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INTELLIGENT TRANSPORTATION SYSTEMS (ITS) OPPORTUNITIES FOR OKLAHOMA

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16 . ABSTRACT

The U.S. Department of Transportation, through the Transportation Equity Act for the 21st Century (TEA-21), and its predecessor, the Intermodal Surface Transportation Efficiency Act (ISTEA), have encouraged research, deployment, and integration of ITS technologies that have led to the implementation of faster, smoother, and cost-effective strategies. Some states have taken advantage of these acts and successfully developed and implemented statewide strategic plans.

This study looked at the potential for applying the Intelligent Transportation Systems (ITS) in Oklahoma using advanced sensor, computer, electronics, and communications technologies and management strategies. The study aimed at identifying and summarizing ITS programs, activities, and opportunities at national, regional, state, and local levels of government; identifying existing resources and ITS related goals in Oklahoma; and providing a strategy, identifying resources, constraints, potential barriers, and recommendations for addressing potential barriers in Oklahoma.

A survey was conducted in Oklahoma among potential stakeholders for the implementation of ITS. These stakeholders represented Federal/State transportation, public safety/emergency, cities/municipalities, private/academia, and public non-emergency/non-transportation entities. ITS technologies exist in Oklahoma that have been individually deployed, especially in the two biggest metropolitan areas: Oklahoma City and Tulsa. Oklahoma is one of the leaders in electronic toll payments through the PikePass. Most ITS technologies are used in emergency and traffic systems. Knowledge on the potential benefits of ITS is limited.

A need exists to educate senior level managers, policymakers, decision makers, and the general public about the benefits of ITS. A statewide strategic plan is needed consisting of key stakeholders who could assist in developing the Oklahoma ITS Architecture and help in deploying and integrating ITS technologies. A Transportation Center to do research, analyze, and disseminate ITS information, as well as a management center are urgently needed. Regional cooperation among the bordering states would enhance commercial vehicle operations.

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Should any mistake be found in this document, we are responsible for it. It should not be attributed to our interviewees.

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ABBREVIATIONS

ACN	Automated Collision Notification
AVCSS	Advanced Vehicle Control and Safety Systems
AMS	Arterial Management Systems
APTS	Advanced Public Transportation Systems
ATIS	Advanced Traveler Information System
ATMS	Advanced Transportation Management System
AVI	Automatic Vehicle Identification
AVL	Automated Vehicle Location
CA	Credentials Administration
CAD	Computer Aided Dispatch
CASPER	Computer Aided System for Planning Efficient Routes
CAW	Collision Avoidance and Warning
CCTV	Closed-Circuit Television
CO	Carrier Operations
CTSCS	Central Traffic Signal Control Systems
CV	Commercial Vehicles
CVISN	Commercial Vehicle Information Systems and Networks Program
CVO	Commercial Vehicle Operations
DSRC	Dedicated Short Range Communications
EFP	Electronic Fare Payment
ERM	Emergency Response Management
ELS	Electronic Screening
ES	Emergency Services
ESUV	Emergency and Special Use Vehicles
ETC	Electronic Toll Collection
ETTM	Electronic Toll and Traffic Management
FHWA	Federal Highway Administration
FMS	Freeway Management Systems
FOM	Fleet Operation and Maintenance
GPS	Global Positioning Systems
HAR	Highway Advisory Radio
HRI	Highway Rail Intersection
IMP	Incident Management Programs
IOM	Infrastructure Operation and Maintenance
IRP	International Fuel Tax Agreement
IS	Integrated Services
ISTEA	The Intermodal Surface Transportation Act of 1991
ITS	Intelligent Transportation Systems
IVS	In-vehicle Signing
NHTSA	National Highway Traffic Safety Administration
ODA	Other Driver Assistance
ODOT	Oklahoma Department of Transportation
OS/OW	Oversize/overweight
PTMS	Public Travel and Mobility Services

PTS	Public Transportation Systems
PV	Personal Vehicles
RESCU	Remote Emergency Satellite Cellular Unit
RMTIS	Regional Multimodal Traveler Information Systems
SA	Safety Assurance
SDAS	Surveillance and Delay Advisory System
TEA-21	The Transportation Equity Act for the 21st Century of 1998
TIMS	Traffic and Incident Management System
TMDD	Advanced Traffic Management Systems Data Dictionary
TMS	Transit Management Systems
TSS	Traveler Safety and Security
TTI	Tourism and Travel Information
TV	Transit Vehicles
USDOT	United States Department of Transportation
VMS	Variable Message Signs
WIM	Weigh-in-motion

EXECUTIVE SUMMARY

Intelligent Transportation Systems (ITS) is the application of advanced sensor, computer, electronics, and communications technologies and management strategies—in an integrated manner—to increase the safety and efficiency of the surface transportation system. The purpose of this project was to understand the extent of the availability and use of ITS technology in Oklahoma. The objectives of the study were to:

(1) Identify and summarize ITS programs, activities, and opportunities at national, regional, state, and local levels of government.
(2) Identify existing resources and ITS related goals by interviewing Oklahoma agencies, organizations, municipalities, legislatures, and universities.
(3) Develop potential ITS goals each with a detailed strategy, identifying resources, constraints, potential barriers, and recommendations for addressing potential barriers.

A survey of literature and interviews among stakeholders who were deemed to have potential for utilizing or developing capacity for ITS technologies were conducted. Stakeholders included public transportation organizations, including the Oklahoma Department of Transportation (ODOT), Federal Highway Administration, Oklahoma Transportation Authority, Oklahoma Transit; public safety and emergency agencies including Emergency Medical Service Authority (EMSA), police, fire, and Sheriff's departments; municipalities including city manager/mayor, traffic manager, and city engineer offices; private consultants and companies including motor carriers and the University of Oklahoma; and public non-emergency and non-transportation agencies including the Oklahoma Tax Commission, Oklahoma Department of Tourism and Recreation, Oklahoma Department of Commerce, and Oklahoma Corporation Commission. Representatives from these organizations were interviewed concerning ITS technologies they use or provide, or are likely to use or provide. They were also asked to identify what they considered to be constraints in implementing ITS in Oklahoma.

The research instrument consisted of a questionnaire that solicited information on the type of agency, ITS technologies (used and potential), ITS goals for respective agencies, and interest in being part of a statewide strategic planning initiative. The sampling frame consisted of all cities (70) with approximately 5,000 population in 1998. Of these cities 50 were randomly selected for study, but only 19 cities (Ada, Altus, Ardmore, Bixby, Chickasha, Choctaw, Enid, Harrah, Lawton, Miami, Moore, Norman, Oklahoma City, Pauls Valley, Ponca City, Purcell, The Village, Tulsa, and Woodward) participated in the actual survey.

Three methods were used to collect information. Eighty-five questionnaires were mailed to stakeholders. Forty questionnaires were returned. Two were eliminated because they were incomplete. Twenty-five questionnaires were completed using telephone interviews. Another 24 questionnaires were completed using face-to-face interviews.

The responses were divided into size of city, either as small or big. Any city other than Oklahoma City and Tulsa was considered small. The data were also divided into north or south. Any city north of Oklahoma City was considered north, otherwise it was called south. Data were further analyzed according to type of organization the respondent represented.

Responses from 87 respondents were used in the survey. The respondents were classified as follows: Federal/State Transportation (18 or 20.7%), Public Safety/Emergency (15 or 17.2%), Municipalities/Cities (30 or 34.5%), Private (15 or 17.2%), Public (non-emergency/non-transportation) (9 or 10.3%).

ITS technologies exist in Oklahoma and are being individually deployed by specific organizations. Those technologies have been implemented with the primary goal of increasing safety, mobility, efficiency, and security. As was expected, rural areas have not benefited much from the deployment of ITS technology. Most of the ITS technologies consist of wireless communication systems used in emergencies, computer-aided dispatching systems, signal systems on arterials, loop detectors, equipment on emergency vehicles that hold through-street lights green, variable message signs, and closed circuit television and loop detectors. Safety and emergency seem to be the main use. Oklahoma is a recognized leader in turnpike electronic payment and collection systems.

Although most respondents indicated they were familiar or somewhat familiar with the term ITS, answers indicated that a very limited amount of ITS knowledge and deployment is being undertaken by respective organizations. Most respondents indicated they would like to utilize or provide the following ITS technologies: automated vehicle location devices, computer-aided dispatching systems, equipment on emergency vehicles that hold through-street lights green, wireless communication systems used in emergencies, variable message signs, closed circuit television and loop detectors, and loop detectors.

Most respondents were interested in the following technologies: emergency response management, incident management, emergency services, and utilization of fiber optics for telecommunication infrastructure.

The major obstacles to implementing ITS in Oklahoma were identified as: (1) lack of knowledge and benefits of ITS by policymakers, decision makers, and general public (39.6%); (2) lack of funding (35.6%); (3) general lack of resources (11.9%); (4) lack of cooperation among agencies (5.9%); and, (5) lack of interest in ITS versus road construction (6.9%).

Without a strategic plan, no serious ITS work would be conducted in Oklahoma. A Working Group, composed of representatives from key stakeholders in the State, should be established immediately to begin the process of developing and implementing a Statewide ITS strategic plan. The strategic plan must include a shared vision, mission, goals/objectives, and actions. It should clearly identify stakeholders and their roles. Steps should be taken to make certain that successful partnerships exist between public and private interests. Resources should be allocated for this process.

All stakeholders need to integrate ITS into their business plans and existing ITS programs into their operating systems. ODOT and other stakeholders need to consider allocating a portion of their annual budgets to ITS deployment and integration. An Oklahoma ITS architecture needs to be developed that would form the basis for integrating individual components to communicate together and work with other components of the transportation system. ITS standards that would allow for system integration and interoperability need to be adopted.

Given that ITS projects are being implemented by individual organizations, they should be carefully scheduled, critical elements should be implemented first, linking related projects together, and analyzing new projects against existing and proposed projects. Future projects should be fitted into the Statewide ITS Architecture.

An urgent need exists to educate ODOT management, stakeholders, and general public about ITS and its benefits. Since the Governor and his commission will play a critical role in deployment and integration of ITS in Oklahoma, they should be educated on the benefits of ITS. Legislators (policymakers) and decision makers (management) should be equally educated. Private meetings with the Governor and legislators should be held. ITS Awareness Seminars should be conducted for personnel in ODOT, city and county public works, transit, public safety and law enforcement, and business interests. The personnel from the National Weather Service should be included. The general public needs separate meetings in order to make their participation meaningful. Short video presentations should be integrated into the meetings. ITS education should be an ongoing process for all stakeholders. Where necessary, the media should be involved in publicizing successful projects.

ITS projects and funding sources should be identified. ODOT should set aside funds for ITS and should leverage Federal and State funds. Private and local government funds should be used to leverage Federal funds. Ways the FHWA could earmark funds for Oklahoma ITS work should be identified. Funds could also be obtained through the Congestion Mitigation and Air Quality Improvement Program (CMAQ), by linking transportation plans to improved air quality.

At the present time, no one place exists in Oklahoma where questions on ITS could be answered. ITS expertise and capacity should be developed in Oklahoma. A need exists to establish a Transportation Center through which ITS training, projects, and related issues could be researched, analyzed, and disseminated.

Oklahoma is an important state in interstate trade. Interstate-35 and Interstate-40 divide the state in almost four equal parts. Particular interest should be interstate freight of goods and services. Commercial vehicle operations could benefit from working with neighboring states to implement such services as electronic screening, weigh-in motion, safety assurance, credentials administration, and carrier operations.

INTRODUCTION

Statement of Problem

The U.S. transportation system has been increasingly facing, and will continue to face, enormous challenges relating to the smooth, safe, and rapid movement of people and goods. Traffic on highways, arterials, and local roads has increased. In the most recent past, many changes in travel patterns have occurred. Whereas the number of vehicle miles traveled between 1980 and 1995 increased from 1.53 trillion to 2.42 trillion miles (or by 58 percent), the capacity of the public road system only increased from 3.86 million to 3.91 million miles (or 1 percent) per year. At the same time, congestion increased from 7.3 to 14.2 million daily person-hours between 1982 and 1993 in 50 of the nation's urban areas (USDOT 1997). Annually, congestion alone costs the United States about $40 billion while traffic crashes create a $150 billion burden and result in a loss of 40,000 lives (USDOT Joint Program Office 1997, 1). Travel times increased outside of the central cities and between suburbs of metropolitan areas (Siwek and Associates 1999).

These changes stretch the ability of the transportation system to provide mobility, accessibility, and safety of consumers and business. Expanding the size of the transportation system is difficult because of financial, environmental, safety, policy, and political concerns. In metropolitan areas with air quality problems, expanding highways or roads would not solve the problems associated with environmental quality. Thus, mobility and accessibility needs (desire for people to work, conduct personal business, and enjoy recreational opportunities as well as for businesses to deliver goods and services fast and economically) must be considered in view of the social, economic, and environmental factors (Siwek and Associates 1999).

Intelligent Transportation Systems (ITS)

One of the most cost-effective and efficient ways of addressing the challenges is by implementing the Intelligent Transportation Systems (ITS) program. The ITS program was initiated by the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 which was superseded by the signing into law of the Transportation Equity Act for the 21st Century (TEA-21) on June 9, 1998 (Mitretek Systems Inc. 1999). ITS is, "The application of advanced sensor, computer, electronics, and communications technologies and management strategies – in an integrated manner – to increase the safety and efficiency of the surface transportation system" (TransCore 1998, 10). ITS encompasses technologies that collect, store, process, and distribute information relating to the movement of people and goods. ITS systems include technologies designed to manage traffic, public transportation, emergencies, traveler information, advanced vehicle control and safety, commercial vehicle operation, electronic payment, and railroad grade crossing safety. ITS strives to solve problems related to traffic accidents, traffic congestion, environmental pollution, and massive energy consumption by creating ideal traffic conditions. Advanced communications and control technologies, such as computers, electronics, and advancing sensing technologies are available and more are being developed to reduce congestion, provide driving comfort, and eliminate unnecessary vehicle idling. These technologies receive and transmit information on drivers, roads, and automobiles.

ITS attempts to enhance traffic safety, smooth traffic flow, and improve the environment. Traffic safety is enhanced when traffic accidents are reduced, accident damages are alleviated, and secondary accidents are prevented. Traffic flow is smoothed if transport efficiency is improved, facility usage is improved, and traffic demand is effectively and efficiently managed. The environment is improved when traffic congestion is reduced or eliminated because reduced traffic congestion will lead to a reduction in environmental pollution. When effectively implemented, ITS technologies offer many benefits such as more efficient use of infrastructure and energy resources as well as improved safety, mobility, accessibility, and productivity (U.S. Department of Transportation (USDOT) Joint Program Office 1998, 3).

The problem is that current ITS technologies and services are being deployed as independent projects by individual agencies leading to fragmented systems that cannot exchange information and realize ITS's full potential. To help solve this problem the National ITS Infrastructure Initiative was launched (USDOT Joint Program Office 1997). ITS infrastructure refers to the integrated electronics, communications, hardware, and software elements that can support ITS products and services. The goal of the national ITS infrastructure is to make a collection of technologies and components to communicate with each other and work together. Partnerships between ITS-related organizations, public and private corporations, and academia must be established for ITS to be successful.

OBJECTIVES OF THE STUDY

The purpose of this project was to evaluate ITS Opportunities for Oklahoma. To conduct the study, the following objectives were developed. The study was designed to:

- Identify and summarize ITS programs, activities, and opportunities at the national, regional, state, and local levels of government;
- Identify existing resources and ITS related goals by interviewing Oklahoma agencies, organizations, municipalities, legislatures, and universities; and
- Develop potential ITS goals each with a detailed strategy, identifying resources, constraints, potential barriers, and recommendations for addressing potential barriers.

METHODOLOGY

This work was conducted in two phases. Phase I consisted of the review of literature and understanding what ITS was and how ITS benefits the transportation industry as well as the environment. The report on literature was furnished in early January 2000 (Lewis, Mundende, and Sagini 2000), and a large portion of it is included in this report. Phase II consisted of conducting an actual survey on the available (utilized) and potential ITS technologies that can be adopted for Oklahoma and generating interest in the development of a Statewide ITS strategic plan. The results of the study arising from interviews are provided in this report.

A priority in Phase II was to identify key stakeholders. Key stakeholders were defined as organizations and institutions that had transportation as a major focus in their daily activities. For example, Federal and State transportation agencies, such as the Federal Highway Administration, Oklahoma Department of Transportation, and Oklahoma Transportation Authority were key stakeholders. Organizations that were involved in public safety and emergency management were also identified as key stakeholders. In addition, the study included those institutions that could play a major role in the deployment of ITS technologies but probably did not know that their role was crucial, such as the Oklahoma Department of Commerce, Oklahoma Tax Commission, and Oklahoma Department of Agriculture. Cities were key stakeholders because they have a lot to do with planning traffic, tourism, special events, and emergency management. Key stakeholders were jointly identified by ODOT, Langston University, and key stakeholders themselves.

Key stakeholders were divided into Federal/State transportation institutions, public safety/emergency institutions, municipalities/cities, private and academia, and public non-transportation and non-safety/emergency institutions. Federal/State transportation stakeholders included Federal and State agencies that dealt with transportation as their chief occupation, such as the Federal Highway Administration, Oklahoma Department of Transportation, Oklahoma Transit Authority, and Oklahoma Transportation Authority. Public safety and emergency agencies included the Emergency Medical Service Authority (EMSA), police, fire, and sheriffs' departments. Representatives from municipalities and cities included managers, mayors, traffic managers, and city engineers. Private consultants, representatives of motor carrier operations, and representatives of the University of Oklahoma formed another group. Public non-transportation and non-emergency agencies included the Oklahoma Department of Commerce, Oklahoma Tax Commission, and Oklahoma Department of Agriculture. These State agencies will have a major role to play if ITS deployment and integration will be successful.

A questionnaire was developed and used in the survey. Because some stakeholders might have been utilizing ITS technologies without knowing they were doing so, common types of ITS technologies were specifically identified. Respondents were requested to choose those technologies they were currently utilizing or providing and those they would like to use or provide. Stakeholders were also asked to list ITS-related goals (if they had any), major ITS obstacles they felt needed to be addressed in Oklahoma, as well as to indicate if they were interested in becoming part of the Statewide ITS Strategic Initiative. The questionnaire was pilot-tested at ODOT. After the pilot study, some questions were either eliminated or changed.

Seventy cities were selected based on their 1998 estimated populations. Any city that had approximately 5,000 people or over was selected for study. Of these 70 cities, 50 were selected using random numbers that were computer-generated using the Microsoft EXCEL program. These 50 cities were then further divided into three groups according to the type of survey to be conducted: mail interviews, telephone interviews, or face-to-face interviews. Eighty-five questionnaires were mailed. Forty were returned, of which two were rejected because they were incomplete.

Data were coded using Microsoft Excel and analyzed according to whether the response was from a big or small city, north or south, type of agency, or type of technology used (or provided) or likely to use (or to provide). Cities were considered small if they were not a major metropolitan areas, that is, Oklahoma City or Tulsa. Oklahoma City and Tulsa were considered big cities. Also, any city on or south of the latitude of Oklahoma City was considered to be in the south. Otherwise it was considered to be in the north. As indicated above, agencies were classified as Federal/State transportation agencies, municipalities/cities, private/academia, public safety/emergency, and public non-emergency and non-transportation. In addition, technologies were further divided into traveler information, public safety/emergency, enforcement, timesaving, and a combination of these categories.

RESULTS

NATIONAL INITIATIVES

Mission of U.S. Department of Transportation (USDOT)

The mission of USDOT is to ensure "a fast, safe, efficient, accessible and convenient transportation system that meets our vital national interests and enhances the quality of life of the American people, today and into the future" (USDOT 1999a). The strategic goals of USDOT are safety, mobility, economic growth and trade, human and natural environment, and national security. The outlines of these strategic goals are as follows:

1. Safety: Promote the public health and safety by working toward the elimination of transportation-related deaths, injuries, and property damage.
2. Mobility: Shape America's future by ensuring a transportation system that is accessible, integrated and efficient, and offers flexibility of choices.
3. Economic Growth and Trade: Advance America's economic growth and competitiveness domestically and internationally through efficient and flexible transportation.
4. Human and Natural Environment: Protect and enhance communities and the natural environment affected by transportation.

