PUBLIC SAFETY PSWN PROGRAM WIRELESS NETWORK

Saving Lives and Property Through Improved Interoperability

Wireless Data Networking Standards Support Report: Intelligent Transportation Systems (ITS)

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1. INTRODUCTION

In response to new political and economic constraints, transportation and public safety agencies are maximizing the efficiency of technology investments through cooperative efforts. These efforts enable joint acquisitions of technologies and facilities, and provide new information streams and capabilities that were previously unavailable. Transportation and public safety agencies are investing in new information and communication technologies that—

- Centralize traffic operations and public safety communications centers
- Deploy traffic and road condition monitoring systems
- Incorporate automatic vehicle location (AVL) systems and geographic information systems (GIS)
- Provide enhanced mobile information and communications systems for vehicle dispatch and status control.

To benefit from the potentially broad uses of these new information-sharing technologies and to improve the efficiency of transportation and emergency services, public safety and transportation agencies must work together in new ways by the sharing of informational assets, facilities, and communications infrastructure. Building new relationships between transportation and public safety entities is an important link in enhancing community safety. Regional, cross-agency, and cross-jurisdictional cooperation, along with jointly developed programs, plans, procedures, and technologies are fundamental to this effort. Detecting and effectively managing transportation incidents and efficiently sharing information with various emergency response agencies will decrease response times and reduce the impact on community health, safety, and commerce.

Intelligent Transportation Systems (ITS) encompass the application of advanced technologies and techniques such as communication systems, computers, electronics, and information processing in an integrated approach to improve the efficiency and safety of the nation's multimodal transportation network. ITSs improve the efficiency and effectiveness of the public safety services delivery through technological advancement in transit, traffic, and vehicle operations. Applying new information technologies to traffic and surface transportation incidents will improve detection, response, and recovery in emergencies.

In addition to this introduction, this report contains the following sections:

- **Section 2, Intelligent Transportation Systems Overview—**details the origins and initial developments of ITSs in the United States and reviews the goals, objectives, and vision of ITS planners and participants.
- **Section 3, Intelligent Transportation Systems Programs and Initiatives—** describes the various initiatives under way to develop and deploy ITS capabilities

throughout the Nation. Specific information is provided regarding the U.S. Department of Transportation's (USDOT) ITS Public Safety Program initiative.

- **Section 4, Intelligent Transportation Systems Technology Overview**—discusses the National ITS Architectures and the variety of existing and emerging technologies and services implemented and provided by advanced ITSs.
- **Section 5, Public Safety Applications and Intersections—**provides discussion and information regarding several ITSs and public safety projects in which partnerships and technical integration are enhancing services delivery for all participating agencies.
- **Section 6, Future Impact—**summarizes the expected impact of ITS technologies.

2. INTELLIGENT TRANSPORTION SYSTEMS OVERVIEW

An ITS is the integrated application of computers, communications, and sensor technology to increase the safety and efficiency of the Nation's transportation systems. "ITS means powerful benefits in managing congestion, reducing crashes, and improving the efficiency of the trucking and transit industries. Intelligent Transportation Systems have already demonstrated their value in improving mobility and safety, not only in North America but in Europe and Asia as well."[1]

The ITS initiative of USDOT represents the next step in the evolution of the Nation's entire surface transportation system. The ITS program was created by congressional legislation in 1991, after it became imperative to update the existing transportation networks and technologies, and to address related challenges of the aging systems. During the program's first 2 years, modal (i.e., automobile, bus, train, and airplane) administrations were responsible for different areas of the program. The Federal Highway Administration was responsible for ITS roadway-based research and testing, the National Highway Traffic Safety Administration for ITS safety programs, the Federal Transit Administration for transit applications, and the Federal Motor Carrier Safety Administration for commercial motor vehicle applications. Over the years, USDOT has realized the potential of the innovative ITS program. ITSs can be applied to the vast majority of transportation infrastructure, including highways, roads, and bridges, as well as cars, buses, trucks, and trains. ITS technologies also help to develop and deploy systems that can improve the service offerings of the surface transportation industry.

Through the Transportation Equity Act for the 21st Century (TEA-21), enacted on June 9, 1998, the Congress authorized continuation of many of the ITS programs and projects it initially authorized in 1991. TEA-21 authorized federal surface transportation programs for highways, highway safety, and transit for the 6-year period from 1998–2003. However, TEA-21, is scheduled to expire on September 30, 2003. USDOT is preparing for the reauthorization of surface transportation programs by working with the Congress, state and local officials, tribal governments, and other stakeholders to develop the required continuation proposals.

The ITS initiative serves as the means to advance safety, efficiency, and security of the surface transportation system. One of the primary objectives of ITSs is providing increased access to transportation systems while reducing fuel consumption and environmental impact. In addition, ITSs and the communications networks associated with ITSs aid in detecting and managing possible problems the surface transportation systems may face during times of crisis. The terrorist attacks on September 11, 2001, showed that security is often inadequate for air travel. In a time when the most significant travel restrictions ever implemented across the United States were in effect, the role of ITSs was exemplified by providing timely information to travelers and responding to regional crises through management of highways and public transportation systems.

If used effectively, ITSs can lead to new ways of understanding, operating, expanding, refining, reconfiguring, and using the Nation's transportation systems. In the past decade, the

[1] Secretary of Transportation, Norman Mineta, April 2001

public and private sectors have invested billions of dollars in ITS technology research and development. Billions more have been invested in the initial deployments of the resulting products and services. In the next decade, a projected $209 billion will be invested in ITSs, with a full 80 percent of this investment coming from the private sector in the form of consumer products and services. The intelligent transportation industry is expected to have a market worth of more than $430 billion by the year 2015.[2]

ITS advocates and planners have a definitive vision to ensure that—

- Future transportation systems will be managed and operated to provide seamless, end-to-end intermodal passenger travel regardless of age, disability, or location and efficient, seamless, end-to-end intermodal freight movement.
- Public policy and private sector decision makers will seize the opportunity to make ITSs a vital component in achieving the vision of the transportation system for the 21st century.
- Future transportation systems will be secure, customer oriented, performance driven, and institutionally innovative, enabled by information from a fully integrated spectrum of computing, communications, and sensor technologies.[3]

To measure change and progress in the ITS initiative, it is important to look at the benefits already associated with achieving this vision. One of the most pertinent benefit areas in which ITSs could potentially save lives and money is transportation safety. Some associated safety improvements include—

- Minimizing vehicular crashes in large numbers through technology that improves the performance of drivers, vehicles, and the highway infrastructure
- Reducing the severity of the crashes that do occur and mitigating their consequences through improved, sensor-based injury-reducing technology in vehicles and highways that enable more positive and swifter responses by emergency first responder services
- Identifying and influencing the behavior of high-risk commercial drivers; identifying high-risk carriers and working with them to improve their safety management processes
- Encouraging safe and responsible driver behavior through automated surveillance and enforcement technologies and activities
- Enabling communication and cooperation between vehicles and the transportation infrastructure to allow vehicle performance to adapt to changing traffic patterns, traffic incidents, weather conditions, and topographic features

[2] ITS America web site (http://www.itsa.org)
[3] National Intelligent Transportation Systems Program Plan: A Ten-Year Vision

- Connecting vehicles, vehicle operators, travelers, public safety agencies, and the transportation infrastructure through an integrated network of transportation, public safety and environmental information systems and applying derived information to enhance safety management by both the public and private sectors

- Helping to ensure that the transportation systems are protected to the highest possible degree from terrorist attacks.

Other benefit areas include increased security, greater efficiency, and economy for transportation system users, enhanced mobility and access, and energy conservation. Table 1 summarizes the ITS benefits and associated goals and vision.

