Technical Report Documentation Page

1. Report No. FHWA/TX-13/0-6672-2-Vol-1	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle RESEARCH TO DEVELOP AN ITS STRATEGIC PLAN FOR TEXAS		5. Report Date Published: April 2014
		6. Performing Organization Code
7. Author(s) Ed Seymour, Beverly Kuhn, Kevin Balke, Nadeem Chaudhary, Debbie Jasek, Rajat Rajbhandari, Tony Voigt, Kristine Miller, Tina Geiselbrecht, and Steven Venglar		8. Performing Organization Report No. Report 0-6672-2-Vol-1
9. Performing Organization Name and Address Texas A&M Transportation Institute College Station, Texas 77843-3135		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. Project 0-6672
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Implementation Office 125 E. 11th Street Austin, Texas 78701-2483		13. Type of Report and Period Covered Technical Report: October 2010–August 2013
		14. Sponsoring Agency Code

15. Supplementary Notes
Project performed in cooperation with the Texas Department of Transportation and the Federal Highway Administration.
Project Title: Developing an ITS Strategic Plan for Texas
URL: http://tti.tamu.edu/documents/0-6672-2-Vol-1.pdf

16. Abstract
TxDOT's mission is to provide safe and reliable transportation solutions for the citizens of Texas. Intelligent transportation systems (ITS) can play a pivotal role in meeting that mission. TxDOT can take advantage of advanced and emerging technologies to enhance safety and promote reliability by ensuring that travelers see the transportation network as a seamless system that helps get them to their destinations and deliver goods and services to the citizens of Texas with as little disruption as possible. ITS is a critical component of the transportation infrastructure that helps ensure the system operates in the most efficient way possible every day, every night, and during all types of situations and weather conditions. TxDOT has four primary goals related to meeting its mission. These goals are: maintain a safe system, address congestion, connect Texas communities, and become a best-in-class state agency. The agency cannot hope to successfully meet these goals without ITS in its arsenal of strategies to advance transportation across the state. This report documents the research that was undertaken to develop the ITS Strategic Plan for Texas. This research included an assessment of current U.S. trends in ITS and related initiatives, interviews with ITS stakeholders across Texas to determine needs, and a peer state review. The plan provides a framework to guide the development and deployment of an integrated statewide program for Intelligent Transportation Systems. The Texas Transportation Commission, TxDOT, as well as the broad community of ITS providers, stakeholders, and agency partners, will use this plan to promote the development, deployment, and use of ITS statewide. If this plan is to succeed, it needs the cooperation of all affected groups involved in ITS and transportation planning, design, funding, and implementation in the state.

17. Key Words ITS Initiative, Stakeholder, 511 Deployment, Performance Monitoring, Aggregation Level, Data Filtering, Data Imputation, Data Provision, Map Matching, Accuracy Check, Light Flow, Connected Vehicle Initiative		18. Distribution Statement No restrictions. This document is available to the public through NTIS: National Technical Information Service Alexandria, Virginia 22312 http://www.ntis.gov	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 174	22. Price

Form DOT F 1700.7 (8-72)Reproduction of completed page authorized

RESEARCH TO DEVELOP AN ITS STRATEGIC PLAN FOR TEXAS

by

Ed Seymour, Ph.D., P.E.
Associate Director

Beverly Kuhn, Ph.D., P.E.
Senior Research Engineer

Kevin Balke, Ph.D., P.E.
Research Engineer

Nadeem Chaudhary, Ph.D., P.E.
Senior Research Engineer

Debbie Jasek
Research Specialist

Rajat Rajbhandari, Ph.D., P.E.
Associate Research Engineer

Tony Voigt, P.E.
Research Engineer

Kristine Miller
Associate Transportation Researcher

Tina Geiselbrecht
Associate Research Scientist

Steven Venglar, P.E.
Research Engineer

Report 0-6672-2-Vol-1
Project 0-6672
Project Title: Developing an ITS Strategic Plan for Texas

Performed in cooperation with the
Texas Department of Transportation
and the
Federal Highway Administration

Published: April 2014

TEXAS A&M TRANSPORTATION INSTITUTE
College Station, Texas 77843-3135

DISCLAIMER

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation.

This report is not intended for construction, bidding, or permit purposes. The engineer (researcher) in charge of the project was Edward Seymour, P.E. #50413.

The United States Government and the State of Texas do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

ACKNOWLEDGMENTS

This project was conducted in cooperation with the Texas Department of Transportation and the Federal Highway Administration. The authors appreciate the guidance provided by the Project Director Carol Rawson and the Project Monitoring Committee team: Natalie Bettger, Stuart Corder, Rick Cortez, Brian Fariello, Charlie Farnham, Edgar Fino, Meg Moore, and Jack Whaley.

TABLE OF CONTENTS

Page

LIST OF FIGURES

LIST OF TABLES

Page

EXECUTIVE SUMMARY

TxDOT's mission is to provide safe and reliable transportation solutions for the citizens of Texas. Intelligent transportation systems (ITS) can play a pivotal role in meeting that mission. TxDOT can take advantage of advanced and emerging technologies to enhance safety and promote reliability by ensuring that travelers see the transportation network as a seamless system that helps get them to their destinations and deliver goods and services to the citizens of Texas with as little disruption as possible. ITS can also help support the values of TxDOT that are cornerstones of its philosophy: trust, integrity, responsibility, excellence, and service. ITS is a critical component of the transportation infrastructure that helps ensure the system operates in the most efficient way possible every day, every night, and during all types of situations and weather conditions.

TxDOT has four primary goals related to meeting its mission. These goals are: maintain a safe system, address congestion, connect Texas communities, and become a best-in-class state agency. The agency cannot hope to successfully meet these goals without ITS in its arsenal of strategies to advance transportation across the state. This document provides a framework to guide the development and deployment of an integrated statewide program for intelligent transportation systems. The Texas Transportation Commission, TxDOT, as well as the broad community of ITS providers, stakeholders, and agency partners will use this plan to promote the development, deployment, and use of ITS statewide. If this plan is to succeed, it needs the cooperation of all impacted groups involved in ITS and transportation planning, design, funding, and implementation across the state. The TxDOT ITS Strategic Plan 2013, which is Volume 2 of this document and an outcome of this research project:

- Provides concise ITS strategic plan goals and objectives for TxDOT.
- Highlights the ITS priorities from the regional and local perspective.
- Summarizes national trends in ITS strategies.
- Presents a status report on regional ITS in Texas.
- Introduces anticipated ITS services that TxDOT may need in the future.
- Presents a candidate ITS archetype as potential guidance for moving forward with ITS across the state.

Initially, the researchers evaluated the presence of intelligent transportation systems for all 50 states and five U.S. territories. Of the 55 locations studied, evidence of statewide ITS architecture was found in 36. The research team then conducted interviews with stakeholders in various regions across Texas, including TxDOT district staff, municipal staff, and representatives from metropolitan planning organizations, transit agencies, and other agencies involved in transportation, including police and fire departments, public works, the Department of Public Safety (DPS), and U.S. Customs and Border Protection. Stakeholders were provided with maps showing current and potential TxDOT ITS implementation and coordination. Using information gathered from previous stakeholder interviews, researchers developed a sample ITS archetype, presented it to stakeholders, and discussed their concerns and perspective relative to their region. One candidate ITS scenario brought to stakeholders to consider is consolidation of the operations of core TxDOT ITS functions into six primary traffic management centers (TMCs).