National Security:

Also, USDOT should advance the nation's vital security interests in support of national strategies, such as the National Security Strategy and National Drug Control Strategy, by ensuring that the transportation system is secure and available for defense mobility and that borders are safe from illegal intrusion (USDOT 1999a).

The initial driving force for ITS was the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, which established the national Intelligent Vehicle-Highway Systems (IVHS) Program later renamed the Intelligent Transportation System (ITS), in order to promote the use of advanced technologies in multimodal transportation. Through ITS, advanced technologies previously developed for space, defense, and related fields, were being introduced into transportation in order to operate a better and smarter transportation system. The policy challenged transportation planners and systems managers to develop solutions to transportation needs that were both efficient and economically sound. ISTEA encouraged the adoption of systems management and investments in a combination of capital, operating and management strategies to comply with the Federal Clean Air Act requirements. ISTEA promoted the implementation of ITS applications and provided special research funding to help in the implementation of ITS technologies and strategies. The development of the National ITS Architecture (a framework for deploying ITS across state, regional, and jurisdictional boundaries) and standards was facilitated by federal funding and research. ITS field operational tests were conducted to deploy and evaluate specific technology applications.

The Transportation Equity Act for the 21st Century (TEA-21)

ISTEA was replaced by the Transportation Equity Act for the 21st Century (TEA-21) on June 9, 1998. TEA-21 wrote ITS standards into the nation's transportation law. The law provided for the identification of ITS standards that were critical to ensuring national interoperability, development of other standards, specifying the status of the development of other standards, and specifying the status of the development of each standard identified by June 1, 1999 (Smallen 1999, 3). Interoperability means ITS systems are able to exchange and share information freely.

The law also directed the Secretary of Transportation to issue provisional standards for those standards that were deemed critical but for which no standards had been endorsed and published by January 1, 2001. The law specifies that ITS standards should conform to the National ITS Architecture, which ensures that ITS systems have the ability to communicate and share information within and across jurisdictional and geographic areas. The National ITS Architecture provides the framework or guidelines for the integration and standardization of ITS technologies.

TEA-21 established the Deployment Program. The Deployment Program has two components: the ITS Integration Program and the Commercial Vehicle Intelligent Transportation Infrastructure Deployment Program, commonly known as the Commercial Vehicle Information Systems and Networks (CVISN) Program. The ITS Integration Component of the ITS Deployment Program aims at accelerating the integration and interoperability of ITS across systems, jurisdictional, and modal boundaries in metropolitan, regional, statewide, and rural areas. The major goals are to "improve transportation mobility; promote safety (including safe freight movement); improve traffic flow (including the flow of intermodal freight at ports of entry); improve transit operations, reduce emissions of air pollutants; improve traveler information; promote tourism; enhance alternative transportation modes; and expand existing ITS projects" (USDOT 1999a, 2).

USDOT intends to create a critical mass of integrated ITS deployments with incentives for industry consensus, institutional integration to support information exchange, and leverage of local funding of ITS integration. Although ITS components are being deployed across the country, many are being implemented individually. The ITS Integration Component provides a mechanism to integrate components across jurisdictions and systems. Rural areas are just starting to see the deployment of ITS technologies that address their needs (USDOT 1999a). USDOT encourages participation by forming partnerships among large and small metropolitan areas, regional areas, rural areas, Statewide or multi-state regions. USDOT strongly encourages but does not require participation by the private sector.

Section 5208 of TEA-21 (Intelligent Transportation Systems Integration Program) states: "The Secretary shall conduct a comprehensive program to accelerate the integration and interoperability of intelligent transportation systems in metropolitan and rural areas" (USDOT 1999a, 3). Priority is given to integration projects that:

- Contribute to national deployment goals and objectives outlined in the National ITS Program;
- Demonstrate a strong commitment to cooperation among agencies, jurisdictions, and the private sector, as evidenced by signed memoranda of understanding that clearly define the responsibilities and relations of all parties to a partnership arrangement, including institutional relationships and financial agreements needed to support integrated deployment;
- Encourage private sector involvement and financial commitment, to the maximum extent practicable, through innovative financial arrangements, especially public-private partnerships, including arrangements that generate revenue to offset public investment costs;
- Demonstrate commitment to a comprehensive plan of fully integrated Intelligent Transportation System deployment in accordance with the national ITS architecture and standards and protocols;
- Are part of approved plans and programs developed under applicable Statewide and metropolitan transportation planning processes and applicable State air quality implementation plans, as appropriate, at the time at which Federal ITS funds are sought;

- Minimize the relative percentage and amount of Federal ITS funding to total project costs;
- Ensure continued, long-term operations and maintenance without reliance on Federal ITS funding as is indicated by documented evidence of fiscal capacity and commitment from anticipated public and/or private sources;
- Demonstrate technical capacity for effective operations and maintenance or commitment to acquiring necessary skills;
- Mitigate any adverse impacts on bicycle and pedestrian transportation and safety; or
- In the case of a rural area, meet other safety, mobility, geographic and regional diversity, or economic development criteria.

The Critical Standards

The U.S. Department of Transportation announced 17 standards on July 6, 1999 (USDOT 1999b). These standards were deemed critical to the smooth deployment and operation of ITS. One of the standards will enable vehicles to receive traveler information anywhere in the United States. The 17 critical standards are:

- **Advanced Traveler Information System (ATIS) Data Dictionary**: To enable traveler information providers, such as traffic reporters and police, with conforming products to provide travel information to mobile users, including the general public, nationally.
- **Advanced Traveler Information System (ATIS) Message Set**: To enable service providers, with conforming products, to provide travel information to mobile users nationally.
- **Advanced Traffic Management Systems (ATMS) Data Dictionary (TMDD)**: To be used by traveler information systems that provide services to mobile users nationally, such as

information about roadway conditions, and traffic management systems that collect, interpret and present traffic management information.

- **Commercial Vehicles Credentials**: To enable commercial carriers, such as large trucks and interstate buses, to communicate with and transmit required information to state transportation agencies and relevant state and national databases electronically.
- **Commercial Vehicle Safety and Credentials Information Exchange**: To enable commercial carriers to communicate with and transmit required information to state transportation agencies and relevant state and national databases electronically.
- **Commercial Vehicle Safety Reports**: To enable commercial carriers to communicate with and transmit information to state transportation agencies and relevant state and national databases electronically.
- **High Speed FM Subcarrier Waveform Standard**: To allow traveler information messages to be broadcast to travelers nationally.
- **Information Service Provider-Vehicle Location Referencing Standard**: To assure consistency in location referencing and uniform processing for mobile users nationally; used in other standards that specify location information.
- **Message Sets for Dedicated Short Range Communications (DSRC), Electronic Toll and Traffic Management (ETTM) and Commercial Vehicle Operations (CVO)**: To provide content and order of information transmitted in messages for various ITS user services, such as electronic toll, traffic management, and commercial vehicle operations.
- **On-Board Land Vehicle Mayday Reporting Interface**: To provide for the transmission of messages and information between emergency management centers and mobile users nationally.

- **Standard for Common Incident Management Message Sets for Use by Emergency Management Centers**: To allow incident management messages to be shared among different ITS systems and entities and to assure consistency of incident management messages.
- **Standard for Data Dictionaries for Intelligent Transportation Systems**: To establish the requirements for the attributes to be used by all ITS data dictionary standards to assure unambiguous information transfer.
- **Standard for Message Set Template for ITS**: To standardize the structure for messages used in all ITS standards.
- **Standard Specification on DSRC-Data Link Layer**: To allow for short-range communications between roadside equipment and vehicles nationally.
- **Standard Specification on DSRC-Physical Layer**: To allow for short-range communications between roadside equipment and vehicles nationally.
- **Standard Specification on DSRC at 5.89 GHz**: To allow for short-range communications between roadside equipment and vehicles nationally.
- **Standard for ATIS Message Sets Delivered Over Bandwidth Restricted Media**: To allow mobile users with conforming products to access traveler information services uniformly nationally.

FUNDING

The National ITS Program consists of activities (projects) that have been conducted by private companies, state and local governments, universities, and the U.S. Department of Transportation. The National ITS Program has been funded by ISTEA and TEA-21 annual appropriations. Under ISTEA, the National ITS program was essentially a research and testing program. Although research and testing continue under TEA-21, the primary focus for TEA-21 is integrating ITS components in metropolitan areas as well as deploying and integrating ITS components in rural areas (USDOT 1999a). By 1997 federal funds were provided for over 75 ITS research and development projects, 83 operational tests, 90 early deployment projects, and 11 model deployment projects which were in various stages of implementation (Rothberg 1997, Summary). The federal government has invested over $1.6 billion in the National ITS Program.

The USDOT is the major funding source and stimulus for the National ITS Program, working through the Federal Highway Administration (FHWA), the National Highway Traffic Safety Administration (NHTSA), the Federal Transit Administration (FTA), and the ITS Joint Program Office (coordinator and lead agency of the federal effort). These entities work with highway and transit communities, elected officials, academics, major corporations, and small businesses to advance ITS technologies. But USDOT tries to convince state, local, and regional governmental entities to use their own funds to deploy ITS because state and local governments already spend more funds in highway deployment projects than USDOT (Rothberg 1997).

Through the "Operation Timesaver" initiative USDOT intends to reduce travel time by 15 percent for about 50 percent of all the travelers. State and local governments have been encouraged to deploy integrated ITS technologies, such as smart traffic signal controls, ramp metering, and automated toll collection systems, in 75 of the largest metropolitan areas since

1996. USDOT provides funds to state transportation departments and Metropolitan Planning Organizations (MPO) to encourage them to invest in ITS. Through this initiative local integration strategies and agreements are fostered, private sector involvement maximized, and interoperability promoted. USDOT requires federal funds to be matched by 60 percent.

Funding for USDOT's National ITS Program is derived from (1) contract funds authorized under TEA-21 and (2) annual appropriations to the Secretary of Transportation. These funds are then leveraged with funds from the states and other sources. Rothberg (1997, CRS-15) reports that:

> "At a minimum, the department obtains cost shared funds of 20% from non-federal sources, and often about 50%, of the total costs of the various operational tests. At least a 20% total match is obtained for the activities pursued under the Automated Highway Systems Program. Model deployment activities are funded at least with a 50% non-federal contribution. Much of the applied research and early developmental work is funded with 100% federal monies, because risks are substantial and return on investment is highly uncertain."

ITS Service Plans: Service Plans "define how FHWA and FTA will support a metropolitan area and/or statewide area in enhancing transportation operations through improved near-term deployment and integration of ITS technologies and procedures" (USDOT 1999c, 1). The purpose is to facilitate ITS deployment and integrate institutional partnerships and technical resources across intermodal and interagency lines. Service planning sets ITS deployment and integration of both short-term and long-term goals with partners, defines and implements alternatives with partners to help achieve set goals, and monitors deployment and integration performance and budgets. Service Plans can fall into Multi-state/statewide plans, Metropolitan plans, or Non-targeted funds. Targeted plans get the bigger allocation. The goals for FY2000 Service Plans were to:

- Emphasize strategic investments that link proposed actions to desired outcomes, such as assisting metropolitan areas from one level of deployment or integration to the next higher level;
- Emphasize metropolitan areas, with an end-of-year-target to support and affect ITS deployment and/or integration in at least 55 metropolitan areas;
- Recognize and support the value of metropolitan transit, rural, and multi-state deployment and integration initiatives;
- Stress near-term outcomes that will yield meaningful results within one to two years;
- Include both targeted funds through a "two call" process in October and March, giving the field more flexibility in developing the Service Plans and improving chances of selection and implementation;
- Encourage Division Offices to link Service Plan goals to agency-wide goals, especially the Mobility Goal;
- Fund training only when NHI courses are an integral part of the Service Plan goal; and
- Give the field greater flexibility in the management and reallocation of unanticipated, under-used or unused funds (USDOT 1999c, 2). Funding was anticipated at $1.5 million for FY2000. Two calls are made for Service Plans on October 1st and March 1st, respectively.

Annually, between 40 to 60 percent of TEA-21 contract funds are earmarked for special projects. For example, between 1992 and 1997 of the $1.27 billion federal funds available, $473.6 million were earmarked for specific ITS projects and studies (Rothberg 1997, CRS-15).

Federal funding is authorized by Section 5001 (a)(6) of TEA-21. Emphasis in metropolitan areas is placed on integrating ITS infrastructure components for existing (deployed) projects. Deploying ITS technologies in metropolitan areas should involve non-federal sources of funds. Funding for Statewide applications or rural areas covers both integration and limited deployment of ITS infrastructure components to support integration. Eligible activities for Federal funding of ITS Integration Components include:

- System design and integration of existing ITS infrastructure components, such as traffic signal control, freeway management, incident management, transit management, electronic fare payment, highway-rail intersection control, emergency services management, traveler information services, paratransit and demand-responsive transit, and electronic toll collection;
- Creation of a regional multi-modal transportation information system that would support public sector transportation management needs;
- Creation of a data repository of real-time, multi-modal traveler information for dissemination to the traveling public, businesses and commercial vehicle operations through a variety of delivery mechanisms, and possibly as a value-added service by the private sector;
- Creation of a process to use ITS systems to automatically capture or archive operational transportation data for later use in planning, evaluation, performance monitoring, or other similar purposes;
- Deployment of system components that support integration of systems outside of metropolitan areas; and/or
- Development of a regional or Statewide ITS architecture to support integrated ITS deployment.

Work in ITS fall into two broad areas: (1) research and development, and (2) deployment of technologies. Funding follows these two areas (Table 1). These funds are provided under specific provisions briefly explained below, namely: Eligibilities, General Authorities, National ITS Program plan, National Architecture and Standards, Research and Development, ITS Integration Program, Corridor Development and Coordination, Commercial Vehicle ITS Infrastructure Deployment, Limitation on Funds, and Other considerations.

Table 1. Funding for Intelligent Transportation Systems Program (Millions of Dollars)

Program Area	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**TOTAL**
ITS Research and Development	95	95	98.2	100	105	110	603.2
ITS Deployment	101	105	113	118	120	122	679.0
Total	**196**	**200**	**211.2**	**218**	**225**	**232**	**1,282.2**

Source: U.S. Department of Transportation. 1999d. *ITS Fact Sheet.* Washington, D.C.: Federal Highway Administration; and Rothberg, Paul F. 1997. *Intelligent Transportation Systems Program: Importance, Status, and Options for Reauthorization.* Washington, DC: Congressional Research Service, CSR Report for Congress (Table 2).

Key Provisions: Provisions determine the specific areas where to spend federal funds. The key provisions are outlined below in the order they appear in the legislation (USDOT 1999d):

- **Eligibilities** (listed outside of the ITS subtitle): Eligibilities for the National Highway System (NHS) and Surface Transportation Program (STP) are clarified to allow funds to be used for infrastructure-based ITS capital improvements. Also, funding eligibilities for the Congestion Mitigation Air Quality (CMAQ) Improvement Program are clarified to include projects or programs that implement ITS strategies.
- **General Authorities:** Key provisions include Procurement Methods, Intelligent Transportation System Software, and Project Evaluation. The USDOT develops technical assistance and guidance to assist state and local agencies in evaluating and selecting

appropriate methods of procurement for ITS projects through the Procurement Methods. Through the Intelligent Transportation System Software, contracting officials are advised to use the Capability Maturity Model developed by the Software Engineering Institute or a similar recognized standard risk assessment methodology. Stressing objectivity and independence USDOT issues guidelines for the evaluation of operational tests and deployment projects through Project Evaluation.

- **National ITS Program Plan**: Working with ITS America, USDOT maintains and updates the National ITS Program Plan. The Plan includes goals, objectives and milestones for ITS research and development, identifies standards development activities, and works with state and local governments to develop plans for incorporating ITS into surface transportation.
- **National Architecture and Standards**: To promote the widespread use of ITS technology and ensuring interoperability and efficiency, USDOT develops, implements, and maintains a National Architecture and supporting standards and protocols. Critical standards have been developed and reported in this document. (See pages 11-13 of this document.) Also USDOT, through the Architecture Conformity provision, ensures that ITS projects funded from the Highway Trust Fund, conform to the national architecture, as well as the applicable (or provisional) standards and protocols. Through the Spectrum provision, USDOT and the Federal Communications Commission (FCC) are to work together to define needs.
- **Research and Development (R&D)**: USDOT gives priority areas for a comprehensive R&D program. Operational tests must permit objective evaluations, obtain cost-benefit analysis, and develop and implement standards. The federal share is not to exceed 80 percent.
- **ITS Integration Program**: USDOT is to conduct, through a competitive basis, a comprehensive plan to accelerate the integration and interoperability of ITS in metropolitan

and rural areas. The Department of Transportation encourages metropolitan areas to deploy ITS using non-federal funds. Outside the metropolitan areas, funding may be used to install ITS infrastructure elements. Not less than 10 percent of ITS integration program funds are to be used in rural areas. Federal fiscal year limitations include (1) No more than $15 million for a single metropolitan area, (2) No more than $2 million for projects in a rural area, and (3) No more than $35 million in any one State. The federal share of ITS Funds is not to exceed 50 percent while Federal Share from all sources should not exceed 80 percent.

- **Corridor Development and Coordination**: USDOT encourages multistate cooperative agreements for ITS deployment.
- **Commercial Vehicle ITS Infrastructure Deployment**: USDOT is to conduct a comprehensive program to advance technological capability and promote deployment of ITS applications to CVO. The federal share of funds is not to exceed 50 percent and federal share from all sources not to exceed 80 percent.
- **Limitations on Funds**: (1) ITS outreach activities are limited to $5 million per year. (2) ITS funds are to be used for operational tests. Deployment funds may not be used for construction of physical highway and transit infrastructure. (3) An analysis of life-cycle costs of the operations and maintenance of ITS elements must be submitted for projects costing more than $3 million.
- **Other**: (1) Hazardous Materials Monitoring Systems are funded at $1.5 million annually. (2) $500,000 of ITS R&D funds is allocated for the Urban Consortium's outreach and technology transfer activities per year, while (3) $1.3 million per year has been allocated to the Texas Transportation Institute for the Translink research program (USDOT 1999c).

ITS STRATEGIC PLANS IN OTHER STATES

Review of the literature indicated that several states have developed and/or have started to implement statewide strategic plans. This section highlights findings from four states: Arizona, Iowa, Kansas, and Minnesota. Their experiences could prove valuable as Oklahoma begins to grapple with the process of developing and implementing its strategic plan.

Arizona

In Arizona, the Arizona Department of Transportation (ADOT) spearheaded the process. One of its earliest tasks was to identify the various people, organizations, and agencies that had a vested interest in finding solutions to transportation needs along I-40. Services of a consultant were employed to obtain a list of over 450 individuals who were invited to participate in the development and implementation of the strategic plan. Fifty people responded and consequently became the core stakeholders. All the stakeholders were kept updated through newsletters.

This consulting agency worked closely with ADOT's Public Relations Office to organize public forums and workshops that helped introduce ITS goals. Bringing in "key stakeholders" was successful in the development of the I-40 strategic plan and statewide architecture. Stakeholders became the most effective recruiters. According to the September 1999 report, "Building a Framework for Statewide ITS Integration," ADOT stakeholders appreciated "the potential of ITS applications to solve their unique transportation problems" (USDOT 1999e, 7). The stakeholders defined the needs of their community, identified goals, and created a plan to achieve those goals.

Other key players in the cultivation of interest in ITS included the ADOT Transportation Research Center, the FHWA, local advocates, and proactive, non-traditional and non-transportation stakeholders. Non-traditional stakeholders were shown the mutual benefits of a

Statewide Deployment Plan. Many non-traditional stakeholders were concerned about where funding could come from and about the cost-effectiveness of ITS technologies. Information on the cost-effectiveness of ITS technologies proved beneficial to potential stakeholders. Also, allowing them to assume leadership positions validated their contributions and helped to alleviate concerns that ADOT was controlling the process.

All ADOT district engineers, maintenance engineers, maintenance supervisors, and ITS-related stakeholders in the state were included in assessment of rural ITS infrastructure needs. Unique needs of each district were individually identified. After compiling all the data, ADOT then sent a survey questionnaire to each district asking those concerned to rank ITS needs listed in the survey. From the results of this information a ten-year, $33 million ITS strategic deployment plan was developed and published in February 1997.