Table 1
ITS Benefit Areas and Associated Goals and Visions

Benefit Area	Goal	Associated Vision
Safety	Reduce the number and severity of accidents, saving 5,000–7,000 lives each year by 2011	Safer vehicles and roadways, with fewer and less-severe crashes
Security	Create a secure system that relies on gathering and sharing real-time information to improve detection and response to national emergencies or dangerous manmade and natural events	System that enhances personal security on the roads, rail lines, and ports, and knows exactly where freight is as it moves efficiently from ship to rail or truck on its way from manufacturers to distributors to retailers
Efficiency and Economy	Help operate the transportation system more efficiently, generating cost savings of at least $20 billion each year	System that uses technology to make travel less stressful and that operates correctly regardless of traveler age, disability, location, or destination
Mobility and Access	Support travel choices with current and valid information available to all	System that allows easy transfers between rail and bus, auto and transit, and auto and parking facilities
Energy	Save time by reducing congestion, which will save a minimum of 1 billion gallons of gasoline each year, and realize proportionate gains in reducing tailpipe emissions	System that provides real-time information to reduce congestion and expand personal travel choices, while improving the environment

In pursuing these visions and goals, two entities champion ITS programs and initiatives, USDOT and Intelligent Transportation Society of America (ITS America). The role of USDOT is threefold—

- Oversight, through the Joint Program Office, of areas including architecture, standards, modal and intermodal concerns, and modal deployments and other field tests

- Focused funding to accelerate the process associated with ITSs

- Assurance of safety and national interoperability with critical standards and conformance of ITS technologies.

In addition, it is important to understand that the Federal Government must continue to champion ITS technologies. For the initiatives to be successful, both the public and private sectors must continue to embrace and make use of ITS technologies, products, and services. A variety of sites around the country raise awareness of ITSs by performing demonstrations of the technologies. Many state departments of transportation (DOT) have embraced ITSs and are participating in both pilot and permanent projects using the various technologies to improve the transportation infrastructure and enhance public safety capabilities. These efforts provide an open forum for other public sector officials to see the technologies that can be built locally to apply ITS technologies for the future in their areas. These efforts also provide private industry with a forum and test bed to further research and develop new ITS products, processes, and applications.

ITS America, created by the Congress in 1991, is the only national public–private organization established to organize the development, deployment, and use of ITSs in the United States. It serves as a not-for-profit public–private partnership that promotes the increased safety and efficiency through the application of advanced technologies to the transportation sector. ITS America members are commonly stakeholders that have an interest in ITSs, including local, state, federal, and foreign government agencies; national and international companies involved in developing ITSs; universities; and independent research organizations. The annual budget of ITS America exceeds $8 million, with a staff of more than 45 professionals. The society serves three primary roles—

- Federal Advisory Committee to USDOT
- Scientific and education association dedicated to advancing ITS professions
- Trade association representing the interests of the manufacturers and users of ITSs.

ITS America's function is to identify standards necessary for sensible implementation of ITSs. ITS America also helps identify organizations, including standards development organizations, that should be involved in formulating standards, as well as specific people who should participate in the standards development processes.

In addition to the roles of USDOT and ITS America, funding continues to play a critical role in attaining ITS goals. Today, funding for ITS applications comes from an assortment of federal and state government sources. The Congestion Mitigation & Air Quality Improvement Program and the Surface Transportation Program are the two primary resources for ITS funding. Federal support also comes from the National Highway System Program. Over the next decade, increased funding for ITS programs will be required to develop and deploy new systems, maintain operations of existing and new systems, and to hire and train the personnel required to manage these systems. The Highway Trust Fund is also viewed as a traditional resource that local, state, and the federal governments use for funding transportation projects.

3. INTELLIGENT TRANSPORTATION SYSTEMS PROGRAMS AND INITIATIVES

There are several ITS activities currently ongoing in a variety of different programs ranging from public safety, to transportation security, to intermodal freight. These activities are indirectly responsible for the growth of ITS industry, as each task adds value to the overall ITS program.

3.1 Overview of Intelligent Transportation Systems Initiatives

Because this report focuses on the public safety aspects of ITSs, the scope will be limited to those efforts. However, it should be noted that in addition to the ITS Public Safety Program, there are a variety of other ITS initiatives including—

- Transportation security
- Intelligent Vehicle Initiative
- Metropolitan and Rural ITSs
- Commercial Vehicle Information Systems and Networks
- Intermodal Freight
- National ITS Architecture.

Table 2 summarizes some of the ongoing tasks related to the Public Safety Program and the other programs listed above. Section 3.2 discusses the Public Safety Program in more detail.

Table 2
ITS Program Activities

Program Activity	Ongoing Tasks
ITS Public Safety Program	• Wireless Enhanced 911 (E911) summit and action plan • Wireless E911 deployment readiness • Wireless E911 technology innovation roundtable • Mayday/E911 Field Operation Test (FOT) • Integrated incident management FOT • Computer-aided dispatch (CAD)/ITS field FOT
Transportation Security	• New technology to secure cargo at U.S. ports • Request for Applications security model deployment • FY 03 ITS deployment program on security • Security workshops

Program Activity	Ongoing Tasks
	• Potential operational tests
Intelligent Vehicle Initiative	• Mack partnership generation zero FOT[4] • Pre-solicitation notice for Electronically Controlled Braking Systems (ECBS)[5] FOT • Drowsy driver warning system FOT • Minnesota snowplow project FOT • Naturalistic driving study
Metropolitan and Rural ITSs	• 511[6] travel information model deployment • State participation in 511 • Archive of user data service operational test solicitation • Variable Speed Limit (VSL)[7] FOT • Architecture conformity guidance document • Rural ITS strategic planning best practices document • Rural ITS toolbox document
Commercial Vehicle Information Systems and Network	• Commercial Vehicle Information Systems and Networks (CVISN)[8] Level 1 developments
Intermodal Freight	• Asset and cargo visibility test • Terminal dray[9] feasibility study
National ITS Architecture	• ITS deployment support • Turbo architecture • National ITS architecture evolution • National ITS architecture training

For more information about ITS programs and initiatives throughout the country, visit the ITS Web site at http://www.its.dot.gov/.

3.2 ITS Public Safety Program

USDOT initiated the ITS Public Safety Program in calendar year 2000 to increase transportation safety and mobility through new and dynamic partnerships linking the transportation and public safety communities at local, state, and federal levels.

[4] Mack Partnership Intelligent Vehicle Initiative (IVI) Generation Zero FOT refers to the partnership of Mack Trucks and McKenzie Tank Lines with USDOT to evaluate the benefits of three IVI systems.
[5] ECBS benefits the trucking industry by dealing with the replacement of current brake application signals. This emerging technology will aid in the success of electronically controlled engines and transmissions. For further information, refer to the ITS Web site.
[6] On July 21, 2000, the Federal Communications Commission (FCC) assigned the 511 abbreviated dialing code on a national basis for the provision of transportation information. Further, the FCC ruling leaves it to state and local transportation agencies, telecommunications carriers, and regulators to determine the appropriate courses of action to make these services available. The USDOT ITS Joint Program Office is sponsoring an effort to document the progress of early implementers of 511 services for the benefit of the entire transportation community.
[7] VSL systems are sensory applications that help determine appropriate speeds for travelers, given current road and traffic conditions. The systems are used to reduce driver error and speeds, as well as to enhance roadway safety.
[8] CVISN Level 1 Developments deal with the electronic exchange of safety and credentialing information and electronic processing of interstate registration and fuel tax credentials, in addition to implementing roadside electronic screening at a fixed or mobile site.
[9] The terminal dray operations test will potentially improve cross-town movements of freight in Chicago, Illinois.