In this scenario, the primary TMCs would be located in strategic metropolitan areas—Dallas, Fort Worth, Houston, San Antonio, El Paso, and Amarillo—and would assume responsibility for operating ITS devices on state-supported highway/freeway facilities and neighboring districts, primarily after regular business hours or as preferred by the districts. Local TxDOT district traffic management personnel would have the ability to remotely operate the ITS devices within their districts for specific traffic management purposes (such as local support of traffic incidents or special events), but the primary TMC would maintain responsibility for the day-to-day operation of the TxDOT ITS. TxDOT Traffic Operations Division will be responsible for overseeing TxDOT's ITS programs, projects, equipment, and agreements statewide. With this role for TxDOT, local partners would be responsible for developing pre-trip planning and non roadway-based traveler information systems (such as 511, social media, etc.). Local partner agencies would also be responsible for maintaining their current responsibilities for operating and maintaining traffic signal systems and other traffic management systems, and developing, operating, and maintaining their own ITS/traffic management infrastructure and maintaining transit ITS. It is important to note that this archetype is only one potential concept of how the primary and supported districts could be aligned, and TxDOT would need to consider current operating strategies and partnerships before settling on a final conceptual framework.

Stakeholders at the follow-up interviews were asked several questions about this scenario, including:

- Would this be effective for your region?
- Is there a different way to structure it that would be more beneficial to you?
- How do you see your organization fitting into this structure?
- What would be your preferences in how this structure functions?

There was a general consensus among stakeholders to move primary centers to urban areas, in terms of equipment and after-hours staffing capability, as long as there is coordination with local agencies and partners. Doing so would make efficient use of resources and limited funding. Many of the responses were similar to those received in the previous interviews:

- Agencies found their existing ITS infrastructure to be useful to accomplish a number of ITS services.
- Agencies with ITS infrastructure desired to fill in the gaps in their deployment and complete the build-out of their systems.
- Many agencies did not have dedicated funding for ITS and they desire budgets adequate for the ITS services they are to provide.
- The desire for additional ITS services is tempered by funding and staffing limitations.

The following summarizes the other responses gathered from follow-up interviews with respect to consolidating core ITS functions and the example business scenario:

- Local needs should be the local partner's responsibility, particularly in matters regarding prioritizing local work zones or incidents, how video data can be shared, and operations and maintenance staff chain of command.
- There is a clear desire to have a regional vision for what constitutes a successful ITS system and to have the appropriate people empowered with decision-making authority to effectively manage that system.
- Clear communication between partners is very important. A clear, detailed communication plan, or standard operating procedure manual, between the primary TMC and local partners should be in place, and it should clearly define when and under what circumstances local staff will take "control" of ITS, as well as agreements for two-way communication.

- The Traffic Operations Division must have enough staff in place if it plans to approve and handle all ITS procurement activities.

Many stakeholders felt that regionalization made sense for their area/district because there would be more consistency and potentially more cost savings, which would ultimately lead to more funding for ITS, though many questions remained regarding how the proposed regionalization would be implemented. During the follow-up interviews, researchers also asked stakeholders what additional ITS services they would like if funding was not a concern. There was an overall willingness to consider additional ITS services throughout the state, and many regions would like to expand their ITS.

TxDOT cannot hope to successfully meet its goals without ITS in its arsenal of strategies to advance transportation across the state. For example, maintaining a safe system translates into reducing crashes and fatalities, reducing the likelihood of crashes and those involving transportation workers, and helping facilitate safe evacuation efforts in the event of emergencies. ITS in its various forms can help address these safety challenges. Congestion continues to grow on Texas' urban and suburban roadways. Regions can work to grapple with this problem by deploying ITS solutions that help optimize the existing infrastructure and make the most of every square foot of pavement and every installed device that help manage traffic. Furthermore, ensuring that ITS is part of the connectivity between communities can help foster collaboration and efficient use of the infrastructure along major corridors that serve key regions of the state and beyond. Finally, incorporating ITS into every aspect of TxDOT's traffic management approach helps ensure that every tax dollar from the citizens of Texas is used to optimize the valuable assets in the transportation system and help TxDOT be a forward-thinking and proactive agency that promotes the development and deployment of innovative traffic management concepts and technologies to take Texas into the future and meet the challenges and demands of a growing population. This ITS Strategic Plan can help advance TxDOT in achieving its strategic plan both now and in the future.

CHAPTER 1:
PROJECT OVERVIEW

The Texas Department of Transportation's (TxDOT's) mission is to provide safe and reliable transportation solutions for the citizens of Texas. Intelligent transportation systems (ITS) can play a pivotal role in meeting that mission. TxDOT can take advantage of advanced and emerging technologies to enhance safety and promote reliability by ensuring that travelers see the transportation network as a seamless system that helps get them to their destinations and deliver goods and services to the citizens of Texas with as little disruption as possible. ITS can also help support the values of TxDOT that are cornerstones of its philosophy: trust, integrity, responsibility, excellence, and service. ITS is a critical component of the transportation infrastructure that helps ensure the system operates in the most efficient way possible every day, every night, and during all types of situations and weather conditions.

SCOPE AND PURPOSE

The purpose of this project was to provide research and technical assistance to TxDOT to develop a strategic plan for TxDOT's ITS program. Thus, the research team undertook a variety of tasks to assess the state-of-the-practice nationwide regarding ITS deployments and programs, define the ITS needs of peer states and TxDOT districts and stakeholders, and identify ITS strategic plan solutions for TxDOT for the future. This report documents the research completed to accomplish this objective.

DOCUMENT OVERVIEW

This document is divided into thirteen chapters that discuss in detail the results of the study and the critical issues and findings related to the development and sustainability of an ITS strategic plan for Texas. The titles of the chapters along with major topics covered are highlighted below.

- **Chapter 1—Project Overview:** Provides an overview of the document, including its scope and purpose.

- **Chapter 2—U.S. State DOT Trends in ITS Strategies:** Discusses the state of the ITS industry and provides a reference point that was used in soliciting ITS strategic plan inputs from stakeholders in Texas.
- **Chapter 3—Private-Sector Data:** Provides a summary of trends in private-sector data, its providers, and its potential use in ITS deployments.
- **Chapter 4—Connected Vehicle Initiatives:** Introduces the connected vehicle initiative emerging in the U.S. and how it may play a role in ITS in Texas.
- **Chapter 5—State of ITS Deployment in the U.S. and Anticipated ITS Services:** Summarizes the current state-of-the-practice in ITS deployments in the United States, including various ITS services, the status of traffic signals within the ITS context, and the status of ITS communications infrastructure.
- **Chapter 6—Emerging Technologies and National Trends:** Describes emerging technologies and national trends in this area that either are currently having or will have an impact on the delivery of ITS services.
- **Chapter 7—Peer State Review:** Includes a review of the ITS programs in nine peer states garnered through interview with key ITS personnel.
- **Chapter 8—Funding, Procurement, and Partnerships:** Examines funding and financing options for ITS, alternative procurement mechanisms, and innovative partnerships, including privatization, public-public partnerships, and public–private partnerships.
- **Chapter 9—Regional Needs Meetings with TxDOT Staff and Stakeholders:** Summarizes the results of the various regional needs meetings held across the state with TxDOT staff and stakeholders to help identify the future direction of ITS in Texas.
- **Chapter 10—Draft Vision for ITS in Texas:** Presents a draft set of ITS plan elements for consideration by TxDOT derived from stakeholder interviews and the assessment of current needs and the future direction of ITS in their operating venues.
- **Chapter 11—Follow-up Interviews with TxDOT Staff and Stakeholders:** Summarizes the results of follow-up interviews with TxDOT staff and stakeholders where individuals provided feedback to the draft ITS strategic plan and a sample archetype for future ITS operations in Texas.