This initial I-40 study laid the foundation for the Strategic Plan for the Statewide Deployment of Intelligent Transportation Systems launched in 1997. The lessons learned by the Technical Advisory Committee and the I-40 consultant helped to complete the more extensive statewide process in a shorter time period. The tasks of the Arizona Strategic Plan were to: (1) identify stakeholders and develop a public information campaign, (2) assess rural Arizona's transportation needs, (3) integrate user needs, (4) develop a system architecture, and (5) formulate funding requirements for deployment.

The process of mapping user needs to user services, markets, and equipment needs was complex and difficult. Most stakeholders focused on ITS applications and deployment rather than the architecture. The National ITS Architecture was used as a basis for the ADOT architecture. Using the National Architecture saved time and resources, assured eligibility for future federal funding, and gave confidence that the links between components were adequate.

Iowa

Iowa developed its ITS Plan using a consultant. The consultant surveyed stakeholders, defined the ITS Plan Development Process, identified needs, prepared a list of intermediate-term ITS projects, and developed the ITS Plan. ITS activities were organized into four subsystems, namely: vehicle, traveler, roadside and center subsystems. These subsystems were further divided into wide-area wireless, short-range wireless, or wire-line communications facilities. A clear distinction was made between existing interface communication devices and future/planned communication devices so that the stakeholders could see what they had and what they needed. Projects were identified as current initiatives/projects (first-year projects), intermediate-term projects (2–5 years), and recommended long-term projects (6-10 years). Included among the immediate term projects were marketing, education, and statewide communication strategies.

Iowa focused on six different funding areas: plans and studies, traffic management, transit management, traveler information, commercial vehicle operations and emergency management. First 5-year plan costs were earmarked at $46,917,500 (*Iowa Statewide ITS Plan 2000*).

Kansas

To avoid duplication of their efforts, the Kansas Department of Transportation (KDOT) incorporated new ITS initiatives and technologies into the existing programs and projects. KDOT began by assessing the needs for ITS in Kansas and developed short and long-term strategies to address those needs. Because of the high ratio of fatal accidents on rural roads and highways (78% statewide), KDOT looked closely at improving safety in rural areas. They found emergency services; tourism traveler information services; public mobility services; commercial vehicle operations; fleet operations and maintenance; travel safety and security, and infrastructure operations and maintenance to be critical in the deployment and integration of ITS.

The review of existing documentation, ITS Awareness Seminars at the six KDOT district offices, interviews and meeting with KDOT personnel, and analysis of existing survey information led to the development of a strategic plan. The ITS Awareness Seminars included KDOT personnel, city and county public works officials, transit and paratransit providers, EMS/law enforcement, farming, and other business interests. From the gathered information Kansas defined goals and a vision for a statewide ITS system, focusing on rural applications. KDOT entered all projects into an Access database and tracked the status of all Kansas ITS projects. Using the National ITS Architecture, Kansas developed its state architecture.

Many benefits were identified for forming multi-state alliances for the deployment and operation of ITS. Commercial vehicle operations required interstate cooperation, especially in regards to using compatible systems. Other areas that needed cooperation from other states included traveler information regarding road and weather conditions, a shared Traffic Operations Center between Kansas and Missouri, and ITS Heartland, a cooperative agreement between Kansas, Missouri, Iowa and Nebraska. This agreement increased inter-regional coordination between the states on ITS related projects and research, pooled fund studies, shared ITS data, and interoperability between systems.

Kansas also grouped like projects together into program areas for analyzing and developing recommendations. These were further divided into five program areas: priority corridors, CVO, maintenance, traffic operations and rural safety and mobility. The statewide architecture ties each of these program areas together and provides a framework for ensuring an interoperable statewide ITS system.

As with new programs, ITS deployment and integration in Kansas had its share of institutional barriers. Because ITS was a new concept, stakeholders did not easily buy in into using the systems. Although state ITS standards were developed using the National ITS Architecture, many standards elements have yet to be defined. Also designers need to be encouraged to include ITS as a part of their plans. Thus, there was still a need for projects and bureaus to help identify potential ITS elements in projects, create informal working groups for interagency coordination, and to communicate with other states to solicit ITS standards and detail sheets (Transystems Corporation 2000).

Minnesota

ITS deployment and integration in Minnesota began in the early 1990s. The ITS program was initiated in the Twin Cities area with several operational tests that evaluated ITS concepts and technologies. In an effort to move toward a statewide deployment plan, a Rural ITS Scoping Study, the Minnesota Guidestar was conducted. The study was completed in 1994 to identify and prioritize the needs of travelers in Greater Minnesota.

In 1995, the Polaris Statewide Architecture Project confirmed and expanded the Rural Scoping Study. The Polaris Statewide Architecture Project became the basis for a statewide ITS architecture. In addition, the Minnesota Guidestar developed a statewide business plan for Commercial Vehicle Operations (CVO), and in 1996-97, developed a strategic plan that led to 14 separate projects. In 1998, a Statewide Advanced Traveler Information Plan was prepared, that was soon followed in 1999, with the Intelligent Vehicle Initiative (IVI) project.

The Minnesota Guidestar was founded as a partnership of the public, private, and academic sectors. Structurally, the Minnesota Guidestar included officers and senior managers from public and private sector organizations, representatives from academia, and the general public. Partners included private corporations, universities, the Department of Public Safety/Minnesota State Patrol, the Department of Public Commerce, cities, counties, councils of government, metropolitan planning organizations, transit agencies, local emergency response units, and the Department of Transportation.

Minnesota has a new strategic plan, ITS Strategic Plan 2000. Like all the other states previously mentioned, it has a mission, vision, and goals which are the driving and directing force behind the statewide program. The Strategic Plan 2000 is a result of information gathered from the 1997 Minnesota Guidestar Strategic Plan, Minnesota Guidestar initiatives and program activities, the 1999 retreat, continuing input from the Executive Committee and the key stakeholders, and an analysis of existing transpiration processes and systems.

Minnesota Guidestar recognizes that if ITS is to be mainstreamed and accepted, its benefits need to be promoted, especially to three groups: (1) the general public, (2) agencies and institutions, and (3) policymakers and legislators. Key individuals in these respective groups needed to be identified and provided with outreach programs to educate them about ITS benefits needed. The Strategic Plan 2000 felt that the best way to present ITS was to: (1) identify current problems, (2) demonstrate how specific ITS programs can improve those problems, and (3) quantify the direct and indirect benefits of ITS.

Also needed were communications of the purpose and benefits of ITS to opinion leaders, elected officials, policymakers, transportation and planning professionals and managers, other governmental agencies, and the traveling public. In addition, a person or lead stakeholder to take the lead in outreach efforts to present the message at conferences, workshops, and a variety of public forums, had to be clearly identified. To ensure the continuance of successful public/private-sector partnerships, a better understanding of shared risks was needed by all partners. Minnesota regarded the principle of migration as very important in its strategy for deployment. Migration would occur by: (1) migration of ITS concepts from research to field testing to deployment, (2) geographic migration from a few sites, roadways, communities, and regions to statewide, (3) migration toward integration and inter-operability between systems and the development of statewide ITS networks, and (4) migration from a few organizations to multiple local partners within an integrated planning contest.

Furthermore, the Strategic Plan 2000 Plan recommends that to be successful, clear linkages needed to be established between deployment programs and any research or testing initiatives (Minnesota Guidestar 2000).

BENEFITS OF ITS

Modern technology is revolutionizing the way people conduct their businesses. Advanced information technology provides elected officials and policymakers a wealth of information that would be used to enhance the economic viability of their communities as well as to improve the safety and quality of life of their citizens. The impacts of communications and electronics have already been seen in the way people travel, how they spend their leisure time, how they run their businesses, and how they educate their young and old (ITS America 1999, 4). Similarly, information technology is changing how transportation services are provided in metropolitan areas, in cities and towns, and in rural areas as computers, electronics, communications, and safety systems are applied to the transportation infrastructure of highways, streets, bridges, cars, buses, trucks, and trains.

In their annual report on the Urban Mobility Study, Schrank and Lomax (1999) found that congestion, measured by the amount of time drivers spend stuck in traffic, has increased by at least 350 percent over the past 16 years (1982-1997) in half of the 68 cities they studied. The effects of congestion are reflected in increased travel time, lost productivity of people and freight-moving vehicles, and increased fuel consumption in the stop-and-go traffic. Congestion leads to other problems such as components not arriving on time indicating that services cannot be provided on time or affecting the businesses to keep inventories they would like to avoid. On average, it took over 29 percent longer to make a peak trip and drivers spent the equivalent of more than a week stuck in traffic in 24 of the urban areas and more than one-half of a work week in traffic in 51 of the urban areas. Oklahoma City's annual delay per eligible driver increased by 800 percent from 1982 to 1997 and by 80 percent from 1992 to 1997 (Schrank and Lomax 1999, Tables 3 and 4). On average a peak trip takes 9 percent longer to accomplish than a trip in free-flow conditions. Also the city has about 18 hours per year of delay.

It was because of problems such as congestion that the ITS concept was born. A number of technologies, including communications, control, information processing, and electronics exist and many more are still being considered as was evidenced at the just concluded 6th ITS World Congress in Toronto, Canada, November 8 - 12, 1999. Systems, products, and services at various levels of complexity exist that serve communities, and many are at various levels of development. Furthermore, technologies and systems are being deployed throughout the nation that are revolutionizing the transportation industry. Overall, ITS systems products, and services promise to use the state-of-the-art technologies to move people and goods fast, smoothly, safely, and efficiently.

The taxonomy used in this report is divided into two components, following Mitretek Systems Inc.'s (1999) classification: Intelligent Infrastructure and Intelligent Vehicles. These component areas are divided into program areas and further into specific application areas. Intelligent infrastructure has three program areas: metropolitan infrastructure, rural infrastructure, and ITS commercial vehicle operations (ITS/CVO) infrastructure (Figure 1). Specific metropolitan ITS areas of application are: arterial management systems (AMS), freeway management systems (FMS), transit management systems (TMS), emergency response management (ERM), electronic toll collection (ETC), electronic fare payment (EFP), highway rail intersection (HRI), regional multimodal traveler information (RMTI), and integrated systems.

Specific rural ITS applications include traveler safety and security (TSS), emergency services (ES), tourism and travel information (TTI), public travel and mobility services (PTMS),

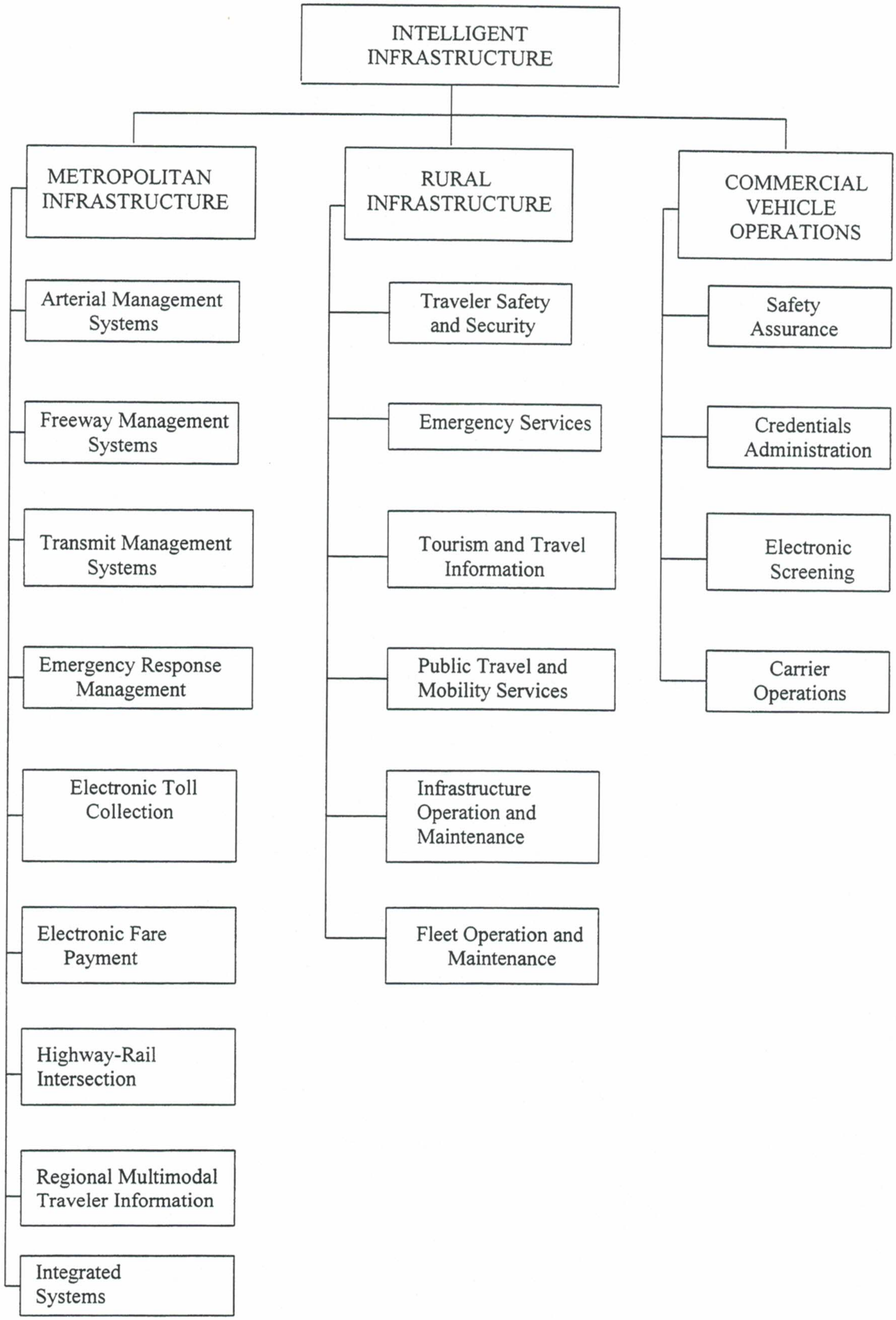

Figure 1. Intelligent Infrastructure

infrastructure operation and maintenance (IOM), and fleet operation and maintenance (FOM). ITS/CVO application areas are for safety assurance (SA) credentials administration (CA), electronic screening (ELS), and carrier operations (CO). Intelligent vehicles applications are based on two platforms, all platforms and platform specific. All platforms include collision avoidance and warning (CAW) and other driver assistance (ODA) systems. Platform specific areas include personal vehicles (PV), commercial vehicles (CV), transit vehicles (TV), and emergency and special use vehicles (ESUV). Platform specific vehicles need to be fitted with special (or specific) technologies.

INTELLIGENT INFRASTRUCTURE

(a) Benefits of Metropolitan ITS Infrastructure

Existing infrastructure is being used to deliver more efficient and effective transportation services (Apogee/Hagler Bailly 1998, Mitretek Systems Inc. 1999). The use of ITS technologies is more advanced in urban areas (in both cities and suburbs). It has been estimated that to integrate the various components of advanced traffic management, traveler information, and public transportation systems will cost about $24 billion over the next 20 years but benefits will exceed $212 billion in the 75 largest metropolitan areas (USDOT Joint Program Office 1997: 1). Metropolitan infrastructure consists of nine major components: Arterial Management Systems (AMS), Freeway Management Systems (FMS), Transit Management Systems (TMS), Emergency Response Management (ERM), Electronic Toll Collection (ETC), Electronic Fare Payment (EFP), Highway-Rail Intersections (HRI), and Regional Multimodal Traveler Information Systems (RMTIS) (Figure 2). Also, some ITS services are very highly integrated into Integrated Services (IS) by creating links between services or program areas. The links

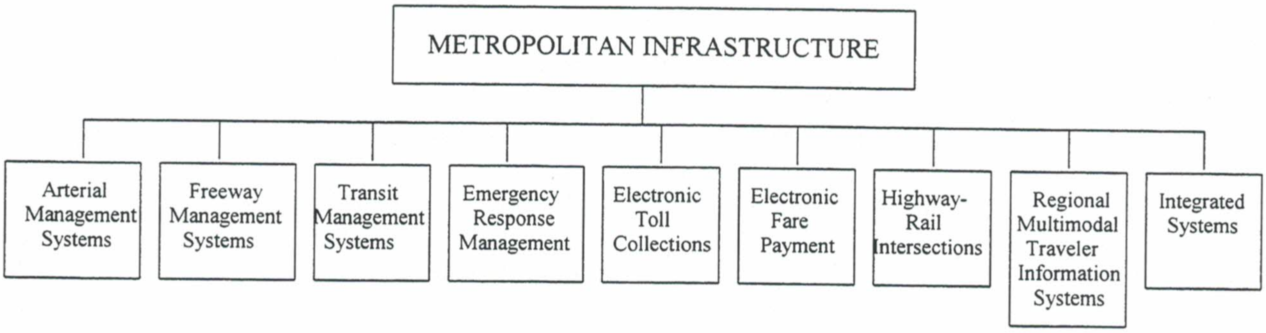

Figure 2. Metropolitan Infrastructure

allow for the sharing of operational information and infrastructure between ITS services or components.

Arterial Management Systems. Arterial management systems are used to manage traffic and control arterial roadways by deploying surveillance and signal control, as well as providing travelers with information on street travel conditions by radio or visual displays. Signal controls are upgraded to improve traffic flow and system maintenance while arterial traffic signal systems provide coordinated control across metropolitan areas. Similarly, traffic information may be shared between jurisdictional boundaries and with other metropolitan infrastructure components. It is estimated that improving traffic signals reduces travel time from 8 percent up to 25 percent (Meyer 1997), and also reduces emissions and fuel consumption (positive environmental impacts). Integrating an Advanced Transportation Management System (ATMS) and an Advanced Traveler Information System (ATIS), FAST-TRAC program has improved safety, reduced delay, and improved operational efficiency in Oakland County, Michigan. Results from FAST-TRAC show a reduced number of accidents, especially those resulting in severe injuries, a decrease in the number of stops in system corridors, and increased speeds, particularly in off-peak periods (Barbaresso 1994). The City of Los Angeles had computerized its signal control system through its Automated Traffic Surveillance and Control

Program consisting of 1,170 intersections and 4,509 detectors by 1994. Fuel consumption decreased by 13 percent, emissions by 14 percent, vehicle stops by 41 percent, travel time by 18 percent, delay by 44 percent, while average speed increased by 16 percent between 1984 and 1994 (City of Los Angeles 1994).

Freeway Management Systems. Freeway Management Systems comprise three major ITS functions: monitoring of freeway operations, control of freeway operations, and display of information on observed freeway conditions gathered through monitoring and surveillance. Travelers (motorists) get this information through Variable Message Signs (VMS), Highway Advisory Radio (HAR), In-vehicle Signing (IVS), or specialized transmission to specific sets of vehicles. Freeway management systems allow a traffic management center to alter signal timing on arterials to regulate traffic entering the freeway, use changeable variable message signs to encourage motorists to use alternate routes, while information on conditions of the freeways can assist commuters to choose other routes.

Henry and Meyhan (1989), in their longitudinal study of the ramp metering/freeway management system reported a reduction in accident rates in spite of the growth of the traffic volume in Seattle, Washington. Robinson and Piotrowicz (1995) report results of a survey on traffic management centers using ramps across the United States. They state that although traffic demand increased by 17 to 25 percent, accidents were reduced 15 to 50 percent, travel time was improved up to 48 percent, while speed increased between 16 and 62 percent. The TranStar system in Houston, Texas, uses loop detectors embedded in the roads with closed circuit television (CCTV) to detect and then monitor delays on the freeways. Once a problem is detected, whether it is congestion, an incident, or more serious emergency, an appropriate transportation response is provided from the central management center (Siwek and Associates 1999).

Transport Management Systems. Advanced Public Transportation Systems (APTS) provide additional safety and security to passengers by allowing remote monitoring of transit vehicle status and passenger activity, while Transit ITS services assist operators in maintaining fleets of vehicles. Through vehicle self-diagnostics, mechanics are alerted of potential problems or when a scheduled maintenance is due while automated vehicle location (AVL) and Computer Aided Dispatch (CAD) devises help operators to improve scheduling activities and to adhere to a given schedule. Electronic Fare Payment systems provide convenience to travelers (Goeddel 1996). ITS technologies are allowing the installation and use of AVL systems based on signpost, triangulation, LORAN, and GPS as well as CAD systems to improve efficiency and service. Benefits are especially noted in improved adherence to schedule leading to increased productivity, improved security, and improved travel time (Jones 1995). In Kansas City, Missouri, where an AVL/CAD system was employed, equipment requirements were reduced by 10 percent while at the same time fewer buses were used to run without reduction in customer service. Seven buses were eliminated allowing Kansas City to recover its investment in AVL in two years. On-time performance was improved by 12 percent in the first year of operation (Jones 1995; Mitretek Systems Inc. 1999). Therefore, the major benefits of transit management systems are the reduction in travel time by improving schedule adherence by reducing passenger wait time and improvement in transfer coordination as well as reduced cost of operations, improved productivity, and better utilization of facilities and equipment.

