strategic and Management Plan that integrates technical and socio-policy elements for next generation E-911 coverage.* The E-911 mandate has created a policy/regulatory context for pushing location-specific emergency services. However, this review has identified a range of technology, organizational, and policy issues that include yet

transcend this policy mandate. A strategic plan would incorporate the E-911 requirements within a broader planning exercise, which importantly should include a funding requirements element. Local areas face very constrained budgets and often need to develop innovative partnerships to deploy new ERS/EMS services. The management plan should remove artificial barriers to establishing interorganizational systems. Common stance in developing ERS/EMS in rural towns and regions is the key to successful cooperation between local entities.

- *Provide adequate training to specialists*. New systems, such as those mandated by E-911, will require training at the local level. Moreover, transportation managers need to become apprised about the relationships between safety related ITS systems and mobility related ITS systems.

In sum, while the proposition that we are living in a "Networked Society" is fairly straight-forward and confirmable, the reality of making these networks work in a manner that is efficient and effective is a much more complicated affair. There is no doubt that the technology exists to support a fully operable, state of the art, end-to-end E-911 Emergency Management System, from the mobile caller to the local PSAP. However, these systems need to be justified in light of competing demands for resources that are particularly acute in rural areas. And at this policy-level, while regulations such as E-911 provide a useful "stick" to drive next generation systems, ultimately these systems need to be financed and supported at the local level. All ERS/EMS systems—like politics, are in the end local; and regional and statewide systems need to be devised to ensure timely deployment and management. Wireless telecommunications and ITS can play an important role in facilitating this deployment, but policymakers and planners must take the necessary steps to integrate into these public and private sector planning and deployment processes.

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***Appendix A.* Organizational affiliation of experts**

Training Officer for Virginia Fire Department (MN)
October 15, 2001

Supervisor, Virginia State Patrol (MN)
October 16, 2001

Director, Office of Electronic Communications
MnDOT
October 16, 2001

Communications Planning Director
Office of Electronic Communications
MnDOT
October 16, 2001

Duluth City Councilman
Duluth Economic Development Association
MN)
October 17, 2001

Communications Manager
Rochester Police Department (MN)
November 14, 2001

Supervisor
Rochester Police Department (MN)
November 14, 2001

Mayo Medical Transport (MN)
November 14, 2001

911 Product Manager
Department of Administration
St. Paul, Minnesota
March 5, 2002

Mayor of the City of Rochester (MN)
November 14, 2001

E-911 Executive Director
Rhode Island
February 7, 2002

Co-Sponsor of National Grid
Public X-Y Mapping Project
Fairfax, Virginia
February 7, 2002

A.K. Associates
Derry, New Hampshire
February 14, 2002

Mn/DOT ITS Program Director
St. Paul, Minnesota
March 5, 2002

Mayo Clinic at Rochester, MN
Dispatch Center Manager
March 7, 2002

Metropolitan 911 Board
Executive Director
St. Paul, Minnesota
March 5, 2002

911 Product Analyst
Department of Administration
St. Paul, Minnesota
March 5, 2002

## *Appendix B.* Minnesota and National Reports Related to EMS/ITS

*Minnesota Reports Related to EMS/ITS*

Advanced Rural Transportation Information and Coordination (ARTIC) Operational Test Evaluation Report (2000)

During Incidents Vehicles Exit to Reduce Time (DIVERT) Evaluation Report (1998)

Emergency Medical Services Radio Communications Needs Assessment Report (2001)

Mayday Plus Operational Test (2000)

Transportation Operations Communications Center (TOCC): Concept and Migration Plan (2000)

800 MHz Statewide Report (2001)

9-1-1 Dispatching: A Best Practices Review Summary (1998)

*National Reports Related to EMS/ITS*

National Intelligent Transportation Systems Program Plan, volume 1 (1995)

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