- **Chapter 12—Development of the ITS Strategic Plan for Texas:** Describes the process the research team took to develop the ITS Strategic Plan for Texas.
- **Chapter 13—Final Remarks:** Provides closing remarks for the research project.

CHAPTER 2:
U.S. STATE DOT TRENDS IN ITS STRATEGIES

INTRODUCTION

This project includes a review of state trends in intelligent transportation systems strategic planning as part of the assessment of the state of the ITS industry. As part of this review researchers collected information from each state and summarized the experiences from 27 states. They also examined a United States Department of Transportation (U.S. DOT) report that documents best state practices related to ITS strategic planning. This chapter summarizes those findings in a form that will be useful for TxDOT and its partners in developing an ITS strategic plan.

After reviewing these documents, the researchers created summaries of key information including the following:

- Key information about ITS strategic planning, including the types of stakeholders who were involved and the time horizon of the planning activity.
- Overall scope of the public outreach activities performed by the states including ITS websites, implementation of 511 services, and branding of the ITS initiative.

SUMMARY OF STATEWIDE ITS PLANNING

Researchers evaluated the presence of intelligent transportation systems for all 50 states and five U.S. territories. Of the 55 locations studied, evidence of statewide ITS architecture was found in 36.

- Twenty-nine have ITS websites.
- Twenty-two have "branded" ITS programs.
- Thirty-six have a Statewide Map link for traffic information. Several states (Utah and New Hampshire, for example) have supplemental websites for road construction projects.
- Twenty-five locations have a Strategic ITS Plan.
    - Of these locations, four plans are over 10 years old, eight plans are 5–10 years old (2000–2004), 12 plans have been recently updated (2005–present), and one plan's version date was not listed.

- Nine states have statewide architecture, and of these, five plans have a 10-year time horizon. Ten additional states have a statewide architecture vision.

Several states included stakeholders in the planning process. These states are Alaska, California, Colorado, Georgia, Illinois, Iowa, Kansas, Louisiana, Minnesota, Mississippi, Montana, Nebraska, Oklahoma, and Oregon. Table 1 provides detailed information about the breadth of stakeholder involvement in the ITS planning process in these states. As the table shows, in addition to state DOTS, most of these states included other state agencies, counties, cities, and commercial interests.

Several of the plans included a description of the kind of stakeholder involvement that was used in the planning process. The majority of these states used surveys and focus groups to engage the stakeholders. Six states involved stakeholders in committees. Illinois and Kentucky were the only states that listed all three types of stakeholder involvement. Five states provide a list of stakeholders (Alaska, California, Iowa, Mississippi, and Oregon).

Stakeholders

Table 1 illustrates the diversity of stakeholders involved in the development of the ITS plans. States routinely involved the key ITS operational agencies and organizational units including state districts, counties, and cities. They also involved other public- and private-sector groups that could be users of ITS information.

Process for Stakeholder Involvement

The state plans used three general mechanisms to solicit input and build consensus. These included establishing an advisory committee, performing interviews and surveys, and leading focus groups and workshops.

Table 2 notes that several states used multiple approaches.

Table 1. Stakeholders in ITS Planning Process.

State	State DOT	Other State Agencies	District/Region	Counties	Cities	Commercial Interest	Public	Media Outlets	Advocacy Groups	ITS Service Providers
Alaska	x	x			x	x				
California	x	x	x	x	x		x		x	
Colorado	x		x							
Georgia	x	x	x	x	x	x	x		x	x
Illinois	x	x	x	x		x	x			
Iowa	x	x	x	x	x	x		x		
Kansas	x	x	x	x	x	x				
Louisiana	x	x			x	x				
Minnesota	x				x		x			
Mississippi	x	x		x	x					
Montana	x	x		x	x	x				
Nebraska	x	x		x	x	x		x		
Oklahoma	x	x	x		x					
Oregon	x	x		x	x	x				

Table 2. Stakeholder Involvement Process.

State	Advisory Committee	Interview/Survey	Focus Groups/Workshops
Alaska		x	x
California	x		
Colorado	x		
Georgia			x
Illinois	x	x	x
Indiana			
Iowa		x	x
Kansas		x	x
Kentucky	x	x	x
Louisiana	x		
Minnesota		x	x
Mississippi			x
Montana		x	x
Oklahoma		x	x
Oregon	x		x

Time Horizon for ITS Strategic Planning

The ITS documents from the states generally had a 5- or 10-year time horizon established for ITS activities. Table 3 summarizes some of the findings for each state.

Table 3. Time Horizon for ITS Guidance.

State	Strategic Plan	Statewide Architecture	5-Year Term	10-Year Term	Vision
Alaska	x	x		x	
California	x	x		x	
Colorado					x
Florida	x				x
Georgia	x	x		x	
Indiana	x	x			x
Iowa		x		x	
Kansas	x	x			x
Kentucky	x				x
Louisiana	x	x			x
Massachusetts		x			
Minnesota	x	x		x	
Nebraska	x				x
Oklahoma	x				x
Oregon	x				x
Virginia	x				x

Branding ITS

In many cases, a state has branded its ITS initiatives especially when it has taken on a significant role in distributing ITS information. For instance, Florida uses the moniker "SUNGUIDE" to denote its ITS initiatives. The website http://www.sunguide.org is the portal for this brand. In some states, the emphasis on branding is focused around 511 services. For example, California's "Smart-Traveler" links 511 services throughout the state.

ITS branding is also seen within and across state boundaries. The Missouri Department of Transportation (MoDOT) and the Kansas Department of Transportation (KDOT) sponsored the Kansas City SCOUT brand. The website http://www.kcscout.net/ shows its traffic conditions map and provides links for mobile web alerts. The multi-state I-95 Corridor Coalition sponsors traffic information along I-95 from Maine to Florida. Their website is http://www.i95coalition.org/i95/TravelInformation/511Information/tabid/184/Default.aspx. In

Texas, the Houston region promotes traveler information from its website http://traffic.houstontranstar.org/. Table 4 identifies some of the statewide branding.

Table 4. Statewide Branding.