Incident Management Systems. Booz.Allen & Hamilton (1998a) estimate that by 2005, incidents related to congestion will cost the U.S. public more than $75 billion in lost productivity and will result in wasting 8.4 billion gallons of fuel. A traffic incident is an obstruction or restriction to traffic flow, such as a stalled vehicle, construction and maintenance activity, adverse weather condition, or special event. About 65 percent of traffic congestion is caused by accidents. By 2005, this rate is estimated to reach 70 percent (Booz.Allen & Hamilton 1998a). Congestion temporarily causes either a reduction in capacity or an increase in demand of the transportation network. Incident management programs identify and respond to vehicle accidents or break downs with appropriate emergency services in order to restore roadways to complete service. ITS technologies reduce the time to detect incidents, respond to an incident, or return the facility to normal conditions. Also, using video systems and loop detectors, slow traffic could be identified and traffic congestion diverted using call-in systems. The Chicago, Illinois, IMP system has reduced the time to clear incidents by half. The City of San Antonio, Texas, uses a comprehensive incident management system on a 26-mile freeway using detectors to calculate changes in the speed of traffic. Video cameras detect highway problems from the Traffic Management Center and appropriately dispatch emergency vehicles. Data are also sent to a traffic signal computer which produces 34,000 pre-programmed responses compelling adjustment of signal timing on arterials, lane control signal and message signs for highway commuters. Based on the results of a study by the Texas Transportation Institute, ITS technologies have helped the city to reduce accidents by 15 percent and to decrease police personnel by 20 percent. These reductions in accidents and personnel are expected to save $67 million for the next 20 years (U.S. Industry and Outlook 1999; Siwek and Associates 1999).

The most advanced incident detection system deployed in the United States is the Gowanus Expressway/Prospect Expressway rehabilitation project in Brooklyn, New York (Mitretek Systems Inc. 1999). The system consists of an automated incident detection system and 20 closed-circuit television (CCTV) cameras with pan, tilt, and zoom capabilities. Processors to determine speed, occupancy, and volume of the traffic analyze data from the CCTV. The time to clear an incident has been reduced from 1.5 hours to 31 minutes, or by 66 percent (Samartin 1997). In Philadelphia, Pennsylvania, the Traffic and Incident Management System (TIMS) helps traffic to avoid highway incidents and emergencies on I-95 by rerouting vehicles immediately after an accident is detected. This response dilutes traffic flow, reducing the risk of secondary incidents. TIMS is said to have decreased freeway incidents by 40 percent, freeway closure time by up to 55 percent, and the severity rate of the incident by 8 percent (Taylor 1997).

In July 1995, the first phase of the TransGuide System became operational in downtown San Antonio using a digital communications network, variable message signs, lane control signals, loop detectors, and freeway surveillance cameras. Immediately, the number of total accidents was reduced by 35 percent, secondary accidents by 30 percent, accidents in inclement weather by 40 percent, and overall accident rate by 41 percent. Response time was reduced by 20 percent (Henk et al. 1996).

The Houston TranStar system covers 127 miles of the Houston, Texas, freeway network. The Parsons Transportation Group (1997) reports that based on freeway incidents alone, the TranStar system saved 572,095 vehicle-hours and $8.4 million annually in terms of delays. Also, due to reduction in incident detection and response time, the TranStar Management Center helps to reduce hydrocarbons by 91 kg/day (Parsons Transportation Group 1997; U.S. Department of Transportation 1996). San Francisco, California, established a freeway patrol in August 1992 under the Federal-Aid Congestion Mitigation and Air Quality Improvement Program. The program has helped in decreasing air pollution and fuel consumption by helping to reduce the impact of incident-caused congestion, vehicle idling, and start-and-stop travel. It has been estimated that the program has reduced hydrocarbons by 32 kg/day, carbon monoxide emissions by 322 kg/day, and nitrogen oxides by 798 kg/day (U.S. Department of Transportation 1996).

Emergency Response Management. Emergency response management is closely tied to incident management systems. Emergency response management systems enable rapid dispatch of emergency vehicles and personnel to the scene of an incident, especially an accident, using a guidance system. For example, when an accident occurs, the location of 911 calls appears on a digital map enabling the emergency personnel to pinpoint the exact location of the calls. Global positioning systems (GPS) onboard vehicles (buses, trucks, cars, etc.) which are equipped with emergency response management systems are becoming common. For example, Chicago, Illinois, has upgraded its 911 system to include an electronic map of the city with a high level of detailed information including 20,000 street segments, over 20,000 alleys, the location of hydrants, and footprints of buildings. Emergency vehicles are outfitted with automatic vehicle locators which allow a central computer system to locate the nearest emergency vehicle to the scene of an emergency and to dispatch the vehicle with instructions and routing alternatives (Siwek and Associates 1999).

In Albuquerque, New Mexico, a map-based computer-aided dispatch system is used in an ambulance fleet. The dispatch center guides an emergency ambulance to the exact location of an emergency. The company's efficiency has increased by 10 to 15 percent (Taylor 1997). Palm Beach County, Florida, is in the process of installing the Priority One traffic system that will connect GPS to emergency vehicles. An emergency vehicle approaching a traffic light transmits a signal that interrupts the normal cycle, allowing the vehicle to go through the intersection without stopping. Though a relatively costly system ($4,000 per intersection and $2,000 per vehicle) the system will allow dispatchers to figure out the closest emergency unit. The system is likely to cut down the response time by 20 percent depending on the time of the day and intersection (Shifrel 1997, quoted in Mitretek Systems Inc. 1999, 29). Also, in Portland, Oregon, traffic lights technologies allow signal systems to respond to real time traffic conditions and to give emergency and transit vehicles priority (Siwek and Associates 1999). Emergency vehicles are equipped with devices that hold through-street lights green, signal coordination systems that respond to events at special event centers, such as sports arenas, allowing for the smooth flow of traffic entering and exiting the event location. Signal systems can also be adjusted from a traffic control center to respond to incidents or congestion.

Drivers can also send a message to the response center specifying the location of the incident using the Puget Sound Help Me (PuSHMe) Mayday System. The system includes 2-way pagers and cellular telephones that transmit vehicle location, nature of the problem, and a priority level of the problem to a response center. Automated signals are sent when the driver is incapable of manually initiating a signal (Haselkorn et al. 1997).

Electronic Toll Collection. Electronic Toll Collection (ETC) has greatly impacted the administration, management, and collection of tolls by reducing delays and throughput at toll plazas. The toll plaza's computer identifies a transponder in the vehicle and automatically bills or deducts credits from the owner electronically. Modern technologies allow for the identification of vehicles traveling at mainline speeds accurately. The Pike Pass ETC program on the Oklahoma Turnpike system started in January 1991. By June 1994, 250,000 passes had been issued, 90 percent were still active, and generated 35 percent of the revenue for the Turnpike Association (Clean Air Action Corp. 1993). The ETC has reduced the amount of carbon monoxide by 72 percent, hydrocarbons by 83 percent, and nitrogen oxides by 45 percent on the Muskogee Turnpike (Oklahoma), the Asbury Plaza on the Garden State Parkway (New Jersey), and the Western Plaza on the Massachusetts Turnpike (Clean Air Action Corp. 1993). Oklahoma has reduced pollution between 27 and 70 percent on the turnpikes through the use of ETC. It is also estimated that the State of Oklahoma saves $160,000 per lane annually through using automatic collection instead of a manual toll booth (Siwek and Associates 1999).

Electronic Fare Payment Programs. Electronic Fare Payment (EFP) technologies (such as smart cards or credit cards) allow electronic debit or credit processing of transit fares at subways, bus and park-and-ride lots, and smart fareboxes. Test programs have been conducted in bus and rail systems to address customer convenience and security as well as provide centralized information to transit agency managers. In Los Angeles, California, EFP systems have tried to consolidate all transit and parking transactions into one "smart card."

In the late 1980s, the Arizona legislature passed an air quality bill. Responding to this law, in 1991, the Maricopa County passed a travel reduction ordinance that required each employer in the Phoenix area with at least 100 employees to reduce single-occupancy-commuting trips by 5 percent in two years. This requirement led to the use of the electronic fare payment systems since 1991. The City of Phoenix Public Transport System developed the Bus Card Plus system that could read magnetically encoded plastic passes. Employers were then billed monthly for transit use. By 1996, 35,000 cards were in use by 190 companies that were participating. Ninety percent of the fares on express routes are paid through bus pass cards. Costs to employers have been decreasing because employers are only billed for transit usage rather than on monthly passes. From May 1995, even VISA and MasterCard can be used for payment (Schwenk 1996). New York has increased its ridership as a result of EFP by $49 million while New Jersey has reduced the cost of cash handling by $2.7 million and Atlanta by $2 million (Jones 1995).

Highway-Rail Intersections. Although the number of accidents and fatalities occurring at highway-railway intersections (HRIs) has been declining, accidents still do happen, sometimes involving school children and hazardous materials and drawing much national attention (Mitretek Systems Inc. 1999). Technologies are available that respond to incoming trains by employing enhanced warning and barrier systems at highway-railway intersections. Photo enforcement of grade crossing and red-light violation, traffic signal systems adapt to incoming trains to stop traffic early. Los Angeles, California, uses video surveillance of crossings and intrusion detection devices (Siwek and Associates 1999; Intelligent Transportation Systems Professional Capacity Building Course Catalog 1998).

Regional Multi-Modal Traveler Information. Providing traveler information over several modes of travel can be beneficial to both the traveler and service provider. Systems that provide real time travel information to the public allow them to predict trip times accurately and make sound route and mode choices. This service can be achieved by providing regional multimodal traveler information (RMTI) centers that collect, analyze, and distribute accurate, reliable, and timely travel information. Information kiosks and web sites provide schedules, expected times of arrival, expected trip times, and route planning services for travelers. Similarly, traffic management centers provide current traffic conditions and expected travel times. Such services have been shown to increase transit usage and even reduce congestion in times when travelers defer or postpone their trip or select an alternate route (Mitretek Systems Inc. 1999). Montgomery County, Maryland, broadcasts traffic conditions on major roadways to 180,000 homes using cable television (Crowell 1997). In addition, the internet shows pre-trip traveler information and the current status of traffic on the highways.

(b) Benefits of Rural ITS Infrastructure

Rural areas consist of 80 percent of the total U.S. road mileage, 40 percent of the vehicle miles traveled, and 60 percent of all fatalities (USDOT Joint Program Office 1997, 2). The rural environment has its own set of priorities and needs, including lower traffic volumes, longer distances, unfamiliar surroundings, and longer emergency response times (Mitretek Systems Inc. 1999). Although many ITS services provided in metropolitan areas can apply in the rural environment, specialized services are usually needed in the latter. Rural ITS infrastructure is classified into 6 major program areas, including the Traveler Safety and Security, Emergency Services, Tourism and Traveler Information, Public Travel and Mobility Services, Infrastructure Operation and Maintenance, and Fleet Operation and Maintenance (Figure 3). Unlike the metropolitan infrastructure, the rural initiative is a relatively new program. Even the ITS World Congress in Toronto, Canada (November 8-12, 1999) devoted only two sessions to Rural ITS. However, potential solutions have been described in Deeter and Bland (1997).

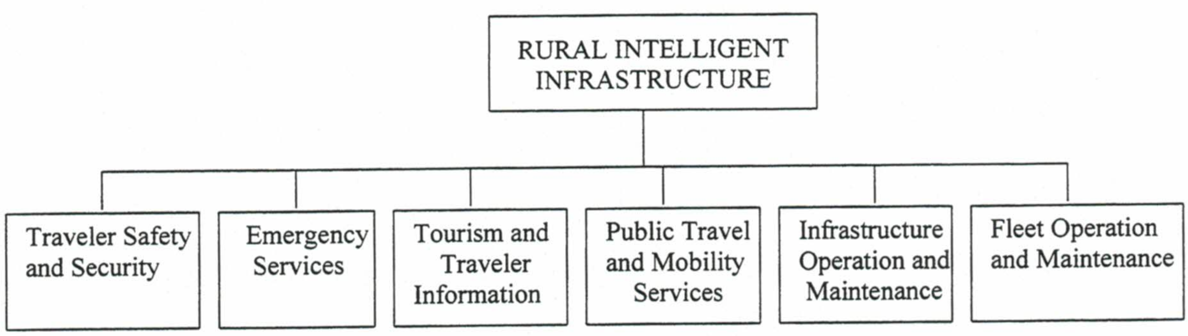

Figure 3. Rural Intelligent Infrastructure

Traveler Safety and Security. Improving safety and security is a major goal of Rural ITS. Services geared to traveler safety and security are closely tied to emergency response as well as to information on hazardous conditions or site specific safety and remote surveillance and monitoring. Rural travelers would benefit from real-time or static information that would assist them in making travel decisions. Such information can be provided at such places as rest areas and park-and-ride lots. Zarean, Pisano, and McBride (1999) report on a study on the development of a Surveillance and Delay Advisory System (SDAS) in south New Jersey, a place they stated received seasonal or episodic traffic congestion and excessive delays in construction areas or when near rural attractions. Several techniques were evaluated with the aim of making recommendations for the Federal implementation of the ITS technologies in rural and small urban areas and to provide guidelines for ATIS implementation. Data from a test zone were gathered, travel times computed, and delay messages transmitted to travelers. The radar and weigh-in-motion (WIM) automatic vehicle identification techniques (AVI—vehicle's weight, number of axles, and axle spacing) gave reasonable travel time estimates. Although the radar was easy to set and performed well, the WIM subsystem was the most stable system. However, the WIM was more expensive and less mobile. Radio communication could be improved while the solar collectors could not be used at night. Video-based AVI were less reliable and less appropriate for use on rural highways.

Yang, Sisiopiku, and Pisano (1999) reviewed the wireless communications systems and technologies because existing wireless communication systems may not be fully applicable to rural areas due to limitations in such aspects as coverage and transmission rates. Yang, Sisiopiku, and Pisano (1999) concluded that providing rural ITS is a challenge because of problems associated with adequate monitoring and data collection in sparse areas; effectiveness and efficiency in information dissemination; ruggedness of some areas; reliability of given communication systems; and issues associated with in-vehicle equipment and standardization for maximum user coverage.

Emergency Services. Emergency services relate to the response to incidents and other events such as natural disasters. In rural areas, emergency medical services take much longer to respond from the time of incident notification to the time resources are mobilized for response. Field tests on the Ford Lincoln Continental Remote Emergency Satellite Cellular Unit (RESCU) security system indicated it took less than a minute for a driver to make voice contact with a response center operator. It took less than 11 minutes on average from the time the button was punched to the time emergency vehicles arrived at the scene of the incident (Meyer 1997, 24-27). One of the most promising (and yet not completed) rural highway safety projects is being undertaken is the NHTSA/Calspan Automated Collision Notification (ACN) Field Operational test in Western New York State (Blatt, et al. 1999). About 700 vehicles have been fitted with the ACN system. The ACN system collects accurate time histories for vehicle crashes. Data include the time of the crash, ACN notification of the crash to the public service answering point dispatch center, land-line or cellular notification of the crash received by 911, emergency services dispatch time, emergency services arrival at and departure from the crash scene, and hospital arrival time. ACN vehicles have been involved in 44 crashes (October 1995 – May 1999), but only 12 events met or exceeded the ACN crash definition to trigger the system to work. The system is also able to provide information between the actual crash time and the crash time as reported on the Police accident report. There is potential for liability should the system fail to perform accordingly. The tests will be completed next year (September 2000).

Tourism and Travel Information. Travelers who may be unfamiliar with the area in which they are traveling through need tourism and travel information. Although the information is geared to address aspects of mobility and convenience, it also helps improve the economy of the rural and tourist areas. Information could be provided through electronic yellow pages as well as parking and transit availability, pre-trip route selection, and en route navigation. Available services such as hotels, service stations, and restaurants are included.

Public Travel and Mobility Services. About 38 percent of rural residents have no access to public services and another 28 percent live in areas with negligible transit services (Mitretek Systems Inc. 1999). Mobility services can be extended to increase the mobility of those who are not in position or those who choose not to drive their own vehicles. It is a formidable challenge to deliver transit services to rural residents but a system can be created that provides such services (Deeter and Bland 1997, 119). Different providers can work together to coordinate origins and destinations over wide areas. Other services could include advanced transit with AVL-assisted dispatching and routing with fare payment strategies and advanced ride sharing with improved parking information. The Potomac and Rapphannock Transport Commission operates demand–responsive transit to serve transit needs and commuter rail stations in suburban Washington, DC. The demand-responsive system is estimated to save about 40 percent in total cost when compared to the fixed route service (Farwell 1996; quoted by Mitretek Systems Inc.1999, 45). In the State of Florida, use of a coordinated paratransit with a dispatch system including AVL has potential to reduce fraud in Medicaid transportation by $11 million per year (Ride Solutions No Date). Ridership has increased from 5,000 to 9,000 passengers a month in Sweetwater County, Wyoming, by allowing same-day ride requests. This increase has been made without a corresponding increase in the dispatch staff while operational expense has been cut by 50 percent over 5 years based on a per passenger-mile (Casey 1996).

To increase the safety of drivers, Washington State experimented with traveler warnings for spot hazardous conditions on Highway 101 near Port Angeles. Ice sensors were installed on bridges and when they detected ice on the pavement, flashing beacons were activated on a sign reading "ICE ON BRIDGE WHEN FLASHING." Although the system was deemed satisfactory, liability concerns (should the signs not work and a driver gets hurt) may prevent eventual deployment (Deeter and Bland 1997).

Infrastructure Operation and Maintenance. Operating and maintaining rural transportation is costly. Also because of distance, isolation, and the number of road miles managing and monitoring rural roadway conditions are often difficult. Rural roadway management systems provide devices and operations that maintain effective operations along roadways including road maintenance, infrastructure design, and construction to meet the needs of the traveler. The safety of work zones and construction areas need improvement. ITS technologies are being used in optimizing winter weather maintenance (Mitretek Systems Inc. 1999, 46). Of great interest and potential is the Finnish National Road Administration's road weather system where winter maintenance is carried out systematically and at the right time. A network of 11 central stations, approximately 2000 workstations, and about 150 observation stations sends out actual and predicted weather and road surface conditions to road maintenance personnel (Mitretek Systems Inc. 1999, 46). The Department of Transportation in Indiana has implemented the Computer Aided System for Planning Efficient Routes (CASPER) for districts in the State—a software used to design routes needed to service the roadway network. It is claimed that CASPER has reduced equipment and operating winter maintenance costs by $11 to $14 million and reduced the number of routes needed to service the network by 8 to 10 percent (Deeter and Bland 1997).

Fleet Operation and Maintenance. Fleet Operation and Maintenance (FOM) is similar to transit operations, but here ITS is concerned with operating and maintaining state-owned vehicles. FOM includes technologies that lead to vehicle self-diagnostics that can alert mechanics of potential problems and automated vehicle location devices to improve the scheduling of maintenance activities. No data on benefits are available from the deployed FOM services.

(c) Benefits of ITS for Commercial Vehicle Operations

Commercial vehicle operation (ITS/CVO) systems are designed to keep freight traffic flowing through States and across interstate and international borders. ITS/CVO uses WIM devices embedded in roads that are linked to computer systems to clear trucks in advance so that they can pass weigh or inspection stations without stopping. ITS/CVO are preclearance systems that allow trucks to communicate electronically with state computers to verify that registration, safety, and other credentials are in order. All services are geared to improve carrier operations. Benefits of such systems include improved administrative efficiency, reduced infrastructure investment, improved highway data collection, reduced operating costs, and enhanced environment.

Four major programs exist in ITS/CVO including Safety Assurance, Credentials Administration, Electronic Screening, and Carrier Operations (Figure 4). California, Oregon, Arizona, New Mexico, Texas, Arkansas, Colorado, use this technology for preclearance (Siwek and Associates 1999). A benefit/cost analysis study conducted on ITS/CVO found that operations would benefit by implementing ITS/CVO (American Trucking Associations Foundation 1996).