Through this program, USDOT is working with stakeholders in the public safety community—including law enforcement, fire and rescue, and emergency medical service (EMS) providers—to develop and demonstrate innovative procedures and technologies to bring enhanced coordination to public safety and transportation operations. Until recently, ITS technologies have been developed largely without input from the public safety community. These technologies may dramatically improve public safety response if transportation and public safety agencies at local, state, and federal levels work with industry to organize future product development and deployment. The mission of the ITS Public Safety Program is to provide this coordination of future development and deployment. In addition, the program is closely coordinated with the Federal Emergency Management Agency (FEMA) and with the Office of Justice Programs of the U.S. Department of Justice. An example of an ITS Public Safety Program activity is the program's involvement in numerous initiatives to implement advanced technologies in the surface transportation arena. In general, the program helps transportation and public safety professionals improve interagency coordination and operations by building more effective partnerships and technology.

The ITS Public Safety Program has three primary goals—

- More expedient and better informed emergency medical response through upgraded incident detection and notification, as well as updated wireless data communications links among emergency responders

- Improved incident management by integrating operations through real-time voice and data communications

- Enhanced public safety and security for dealing with natural and manmade disasters.

At a national E911 summit in April 2002, public safety officials, the telecommunications industry, and representatives from communities across the United States were urged to accelerate the development and deployment of wireless E911 services. These services incorporate location identification technologies that enable Public Safety Answering Points (PSAP) to pinpoint the location of a wireless E911 caller.

At the summit, an action plan was developed for the ITS industry that includes three primary areas of concern—national leadership and attention, PSAP deployment readiness, and technological innovation. The plan specifies a set of priority actions to accelerate the implementation of wireless E911 services. Additionally, the plan defines the wireless E911 deployment readiness project. The objective of this project is to work with public safety associations and government executives to provide technical assistance, guidance, and training to accelerate PSAP readiness for wireless E911.

The ITS Public Safety Program is also involved with several important technology assessments and FOTs. One of these tasks is the wireless E911 technology innovation roundtable, in which information technology experts are reexamining the technical approach to providing wireless location services for E911. E911 roundtable discussions are planned around

the country so experts can examine new solutions for both near- and long-term wireless E911 location technology issues.

Additional activities include three FOTs, which are demonstrating the integration of various technologies for different purposes—

- The MayDay/911 FOT demonstrates the integration of calls from in-vehicle automatic crash notification (ACN) (MayDay) systems directly to PSAPs, i.e., 911 systems using the existing cellular telephone networks.

- The Integrated Incident Management FOT demonstrates the integration of technology within vehicles, highways, and transportation management centers and PSAPs to improve the efficiency of emergency response and incident management.

- The CAD/ITS FOT demonstrates the integration of ITS technologies and CAD systems from numerous vendors in different organizations and the ability to move critical information between these systems efficiently. The outcome of this FOT will be sharing of information and the potential control of field-deployed assets or resources across organizational and jurisdictional boundaries and enhancing emergency response to scenes of accidents or other critical incidents.

4. INTELLIGENT TRANSPORTATION SYSTEMS ARCHITECTURE OVERVIEW

Advances in the information technology industry have brought about many significant advances in ITS technology over the past decade. Advancements in graphical user interfaces, database management systems and tools, wired and wireless networking technologies, and incremental increases in computer processing speeds have accounted for significant improvements to traffic management systems. However, a significant disconnect still exists in the provision of timely information on current traffic conditions to travelers, other transportation systems users, and the public safety community. Additional research is continuing regarding the use of artificial intelligence applications and predictive and adaptive modeling techniques for ITSs, but these opportunities have not become significant components of ITSs to date. The largest ITS technical advances will likely continue to center on applications and services using wireless geo-location technologies, emerging wireless network and wide-area communications capabilities, and the potential development of virtual traffic management and control centers.

The National ITS Architecture is an overall ITS framework. It defines how transportation system components interconnect and interoperate. Its primary focus is user services, but it also identifies system components and key functions and organizations involved in developing ITSs. Another focus of the national architecture is to create a model that sufficiently encompasses the goals and visions of ITSs, and aids in the development of standards to shape the projects, applications, and components to ensure interoperability between the disparate systems. Figure 1 depicts the model created to illustrate the goals and visions of the ITS initiative.

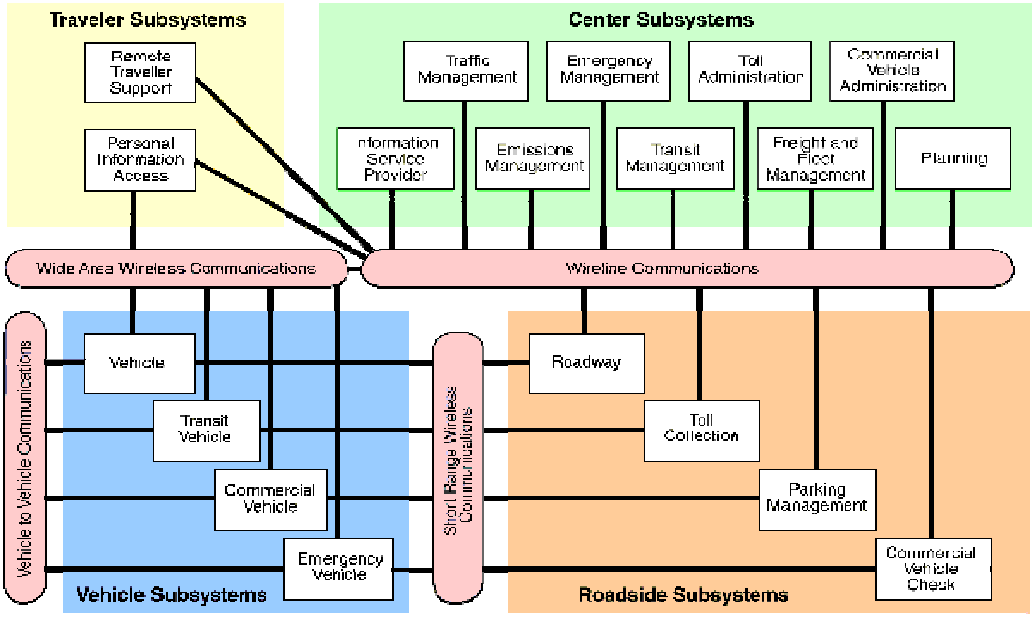

Figure 1[10]
National ITS Architecture Subsystems and Communications

[10] Source: ITS America, http://www.itsa.org/archdocs/web/keyconcepts.htm

Within the National ITS Architecture, ITS standards are identified to promote interoperability. Because ITSs depend on the ability to integrate advanced transportation technologies, standards are vital. The framework contains detailed requirements that guide the standards development process. ITS standards exist that define how the various system components operate within the consistent framework of the National ITS Architecture. These standards are agreed upon by industry and promote interoperability of ITS systems by detailing how systems and components may interconnect. The standards also encourage a competitive market and contribute to a more efficient transportation system that can interoperate so that information can be shared automatically between disparate systems. In other words, the USDOT Standards Program exists to encourage the widespread deployment of integrated ITSs through non-proprietary standards.

ITS technologies provide a more informed decision process for assignment and response of emergency first responder equipment to accident scenes or other highway incidents. These more efficient and effective decisions and response processes translate into saved lives, more expedient incident resolution, and restored transportation network efficiency. With ITSs, freight commerce and deliveries can be made more efficient. For example, trucks can be weighed while in motion and shipments can be tracked automatically, which in turn can save time and money.

The following examples of some existing and emerging technologies incorporated into ITSs illustrate the scope and complexity of ITSs—

- **Frequency modulation (FM) subcarrier broadcasting—**A system based on this technology will allow a commercial FM broadcast station's subcarrier to transmit traffic and other data at rates higher than previously achieved. The data rate for this system will be high enough to support broadcast of individual link travel times for transportation routing applications.