State	Brand
Alaska	Iways
Colorado	CoTrip
Delaware	DelTrac
Florida	SUNGUIDE
Georgia	NaviGAtor
Illinois	Getting Around Illinois
Indiana	TrafficWise
Iowa	Trip Guide
Kansas	KanDrive
Michigan	MiDrive
Minnesota	Guidestar
Mississippi	MsTraffic
Missouri	Traveler Information Map
New York	New York MOVES
Oklahoma	Pathfinder
Oregon	Trip Check
Rhode Island	RhodeWays
Tennessee	SmartWay
Utah	CommuterLink
Virginia	Smart Travel
Washington	Moving Washington
Wisconsin	Smart Ways

511 FOCUS

Many states are currently providing 511-based traveler information. The U.S. DOT website (http://www.fhwa.dot.gov/trafficinfo/511.htm) identifies the states that have deployed 511. Operation of a 511 website is a routine part of the 511 deployment process, and this website contains links to those 511 sites for 43 locations. Figure 1 shows the states that have implemented 511.

As part of 511 deployments, states routinely have a reference website that points to statewide and regional governmental sponsored websites in that state. For example, the Caltrans QuickMap website (http://quickmap.dot.ca.gov) links to various regional 511 sites such as San

Diego (http://www.511sd.com/ that San Diego Association of Governments [SANDAG] sponsored) and to the San Francisco Bay Area traffic conditions website (http://www.511.org/) that the Metropolitan Transportation Commission (MTC) has sponsored. Caltrans also sponsors a real-time freeway conditions map at http://www.dot.ca.gov/dist11/d11tmc/sdmap/showmap.php.

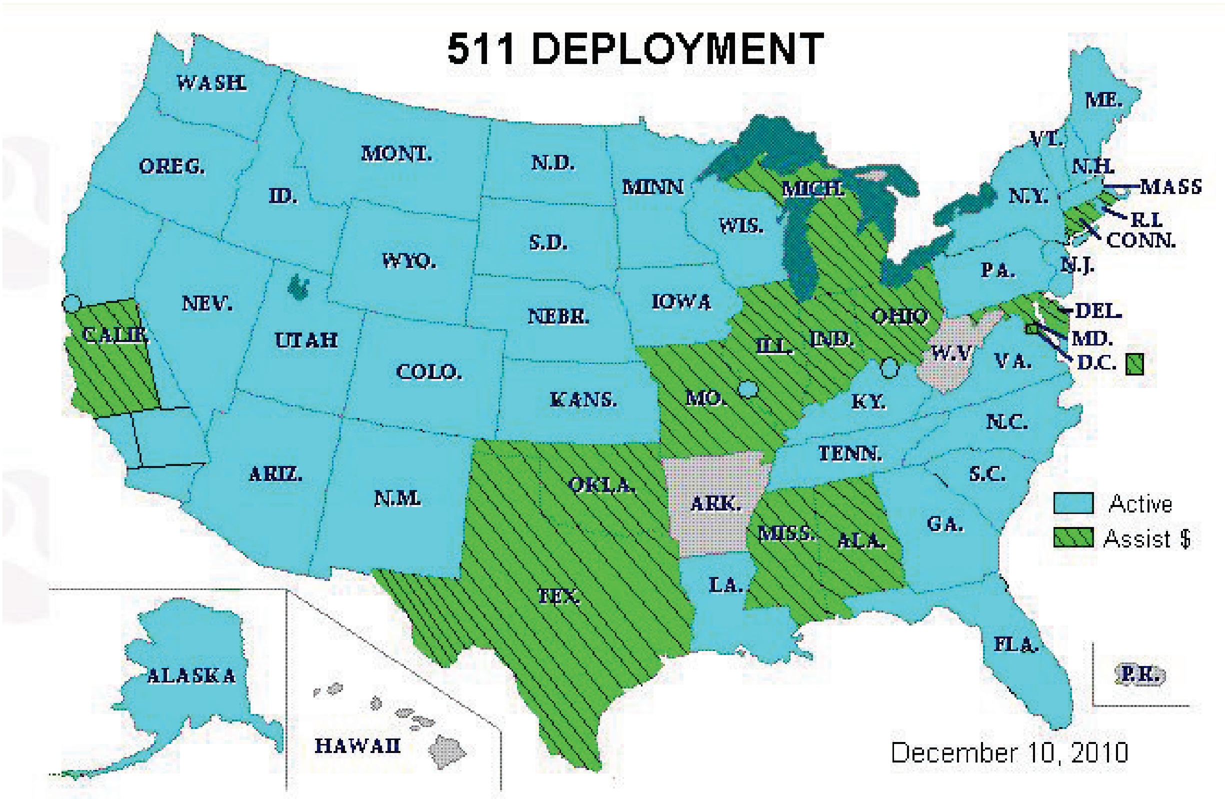


Figure 1. States with 511 Deployments.
From http://www.fhwa.dot.gov/trafficinfo/511.htm

Operation of a 511 website is a routine part of the 511 deployment process. Examples of agencies that provide 511 websites are: Colorado (http://www.cotrip.org/speed.htm), Idaho (http://hb.511.idaho.gov/main.jsf), and Maine (http://www.511.maine.gov/main.jsf).

BEST PRACTICES

The Federal Highway Administration's (FHWA's) *Best Practices of Rural and Statewide ITS Strategic Planning* (*1*) conducted 12 in-depth studies and performed detailed surveys of agencies that were involved in ITS planning. The objective of the report was to capture best practices, including the planning process, which can be transferred to other jurisdictions.

Chapter 11 of that report summarizes guidance highlights from the case studies. The best practice guidance includes the following:

- Develop system inventories with stakeholder involvement.
- Identify user needs with stakeholder involvement.
- Partition urban and rural needs to ensure that rural needs are adequately identified separate from traditional urban congestion issues.
- Develop an ITS vision using the national ITS architecture's "user services" and "user services objectives."
- Use workshops and focus groups to develop goals and objectives for ITS.
- Define ITS user services objectives on a regional basis to address specific objectives, meet customer needs, and target solutions to specific problems.
- Develop performance criteria or measures-of-effectiveness (MOEs) to screen national ITS architecture market packages.
- Develop a clear association between market packages and identified needs/problems (*1*).

The following list highlights those key findings. These recommendations are applicable to the strategic planning process in Texas. The ITS strategic plan is a road map on how to implement a system of technology-based strategies over time. It provides a starting point for bringing ITS projects and systems together into an integrated system to solve the regional needs in the most effective manner. Specifically, an ITS strategic plan should:

- Follow a structured approach to ensure proper coverage of all issues.
- Have a vision.
- Identify needs, goals, and objectives.
- Permit input from key stakeholders in the region.
- Identify integrated solutions that can permit evolution as state-of-the-art changes.
- Have plans on how to leverage funding opportunities to sustain adequate funding (i.e., including ITS components into major construction projects, initiating major ITS projects, and exploring federal funding and public–private partnerships).
- Includes ITS concept definition (Phase I), ITS framework development, and Implementation plan (Phase II).

- Address costs and responsibilities of operations and management.
- Estimate planning level costs.
- Identify potential benefits in relation to goals/objectives and performance criteria.

In developing the strategic plan, note:

- There is no single right approach.
- The plan may need to be updated to accommodate changes in conditions.
- Strategic planning is most effective when undertaken as an integral part of the transportation planning processes.

Table 5 lists two types of stakeholders. In addition to getting the stakeholders' input to identify needs, the plan should engage them at an early stage to:

- Identify their roles and responsibilities.
- Identify expectations from their agencies.
- Develop decision-making structure.