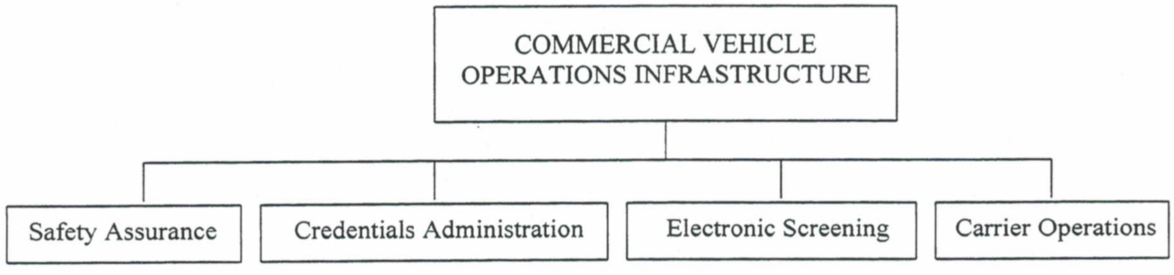

Figure 4. Commercial Vehicle Operations Infrastructure

Safety Assurance. Safe operation of commercial vehicles will largely depend on improved safety information exchange. Inspectors need access to safety information, number of unsafe vehicles, and number of unsafe commercial drivers while onboard monitoring devices can alert drivers and carriers about potential unsafe load conditions.

Credentials Administration. Commercial vehicle operations (ITS/CVO) administrative processes comprise those activities and transactions that must take place for commercial vehicles to legally operate on the highways. In a single, simplified electronic system, motor carriers or their representatives, request, pay for, and receive credentials. Such activities and transactions include vehicle registration, carrier operating authority, fuel tax registration and reporting, and permitting for the movement of over-dimensional vehicles and hazardous materials. Credentials administration largely deals with in-house administrative functions. Whereas data warehousing can facilitate the exchange of credentials among agencies, electronic credentials actually improve the time required for states to approve operating permits. Thus, permit officials actually spend less time on paperwork and more time in examining routes. By using the Internet to fill out applications rather than by filling them out in person, the turn around on permits has been reduced. Minnesota is reported to have reduced its workforce from 20 to 5 people (Mitretek Systems Inc. 1999, 51).

Booz.Allen & Hamilton Inc. (1998b) report three field tests for electronic one-stop processing. Automated application reduced the amount of time needed to review an application and labor required to review and process applications. Monsere and Maze (1999) have studied the potential benefits and costs of the mid-continent corridor, I-35, from Laredo, Texas, to Duluth, Minnesota. I-35 is an important trade corridor that was designated a high priority corridor in the National Highway System Designation Act of 1995. Using the number of

International Registration Plan (IRP) accounts, International Fuel Tax Agreement (IFTA) accounts, and Oversize/Overweight (OS/OW) permits from all the states in the corridor, Monsere and Maze (1999) estimated cost savings of $7 per permit application compared to manual transactions. The cost for deploying electronic credentialing will be shared by state agencies and motor carriers, but the majority of the costs will be borne by state agencies. The costs would cover expenses associated with personal computer-based software, annual communication, and system maintenance for motor carriers, and modification of legacy computer systems, interface systems for communication with carriers, annual communication, training of employees, annual maintenance, software development, and new hardware. Though extrapolation of credentialing costs was difficult for the entire state agencies, deployment would cost $1-$2 million per state. Benefit/cost analysis was better for motor carriers and not for the states.

Electronic Screening. Electronic screening takes place at fixed location weigh/inspection facilities and possibly at inspection sites. That is, electronic screening is possible where the following technologies are used: automatic vehicle identification, weigh-in-motion, automatic vehicle classification, and integrated communications systems and databases. Vehicles deemed to be safe bypass the weigh and/or inspection stations. If safe and legal carriers are allowed to pass without stopping at weigh in and inspection stations, congestion will be reduced. Also, roadside electronic screening allows authorities to put more energy on potential unsafe vehicles. Booz.Allen &Hamilton (1994) estimate that electronic clearance could generate a benefit/cost ratio of 7.2, one-stop/no-stop shopping of 7.9, and automated roadside inspections of 5.4.

Monsere and Maze (1999) contacted each agency that operates static scales along I-35 for the hours of operation, the number of trucks weighed, and the number of safety inspections performed. They found that the states, with the exception of Kansas, have low levels of enforcement and weighed only between 2 to 10 percent of the total truck traffic at static scales. Also, Minnesota does not operate fixed scales on I-35. Benefits to motor carriers included time and fuel savings (deceleration time off the mainline, time spent in queue, time at the scale, and time spent to accelerate on the mainline after the weighing episode. The vehicles saved 3 minutes by bypassing the weigh station while fuel savings were assumed as 1/3 gallon per bypass per truck. Electronically, more vehicles were inspected while less pavement wear was also noted. Reduced labor costs also accrued because of fewer people to work the system. The major consideration is that although motor carriers and state agencies will share the costs for electronic screening, state agencies will cover most of the costs.

Carrier Operations. Scheduling of vehicles can be improved and the number of empty loads reduced if ITS/CVO is used. Also, administrative compliance costs can be reduced if carriers participate in automated state credentialing processes. A combination of GPS-based tracking system and remotely-accessed on-board computers can be used to reduce wasted mileage and emissions as has been evidenced in Scandinavia (Bunting 1997).

INTELLIGENT VEHICLES

Engineers and scientists have been looking for ways to improve the driving task and safety of vehicles. Air bags and computer-designed impact absorbing chassis are some of the current technologies that have drastically reduced the severity of crash-related injuries and fatalities. However, these are passive technologies. Research is underway to develop active technologies, known as Advanced Vehicle Control and Safety Systems (AVCSS) that actually prevent collisions and mitigate injuries. ITS services applied to the vehicle include functions that assist the driving task or recommend control actions. Most Intelligent Vehicle services apply to all platforms of vehicles, although some services apply to specific types of vehicles. For instance, commercial vehicles may be fitted with monitoring systems that alert the drivers when a possible load shifts or when a hazardous material leaks. This section highlights information related to driver assistance and collision avoidance and warning systems (Figure 5).

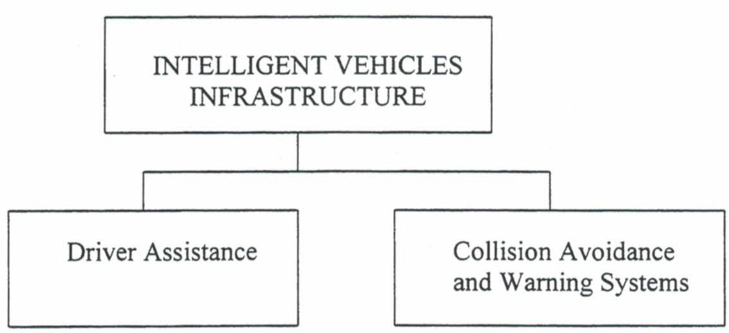

Figure 5. Intelligent Vehicles Infrastructure

Driver Assistance. ITS services that assist in the driving task are considered here. Particularly two systems apply. In-vehicle vision enhancement may improve safety for driving conditions when conditions change. For example, in-vehicle vision enhancement may be fitted in a vehicle to assist the driver during night travel, or when inadequate lighting, fog, snow, or other inclement weather conditions exist. The second mode consists of navigation systems that assist drivers to move in unfamiliar environments. Mitretek Systems Inc. (1999) reports on the INTEGRATION TravTek simulation model on the Orlando roadway network as well as the performance parameters from field studies. The objective of the TravTek system was to estimate crash risk of motorists using navigation devices compared to motorists without them as well as to analyze the safety impacts on the entire traffic network system using vehicles equipped or not equipped with navigation devices. Generally, a 4 percent reduction in crash risk was realized by motorists who used navigation devices because of improvement in turns ("right" turns) and navigation systems usually routed travelers to safer facilities. Equipped vehicles reduced the incidents risk by about 10 percent while overall network safety improvement was realized in places where congestion was the problem. TravTek users felt that their driving was safer, felt less nervous or confused, and were more confident, attentive, and safe. Similarly, the Pathfinder project implemented in the Los Angeles area was an in-vehicle navigation and motorist information system. The navigation system showed that fewer travelers failed to follow desired routes. Mitretek Systems Inc. (1999, 59) warns that "Since in-vehicle systems operate in a complex environment, specific results vary with the conditions and options selected."

Collision Avoidance and Warning. Systems that apply to avoidance of collision or giving warnings are chiefly geared to reducing the number of accidents. Collision avoidance includes such user services as Intelligent Cruiser Control, Rear-end crash avoidance, and Road Departure avoidance. The devices are equipped to first warn or suggest to the driver what action to take. Devices may take some limited control of the vehicle in safety-compromising conditions, as when intelligent cruise control slows down a vehicle when it approaches a lead vehicle too quickly. The highest level occurs when the systems overrides the driver and takes full control of the vehicle. The National Highway Traffic Safety Administration (1997) has estimated that rear-end collision effectiveness with the lead vehicle to be 42 percent. The overall effectiveness of rear-end collision is 51 percent while lane change or lane merge warning systems decrease all lane collisions by 37 percent. The systems have potential for saving billions of dollars.

The virtual bumper is one possible technology. The virtual bumper integrates longitudinal and lateral collision avoidance capabilities to control a vehicle in normal and emergency situations (Hennessey, Shankwitz, and Donath 1995). The virtual bumper consists of three main subsystems: the longitudinal control subsystem, the lateral control subsystem, and the lane change subsystem. The longitudinal control subsystem adjusts the headway to proceeding vehicles and maintains the desired traveling speed when no obstacles are present. The lateral control subsystem maintains the host vehicle's position in the lane and performs collision avoidance in the side regions of the vehicle. The lane change subsystem determines the safest lane of travel based on the road environment and issues lateral position comments that perform lane changes (or direct the vehicle off the road if necessary).

Gorjestani and Donath (1999) present results from a virtual bumper collision avoidance system on a Navistar tractor in a major traffic slow down as well as stop-and-go traffic using the longitudinal control subsystem. The virtual bumper is essentially an algorithm, a programmable boundary, that defines a "personal space" around the "host vehicle," using a radar and a laser range sensor mounted on the host vehicle. The radar and sensor sense the location of vehicles in the region in front of the host vehicle. When the personal space is "invaded" a virtual force on the host vehicle is activated using impedance control, which in turn modifies the vehicle's trajectory to avoid (or at least mitigate) collision. Gorjestani and Donath (1999, 7) report that the "system effectively reduced the headway and velocity to the desired state, while maintaining a reasonable deceleration profile." Also, in a stop-and-go scenario the system was able to stop the truck with a safe headway.

SURVEY

Respondents

The respondents consisted of upper level managers, supervisors, and mid-level managers. A total of 87 respondents, representing 19 cities, were included in the following analysis. The cities were Ada, Altus, Ardmore, Bixby, Chickasha, Choctaw, Enid, Harrah, Lawton, Miami, Moore, Norman, Oklahoma City, Pauls Valley, Ponca City, Purcell, The Village, Tulsa, and Woodward. We interviewed mayors, city managers, fire chiefs, chiefs of police, and traffic managers in the cities. At ODOT, we interviewed divisional or assistant division directors. Additionally, we interviewed heads of transportation associations, professors in electrical engineering, division heads at the Oklahoma Transportation Authority, Oklahoma Department of Commerce, Oklahoma Department of Agriculture, Oklahoma Tax Commission, and Oklahoma Department of Tourism and Recreation. We also interviewed key ITS personnel at the Indian Nations Council of Governments (INCOG) and Association of Central Oklahoma Governments (ACOG).

Eighty-five (85) questionnaires were mailed out. Of the 40 returned, two were eliminated because they were incomplete. Also, 25 telephone interviews and another 24 face-to-face interviews were conducted (Figure 6).

Respondents were classified as belonging to the following categories: Federal/State Transportation (18 or 20.7%), Public Safety/Emergency (15 or 17.2%), Municipalities/Cities (30 or 34.5%), Private and Academia (15 or 17.2%), and Public Non-transportation and Non-emergency (9 or 10.3%) (Figure 7).

Familiarity with the Term ITS. The majority of the respondents (56.3%) indicated they were "Familiar" with the term ITS. Slightly over a quarter (26.4%) of the respondents stated

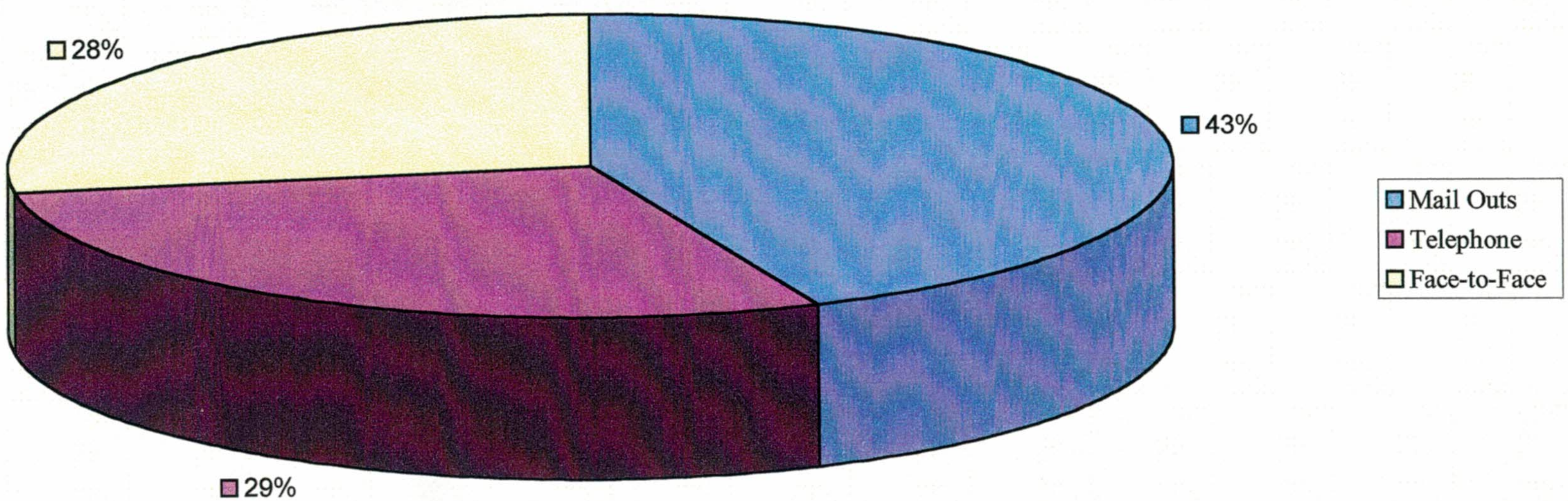

Figure 6. Interviews by Method Used

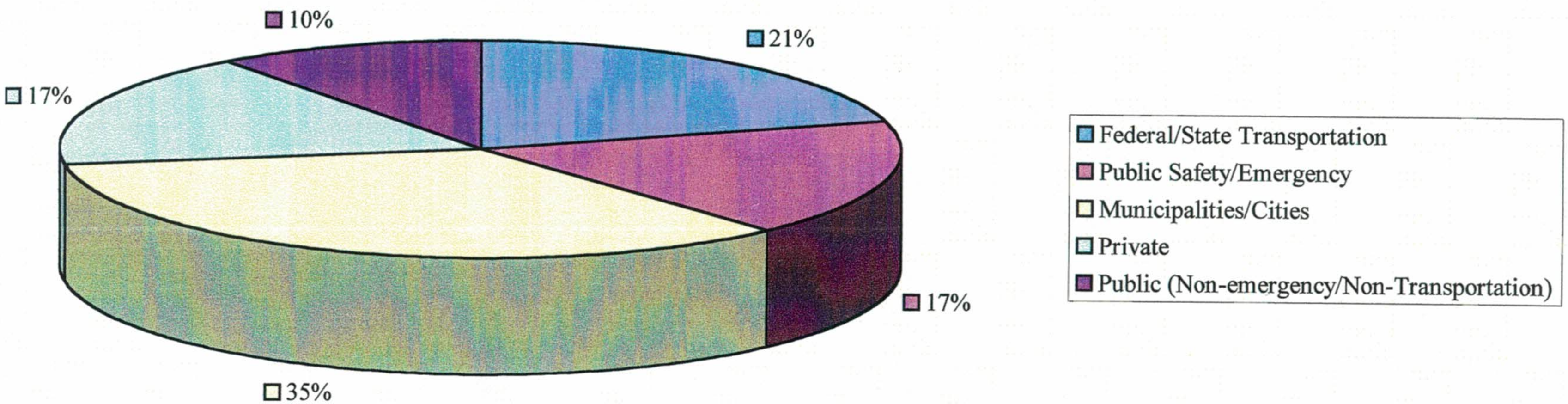

Figure 7. Respondents by Type of Organization

that they were "Somewhat Familiar" with the term. Sixteen percent were "Not Familiar" with the term. However, most of those who were either familiar or somewhat familiar did not exhibit intimate knowledge of ITS technologies. Particularly, respondents from small cities and non-emergency and non-transportation agencies, including emergency and highway patrol personnel, were not familiar with ITS. It is likely that without a concerted effort in imparting knowledge and information on ITS, small cities will not participate in the Statewide initiative.

Major ITS Goals. Thirty-seven (42.5%) respondents did not indicate they had ITS goals in their respective agencies. Table 2 portrays the major ITS goals for only those respondents who indicated that they had goals related to ITS. The percentages reflect only answers for the stakeholders that had ITS related goals. Smooth or efficient traffic flow (19.3%) and enhanced safety and reduced accidents (15.7%) were the top two goals. Lowering costs of operation, providing weather/traveler/driver information, redirecting traffic in emergency/manage incidents, providing timely traveler information, and reducing ambulance dispatch time were the other five goals. Together, these goals accounted for 71 percent of the responses. The remainder (29%) of the responses involved the following goals: developing and setting up the geographic information systems (GIS), updating 911 systems, implementing ITS Statewide, coordinating traffic signals, facilitating intra/interstate trade, implementing wireless communication, integrating signals to fiber optics, developing an ITS management center, incorporating ITS in future plans, installing cameras at major intersections, upgrading signals and vehicles, and enhancing public image.

Most respondents (83%) stated that ITS technologies are needed in Oklahoma while the remainder (17%) did not know whether or not ITS technologies were needed. The majority of those who did not know (87%) whether ITS technologies were needed did not want to participate

Table 2. Major ITS Goals

	Number	Percent
Efficient or smooth traffic flow	16	19.3
Reduce accidents/Enhance safety	13	15.7
Lower costs	8	9.6
Provide weather/road/driver information	7	8.4
Redirect traffic in emergency/Incident management	6	7.2
Timely traveler information	5	6.0
Reduce ambulance dispatch/Emergency dispatch time	4	4.8
Total	**59**	**71**

in the Statewide plan, but most of the respondents (72%) were interested in being part of the strategic planning committee.

ITS Technologies

Respondents were asked to select ITS technologies that were used or provided. A list specifically identifying common ITS technologies was provided (Table 3). Respondents were asked to choose as many of the technologies as they used or provided. The selections were later compared to those technologies the respondents would like to use or provide.

Utilized or Provided Technologies. ITS technologies that received at least 10 responses were included as the major technologies used or provided by the stakeholders. Wireless communication systems used in emergencies and computer-aided dispatch systems tied for the most used or provided technologies. They were followed by the signal systems at arterials, loop detectors, and signal preemption equipment on emergency vehicles that hold through-street lights green. The bottom of the list consisted of digital map displays, global positioning systems (GPS) onboard buses, cars, and trucks using Mayday systems, signal coordination that respond to special event centers, and adjustable ramp meters (Table 4).