- **Global Positioning System (GPS)**—This is a worldwide medium Earth orbit satellite navigational system, consisting of 24 satellites orbiting the Earth and their corresponding terrestrial receivers. The satellites orbit the Earth at approximately 12,000 miles above the surface and make two complete orbits every 24hours. GPS satellites continuously transmit digital radio signals containing data on the satellites' location and the exact time to the Earth-bound receivers. The satellites are equipped with atomic clocks that are precise to within a billionth of a second. GPS has applications beyond navigation and location determination. It can be used for cartography, forestry, mineral exploration, wildlife habitation management, monitoring the movement of people and things, and bringing precise timing to the world. In ITSs, GPS is a fundamental technology that supports location identification of wireless telephones and other wireless communications devices that are communicating with various ITSs.

- **Dedicated short-range communications (DSRC)**—Various existing and emerging ITS applications require a short range, wireless communications link. Wireless transmission of information between vehicles and the roadside ITS infrastructure is the

most popular example of such applications. DSRC is used for electronic toll tags, commercial vehicle transponders that allow electronic transactions, transit and emergency vehicle traffic signal prioritization, and some portable changeable message signs applications.

- **Internet communications**—Many DOTs across the country use Internet Web sites as public access to ITS information. These sites provide real-time access to video surveillance monitors as well as the status of dynamic traffic message signs. Road closure and congestion information is also available through many DOT sites. Expansion of wireless Internet access is providing access to these sites via wireless connections to compatible wireless telephones, personal digital assistants, and other devices.

- **Highway sensory applications**—Detection and surveillance systems provide support for highway traffic management functions such as incident detection, ramp and freeway-to-freeway metering, traveler information, and congestion mitigation. Inductive loop detectors are used extensively on freeways; other sensors, such as magnetometers, video image processors, microwave radars, passive and active infrared sensors, and acoustic sensors, are included in freeway traffic management applications that require vehicle detection. These advanced sensors can provide data not available from inductive loop detectors and enhanced safety for the personnel who install and maintain them. Additional applications include sensors for measuring road surface conditions (e.g., dry, wet, ice, and chemicals), weather conditions (e.g., temperature, humidity, wind, and visibility), and environmental conditions (e.g., pollutants and chemicals), as well as for assessing maintenance functions (e.g., snow maintenance, traveler warnings and reduced speed conditions, and tunnel ventilation).

- **Video camera technology**—ITSs incorporate video camera and surveillance technologies to identify and confirm the exact location and severity of incidents to improve emergency vehicle response time and provide accurate information to other motorists. Such technology is also used to assist in dispatching DOT courtesy vehicles to render aid to disabled vehicles and to initiate response of area public safety agencies to highway incidents. Some ITS deployments incorporate video analysis techniques and video sensing technologies to enhance information derived from video applications and other sensors. This information can include traffic counts and entry and exit ramp metering.

- **Lane Control Signs**—These symbol-display devices are mounted above each traffic lane on structures such as cross-street bridges and sign structures that overpass major freeways. Freeway lane control signals are effective in warning motorists of lane closures ahead to help alleviate bottlenecks created by merging vehicles. Lane control signals may also be used over primary roadways where reverse (contra-flow) traffic is used.

- **Wireless network communications**—Wireless network communications facilities are a fundamental requirement for ITS deployment. Many of the different technology

applications incorporated in or along side the roadways require wireless network communications to facilitate the transmission and receipt of information between the ITS devices and the traffic management centers (TMC). The 802.11a wireless networking standard developed by the Institute of Electrical and Electronics Engineers (IEEE) has been recommended for adapted use for roadside-to-vehicle DSRC that will provide a high-speed wireless local area network for ITS applications ranging from alerting drivers to icy surfaces ahead to traffic signal preemption for emergency services or transit, and for broadening mobile commerce applications.

- **Wireless E911 location technology**—In response to FCC mandates, wireless carriers are finally beginning to deploy location technology that will identify, at a minimum, a cellular caller's longitude and latitude to the receiving PSAP. For ITSs, cellular E911 emergency calls coupled with location-based services show great promise for providing low-cost anonymous traffic probe information on major highways as well as freeways; however, field-testing is just beginning. The geo-location techniques being tested and deployed include systems using GPS-equipped telephones, radio triangulation from multiple cellular sites, and location pattern matching of multipath signatures. Over the next 10 years, new wireless location technologies may enhance how ITSs use traffic surveillance applications and activities. Cellular technology enjoys extensive coverage and is already established in most of the country, so right-of-way issues will be minimized. In addition, this technology is affordable. Location technology is another good example of advancements in the information technology industry that are driving ITS development. Although this technology was not specifically developed for traffic management purposes but, rather, in response to a federal mandate, traffic management and ITSs will benefit from its use.

- **Cable and broadcast television**—Existing ITS deployments rely heavily on interactions with local media outlets to disseminate traffic- and transportation-related information. Many existing ITS projects provide direct video camera feeds to area newsgathering organizations indicating real-time traffic and congestion information. The media also take advantage of interactive Internet Web sites that provide similar information in real time from the ITS. These publicly accessible Web sites provide detailed real-time traffic flow maps, video camera surveillance feeds, road closure information, and real-time representations of dynamic traffic message sign displays.

- **Wireless communications and land mobile radio**—A continuing challenge to improve transportation system management is the improvement of coordination of activities of a variety of public safety and non-public safety agencies playing key roles in transportation management incidents. In particular, it is essential to achieve integrated decision making between state and local transportation agencies (typically DOTs) and state and local public safety agencies (usually police, fire/rescue, and EMS). This challenge is exacerbated because in most areas of the country, there are multiple transportation and public safety agencies for each political jurisdiction. As a result, the problem is quite complex both technically and institutionally. Wireless communications technology is advancing to the point that it may soon be the main provider of voice, video, and data for the traffic management industry. The number of

wireless communications technology choices is growing rapidly, and many new protocols are being introduced—making interoperability decisions more important but also more difficult than ever.

Due to the technological evolution that has occurred in the commercial and military sectors over the past 10 years, many inexpensive, commercial wireless voice and data technologies have become more appealing for inclusion in ITS projects. As such, it has been possible for regional ITS efforts to develop advanced technology field demonstrations. Some of these efforts include the integration of wireless technologies into functionally specific vehicles, such as police cars or ambulances, to provide these systems initially where they appear to be most valuable. Despite the obvious benefits to the integration of wireless information systems and interoperability, many public safety and transportation agencies have yet to venture into the information-sharing world. The reasons remain consistent and can be summed up in five categories—

- Individual and organizational resistance
- Institutional barriers
- Systematic constraints
- Perceived technology barriers
- Funding limitations.

These technologies are just a few of many being integrated into ITS deployments throughout the country. Also related are the resulting service offerings provided by the deployed ITS technologies. These may include—

- **Traveler information**—Information systems deal with the acquisition, analysis, communication, presentation, and use of information to assist the surface transportation traveler in moving from origin to destination in the way that best satisfies the traveler's need for safety, efficiency, and comfort. Travel may involve a single trip, linked trips, or multiple trips. Travel information resources may be presented through a variety of outlets such as—

  - Kiosks
  - Internet Web sites
  - 511 telephone systems
  - Cable and broadcast television
  - Broadcast radio
  - Sub-carrier radio facilities
  - Wireless reverse[11] 911 system
  - Dynamic message signage.

[11] Reverse 911 was originally developed for PSAPs. This system uses GIS technology and the public switched telephone network to communicate critical information to a specifically defined target area of receivers. In the wireless arena, the system functions similarly but uses wireless location technologies to communicate information within a specified geographical area.

- **Traffic management**—These systems monitor and control the speed and flow of traffic. A traffic control center (TMC) analyzes data collected from sensors, cameras, and other devices on the roadway and broadcasts the information to travelers via message signs, three-digit traffic information numbers, and other means.