The document also suggested that the plan should have mechanisms (i.e., educational workshops, outreach materials, scanning tours, conferences, etc.) to ensure sustained stakeholder participation in the regional ITS program.

Table 5. Types of Stakeholders.

Traditional Stakeholders	Nontraditional Stakeholders
• Transportation Agencies (e.g., Federal, State, County, City) • Local Government Agencies • Public Transit Agencies • Toll Authorities • Regional Planning Agencies • Regional Transportation Planning Agencies (RTPAs) • Metropolitan Planning Organizations (MPOs) • Councils of Governments (COGs)	• Emergency Medical Community • Public Safety and Law Enforcement Agencies • Fire and Rescue Groups • National Parks • Business and Industry Groups • Information Service Providers (ISPs) • Communications Carriers • Tourism Bureaus • Weather Services • Other Government Agencies and Departments

WHY DEVELOP ITS REGIONAL ARCHITECTURE

Federal regulations require that ITS projects funded by Highway Trust Fund and Mass Transit Account conform to the national ITS architecture and U.S. DOT adopted standards. Conformance implies the use of national ITS architecture in developing regional architecture.

ITS regional architecture, which should be consistent with statewide and metropolitan planning processes, guides the development of ITS projects and programs and is consistent with the strategic plan. It describes system elements, their relationships to one another, and how the ITS projects in the strategic plan will work together in a coordinated manner. The regional architecture ensures institutional agreement and technical integration. It is a living document that should be frequently updated to adapt to changing needs, new opportunities, and evolving technology. As a minimum, it consists of:

- Description of the region.
- Identification of participating agencies and other stakeholders.
- Identification of ITS projects and systems to be implemented.
- An operational concept that identifies agency roles and responsibilities in the operation and implementation of the identified ITS projects and systems.
- Agency agreements required for the operations and maintenance of the ITS projects identified.
- System functional requirements.
- Interface requirements and information exchanges with planned and existing systems.
- Identification of ITS standards to be used for supporting regional and national interoperability.
- The sequence of ITS projects required for implementation.

CHAPTER 3: PRIVATE-SECTOR DATA

To effectively manage the use of transportation infrastructure and to inform travelers about the existing and predicted roadway conditions, both infrastructure operators and travelers require accurate and timely performance data. Traditionally, public agencies have used vehicle sensors and cameras, and they have distributed to the public the information that they gathered. The business model has been as follows:

- Public-sector investment for performance monitoring and control.
- Free distribution by public agencies of information to travelers, other public agencies, and private information providers.

This approach has been used since the late 1960s and 1970s when the FHWA began investing in the Urban Traffic Control System (UTCS) Project (*2*). However, private-sector companies have recently begun to provide increasing amounts of data with increasing accuracy. INRIX® was spun out of Microsoft® research in 2004 (*3*). NAVTEQ® began as a privately held company in 1985, and it became a public company in 2004 (*4*). AirSage® was founded in 2000 (*5*), and TomTom® was founded in 1991 (*6*).

In addition, the growth of smart phones has provided an increasing number of opportunities to monetize transportation information and an increasing number of ways to engage travelers in gathering transportation information through social networking. The iPhone®, introduced in 2007, has accelerated this environment (*7*). Many of the traffic applications for mobile devices are supported on popular platforms including iPhone®, Android®, and BlackBerry®, among others. As an example, INRIX Traffic is supported on the iPhone®, iPad®, and Android® (*8*).

MARKETPLACE REVIEW OF PRIVATE-SECTOR PROVIDERS

The Texas A&M Transportation Institute (TTI), working under a Battelle Technical Support and Assistance contract for FHWA's Office of Transportation Operations, developed a marketplace review of private-sector transportation service providers (*9*). Portions of those results are also being incorporated into TxDOT Research Project "Synthesis of TxDOT Uses of

Real-Time Commercial Traffic Routing Data" (*10*). The Battelle project surveyed six private companies:

- AirSage.
- American Trucking Research Institute (ATRI)®.
- INRIX.
- NAVTEQ.
- TomTom.
- TrafficCast®.

Table 6 summarizes the results of the survey. Providers are using a combination of global positioning system (GPS) data from fleet vehicles, consumer devices, and cell phone applications, as well as data from fixed sensors installed and maintained by other agencies, and fixed sensors that the data provider had installed and maintained.

The providers did not use one single data source model. Correspondingly, there does not appear to be any single business model in use. Each provider has developed a somewhat well-defined niche or area, although many providers spoke about a desire to break out of that niche and expand their potential market, perhaps with new data offerings.

Even the fleet-equipped GPS data sources show a wide range of diversity. While no provider would detail their fleet arrangements for protection of their business practices, several spoke in general about the range of fleet types. From long-haul trucking, to delivery vehicles, to taxicabs, providers have actively sought data from whatever fleets are available. Many spoke about continuing to expand their fleet coverage as the best method of accessing additional data points.

Several providers spoke about the changing marketplace in terms of the amount of data now available. While low availability of data used to be the paradigm a few years ago, the new paradigm is the vast availability of data and the comparative richness of the sources. Some providers spoke about past moves to change their models and business practices to actually reduce the number of individual data sources, primarily migrating to consumer GPS information. More than one provider spoke of receiving millions, if not billions, of individual data points per day.

Table 6. Summary of Data Provider Information.

	AirSage	ATRI	INRIX	NAVTEQ	TomTom	TrafficCast
Data Available [a]	S, TT, I, Q, V	S, TT, Q	S, TT, I, Q, V	S, TT, I, Q, V (portion of network)	S, TT, I, Q	S, TT, I, Q
Services Available [b]	D, A, PM	D, A, PM	D, A	D, A	D, A, PM	D, PM
Data Source	Cell phone, 911, traffic counts.	GPS on commercial truck-only fleets.	State-installed sensors, commercial fleets, consumer GPS.	State-installed sensors, commercial fleets, consumer GPS.	Consumer GPS, fleet GPS.	State-installed sensors, commercial fleets, consumer GPS, Bluetooth systems.
Aggregation Levels for Historical Usage	None; as captured	1 mile, 1 minute	15–60 minutes	15 minutes	1 hour	15 minutes
Accuracy Checks Performed	Visual camera count, probe vehicles.	Anomaly checking done, routines not disclosed.	Independently verified in large-scale testing.	Data checks prior to map matching. Comprehensive drive testing.	Data checks prior to map matching.	Simple-adjacent points compared, some clients doing accuracy checks.
Documented Quality Levels	None provided. Stated they meet Section 511 requirements.	None. Burden is on receiver of data.	Accuracy above 95%. Availability above 99.9.	None provided.	None provided. Stated they can meet Section 511 requirements.	None provided. Stated they can meet Section 511 requirements.

NOTES:

(a) Data Available: "S" = Speed, "TT" = Travel Time, "I" = Incidents, "Q" = Quality, "V" = Volumes, "GPS" = GPS fleet

(b) Services Available: "D" = Discrete Data (individual data points), "A" = Aggregate Data, "PM" = Performance Measures

National Coverage: Not listed in table. All providers indicated national coverage, except TrafficCast, which is currently in urban areas. Map Matching: Not listed in the table. All providers except ATRI indicated a minimum use of traffic message channel. ATRI uses mileposts. INRIX, NAVTEQ, and TomTom also use proprietary segmentation smaller than traffic message channel.