Table 3. ITS Technologies

- ❑ Kiosks at transit stops
- ❑ Real time information on bus schedules and arrival times
- ❑ Pre-trip traveler information, e.g., Internet Home page and updates information on current traffic flow
- ❑ Closed circuit television and loop detectors
- ❑ Digital map displays of 911 calls
- ❑ Call-in systems for travelers or transit operators
- ❑ Wireless communication systems used in emergencies
- ❑ Global Positioning Systems onboard buses, cars, and trucks using Mayday systems
- ❑ Computers that identify in-vehicle transponders at toll plazas
- ❑ Adjustable ramp meters
- ❑ Variable message signs
- ❑ Signal systems on arterials
- ❑ Automatic vehicle location devices
- ❑ Computer-aided dispatching systems
- ❑ Equipment on emergency vehicles that hold through-street lights green
- ❑ Signal coordination that respond to special event centers
- ❑ Signal systems that can be adjusted from a traffic management center
- ❑ Photo enforcement of grade-crossing and red-light violations
- ❑ Traffic signal systems that stop traffic early because of incoming trains
- ❑ Systems that detect vehicles that illegally cross barriers onto rail tracks
- ❑ Smart cards that encode credits or credit cards used to pay bus and park-and-ride lot fares
- ❑ Smart fareboxes that record riders and bill employers for employee transit use
- ❑ Weigh-in-motion devices linked to computers to clear trucks in advance
- ❑ Electronic pre-clearance systems to verify registration, safety, and other credentials
- ❑ In-vehicle sensors to measure relative speed and distance of lead vehicle
- ❑ Intelligent cruise control
- ❑ All of the above
- ❑ Other (specify) ______________________________

The ITS technologies respondents would like to use or provide were similar to the ones they were currently using (Table 5). However, the ranking changed. Automatic vehicle location devices were ranked first. Computer-aided dispatching systems remained second, followed closely by equipment on emergency vehicles that hold through-street lights green, wireless communication systems used in emergencies, and variable message signs. Closing the list were digital map displays of 911, smart fareboxes that record riders and bill employers for employee transit use, photo-enforcement of grade-crossing and red-light violation and real time

Table 4. ITS Technologies Utilized or Provided

	Number	Percent
Wireless communication systems used in emergencies	28	8.6
Computer-aided dispatching systems	28	8.6
Signal systems on arterials	24	7.4
Loop detectors	23	7.1
Equipment on emergency vehicles that hold through-street lights green	23	7.1
Variable message signs	21	6.5
Closed circuit television and loop detectors	21	6.5
Call-in systems for travelers or transit operators	15	4.6
Pre-trip traveler information	14	4.3
Signal systems that can be adjusted from a traffic management center	13	4.0
Traffic signal systems that stop traffic early because of incoming trains	12	3.7
Digital map displays of 911	11	3.4
Global Positioning Systems onboard buses, cars, and trucks using Mayday systems	11	3.4
Signals coordination that responds to specials event centers	11	3.4
Adjustable ramp meters	10	3.1
Total	**265**	**85.5**

Table 5. Potential ITS Technologies

	Number	Percent
Automatic vehicle location devices	27	6.9
Computer-aided dispatching systems	25	6.9
Equipment on emergency vehicles that hold through-street lights green	24	6.1
Wireless communication systems used in emergencies	23	5.9
Variable message signs	23	5.9
Closed circuit television and loop detectors	19	4.9
Loop detectors	19	4.9
Global Positioning Systems onboard buses, cars, and trucks using Mayday systems	17	4.2
Pre-trip traveler information	16	4.1
Signal systems on arterials	15	3.8
Call-in systems for travelers or transit operators	15	3.8
Signal systems that can be adjusted from a traffic management center	14	3.6
Signals coordination that responds to specials event centers	14	3.6
Adjustable ramp meters	14	3.6
Kiosks at transit stops	13	3.3
Traffic signal systems that stop traffic early because of incoming trains	12	3.1
Digital map displays of 911	11	2.8
Smart fareboxes that record riders and bill employers for employee transit use	11	2.8
Photo enforcement of grade-crossing and red light violation	11	2.8
Real time information on bus schedules and arrival times	10	2.6
Total	**333**	**85.5**

information on bus schedules and arrival times. Real time technologies did not even make the top list. Real time technologies deal directly with traveler and operator information. ITS technologies could be used to reduce waiting time periods, current weather information, and places to avoid due to construction, accidents, or detours. Traveler information technologies should then be a major consideration for ITS deployment and integration.

Responses were also grouped in terms of ITS emphasis, that is, traveler information; safety/emergency; enforcement; timesaving and various combinations of these particular interests: safety/emergency and enforcement; traveler information, safety/emergency, and enforcement; traveler information, safety/emergency, enforcement, and timesaving; traveler information and safety/emergency; safety/emergency, enforcement, and timesaving; traveler information, safety/emergency, and timesaving; safety/emergency and timesaving; and enforcement and timesaving. The idea behind this categorization was to see if there were patterns of responses arising from the types of organizations involved. For instance, were emergency stakeholders mainly interested in safety/emergency technologies? Figure 8 shows that the majority of respondents were involved in utilizing safety/emergency technologies. The Southern Area utilized more ITS technologies than the Northern Area. As was expected, the two big cities, Oklahoma City and Tulsa, utilized more ITS technologies than the small cities (Figure 9). Again, safety/emergency, and traveler information technologies were utilized more than timesaving and enforcement ITS technologies.

The picture changed when respondents were requested to select ITS technologies they would like to utilize. Although safety/emergency services still dominated the answers, various combinations of traveler information, safety/emergency, enforcement, and timesaving services became apparent. Of particular note was that whereas the two big cities would like to utilize

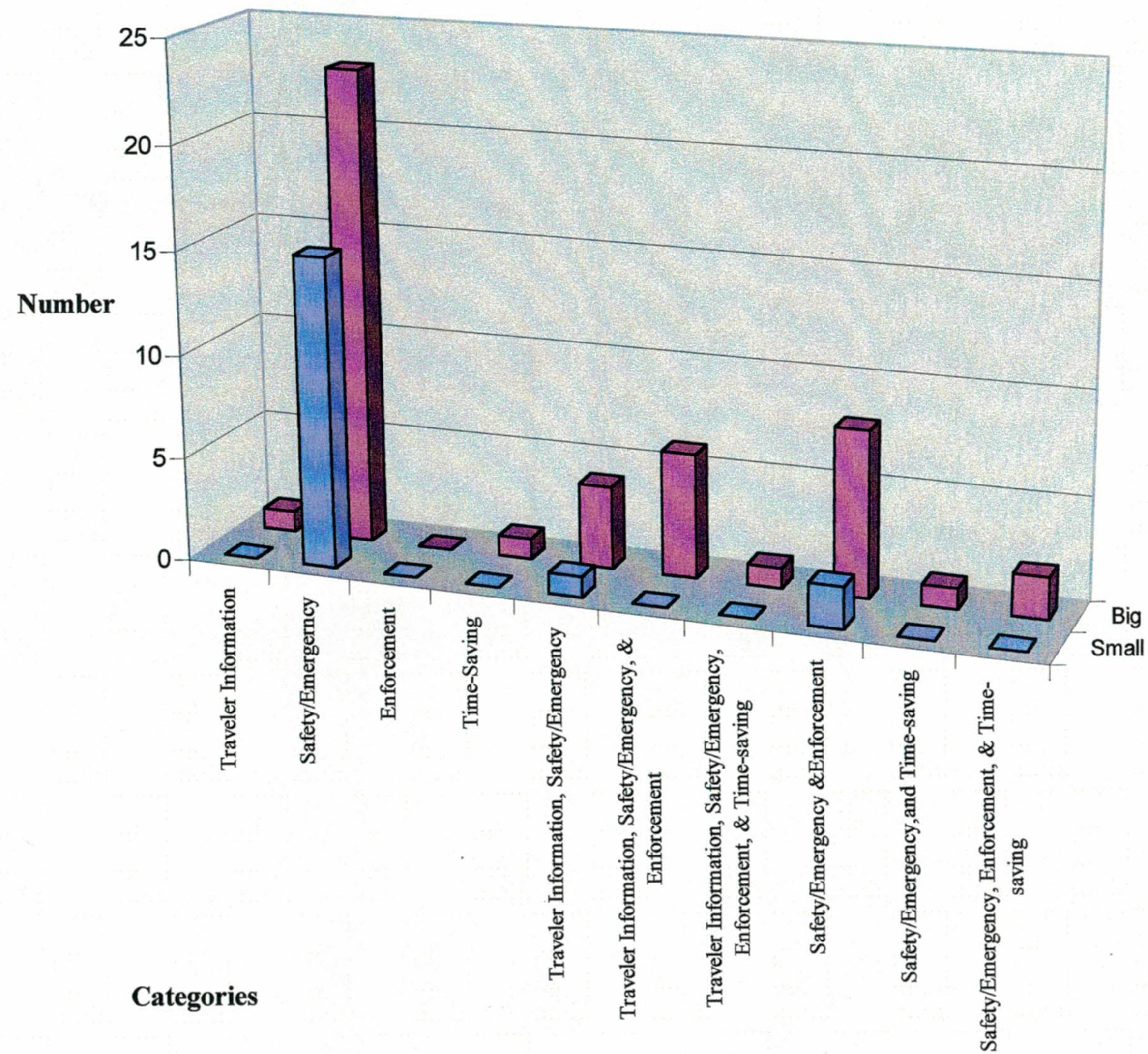

Figure 8. Utilized ITS Technologies by City Size

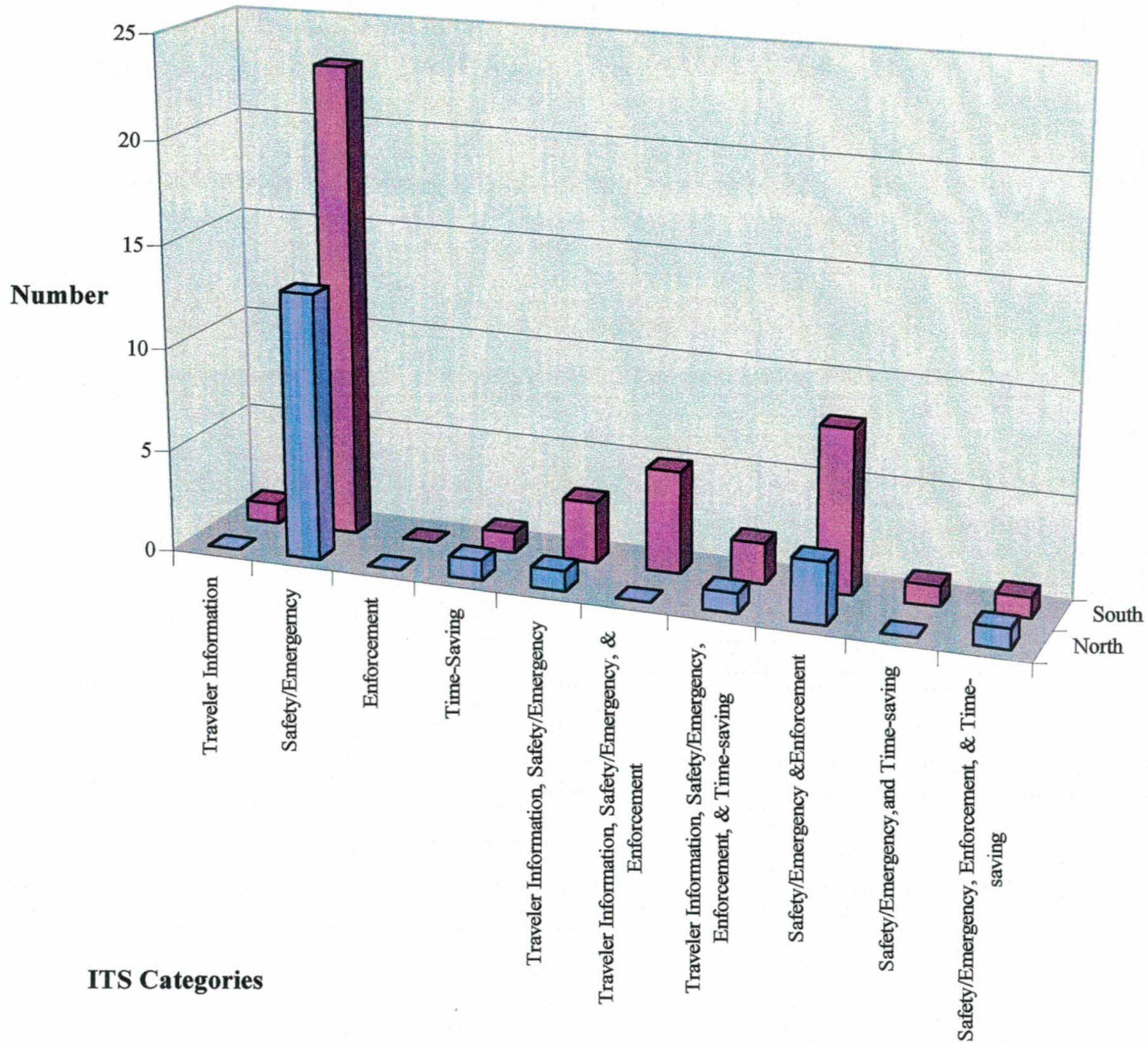

Figure 9. Utilized ITS Technologies by Area

(other than safety/emergency technologies) a combination of safety/emergency, enforcement, and timesaving technologies as well as a combination of traveler information, safety/emergency, and enforcement services and a combination of traveler information and safety/emergency, other than safety/emergency, small cities would rather have a combination of safety/emergency and enforcement ITS technologies (Figure 10). Figure 11 indicates that whereas safety/emergency and enforcement ITS technologies dominate, respondents would like to diversify to other uses.

Respondents were also asked to choose a modified list of ITS technologies. Table 6 indicates that technologies related to public safety, emergencies, and incident management ranked very high whereas information related to commercial vehicle operations ranked low.

Table 6. Technologies Respondents Were Interested In

	Number	**Percent**
Emergency response management	43	12.9
Incident management	38	11.4
Emergency services	33	9.9
Utilization of fiber optics for telecommunication infrastructure	33	9.9
Public travel and mobility services	27	8.1
Freeway management	25	7.5
Safety assurance	24	7.2
Transit safety and traveler information	21	6.3
Commercial vehicle operation	20	6.0
Regional multimodal traveler information	19	5.7
Electronic fare payment	15	4.5
Electronic toll collection	12	3.6
Carrier operations	9	2.7
Credentials administration	8	2.4
Total	**327**	**98.1**

ITS technologies were also arranged according to the type of organization. Figure 12 shows the utilization of ITS technologies by organization type. As has been noted above, most of the ITS technologies were overwhelmingly associated with public safety/emergencies and enforcement. Particularly, municipalities and cities implemented ITS technologies related to