- **Transit management**—The incorporation of ITS technologies with public transit services creates Advanced Public Transportation Systems (APTS). APTSs include a vast array of technologies, from those providing dispatchers a means for visually tracking buses to technologies providing passengers an audio cue and visual display of the next bus stop and other route specific information. APTS technologies also provide transit traffic signal priority, a solution that can make public transit faster and more reliable.

- **Electronic payment and automated fare collection**—Electronic payment systems (EPS) deploy various communications and information technologies to support the automated collection of transportation-related payment. Examples include electronic toll collection, electronic transit fare payment, and electronic parking payment. Emerging EPS solutions may soon include "smart card" based payment options as well as wireless electronic payment transactions via cellular telephones.

- **Electronic toll collection**— Electronic toll collection systems deploy various communications and electronic technologies to support the automated collection of payment at toll booths and other collection points. Collectively, the application of these technologies increases system throughput, improves customer service, enhances safety, and reduces environmental impacts.

- **Courtesy Patrol–Motorist Assistance Program (MAP)**—This program provides state DOT personnel dedicated to assisting motorists along area highways. The program complements ITS technology by working in conjunction with TMC to provide coordinated traffic management. In many cases, DOT personnel assist stranded motorists with a variety of free services, including changing flat tires and providing fuel. Each MAP truck is equipped with traffic control devices, such as cones and arrow boards. These devices provide advance notice to approaching vehicles as well as a safety buffer for public safety emergency response resources. By keeping travelers informed, the MAP program improves highway safety and helps reduce congestion.

- **Commercial vehicle operation and management**—Commercial vehicle operations use technology to improve the flow of commercial vehicles, enhance safe operations, and minimize truck stops at weigh stations and ports of entry. Fewer stops reduce travel time, increase productivity, save fuel, and reduce emissions.

- **Advanced vehicle safety systems**—In-vehicle technologies such as the automated collision notification (ACN) and Mayday systems are becoming increasingly prevalent. These systems are most commonly marketed as OnStar™ (General Motors), RESCU (Ford/Lincoln), and RESPONSE (AAA). Mayday systems enable vehicle operators to

communicate directly with private call centers regarding requests for traveling directions, mechanical assistance, or notification of crashes. These systems are designed to notify the call center automatically upon deployment of a vehicle's air bag. Eventually, the "enhanced vehicle" will support improved collision avoidance systems, automatic speed control to adjust spacing between cars in traffic, communications-based safety and security features, as well as computer-controlled braking and steering.

In May 2000, USDOT and the ComCARE Alliance implemented the National Mayday Readiness Initiative to promote and develop partnerships between private call takers and PSAPs to integrate these calls seamlessly into E911 and other public safety CAD systems.

- **Telematics**—This term refers to the consumer products, services, and supporting systems that deliver information, communications, and entertainment to in-vehicle and mobile devices. Telematics demonstrates value in improved personal safety and security by allowing users to—

  - Quickly call medical help to an accident scene
  - Locate stolen vehicles
  - Receive real-time traffic navigation
  - Report impaired or aggressive drivers.

- **Incident Management System**—The incident management system is composed of distinct functions of the incident management process. The advanced incident management functions are—

  - Detection: Process by which an agency is alerted to an incident and takes responsibility for maintaining traffic flow and safe operations at that facility
  - Verification: Confirmation that an incident has occurred and determination of as many details as possible about that incident
  - Motorist Information: Circulation of incident-related information to affected motorists
  - Response: Dispatching of appropriate personnel and equipment to the incident
  - Site Management: Process of coordinating and managing on-scene resources
  - Traffic Management: Application of traffic control methods in areas affected by the incident
  - Clearance: Removal of wreckage and other elements that disrupt normal traffic flow around area of incident.

Together, ITS technologies (both hardware and software) can be connected into a meaningful network. A deployable system is possible through collaboration among stakeholders, compatibility across jurisdictions, and flexibility to address specific local or regional needs. By addressing these important aspects, ITS technology should fit the needs of the ITS architecture.

5. PUBLIC SAFETY APPLICATIONS AND INTERSECTIONS

According to a recent report from the U.S. House of Representatives Transportation and Infrastructure Committee's Highways and Transit Subcommittee, the Nation's ITS applications "were thought to be limited in helping relieve congestion and improving safety." However, after the events of September 11, 2001, these high technology systems "are finding a more broad, homeland security function."

The potential uses of ITSs complement many of the perceived homeland security requirements, including monitoring critical transportation infrastructures, assisting in evacuating cities, and communicating critical information to drivers. For example, telematics[12] providers—which deliver information to drivers in vehicles—are developing methods to send "reverse 911" informational messages to moving vehicles, alerting the occupants about emergency incidents.

In the moments following the September 11, 2001, terrorist attacks at the Pentagon and in New York City, existing ITSs assisted public safety officials in their emergency response and traffic control efforts. The traffic management center in Arlington, Virginia, used dynamic message signs to quarantine highways around the Pentagon, reverse High Occupancy Vehicle lane direction on Interstate 395, and optimize traffic signal times. These efforts helped to improve the flow of traffic away from the scene, as well as emergency responses to the scene, as people left the area. In New York City, ITSs were used similarly to reroute traffic and to notify commuters of the road closures in lower Manhattan.

The same ITS technologies in use today to manage traffic flow and mitigate congestion can be used and enhanced to make the transportation infrastructure and its users more informed and secure.

The following sections discuss several ITS deployments that champion partnerships between transportation and public safety agencies around the Nation. These deployments are incorporating and integrating ITSs and public safety information and communications technology systems to provide enhanced informational opportunities to a variety of participating agencies.

5.1 San Antonio, Texas

The Texas Department of Transportation's (TxDOT) "smart highway" project called TransGuide became operational on July 26, 1995. TransGuide is an ITS technology project designed to provide information to motorists about traffic conditions such as accidents, congestion, and construction. Using cameras, message signs, and fiber optics, TransGuide can estimate travel times and respond rapidly to accidents and emergencies. Partners in the TransGuide project include TxDOT, the City of San Antonio (police/fire/EMS/traffic), and VIA

[12] Telematics refers to an emerging industry of consumer products, services, and supporting systems that deliver information, communications, and entertainment to in-vehicle and mobile devices. Telematics provides tailored information to users consistent with where they are and what they are doing and in doing so enhances security, navigation, and convenience to mobile users.

Metropolitan Transit. The system will eventually include management of all freeways, traffic signals, transit operations, and emergency response activities in San Antonio.