Specific information related to various private-sector providers was compiled related to the following topics:

- Coverage.
- Map matching.
- Data available.
- Services available.
- Aggregation level.
- Data sources.
- Data filtering.
- Accuracy checks.
- Quality levels.
- Pricing.
- Data imputation.
- Data provision.

FINDINGS

The following sections provide a summary of the findings of this effort.

Coverage

A listing for national coverage is not included as part of the summary information in Table 6. As identified in the notes following the table, with the exception of TrafficCast, all providers indicated a national coverage capability on main roadways, typically down to the primary arterial level. This would correspond to Functional Class (FC) 3 roadways in the Traffic Message Channel mapping system.

Map Matching

All of the private-sector data providers submitted their data mapped to some system that allows for the geographic identification of the roadway segment to which it applies. With the exception of ATRI, which uses mileposts, all providers utilize TMC as a minimum. INRIX, NAVTEQ, and TomTom also have proprietary mapping that allows data to be mapped to segments at a finer (smaller) resolution than TMC.

Data Available

Speeds (S) and travel times (TT) were the prevalent data provided, available from all the vendors as historical data. All vendors also stated the provision of some type of quality (Q) data, although the specific information provided varied by provider. All vendors except ATRI stated the availability of incident (I) data. AirSage and INRIX stated the availability of volume (V) data across the network, while NAVTEQ stated the capability for a portion of the network. Volume data come from a variety of data sources, including fixed sensor data sources that the public agencies, camera counts, and probe vehicles have installed and maintained. Data availability on a per-lane basis is still in its infancy as a provider offering, although a number of respondents stated offerings under research and development.

As expected, the key data of the providers are speed and travel-time data, in both historical and real-time contexts. Associated with those data is the provision of quality or metadata expressing items such as confidence intervals, sample sizes, or other quality indicators. However, there is little consistency in terms of what is actually provided as a quality indicator. This appears to be a negotiable item in contracts.

Some of the data providers use consumer GPS devices to some degree. These data may not arrive in sufficient quantities to include in real-time information, but can be added to the existing data sets once consumers have uploaded these at a later date. Providers spoke of receiving data in this manner that range in age from a few days to several months.

A similar situation exists pertaining to arterial coverage. Some of the data models use data from consumer GPS devices. These data may not arrive in sufficient quantities to include in real-time information, but can be added to the existing data sets once consumers have uploaded these at a later date.

While only one vendor claimed to have per-lane information available, additional respondents indicated they were actively working to provide this level of data service. The responses to other types of data included the use of Bluetooth® data and fleet diagnostics, such as engine parameters. These would primarily be of use only to the original GPS-equipped fleets.

Services Available

The interviewer asked providers if they offered the following types of data products, differentiated as historical or real-time data:

- Raw data for purchase.
- Refined/aggregate data for purchase.
- Data warehousing.
- On-demand data access.
- Performance measures.

Raw or discrete data are defined as the individual or discrete data elements or points. While providers said they would not sell fleet GPS data, many providers do sell the complete data stream on individual points, stripped of any identifying information. When purchasing discrete data, a consumer would get all of the individual speed or travel time points within a section, within a time frame, whereas they would get only one value under the purchase of aggregate data.

Aggregation Level

The principal service offering, however, is refined or aggregated data. Aggregate data are available from all of the responding providers on a historical basis. What is different across the providers is the level of aggregation. Some providers use 5 minutes, others use 15 minutes, and still others use 60 minutes. ATRI provides the lowest level of aggregation, at 1 mile or 1 minute. Other providers vary from 15 to 60 minutes. In part, the differences are due to the wide variety of data sources. On any given device, GPS data are typically recorded at 1-second intervals, but that can be altered. Data from fixed-point sensors are typically recorded at 20-, 30-, or 60-second intervals. Cellular data might be recorded at sub-second levels.

Data Sources

Each provider essentially had a unique (to some degree) set of data sources. While there was some overlap, no responding provider utilized exactly the same data model as another provider. Providers are using an expansive range of data sources including GPS data from fleet vehicles, commercial devices, cell phone applications, fixed sensors that other agencies had installed and maintained, fixed sensors that the data provider had installed and maintained, and cell phone location.

Data Filtering

The interviewers also asked providers to detail the manner in which their data could be analyzed. All respondents indicated the ability to do data filtering or sorting based on typical parameters such as date, time, roadway, region, state, or data source. The provision of these capabilities stands to reason because they are somewhat inherent in any database or archive, although the extent or level of discreteness can vary greatly.

Accuracy Checks

The data providers were very circumspect about discussing any accuracy checks they perform to validate their data offerings. With the exception of ATRI, which stated that none are performed, most providers did not disclose specific checks or algorithms. TrafficCast did state that a part of its general methodology included simple adjacent point comparison routines but also stated that it employed more sophisticated methods. In part due to the comparisons that the I-95 Corridor Coalition performed, INRIX stated that large-scale client testing has verified its data. NAVTEQ claimed that it does extensive drive testing across all types of roadways in all markets at all times of the day and days of the week. With the exception of ATRI, all providers stated they have an extensive data-checking process in place to ensure overall data quality. A number of providers also have integration routines employed to merge data from disparate sources into a seamless coverage of their network. However, they did not provide descriptions of these routines.

Quality Levels

With the exception of INRIX, data providers were also circumspect about the quality levels they meet. INRIX explicitly claimed an availability of more than 99.9 percent and an accuracy of greater than 95 percent.

The interviewers asked providers if they were aware of, and were capable of meeting, the requirements in the FHWA Final Rule on the "Real-Time System Management Information Program," which took effect December 23, 2010 (*11*). While the providers were aware of the ruling, there was no concern associated with either the time frame for implementation or the requirements. In general, based on the information provided during the survey as far as data latency and availability, the existing data parameters would appear to exceed the FHWA rule-making requirements. Only one provider (INRIX) had a specific comparison (available on their website) of information regarding the FHWA requirements and their standard numbers for reporting time frames, accuracy, and availability. Providers were aware of the requirements and expressed no concern over meeting the real-time requirements and by extension, accuracy and availability levels for historical data.

Pricing

In general, the availability of pricing information was minimal. Most providers appear to negotiate each purchase individually. Pricing is tied to the usage of the data. Data that are used for a single application employ one price point. Data used for multiple applications require a different price point. Providers also make a distinction between uses, such as modeling or O-D studies, and derivative products, such as summaries distributed to external sources. While providers did not disclose the various price points, all stated that they exist.

Data Imputation

This aspect of data primarily applies to real-time information and is not detailed as a line item in Table 6. Providers responded in one of two ways when asked about data imputation, or filling in the gaps in real-time data. A number of providers stated they have the ability to impute based on their historical data archives and data-checking routines. Providers also stated that they flag such data as being all or partially composed of historical versus real-time data. INRIX explained in detail how the quality measures associated with any particular data point would change based on the amount of historical data being used. Essentially, the confidence interval expressed for the data point, such as a speed or travel time, would range from very high with no historical data in use to very low with significant historical data in use. ATRI does no data imputation at all.