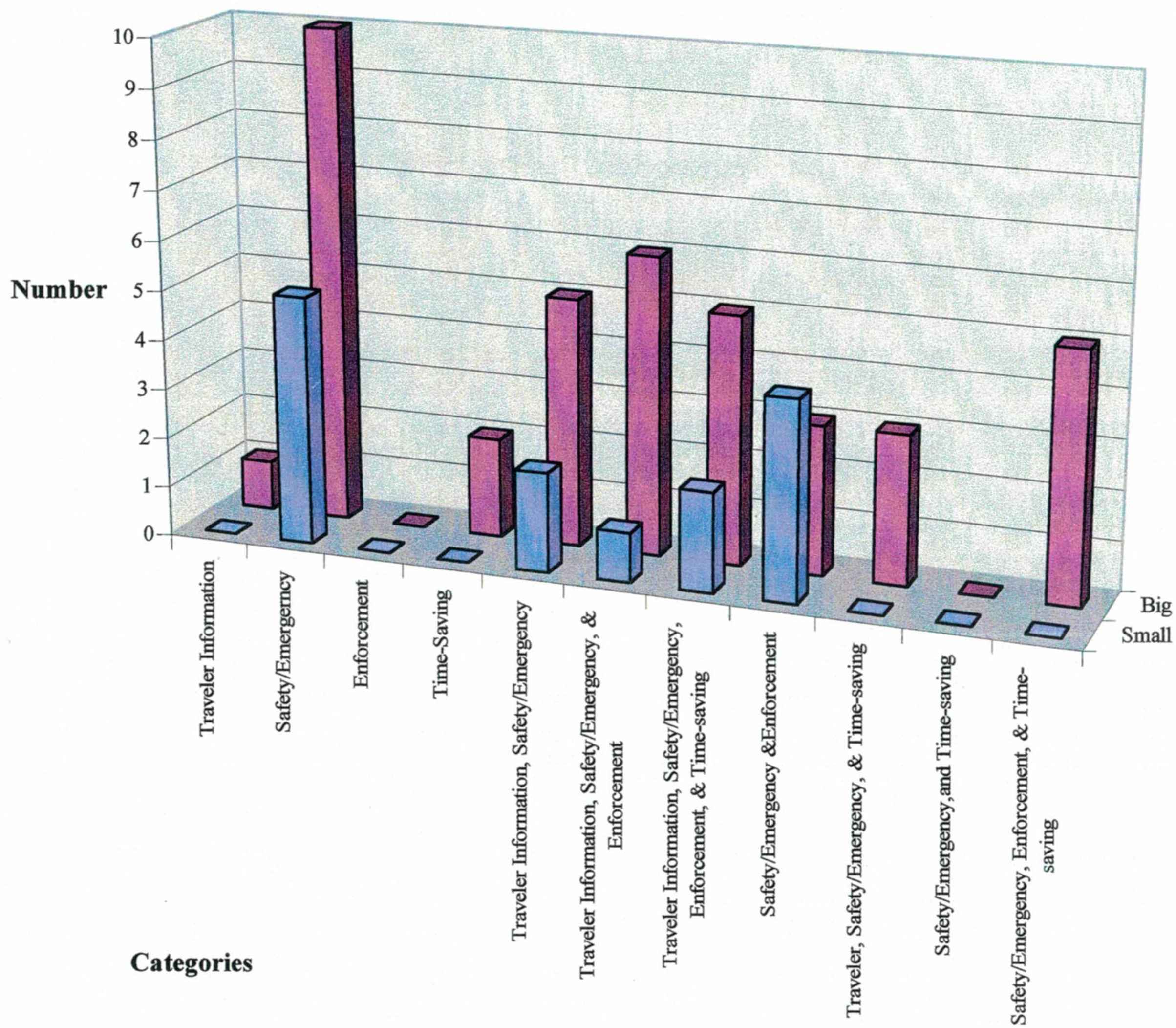

Figure 10. Potential ITS Technologies by Size of City

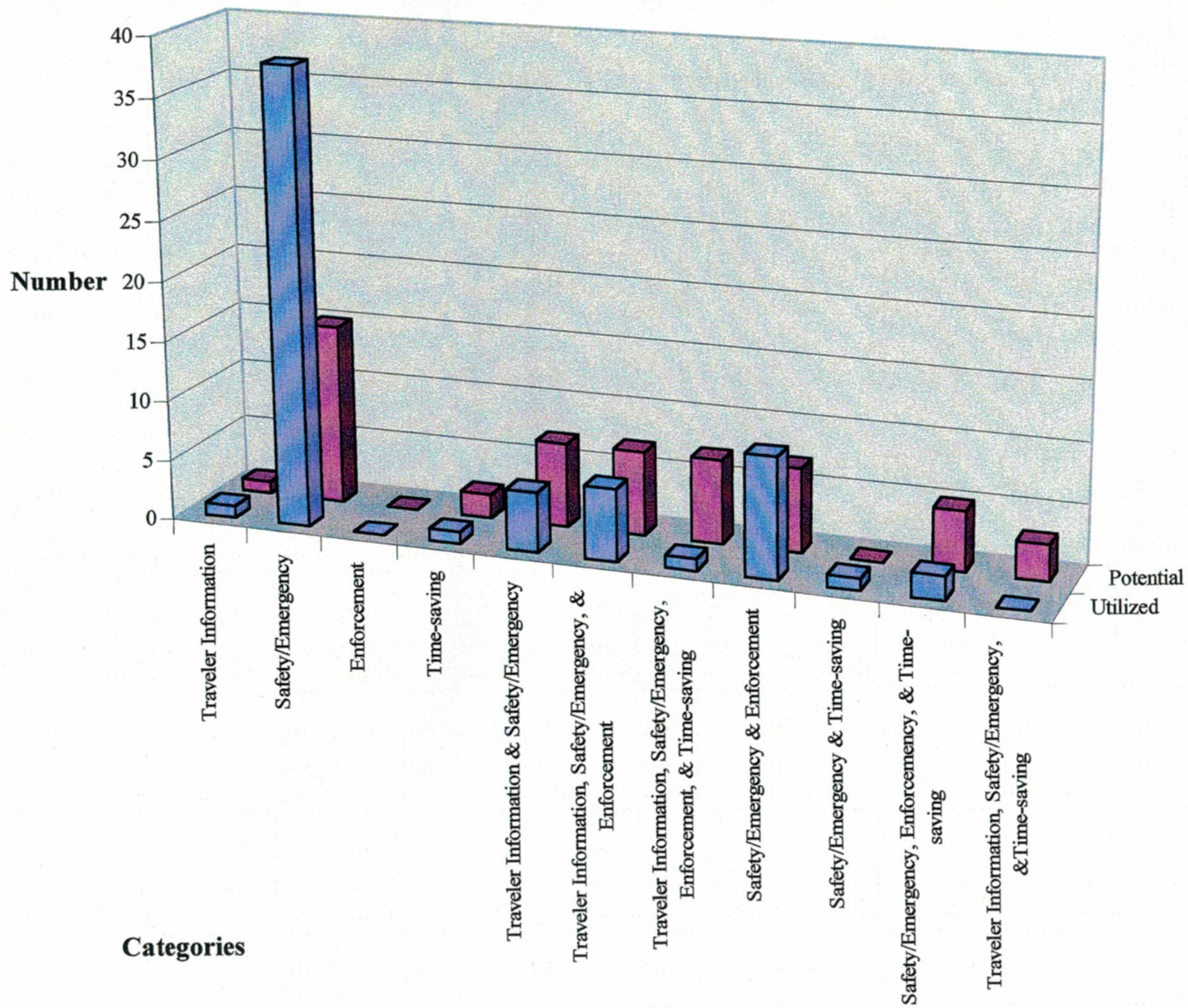

Figure 11. Use Versus Potential Use of ITS Technologies

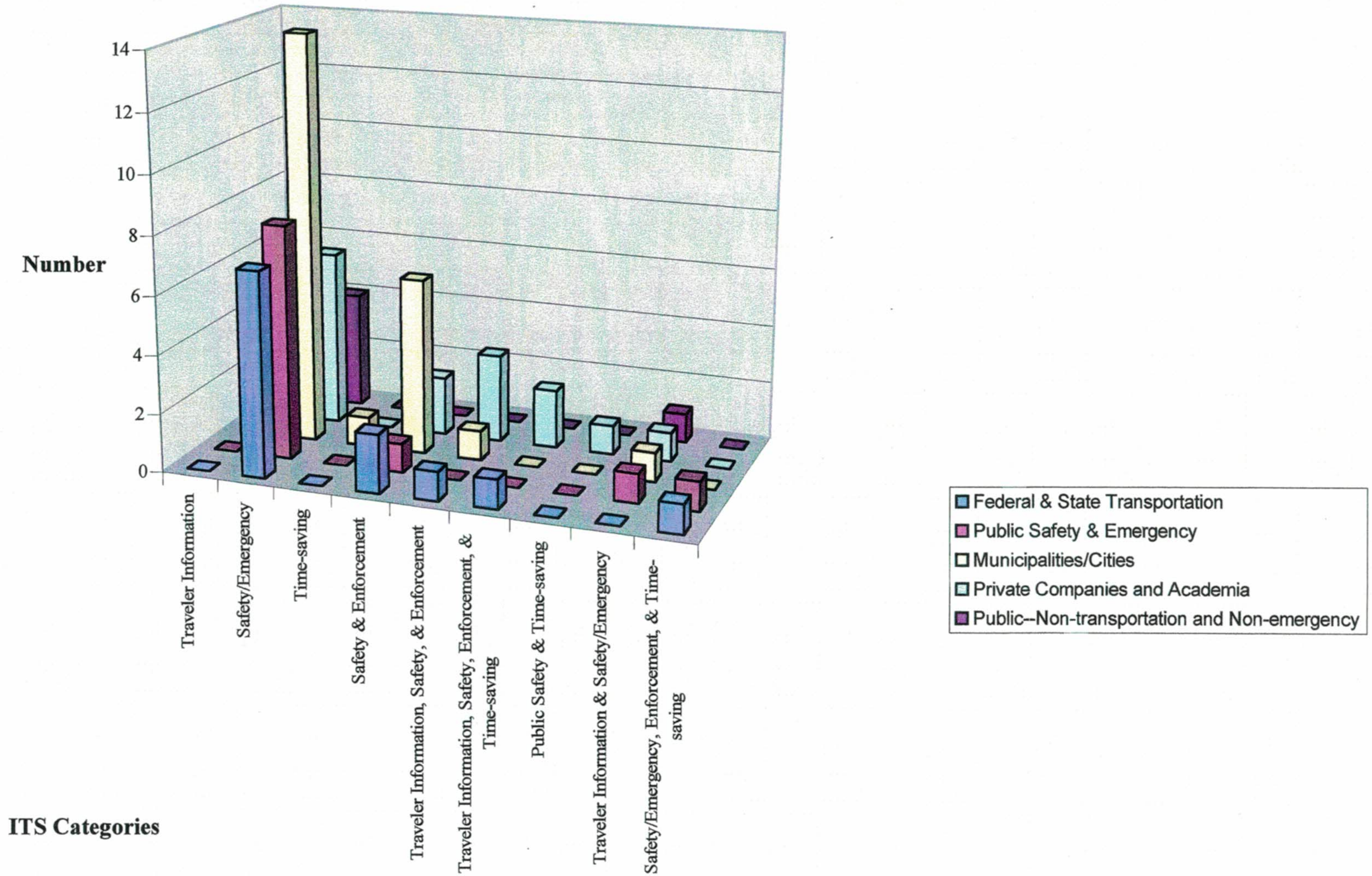

Figure 12. Utilized ITS Technologies by Type of Organization

public safety/emergencies and enforcement. Private companies and academia implemented a more diverse combination of technologies other than public safety/emergencies and enforcement.

Interestingly, respondents stated that they would like to work in a diverse combination of ITS technologies, especially those dealing with traveler information and safety. Public safety and traveler information was deemed high by Federal and State Transportation respondents. Public safety and emergency would rather implement a wide array of technologies especially those dealing with saving time and traveler information in addition to safety/emergencies. Municipalities and cities would rather have traveler information, safety, and enforcement. Public non-emergency and non-transportation would like to deploy public safety/emergency and traveler information technologies (Figure 13).

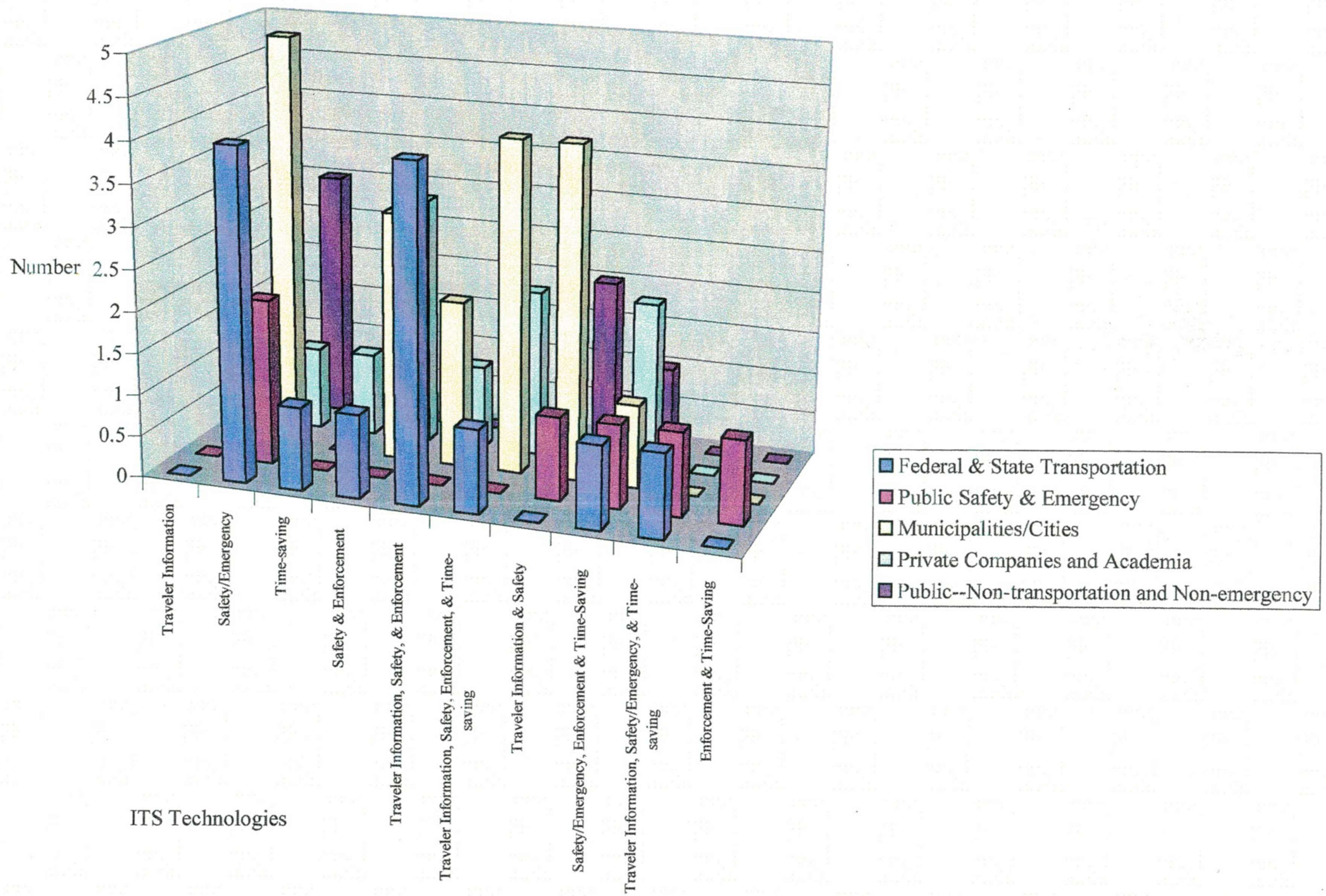

Figure 13. Potential ITS Technologies by Type of Oganization

DISCUSSION

Oklahoma's transportation system comprises just over 112,592 miles of highways and roads. The roads consist of three major interstates (I-40, I-44, and I-35), state highways (12,265 miles), toll roads (552 miles), park roads (310 miles), county roads (86,816 miles), and local city streets (12,647 miles) (*Personal Communication*, ODOT Division of Public Affairs, November 29, 1999). Travel demand, and its attendant problems and challenges in Oklahoma, is expected to increase over the next decade. To reduce or simply maintain the current levels of traffic congestion, new roads must be constructed or alternatives developed that improve the efficiency of the transportation system by increasing effective capacity. Utilizing ITS infrastructure can increase that effective capacity while ITS technologies can reduce the need for new roads (Peters, McGurrin, Shank, and Cheslow 1997).

ITS technologies are available and are at various levels of development and deployment. The purpose of this review has been to survey ITS applications throughout the nation at various levels of government. Many urban areas, especially the largest metropolitan areas, in the United States are implementing and utilizing ITS technologies. Rural ITS still remains a big challenge to implement. Oklahoma has three of the most heavily traveled interstate highways (I-40, I-44, and I-35) with numerous freight facilities for trucking businesses as well as air shipments. Small and medium size cities should take advantage of the ITS opportunities by leveraging funds the federal and state governments allocate and implement ITS by identifying needs, determining priorities, securing funds, and managing the implemented systems (Kothari and Mohaddes 1999).

The results of this study indicate that most respondents are interested in deploying ITS technologies in Oklahoma. The most obvious ITS technologies are the fiber optic cables that have been installed or are under contract for 940 miles of ODOT and OTA right-of-way. Completed installation encompasses I-35 from the Texas State line to north of Oklahoma City, on I-44 from Oklahoma City to Miami, and on U.S. 412 from Stillwater to Tulsa. In Oklahoma City, seven dynamic message signs have been installed and are operational via standard phone lines. Tulsa has proposed to install three signs.

One closed circuit television camera has been installed in Norman. Proposed plans are under way to install 12 cameras in Oklahoma City and five in Tulsa. In conjunction with the University of Oklahoma, ODOT has co-sponsored an ITS Integration Lab to assist in the development of ITS specifications, evaluate emerging ITS technologies, and to develop integration software to operate a prototype traveler information website.

Five areas of intelligent transportation can especially benefit, ATIS, APTS, ATMS, PTS, and CVO. The number of responses was low for technologies dealing with traveler information. Deploying the Advanced Traveler Information System (ATIS) could enhance traveler mobility and security, especially given that Oklahoma promotes tourism and the rich history of its diverse populations and places. In particular, delays can be reduced when ATIS is implemented.

ATIS features assist drivers to plan their trips by providing accurate, real-time information on such topics as routes, road conditions, and weather. Such information is needed to help drivers not getting lost and in reducing fuel consumption. Some of the technologies that can be deployed in conjunction with this technology include:

- Pre-trip traveler information
- Variable message signs (VMS)
- Wireless communication systems in emergencies
- Call-in systems for travelers
- Global Positioning Systems (GPS)
- Digital map displays
- Kiosks at transit stops
- Real time information on bus schedules and arrival times

Advanced Public Transportation Systems (APTS) provide additional safety and security to passengers by allowing remote monitoring of transit vehicle status and passenger activity, while Transit ITS services assist operators in maintaining fleets of vehicles. Through vehicle self-diagnostics, mechanics are alerted of potential problems or when a scheduled maintenance is due while automated vehicle location (AVL) and Computer Aided Dispatch (CAD) devices help operators to improve scheduling activities and to adhere to a given schedule. Advanced Public Transportation Systems (APTS) involve technologies that improve the safety, efficiency, and mobility of the traveling public, especially on transit vehicles. Technologies that can be deployed and integrated include the following:

- Automated vehicle location devices
- Variable message signs
- Traffic signal systems
- Call-in systems for transit operators
- Traffic signal systems that stop traffic early because of incoming trains
- Global Positioning Systems (GPS)
- Digital map displays
- Signal systems on arterials
- Signal coordination during special events
- Real time information on bus schedules and arrival times

Advanced Traffic Management Systems (ATMS) involve technologies geared to improving safety, reducing delay, and improving operational efficiency. Some of the technologies include closed circuit televisions, variable message signs, adjustable ramp meters, loop detectors, call-in systems for transit operators, GPS, digital map displays, signal systems on arterials, signal coordination during special events, and signal systems that can be adjusted from a traffic management center.

ATMS can work very closely with the technologies for the public transit systems. These technologies assist the traveling public and transit operators to utilize and operate a safe, smooth, and efficient transportation system. Variable message signs, real time information on bus schedules and arrival times, traffic signal systems that stop traffic early because of incoming trains, computer-aided dispatch, adjustable ramp meters, loop detectors, GPS, and digital map displays are some of the common ITS technologies.

Commercial vehicle operations (CVO) could benefit from the findings. Technologies that emphasize weigh-in-motion, e-commerce (through one-stop shopping centers), VMS, wireless communications, GPS, digital map displays, and roadside data need to be deployed and integrated. Electronic payment systems would particularly benefit the businesses, administrators, and drivers.

Oklahoma stands to gain by implementing ITS technologies. The Oak Ridge National Laboratory (ORNL) has a web site, www.ntrc.com/reslabs.html, that maintains information related to the deployment of ITS Infrastructure for the 75 largest metropolitan areas in the nation. Oklahoma City and Tulsa are included in these 75 metropolitan areas. ORNL tracks five areas: Freeway Management Systems (FMS), Advanced Public Transportation Systems (APTS), Central Traffic Signal Control Systems (CTSCS), Incident Management Programs (IMP), and Electronic Toll Collection (ETC) Systems. Oklahoma City has the ETC systems on the Turner Turnpike, H.E. Bailey Turnpike, and Kilpatrick Turnpike. It also has the Oklahoma City Traffic Control Center. Similarly, Tulsa has a Downtown Traffic Signal System and operates the Creek Turnpike, Will Rogers Turnpike, and the Muskogee Turnpike. This means that both cities need to develop FMS, APTS, and IMP.

Being one of the main transit corridors for international trade (I-35 corridor), Oklahoma is well advised to seriously engage in implementing ITS technologies. The benefits of ITS are obvious, including reduced operational and maintenance costs, cleaner environment, less congestion, rapid response to incidents, and reduced administrative costs. Transit and highway planners, builders, designers, and operators need to extend and integrate their ITS operations.

Of particular interest is that agencies involved with transportation planning have come to realize the importance of ITS. The Association of Central Oklahoma Governments (ACOG), in cooperation with ODOT, developed an ITS Early Deployment Plan (EDP) in 1999 for the Central Oklahoma Region with the primary goal being to implement an Incident Management and Traveler Information System (BRW 1999). Currently, ODOT, ACOG, and FHWA are working to establishing an ITS Steering Committee for the Oklahoma City Area Regional Transportation Study (OCARTS) area.

The Indian Nations Council of Governments (INCOG) in Tulsa is in the process of developing their ITS plan. Locally, computer-aided dispatch of public sector emergency vehicles, electronic surveillance of highway-rail intersections, and centralized or closed-loop controlled traffic signals have been deployed. Footings for future placement of closed circuit television have been constructed as part of other ODOT construction projects.

Four weigh stations are equipped and/or committed to install PrePass to allow commercial vehicles to bypass them, at OTC's discretion, if the vehicles are fitted with transponders and are pre-certified for safety/credential clearance. The locations are I-40 west-bound (WB) near El Reno, U.S. 69 north-bound (NB) and south-bound (SB) near Texas border, I-35 NB and SB near Davis, and I-35 NB and SB near Tonkawa.

RECOMMENDATIONS AND STRATEGIES

The results of this study suggest the need for new deployment and integration of existing ITS technologies. Seven recommendations have been made with regard to the findings, Statewide strategic plan, integrated ITS deployment, ITS education, leveraging public and private funds, establishing a Transportation Center, and developing regional cooperation.

Statewide Strategic Plan

Oklahoma must have a strategic plan before Federal funds could be used for ITS deployment or integration. Thus, a Statewide strategic plan is urgently needed to develop the vision, mission, strategic goals, and action items. The strategic plan should clearly identify roles stakeholders will play in the implementation of the plan.

Adequate resources should be earmarked for developing the strategic plan by a Statewide ITS Working Group that should consist of key stakeholders. Other than developing the strategic plan, this Working Group should also cultivate partnerships between and among both public and private interests. Resources should include financial, human, and physical resources. The fact that ODOT has recently appointed a person to coordinate ITS activities is now an excellent opportunity to take the development and implementation of the Statewide ITS strategic plan seriously. The ITS Coordinator, Ms. Ginger McGovern, from ODOT Planning Division, needs full support because she faces a formidable task if she is not allocated enough resources to carry out the work.

It would be helpful if the strategic plan includes the establishment of a central management center. Logistics of how the center could operate should be clearly identified.

Integrated ITS Deployment

If ITS deployment is to be successful, it must be integrated into future business plans and wherever applicable, existing ITS programs. The survey indicates that ITS technologies are largely deployed through the ingenuity of the people involved. No actual funds have been appropriated for ITS technologies. Therefore, for successful deployment to be realized, specific ITS line items should be included in annual budgets.

Apart from ITS programs and services budget issues, there is a need to look at integrating the existing technologies in a consistent manner. Existing technologies have been deployed as individual systems, therefore fragmenting the systems that are currently in place. Thus, a State ITS Architecture (standards) is needed to maximize the effectiveness of deployed individual systems, provide consistent services to customers, and to be compatible with national and other state systems to maximize efficiency and leverage funds.

Future deployment of ITS technologies should be carefully monitored. For example, related projects could be linked together. Before deploying new technologies, the existing technologies and projects should be analyzed to assure that new projects fit into the Statewide ITS architecture.

ITS Education

A general lack of knowledge on ITS exists even among the stakeholders. The study shows that not all departments/divisions within agencies and institutions have similar levels of understanding of the potential ITS benefits or the need for supporting ITS deployment and integration. Also, not all stakeholders that have a role in implementing ITS had the same levels of awareness or commitment to ITS. In some cases, senior management did not know the benefits ITS technologies would bring to the transportation industry. Thus, a concerted and organized strategy needs to be developed to inform and educate key personnel in the transportation industry, stakeholders, and the public about ITS and its benefits.

Senior-level managers and decision-makers at ODOT and other stakeholders should be informed on ITS benefits because they will make decisions on deployment of "new" technologies. Without their support, deploying or integrating ITS technologies would be an onerous exercise. In addition, ODOT personnel and other stakeholders should also have a working knowledge of ITS and ways it could fit into the mission of each unit.