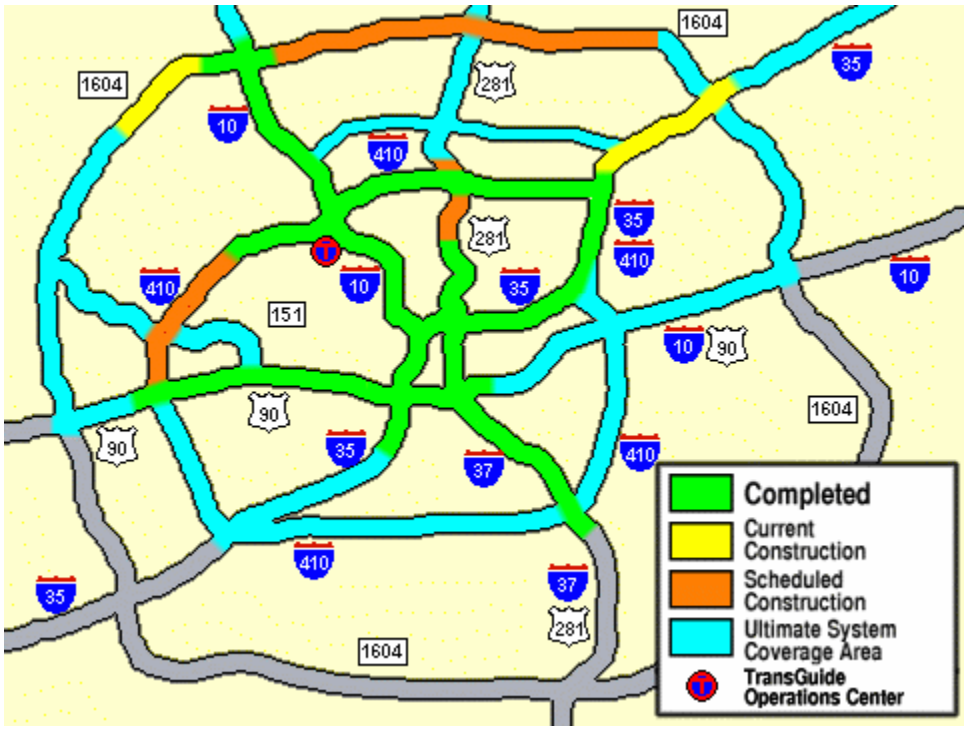

Figure 2[13]
Current TransGuide Network

TransGuide is capable of detecting highway incidents within 2 minutes of occurrence and can initiate a preplanned response within 15 seconds. The system is built on a complete digital communications network using the communication standard "SONET,"[14] a fully redundant fiber optic network, a state-of-the-art fault tolerant computer system, software developed to "POSIX"[15] standards, and field equipment consisting of dynamic message signs, lane control signals, loop detectors, and video surveillance cameras.

San Antonio TransGuide was selected by USDOT as one of four metropolitan ITS Model Deployment projects. This Model Deployment project enhanced the existing TransGuide system for TxDOT; city traffic operations; VIA transit dispatch; police traffic dispatch; and police, fire,

[13] Source: TxDOT San Antonio Division
[14] Synchronous Optical Network is a standard for connecting fiber-optic transmission systems. SONET was proposed by Bellcore in the mid-1980s and is now an ANSI standard. SONET establishes Optical Carrier levels from 51.8 megabits per second (about the same as a T-3 line) to 2.48 gigabits per second. With the implementation of SONET, communication carriers throughout the world can interconnect their existing digital carrier and fiber optic systems.
[15] POSIX, Portable Operating System Interface for UNIX, is a set of IEEE and ISO standards that define an interface between programs and operating systems.

and emergency dispatch. Presently, the City of San Antonio, with Bexar County, is installing a new 800 megahertz (MHz) voice communications system, and is upgrading its public safety communications centers. The city is also planning the acquisition of a new CAD for all emergency services.

The Model Deployment project covered nearly 200 miles of freeways and the majority of streets within the San Antonio metropolitan area. Approximately 78,000 Intelligent Vehicle Tags were distributed. These tags allow the equipped vehicles to serve as roving "traffic probes," reporting on current travel speeds throughout the metropolitan area. Real-time, multimodal (i.e., automobile and bus) traveler information was provided to the public through broadcast television on TransGuide TV54, in-vehicle route guidance systems, kiosks, and the Internet.

The TransGuide communications system also supports the LifeLink® video teleconferencing program between local hospital emergency rooms and San Antonio EMS units, providing physicians with the opportunity to see the patient, maintain constant communications, and directly monitor vital statistics at the accident scene and en route to the hospital. A video camera inside the ambulance allows emergency room (ER) and trauma center physicians to see the patient and read vital signs, allowing the rapid ability to determine the extent of injury and possible treatment options. The two-way visualization of the video enables doctors and paramedics to send and receive treatment instructions. The physician can instruct the paramedic to move the video camera over an area of the patient's body that the physician wants to examine. Newer technology promises the ability to allow the ER doctor to use a remote control device to move the EMS unit's camera and zoom in and out of an area. Figure 3 illustrates the LiveLink equipment in the EMS vehicle.

Figure 3[16]
San Antonio EMS LiveLink System

The San Antonio Fire Department's ambulances have video capability that links ruggedized portable computers, video cameras, and microphones via radio. Transmission of patient statistical data from portable medical instruments is enabled with on-board 2.4 gigahertz computer-controlled wireless spread-spectrum radios. Patient data transmits by radio frequency to 59 receiving antennas placed at hubs of the fiber optic cable lines installed along roadways for

[16] Source: TxDOT San Antonio District TransGuide.

reception at the TransGuide traffic operations center. From the operations center, high-capacity T-1 data lines carry the data to the hospital. The reverse path handles hospital-to-ambulance communications.

Since TransGuide became operational, it has helped to reduce traffic accidents by 15 percent and reduce emergency incident response times by 20 percent. Eventually, the consortium will expand the system to cover 289 miles of highways and city streets around San Antonio.

In addition to the LifeLink EMS system, TransGuide incorporates the following ITS technologies—

- A transit bus incident monitoring system (using surveillance cameras) and AVL
- In-vehicle navigation units in city, county, state, and federal vehicles
- Advance warning to motorists to avoid railway delays
- Traveler information kiosks
- Real-time traffic condition maps on the Internet
- Live traffic video, maps, congestion, and accident information sent to area newspapers and broadcast television and radio stations
- Monitoring of actual travel times and speeds through a voluntary program in which motorists place "Travel Tags" on their windshields that codify the vehicles' identities and the time when the vehicles pass highway sensors.

5.2 Austin, Texas

A new Regional Emergency Communications Center and TMC that will serve the Travis County area surrounding Austin, Texas, will provide an unprecedented degree of coordination among the region's fire and EMS, law enforcement, and transportation services. Several public safety and service agencies in the Austin–Travis County region are actively implementing the upgrade, replacement, and integration of crucial systems, facilities, and operations. These activities present a unique window of opportunity to integrate systems as changes are being made. The electronic exchange of information between systems will enhance existing public safety and service.

The original project began in 1995 when representatives from the various agencies initiated discussions regarding radio communications improvements. At that time, fire and EMS personnel shared radio communications, but the participating agencies recognized the need to extend the radio network to link to public safety, public works, and transportation agencies to deal with freeway incident management more effectively. The committee identified the shared need not only for voice communications, but for wireless data communications systems as well.

The idea of a new shared regional facility to accommodate new communications and ITS technologies was also contemplated.

In some areas of the country, integrated operations between transportation agencies and public safety agencies means the placement of public safety personnel within the TMC. These individuals telephone the public safety communications center when a highway incident occurs. The Austin–Travis County regional system will include real-time software interfaces and integration of the ITS traffic management sub-system with the new TriTech GIS-based CAD system. Officials from Travis County, the City of Austin, TxDOT, and the regional transportation authority agreed to work together to integrate the various command and control systems software and the PSAP and TMC facilities. This integration will provide county and city authorities with highway incident information to support appropriate incident management and emergency response.

The project will also integrate various communications systems including voice radio, wireless data, telephone, video, fax, and microwave technology combined with a countywide GIS mapping system. Both public safety dispatchers and transportation managers will view real-time maps showing traffic and crime incident locations and the location of emergency responders. This will result in quicker, safer emergency response and traffic incident management. The new CAD system will initially support applications that allow public safety dispatchers to share and generate CAD incidents for multiple agencies and the ability to view, control, and manipulate traffic surveillance video cameras from dispatcher workstations. Other potential opportunities will allow further CAD/ITS integration to provide real-time sensor information that can be used by the CAD to augment or modify AVL-based real-time vehicle routing suggestions. The CAD will also provide multiple workstation messaging opportunities to and from fixed and wireless devices.