Data Provision

Researchers asked providers to detail the ways in which they provided data to their customers. For real-time usage, the universal answer was some type of data feed, typically Extensible Markup Language (XML) updated on a 1-minute interval. Providers also stated that they could provide map outputs, but those processes are still fed in the background by a data feed. Smart phone displays were also a standard answer, but they are also powered by a background data feed.

For the historical context, a wider variety of data provision mechanisms is possible. Some providers utilize an internet-based portal access to the database, and customers can perform and save their own query results. Other providers execute the query for the customer and ship the resulting data file via electronic mail or CD-ROM. Typically, they provide the file in either XML or Comma Separated Variable (CSV) format.

QUALITY OF COMMERCIAL SERVICES

During January and February 2011, TxDOT held meetings with INRIX and NAVTEQ. Both companies indicated they were experiencing an exponential rate of growth in the amount of data they were receiving. Additionally, both companies expected the rate of growth to be exponential for at least the next 5 years (*12*, *13*). The expectation from the companies is that both the extent of data coverage and the data quality will continue to increase in the next 5–10 years. This outlook is consistent with information generally available from other traveler information service providers.

To assess quality today, TTI performed an analysis of two commercial traveler information service providers along I-35 in Austin, Texas. The data gathered from the companies were compared with a deployment of Bluetooth readers serving as a benchmark reference (*14*). Three measures of real-time link speed accuracy were used in this evaluation:

- Average absolute error (mph)—as compared to the benchmark's 95 percent confidence interval.
- Average error (bias, in mph)—as compared to the benchmark's 95 percent confidence interval.
- Percent of speed values within 5 mph of the benchmark's 95 percent confidence interval (%).

Researchers computer all three accuracy measures as compared to the benchmark's 95 percent confidence interval. By comparing to the 95 percent confidence interval, the evaluation acknowledges that the benchmark does have measurement error, just like the service provider. When the 95 percent confidence interval is narrow (e.g., lots of Bluetooth matches and low variability), then the benchmark error is low. If the 95 percent confidence interval is wider, then the benchmark error is higher. The true speed value can only be known if the speeds of all vehicles traversing the link are recorded.

To characterize the accuracy of speed data in several different congestion ranges, researchers calculated these three accuracy measures and reported them in four different ranges (based on the Bluetooth-based benchmark speed values):

- **Light flow:** greater than 60 mph.
- **Transition:** 45 to 60 mph.
- **Slowing:** 30 to 45 mph.
- **Stop-and-go:** less than 30 mph.

The "light flow" category is often disregarded following accuracy evaluations for these reasons:

- Service providers have different policies for capping free-flow speeds that exceed the posted speed limit.
- Light flow is the predominant traffic condition for the majority of the day. Because of this, service providers could provide a free-flow speed throughout the entire day and they would likely be close to the benchmark most of the day. Therefore, combining the accuracy during light flow and heavy congestion has a tendency to dilute any poor performance that would occur during heavy congestion.

To determine how the evaluation results on I-35 in Austin compared with evaluation results in other locations, the research team used the results from 2 years of INRIX evaluation conducted along I-95 in six states by the I-95 Corridor Coalition. The findings and conclusions follow:

- The accuracy results from both service providers along I-35 in Austin are better than the accuracy results obtained along the I-95 corridor. There are several possible reasons for better accuracy during this limited I-35 evaluation. Given the small differences in the two sets of evaluation results, there is no cause for concern about either evaluation effort. Possible reasons for the difference include:

  - The four links along I-35 are near the Austin central business district, where the possibility of gathering larger probe vehicle samples (which typically means better accuracy) is greater than in rural or suburban areas.
  - The I-35 evaluation encompassed one month, whereas the I-95 evaluation includes 2 years, which means a greater possibility of capturing extreme traffic-disrupting events for which the service providers may be less accurate.

- For all four links combined, the average absolute error was less than 5 mph for both service providers. When considering the error on each link, the average absolute error increased on some links and speed categories, but still remained below 7 mph. As a comparison, the contract requirement for the I-95 Corridor Coalition is 10 mph (i.e., average absolute error must be less than 10 mph or contractor payment can be withheld). The southbound Woodward-to-Stassney link was the least accurate, but the differences in average absolute errors between links are typically less than 2 or 3 mph for both service providers.
- For the second measure, average error or bias, there was a slight difference between the two service providers, but the difference is less than 2 mph. NAVTEQ data were less biased at low speed ranges and INRIX was less biased at mid-range and higher speeds. The bias is an indicator of whether a service provider consistently reports speeds that are higher or lower than the benchmark. For example, the NAVTEQ data bias in the two higher speed ranges is about −3 mph, which indicates that NAVTEQ consistently reports speeds in this range that are lower than the benchmark. Note that this could be caused by capping the reported speeds at the posted speed limit. The greatest bias for INRIX data is in the lower speed ranges, where it is between 2 and 3 mph. This means that INRIX consistently reports speeds higher than the benchmark in these speed ranges.
- The third measure, percent of values within 5 mph, shows similar results for both data providers, except that INRIX has better results in the 45 to 60 mph speed category. At slower speeds (0 to 30 mph), both data providers were within 5 mph of the benchmark interval about 85 percent of the time. At transition speeds (30 to 45 mph), both providers were within 5 mph about 65 percent of the time. INRIX also had better results than NAVTEQ in the free-flow category, but as mentioned earlier, accuracy in this speed category is often ignored or downplayed.

- On this heavily traveled stretch of I-35, the large sample sizes from Bluetooth produce a more accurate travel time result. However, the average error for both INRIX and NAVTEQ (the two leading providers TTI evaluated) were always less than 7 mph. The key question is how much accuracy is needed for the application. For example, ±7 mph is adequate for a citywide red-yellow-green speed map. But is this accurate enough for posting freeway travel times? If you assume a 4-mile segment at 30 mph true average speed, then the true travel time is 8 minutes. If the provider's error is ±7 mph, then the reported travel time could be 6 minutes (37 mph) or 10 minutes (23 mph), so average travel time error at this speed and segment length is ±2 minutes. Is that acceptable? San Antonio already posts travel times as a 2-minute range (e.g., 6–8 minutes).

TTI's evaluation only considers accuracy and does not include other factors that TxDOT should consider when making decisions about traveler information. The most important other factor is life-cycle cost/maintenance, with mobilization a lesser consideration. The I-95 Corridor Coalition operators did some back-of-the-envelope calculations indicating that the life cycle costs were comparable between Bluetooth traffic monitoring and private-sector traffic data. The mobilization refers to how quickly district-wide traffic information could be provided; Bluetooth reader installation in a cabinet is definitely quick, but the larger traffic information companies can flip a switch today and have real-time data flowing for all major roadways in the Austin District (and statewide for that matter).

CHAPTER 4: CONNECTED VEHICLE INITIATIVES

The U.S. Department of Transportation Research and Innovative Technology Administration (RITA) initiated a series of connected vehicle research initiatives. These initiatives include technologies, applications, policy and institutional issues, and communications (*15*). These initiatives parallel the ITS structure that was launched in the 1990s, which had similar categories of activities.