The Governor plays an important role in making decisions that affect people's health and welfare. He has a Transportation Commission that needs to be better informed of ITS. As the Chief Executive Officer of the State, the Governor can either expedite or frustrate the efforts that could be made. The Transportation Commission, like the senior management in ODOT and other stakeholders, also needs to understand these new technologies. Successful deployment of ITS would require external funding other than Federal funds.

Policymakers and legislators are another group of individuals that need to be informed on the benefits of ITS technologies. As policymakers, their understanding of the common ITS technologies and benefits would equip them with knowledge to articulate the needs and request for appropriations to support future projects. It is crucial that policymakers are behind this initiative because without State matching funds, deploying and integrating ITS technologies would be difficult. They will play an important role in affecting whether and how ITS programs are implemented in the State.

The general public needs to be informed and educated on ITS and its benefits. The traveling public should have knowledge of what is available or possible. Citizens need to understand how ITS can benefit them in their every day travel, especially in terms of travel-time, safety, and better information about transportation choices. With clear information available, the work of the individuals who have been trying to implement some ITS technologies would be easier. How? The public themselves may begin to request these technologies. Once the public is behind an idea, it would be difficult for either management or policymakers not to take notice.

How could this proposal be carried out? Private and public meetings need to be scheduled with the sole purpose being to inform and educate the targeted audience with pertinent knowledge and information. Respective meetings can be held with senior management, the Transportation Commission, legislators, and the Governor. During these educational meetings the benefits and need for ITS, and the needed funding would be stressed.

Awareness seminars, workshops, and outreach meetings should be conducted to inform the general public about ITS and how ITS technologies could help them in their travel and in conducting business. Focus groups could be established. Parallel with the establishment of a Transportation Center (see below), training must be conducted in a way that emphasizes ITS benefits and the various ways ITS could serve the public.

The general public can be made aware of the locations of the meetings through a variety of media, including mail, newsletters, press releases, and outreach meetings. The media should be involved in publicizing success stories. Focus groups can assist in fine-tuning the needed technologies.

Funding

Funding will always be a challenge in an environment where new technologies are being deployed or integrated. All ITS projects funded with Federal highway trust funds must conform to the National ITS Architecture and applicable national standards. Also, all projects funded through the ITS Deployment Program must have at least 20 percent matching funds. In

Oklahoma, funds must be appropriated for ITS if the Statewide strategic plan is to be successful. Given that matching funds are needed in order to receive Federal funds, both private and local stakeholders should be encouraged to cooperate. The challenge would be to identify ITS projects that could be funded. The next challenge could be identifying sources of those funds. The most obvious source is the U.S. Department of Transportation, through its various agencies including the Federal Highway Administration (FHWA), Federal Transit Administration (FTA), and National Highway Traffic Safety Administration (NHTSA). When the strategic plan is in place, Congresspersons should be contacted to support earmarking Federal funds for Oklahoma. Congresspersons will need to be informed and educated about the potential benefits ITS will bring to the State. ODOT should set aside funds for ITS and make ITS deployment and integration part of its strategic plan and annual appropriations.

TEA-21 encourages partnerships among stakeholders, therefore, private sources have to be identified. The State, through the Office of the Governor and the Legislature, must be encouraged to allocate funds for deploying and integrating ITS technologies. As stated above, representatives must be informed about ITS technologies and their benefits, and about how leveraging resources would mean commitments of fewer resources on each partner.

Private funding is imperative if the exercise is going to be successful. Particularly, stakeholders that participated in this study should be followed up for their financial support. They are already spending funds in deploying their technologies. Those who have not participated should be informed about the benefits and asked for their support.

One way of leveraging private funds would be to link new projects with some other programs such as the Congestion Mitigation Air Quality Improvement Program (CMAQ). Since such programs already exist, ways must be identified through which the provisions could be used to support ITS deployment and/or integration. For example, San Francisco, California established a freeway patrol in August 1992 under the Federal-Aid Congestion Mitigation and Air Quality Improvement Program. The program has helped in decreasing air pollution and fuel consumption by helping to reduce the impact of incident-caused congestion, vehicle idling, and start-and-stop travel. It has been estimated that the program has reduced hydrocarbons by 32 kg/day, carbon monoxide emissions by 322 kg/day and nitrogen oxides by 798 kg/day (U.S. Department of Transportation 1996). The City of Tulsa has a CMAQ project.

Transportation Center

The study indicates that general knowledge of ITS is lacking in Oklahoma. There is a need to establish a Transportation Center to deal with transportation-related issues through research, training, and outreach. It would be the centralized location containing the database for all the Statewide ITS initiatives. Transportation education, including ITS education, could be handled by the Transportation Center. The Center would develop expertise and build capacity for ITS. Presently, no place exists in Oklahoma where questions relating to ITS could be answered. The Center could be used to inform, educate, and encourage stakeholders (existing and potential) as well as the public to participate in ITS activities.

Regional Cooperation

Oklahoma is strategically located in the "center" of this nation. It is an important corridor for interstate trade. For example, I-35 is an important route not only for interstate trade but also for international trade. Oklahoma could greatly benefit from the ITS-related activities arising from the North American Free Trade Agreement (NAFTA) from operations taking place in both Mexico and Canada. Also, I-40 runs through the State from east to west. This stretch connects the eastern part of the country to the western part, or vice versa.

Of particular interest here are the commercial vehicle operations (ITS/CVO). By cooperating with Kansas and Texas, states that presently have strategic plans, Oklahoma can be a catalyst in developing regional cooperation. ITS initiatives for advanced commercial vehicle services including electronic screening, weigh-in-motion, safety assurance, credentials administration, and carrier operations, would streamline operations and reduce idling. Also, a one-stop shopping center is needed to coordinate various paper work that would develop as a result of implementing new programs and projects. Oklahoma could join the ITS Heartland cooperative agreement which already includes Kansas, Missouri, Iowa and Nebraska.

POSSIBLE CHALLENGES

As with any new ideas and philosophy, implementing ITS in Oklahoma has its own constraints or challenges. Challenges include dealing with differing objectives of the stakeholders, trust, public involvement, buy in by management and policymakers, resistance to change, and lack of funding.

Differing Objectives

Bringing together different stakeholders that have differing missions and objectives would be a big challenge. The challenge could be reduced if and when each stakeholder understands the missions of other stakeholders. Clear policies on intellectual property and assignment of roles according to the strengths of the partners involved are needed. More time will be needed to develop partnership with others, some of whom might be competitors for the same scarce resources.

Building Trust

If the partnership is to be successful, it should be given time to develop. It takes familiarity and exposure to develop meaningful relations. It takes even longer to build a trusting relationship. One way of creating trust is to recognize individual strengths that are brought together. Clear mission, objectives, and action items might help to develop a successful partnership.

Incentives should be provided in order for stakeholders to feel they are wanted and their contributions valued by the other stakeholders. Roles must be carefully assigned. When something good happens, the particular events must be celebrated and recognized. The media should be involved to publicize these events.

Public Involvement

Since Oklahoma is largely a rural State, public transportation is not high on most agendas. Therefore, the public is not aware of the benefits of pooling resources together or using public transit or transportation systems. The challenge is to get the general public to participate in the use of ITS technology. The public should be reached through research, ITS education, and outreach.

Sometimes the problem is not necessarily due to public non-involvement. Lack of public participation could be due to general disinterest by the staff of the stakeholders. Therefore, just as it is imperative for management to buy in on the deployment and integration of ITS technologies, the staff of all stakeholders should also be actively involved.

Organizational Changes

Trying something new is always threatening. ITS deployment and implementation is no exception. Organizational changes are inevitable. Championing the "cause" for ITS is needed. Therefore, a coordinator whose main function is ITS business is needed. The fact that ODOT has appointed a person to spearhead ITS efforts is a good beginning. As coordinator, the ITS person must increase the visibility of ITS in the region and agency, develop skills and staffing requirements, and recognize training needs. Given that ITS involves new technologies the coordinator must sell the ideas to management so they could participate in ITS activities.

Funding

Funding will always be a challenge in any new endeavor. Given that federal funding for the deployment and integration of ITS technologies requires matching (at least 60% from other federal sources and 40% from non-federal sources) partnerships with private sectors is a must. Rural areas should be integrated into new projects. Federal funding requires at least 10% of the funds going to rural ITS.

CONCLUSION

ITS technologies are being successfully integrated in many states with existing conventional and operational systems. Deployment of ITS technologies will continue to expand throughout the nation. ITS technologies help to reduce many transportation problems associated with congestion, lack of mobility and accessibility, presence of disconnected transportation modes, budgetary constraints, spasmodic emergencies and crashes, injuries and fatalities. As projects are considered for implementation, it is wise to rationalize them in an operational (daily), tactical (short-term), and strategic (long-term) fashion. Implementation should show how ITS technologies might complement the existing transportation infrastructure. This kind of strategic posture, in terms of ITS implementation, requires both incremental investment and long-term vision, both of which are endorsed by the planning process and by the National ITS architecture and infrastructure.

Opportunities exist especially in the development of multi-state deployment of ITS/CVO. Such deployment would benefit Oklahoma, in terms of cost savings and efficient delivery of services; especially the motor carrier industry and state agencies that administer motor carrier programs. This saving can be done through electronic screening and automated credentialing. It would be necessary to involve other stakeholders, such as representatives of state, county, and city transportation agencies, emergency and law enforcement agencies, elected officials, professional drivers, business, and community leaders as has been developed for the Knoxville Urban Area in Tennessee (Havinoviski, Loveday, Welch, and Begg 1999). Several state departments of transportation have started developing statewide management and information systems for current and planned deployment of ITS. For example the Colorado Department of Transportation intends to develop a system that will allow more efficient use of existing freeway and arterial capacity; improve driver information and safety; reduce delays, fuel consumption, and pollution; and make efficient use of personnel resources (Dye and Brookes 1999).

ITS technologies are available in Oklahoma and are being individually deployed by interested organizations and agencies in order to increase safety, mobility, efficiency, and security of the travelers and operators. Oklahoma is a recognized leader in turnpike electronic systems. Given that Oklahoma is the home of the National Weather Service (NWS), an outstanding ITS initiative can be developed for the public by including the NWS and media in the process of developing ITS in the State.

The USDOT/FHWA is interested in deploying and implementing ITS around the nation. States that have been very active in ITS, such as Minnesota and Virginia, have had several projects completed. Many stakeholders in Oklahoma are interested in ITS. In order to receive Federal funds for deployment of ITS, a strategic plan is needed. A Working Group, composed of managers, technical staff, and others, is urgently needed to spearhead the development of the strategic plan. A strategic plan will clearly identify a common vision, mission, goals, and objectives. It will also identify resources to be utilized.

As was expected, rural areas have not benefited much from the deployment of ITS technologies. They will not likely get involved if a conscious effort is not extended to them once the Working Group begins to develop and implement the ITS strategic plan. By including rural ITS in its plan, Oklahoma would benefit by attracting additional funds for deployment of ITS technologies. The current emphasis by the USDOT/FHWA is on integration of existing technologies.

Several obstacles will have to be resolved in order to develop and implement a Statewide strategic plan, but many stakeholders are willing to work together. The identified constraints can be opportunities. This study has highlighted some strategies that can be used to resolve the constraints. Another important issue the State will have to contend with would be the adoption of a State ITS Infrastructure. Although national standards are available, experience from other states indicates that tailoring those standards to local (State or regional) standards is not always easy.

ITS education is imperative and badly needed in Oklahoma. This is the opportune time to begin informing and educating policymakers, decision makers, and the public about benefits ITS brings to the traveling public, operators, and businesses. By making transportation systems safer, smoother, more efficient, and more productive, and the environment cleaner, ITS technologies should be adopted, wherever possible.

The Governor, as the Chief Executive Officer of the State, has an important role in the development of ITS in Oklahoma, therefore, his office and the Transportation Commission must be involved. They can allocate resources that can be used to match Federal resources. But first, the Governor and the Commission must be informed and educated about the benefits ITS can bring to the State—not only in terms of a smoother and safer transportation system, but also more interstate, regional, and international commerce and trade.

LIMITATIONS OF THE STUDY

This study was conducted to understand the extent of the availability and use of, as well as the potential for deploying and integrating ITS technologies. The limitations stem from the sampling frame. It would have been good to receive input from smaller cities—cities that had less than 5,000 population. Thus, the study seems to be biased towards larger cities. On the other hand, bigger cities are the ones that have or are in the process of deploying ITS technologies.

The respondents were mainly those involved in the transportation industry. Although these are the main stakeholders to benefit from implementing ITS technologies, it would have been better had other non-emergency and non-transportation stakeholders responded to the questionnaire.

In addition, this research calls for further work in understanding ITS in Oklahoma, especially in regard to understanding the major obstacles to ITS implementation. We recommend that this work be done, especially among senior management personnel.

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APPENDIX

INTELLIGENT TRANSPORTATION SYSTEMS (ITS) OPPORTUNITIES FOR OKLAHOMA

Name of the Organization: ______________________________

Person answering questions: ______________________________

Title of Person answering questions: ______________________________

1. Which of the following best describes your organization?

- ❑ State government
- ❑ City/County government
- ❑ Rural community planning
- ❑ Metropolitan planning
- ❑ Transit
- ❑ Toll authority
- ❑ Emergency management service
- ❑ Parking operation
- ❑ Vehicle original equipment manufacturer and supplier
- ❑ Communication
- ❑ Contracting, Integrating, and/or Consulting
- ❑ Traveler information service providing and reselling
- ❑ U.S. Department of Transportation
- ❑ Federal agency/department
- ❑ ITS America State and Regional Chapter
- ❑ Commercial Transport
- ❑ Other (specify) ______________________________

2. Which of the following best describes your business? (Choose all that apply.)

- ❑ Public agency
- ❑ Private agency
- ❑ Academia
- ❑ Communications
- ❑ Emergency
- ❑ Public Safety
- ❑ Other (specify)____________

3. Is your organization familiar with the term "Intelligent Transportation Systems" (or ITS)?

- ❑ Yes
- ❑ No
- ❑ Somewhat Familiar

4. What kind of ITS technologies does your organization currently manufacture, research, and/or use? (Choose all that apply.)

- ❑ Kiosks at transit stops
- ❑ Real time information on bus schedules and arrival times
- ❑ Pre-trip traveler information, e.g., Internet Home page and updates information on current traffic flow
- ❑ Closed circuit television and loop detectors
- ❑ Loop detectors
- ❑ Digital map displays of 911 calls
- ❑ Call-in systems for travelers or transit operators
- ❑ Wireless communication systems used in emergencies
- ❑ Global Positioning Systems onboard buses, cars, and trucks using Mayday systems
- ❑ Computers that identify in-vehicle transponders at toll plazas
- ❑ Adjustable ramp meters
- ❑ Variable message signs
- ❑ Signal systems on arterials
- ❑ Automatic vehicle location devices
- ❑ Computer-aided dispatching systems
- ❑ Equipment on emergency vehicles that hold through-street lights green
- ❑ Signal coordination that respond to special event centers
- ❑ Signal systems that can be adjusted from a traffic management center
- ❑ Photo enforcement of grade-crossing and red-light violations
- ❑ Video recording enforcement of toll violations
- ❑ Traffic signal systems that stop traffic early because of incoming trains
- ❑ Systems that detect vehicles that illegally cross barriers onto rail tracks
- ❑ Systems that detect vehicles that illegally cross toll facilities
- ❑ Smart cards that encode credits or credit cards used to pay bus and park-and-ride lot fares
- ❑ Smart fareboxes that record riders and bill employers for employee transit use
- ❑ Weigh-in-motion devices linked to computers to clear trucks in advance
- ❑ Electronic pre-clearance systems to verify registration, safety, and other credentials
- ❑ In-vehicle sensors to measure relative speed and distance of lead vehicle
- ❑ Intelligent cruise control
- ❑ Fiber optics
- ❑ All of the above
- ❑ Other (specify) ______________________________

5. What are your major goals in using ITS technologies?

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6. Would your organization like to research, manufacture, or deploy (use) ITS technologies?

- ❑ Yes
- ❑ No
- ❑ Maybe
- ❑ Do not Know

7. Regardless of the source, if funding were available, would your organization be interested in researching, manufacturing, or deploying (using) ITS technologies?

- ❑ Yes
- ❑ No (Go to Question 9)
- ❑ Not Sure (Go to Question 9)

8. If "Yes", which of the following technologies would you like your organization research, manufacture, or deploy (use)? (Choose all that apply.)

- ❑ Kiosks at transit stops
- ❑ Real time information on bus schedules and arrival times
- ❑ Pre-trip traveler information, e.g., Internet Home page and updates information on current traffic flow
- ❑ Closed circuit television and loop detectors
- ❑ Loop detectors
- ❑ Call-in systems for travelers or transit operators
- ❑ Digital map displays of 911 calls
- ❑ Wireless communication systems used in emergencies
- ❑ Global Positioning Systems onboard buses, cars, and trucks using Mayday systems
- ❑ Computers that identify in-vehicle transponders at toll plazas
- ❑ Adjustable ramp meters
- ❑ Variable message signs
- ❑ Signal systems on arterials
- ❑ Automatic vehicle location devices

- ☐ Computer-aided dispatching systems
- ☐ Equipment on emergency vehicles that hold through-street lights green
- ☐ Signal coordination that respond to special event centers
- ☐ Signal systems that can be adjusted from a traffic management center
- ☐ Photo enforcement of grade-crossing and red-light violations
- ☐ Video recording enforcement of toll violations
- ☐ Traffic signal systems that stop traffic early because of incoming trains
- ☐ Systems that detect vehicles that illegally cross barriers onto rail tracks
- ☐ Smart fareboxes that record riders and bill employers for employee transit use
- ☐ Smart cards that encode credits or credit cards used to pay bus and park-and-ride lot fares
- ☐ Weigh-in-motion devices linked to computers to clear trucks in advance
- ☐ Electronic pre-clearance systems to verify registration, safety, and other credentials
- ☐ In-vehicle sensors to measure relative speed and distance of lead vehicle
- ☐ Intelligent cruise control
- ☐ Fiber optics
- ☐ All of the above
- ☐ Other (specify) ______________________________

9. Does your organization feel there is a need to employ ITS technologies in Oklahoma?

- ☐ Yes
- ☐ No
- ☐ Do Not Know

10. What type of information or product would you be interested in receiving or providing through partnerships with other stakeholders with like interests? (Choose all that apply.)

- ☐ Commercial vehicle operation
- ☐ Transit safety and traveler information
- ☐ Emergency response management
- ☐ Freeway management
- ☐ Incident management
- ☐ Electronic toll collection
- ☐ Electronic fare payment
- ☐ Regional multimodal traveler information
- ☐ Credentials administration
- ☐ Electronic screening
- ☐ Carrier operations
- ☐ Safety assurance
- ☐ Emergency services
- ☐ Public travel and mobility services
- ☐ Fiber optics
- ☐ Other (specify) ______________________________

11. Considering <u>only</u> your particular area of expertise and work, what initiatives would you like to see implemented in ITS? (Choose all that apply.)

___ Reducing accidents
___ Reducing fatalities
___ Reducing personal injury
___ Reducing pain and suffering
___ Reducing anxiety and stress of driving
___ Maximizing efficiency of existing infrastructure investment
___ Achieving smooth traffic flow
___ Developing affordable equipment, vehicles, infrastructure, operations, maintenance, and user fees
___ Reducing fuel consumption, maintenance, labor, wear-and-tear, and property damage costs
___ Using public/private partnerships for shared risk
___ Improving employee on-time performance
___ Facilitating on-time deliveries
___ Providing real-time information
___ Increasing customer access by improving public transportation services
___ Increasing revenue
___ Reducing delays and travel time
___ Making driving accessible to disabled drivers
___ Reducing emissions
___ Providing reliable and lower cost transit
___ Developing a base for alternative fuel vehicles
___ Providing information on alternate routes and weather conditions
___ All the above
___ Other (specify) ____

12. Your organization is considered as one of the stakeholders in the implementation of ITS in Oklahoma. We would like to strengthen connections among cities and counties research institutions, private vendors, and public agencies. Would your organization be interested in working with others to develop a ITS Strategic Plan for Oklahoma?

- ❑ Yes
- ❑ No (Go to Question 15)

13. If "Yes", will you be the contact person?

- ❑ Yes
- ❑ No
- ❑ Do Not Know

14. If "No", who will be the contact person? ____________________

What is his or her title? ____________________

What is his or her telephone number? ____________________

15. If "No", why doesn't your organization want to participate in this project

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Thank You for Your Time and Answers