The project also concentrates efforts on the integration and sharing of electronic voice, data, and video of the existing freeway corridor traffic management system, local traffic signal control system, and local emergency services management systems. The City of Austin and Travis County have established a multi-agency Incident Command System (ICS) designed to optimize use of resources. The project will also update the ICS Operations Plan to integrate law enforcement, fire, emergency response, EMS, and emergency management resources. Through the construction of a single, integrated regional facility that could potentially be shared with other public safety agencies in the Austin and Travis County region, agencies will be able to maximize the efficiency and minimize the costs of integrated emergency and transportation services delivery for the citizens of the community.

5.3 Portland, Oregon, Region

The City of Portland, the State of Oregon, and Tri-Met, the regional light rail and bus authority, are partnering in a strategic alliance to develop a reliable regional government communications infrastructure for a much lower capital investment than otherwise would have been required.

This cooperative network project provides an integrated wired and wireless communications system for transportation, public safety, health care institutions, and public

utilities (i.e., water, sewer, and power) agencies. The system is designed for optimum reliability to survive natural or manmade disasters. The City of Portland's Bureau of General Services Communications and Networking Division (ComNet) is the primary project management agency.

ComNet, already a regional communications provider, was planning to construct a high-speed, high bandwidth, voice and data wide-area network for telecommunications to service public safety related government agencies in the Portland region. However, ComNet lacked the necessary funding to cover the estimated $7 million cost.

Through coordination, partnerships, and outreach to other interested agencies, the project became a reality. The Portland Department of Transportation (PDOT) and the Oregon Department of Transportation (ODOT) were involved in deploying the Portland region's ITS. The new partnership leveraged the ITS infrastructure investment and fostered additional partnering with the State of Oregon and Tri-Met (which had also previously planned to deploy its own fiber optic infrastructures), which enabled ComNet to place fiber assets worth more than $13 million to date.

In addition to seeking a more disaster-proof communications system, project managers surmised that the time was right to invest in a robust fiber optic communications infrastructure. The region's public safety agencies were facing a growing demand for bandwidth to accommodate GIS-based applications showing police, fire, and EMS stations; 911 call locations; and water hydrant locations, to name a few. A final and important benefit is that the partners will manage and control the communications network and are positioned to offer services to other government and public safety agencies and to educational institutions as a private carrier.[17]

Tri-Met, ODOT, and the City of Portland all currently use the City of Portland's 800 MHz public safety radio and mobile data systems. The current goal of the communications infrastructure expansion is to combine voice, video, and data telecommunications infrastructure into a reliable system for all area agencies and users.

In order to formalize and expand opportunities for joint regional fiber infrastructure development, PDOT, ODOT, and Tri-Met entered into a formal memorandum of understanding called "Cooperative Improvement Agreement: Telecommunications Infrastructure." This agreement establishes a working committee for coordinating communications infrastructure of public safety and transportation, with equal representation from each of the partnering agencies and an Executive Committee (Cooperative Telecommunications Infrastructure Committee consisting of one voting member from each agency.) The Executive Committee must establish collaborative network architectures, designs, implementation plans, expansion plans, and maintenance plans to create a regional communications network infrastructure to serve all partner organizations.

The purpose of the working group is to coordinate use of network assets, such as funding, physical assets, rights-of-way, equipment, and labor, to benefit all partners whenever practical and

[17] Although the FCC often licenses government radio networks as private carriers, this status is unusual for wired carriers because commercial carriers run most wired networks.

to avoid the development of duplicative network investment. Each partner agrees to share infrastructure with the other organizations, if such sharing does not compromise the integrity of that organization's telecommunications system. The partners also agree to leverage financial assets where possible to create shared infrastructure, and to provide the other partners with access to the public rights-of-way that each agency may control.

5.4 Shenandoah Valley Initiative

The Integrated ITS Public Safety System is an emerging public–private technology partnership project in a five-county area in the Shenandoah Valley of northern Virginia. This project promises to enhance significantly the communications and coordination of EMS personnel, public safety professionals, and transportation officials responding to vehicle accidents or other incidents on the state's highways.

The initial system concept was developed from a State of Virginia plan to expand and improve overall safety along the Interstate 81 corridor in the northern part of the state. The Virginia Department of Transportation (VDOT) was looking to the healthcare industry, specifically emergency services departments, to find ways to leverage ITS solutions to improve highway safety. In conjunction with the ComCARE Alliance,[18] the initial concept was developed and expanded with input from area hospital emergency departments, local government, public safety officials, and private–industry participation.

The system concept has evolved into a scalable, open infrastructure enhanced wireless transmission system that will communicate vital crash information to emergency responders and other entities involved in the care of accident victims (e.g., hospital ERs) and the mitigation of accident disruption (e.g., law enforcement and state highway authorities). The ultimate goal of the system is to provide better information more expediently to the appropriate emergency responders. The system should improve public safety and transportation efficiency and effectiveness by providing integrated information among participating agencies.

The conceptual system design specifies data collections from a variety of information resources, such as—

- ACN
- Public safety agencies
- Wireless carriers
- 911/E911 systems.

The system will then combine, organize, and route specific information to the various emergency services providers and other entities supporting or involved in accident or incident response. It will supplement and fully integrate with existing systems (such as local CAD systems), will support an almost unlimited number of additional applications, and will provide

[18] ComCARE (Communications for Coordinated Assistance and Response to Emergencies) Alliance, is a non-profit Washington, DC-based coalition that facilitates the deployment of wireless technologies for emergency services.

information to outside applications such as traffic management and traveler alerts provided through 511, Internet, and other applications or outlets.

The system architecture incorporates an Intelligent Message Broker (IMB), which is similar to an information switching system. The system includes an Emergency Provider Access Database (EPAD), which is a set of linked directories containing contact information for area public safety agencies—police, fire, EMS, hospitals, and other emergency responders. The EPAD also contains contacts for telephone carriers, telematics providers, and specific regional contacts for events like hazardous materials (HAZMAT) spills and other disasters. The EPAD is used by the IMB to identify specifically the emergency service responders.

Calls for assistance from accident victims, reporting persons, or automated methods on the highway are received through the IMB. The IMB queries the integrated GISs and data archives and the EPAD, and then routes the incident information to various users and applications. The appropriate law enforcement, fire, EMS providers, potential transport hospitals, and other possible responding agencies are notified of the pertinent information. This dissemination is based on specific operational rules and protocols determined in advance by participating agencies. The IMB then monitors the status of the incident and "tracks" the response to the original incident, facilitating contact between various responding and affected agencies.

The GIS, which receives data from the IMB, plots the incident location on a graphical mapping application and returns that completed map to the IMB for further routing to responding agencies. The GIS correlates differing coordinate systems, such as affixing longitude and latitude information to mile markers along the highway or providing a street address for a specific longitude/latitude.

A unique feature of the system will be the ability of the IMB to receive information from other non-traditional services. ACN/Mayday notification services associated with vehicles can automatically communicate with the system when a crash has occurred, a "mayday" button is pressed, or an air bag deploys. Telematics services can provide personal medical information about the subscribing driver, e.g., a particular car that has crashed is registered to John Smith, who is an asthmatic and allergic to penicillin. Commercial vehicle operators can provide information on cargo loads, which could be HAZMAT, and truck routes. VDOT and other local or state agencies can contribute updates on road conditions or closures. Once the above information is acquired and organized, it can then be distributed by the IMB to PSAPs and forwarded to the actual responding agencies (i.e., EMS, fire, law enforcement, HAZMAT crews, etc.) identified by the EPAD. The incident information can also be routed to devices such as personal digital assistants, mobile data terminals and computers, and other communication devices used by emergency responders, providing them with up-to-the-minute alerts on patient status as they are responding. Local traffic management agencies may also be informed of accidents or other incidents, so they can close roads or reroute traffic. Also, receiving hospital facilities and trauma centers can receive advance notice regarding patients who may be enroute to their facilities.

Once responders are at the scene, they will be able to provide real-time video, using portable equipment taken to the crash site, to the receiving hospital emergency departments, allowing doctors to have some idea of patients' injuries before they are transported to a hospital.

The goal of the system is to coordinate and disseminate critical information in a matter of seconds. The majority of intermediate steps are eliminated, and all stakeholders receive the information almost instantaneously, in formats compatible with their needs, making for a faster response and reducing the potential for human error.

The benefits of such an integrated, multifaceted response are many and obvious, and will be apparent throughout the continuum of care. The system is currently under development subsequent to a preliminary trial and testing phase. A request for proposals was issued for the second phase of the system components, a contract was awarded to ComCARE members, and participating agencies hope to have parts of the system operational in late 2002. The system should be fully deployed by January 2003, when the system will be tested during a HAZMAT drill. During the first quarter of 2003, there are plans for a much larger bioterrorism trial in western Virginia and mobile data trials dealing with HAZMAT data.

5.5 Evacuation Traffic Information System

In response to the potential threat from Hurricane Lili in October 2002, USDOT deployed and used the Evacuation Traffic Information System (ETIS) for the first time to monitor usage of highway evacuation routes in Texas and Louisiana. USDOT is a key agency in the Federal Response Plan for national disasters. ETIS was developed in response to a FEMA request to USDOT for a more sophisticated technology system that would be helpful for major evacuations, especially when neighboring states are sharing major road networks. During the approach of Hurricane Lili and prior to the storm's landfall, nearly 500,000 people were advised to leave coastal and low-lying areas in southeastern Texas and along the Louisiana coastline. The majority of the evacuees used motor vehicles as the primary method of transportation away from the affected areas.

Several key factors were relevant to the deployment of ETIS. These include—

- The ETIS is designed to predict specific levels and direction of evacuation traffic accurately along major evacuation routes.

- ETIS was developed in direct response to significant traffic congestion that occurred in southeastern states in 1999 with Hurricane Floyd's near-landfall.

- ETIS operates using a sophisticated data model that combines behavioral studies, data from past evacuation occurrences, and real-time information from ongoing ITS and non-ITS incidents, including weather information, evacuation percentages, and tourist occupancy rates in affected areas.

According to Chuck Gregg, FEMA Region 6 Hurricane Program Manager, "Deploying the ETIS technology during the approach of Hurricane Lili allowed us for the first time, to gather

more evacuation information in one place than had ever been possible before. Information is power in a crisis situation, and Hurricane Lili gave us a glimpse of the future, where information will help avoid traffic jams that endanger the progress of emergency evacuations."

ETIS displays its calculated results as a series of tables and roadway-network graphics, which provide emergency managers with crucial information to help with decisions regarding highway lane usage and the provision of public safety emergency services. ETIS uses specially designed algorithms that allow display of information in easily read graphics, illustrating congestion levels, for example, by altering the color and size of map lines of highways. Extensive automated information analysis is combined with user-friendly displays, critical for emergency personnel who may use the system only once or twice a year.

The ETIS program, used in conjunction with a USDOT/FEMA-organized Evacuation Liaison Team, is specifically designed to be useful in helping state and local managers anticipate state-to-state traffic. The successful deployment and use of ETIS for Hurricane Lili illustrates the importance of coordination of this system and various supporting systems with USDOT and FEMA officials, state and federal transportation managers, and state and local emergency managers. Hurricane Lili provided an opportunity to prove the effectiveness of both the technology and the administrative networking.

6. FUTURE IMPACT OF INTELLIGENT TRANSPORTATION SYSTEMS

Currently, ITSs are already deployed throughout the country, and new services and opportunities are emerging. The wide-scale development and deployment of ITS technologies exemplifies how ITS visions and goals are being accomplished.

In an unusual example, advanced technology is taking the shape of a "smart" alarm clock that will adjust alarm wake up for an individual depending on real-time traffic conditions. Researchers at Brunel University in southern England have invented the "Rise Alarm" clock that adjusts to traffic conditions retrieved through built-in Internet access via a normal telephone line. The Rise Alarm clock retrieves relevant traffic information from an Internet Web site based on data that the user has provided. The alarm clock's developers are working to provide alternative routes to work and inform individuals of traffic congestion and delay. While this device currently relies on Automobile Association's database[19], access to similar data via a DOT's ITS databases is not an unrealistic vision. Many news-gathering organizations across the Nation are already accessing the ITS information, both in textual and video forms for rebroadcast on drive-time television and radio programs.

The continuing expansion of wireless Internet capabilities is also promoting the real-time dissemination of traffic management information to the public. ATSONIC, LLC a mobile solutions provider located in Schaumburg, Illinois, has introduced sweetTRAFFIC® a wireless solution for live video traffic updates on wireless telephones and personal digital assistants. The sweetTRAFFIC offering provides real-time traffic information to drivers by supplying a complete set of features, including itinerary monitoring, planning, and management. For more information regarding this application see ATSONIC's Web site at:

http://www.atsonic.com/sweettraffic_java.asp.

Despite the progress that ITSs have made in the past decade, the full potential of ITSs have not been recognized. The advantages of using ITSs are exemplified through their benefits and impacts in the surface transportation arena. Over the next 10 years, ITS research, development, and deployment will be influential in reshaping the ways to build, manage, and use transportation systems and to keep them secure. ITSs have the potential of becoming major economic forces in the United States and around the world, reforming the ways that we currently use, share, and manage transportation and public safety information.

The continued investment, development, and deployment of ITSs by both the public and private sectors will enable a greater understanding of the potential of the initiative. The ways in which ITS technologies will be developed and used will be directed by near-term public and private sector decision making and resource allocation. Public and private institutions can also

[19] The Automobile Association UK is one of United Kingdom's roadside assistance providers, similar to American Automobile Association in the United States.

help to evolve and transform similar approaches to meet upcoming transportation challenges of the next decade.

Public safety and other officials at all levels of government should continually assess opportunities to foster coordination and partnerships with local, regional, state, and federal transportation entities. As demonstrated, these partnership efforts can lead to the planning, deployment, and acquisition of enhanced technologies for each participating agency. Public safety and transportation agencies that are contemplating replacements or enhancements to existing communications or information technology systems should coordinate with and include each other and should exercise diligence in leveraging each other's resources, facilities, and assets to generate greater economies of scale and to enhance effective service delivery.

Appendix A—Acronyms

APPENDIX A—ACRONYMS

ACN	Automatic Crash Notification
APTS	Advanced Public Transportation System
AVL	Automatic Vehicle Location
CAD	Computer Aided Dispatch
CapWIN	Capital Wireless Information Network
ComNet	Communications and Networking Division
CVISN	Commercial Vehicle Information Systems and Networks
DOT	Department of Transportation (state)
DSRC	Dedicated Short-Range Communications
E911	Enhanced 911
ECBS	Electronically Controlled Braking Systems
EMS	Emergency Medical Services
EPAD	Emergency Provider Access Database
EPS	Electronic Payment System
ER	Emergency Room
ETIS	Evacuation Traffic Information System
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Agency
FM	Frequency Modulation
FOT	Field Operations Test
GIS	Geographic Information System
GPS	Geographic Positioning System
HAZMAT	Hazardous Materials
ICS	Incident Command System
IEEE	Institute of Electrical and Electronics Engineers
IMB	Intelligent Message Broker
ITS	Intelligent Transportation System
MAP	Motorist Assistance Program
MHz	Megahertz
ODOT	Oregon Department of Transportation
PDOT	Portland Department of Transportation
POSIX	Portable Operating System Interface
PSAP	Public Safety Answering Point
SONET	Synchronous Optical Network
TEA-21	Transportation Equity Act for the 21st Century
TMC	Transportation Management Center
TxDOT	Texas Department of Transportation
USDOT	U.S. Department of Transportation
VDOT	Virginia Department of Transportation
VSL	Variable Speed Limit