U.S. DOT developed an architecture for ITS that defined the services it provides (i.e., market packages). In the connected vehicle realm, RITA is currently defining connected vehicle applications for safety, mobility, and environmental services. In the ITS architecture a communications layer identified the communications technologies and systems that support information exchange. For connected vehicles, dedicated short-range communications (DSRC) technology is being examined for vehicle-to-vehicle and for vehicle-to-infrastructure applications. In both cases an emphasis on institutional issues and topics is important because of the desire to mainstream the initiative. The current applications in RITA's research portfolio follow (*16*):

- Vehicle-to-vehicle safety.
- Vehicle-to-infrastructure safety.
- Real-time data capture.
- Dynamic mobility applications.
- Environment.
- Road weather.

TIME FRAME

At the time of publication, the connected vehicle initiative is in the research stage, and RITA is guiding it. The high-level road maps that describe these initiatives typically run from 2010 to the beginning of 2015. For instance, the road-map applications for the environment define foundational analysis in calendar year (CY) 2010–2012 and candidate application evaluation from CY 2012–2014.

Each of the road maps has a similar structure and timeline. However, in the case of the vehicle-to-vehicle initiative, the research will provide supporting data for a National Highway

Traffic Safety Administration (NHTSA) rule-making decision. NHTSA anticipates that vehicle-to-vehicle communications will support a new generation of motor vehicle safety systems (*17*). The potential rule may set requirements for inclusion of vehicle-to-vehicle communications in new vehicles.

Requirements may also be established for inclusion of communications from the vehicle to the roadside—for instance, to include the current or forthcoming signal light status of a traffic signal for a safety application. In the connected vehicle research program, the Signal Phase and Timing (SPaT) research initiative is focused on communicating traffic signal information to mobile devices (*18*). These types of applications provide a need to communicate with publicly owned infrastructure. The objective is to improve safety. However, a consequence with today's typical transportation business delivery models is that public agencies must also provide the funds for the additional roadside equipment capability.

PUBLIC AGENCY PARTICIPATION

Currently, few states and operating agencies are participating in the connected vehicle initiative. Some states with a historical involvement in the automotive industry are active partners with the U.S. DOT research program. For instance, Michigan is hosting a connected vehicle test bed in Detroit (*19*). Florida, California, and New York have also hosted some connected vehicle initiatives. In Texas, Harris County is considering the addition of traffic signal priority capability that is consistent with connected vehicle technologies. In general, public agencies are not yet involved in this technology except through minor, focused installations or through federally sponsored research initiatives.

CHAPTER 5:
STATE OF ITS DEPLOYMENT IN THE U.S. AND ANTICIPATED ITS SERVICES

For over a decade, the Intelligent Transportation System Joint Program Office (ITS JPO) of RITA has sponsored a project to track the metropolitan deployment of ITS. The most recent ITS deployment survey under this project was conducted in 2010, which surveyed seven types of agencies in 108 cities (*20*). The following sections present a summary of ITS deployments across the country based on this survey.

FREEWAY MANAGEMENT

During the past decade, the number of dynamic message signs (DMS) deployed, freeway miles covered by closed-circuit television (CCTV)-based surveillance, and freeway miles with real-time traffic data collection doubled. Over this period, there was also a significant increase in the number of agencies using CCTV, DMS, highway advisory radio (HAR), and radar detectors. Of these ITS technologies, the biggest increase occurred in the adoption of radar detectors by agencies, which doubled. At the same time, agencies' use of other types of sensors (video, loops, etc.) did not change. Other trends in ITS deployment by these agencies are as follows:

- In recent years, the number of agencies using ramp metering has not changed significantly.
- Approximately 34 percent of agencies use some form of managed lanes. About a quarter of these agencies use high-occupancy toll (HOT) lanes, express lanes, and/or variable speed limits, and 50 percent use high-occupancy vehicle (HOV) lanes. In recent years, the use of HOV lanes has increased slightly.
- Only a small percent of these agencies use automated enforcement technology, but the use of these technologies for automated enforcement of HOV lanes or speeds is almost nonexistent.
- The use of service patrols, which was adopted by agencies for supporting incident management many years ago, has increased slightly. The use of CCTV cameras for incident management has more than quadrupled to the same level as service patrols, while the use of automated incident detection algorithms has remained low.

- Dissemination of traveler information remains a key freeway management function. Even though traditional means of information dissemination (web page, DMS, 511, and HAR) continue to be most prevalent, other modern means such as e-mail, social networking, alerts to mobile/nomadic devices, and subscription service are well established now also. Information disseminated using these means includes incident location and duration, construction duration, travel time by segment, and weather events.
- In coordination with other agencies, these agencies use a number of strategies to manage corridors. Most significant of these strategies include incident management, traffic control during inclement weather, cross-jurisdictional signal coordination and real-time transfer of performance information. In the near future, more agencies plan to utilize these strategies as well as other low-usage strategies (i.e., traffic responsive signal timing, ramp control, and transit operations).
- Traffic volumes, speeds, lane occupancy, vehicles classification, and travel time are the most frequently archived information. A few agencies also archive information about road conditions, weather conditions, and video surveillance data.
- Measures used by agencies to report performance include travel time, travel time reliability, vehicles per lane per mile, volume, and occupancy. More than 50 percent of the agencies now have established performance goals for major, moderate, and minor incidents.
- About 50 percent of these agencies use analysis, modeling, and simulation tools to model freeway systems. In addition, a significant number of agencies use a decision support system to assist with operations decisions related to corridor, weather management, incident management, emergency management, evacuation, and maintenance.

ARTERIAL MANAGEMENT

About half of these agencies have continued to maintain signalized intersections under closed-loop control. However, the use of traffic-responsive control is low due to uncertainty about benefits and costs associated with operations and maintenance of this type of control. A fifth of signalized intersections in the nation are currently equipped to provide emergency preemption, a number that has not changed in recent years. Similarly, the use of loop detectors has remained stable. The use of other ITS elements such as transit signal priority, CCTV surveillance, and HAR also remains low. The biggest recent change is the use of electronic surveillance at signalized intersections, which has increased from 20 percent of intersections to almost 50 percent. There have also been significant increases in the number of agencies using video-based detection (an increase from 26 to 58 percent), DMS (an increase from 10 to 26 percent), and red-light running cameras (an increase from 5 to 26 percent). Other findings from the survey are as follows:

- A full 75 percent of agencies continue to use citizen complaints as the primary method to measure performance of signals. Only 31 percent of these agencies use some form of automated method (i.e., travel time, cycle failure, queue length, speed, etc.) for performance measurement.
- Signal preemption for emergency vehicles, train preemption, and bus priority are used by 75, 50, and 19 percent of agencies, respectively.
- About 26 percent of these agencies use automated enforcement, mostly for red-light running and a few for speeding.
- Less than a third of these agencies provide traveler information. Using the same means as freeway management agencies, they generally provide information about construction (location, duration, and lanes closed) and incidents (location and duration).
- About 10 percent of agencies use service patrol, and 20 percent use CCTV as part of their incident detection/management.
- For providing safety, these agencies use countdown pedestrian signals (70 percent), pedestrian-activated flashing beacons (31 percent), dynamic prohibition of right turn on red (17 percent), bicycle-activated signals (17 percent), and in-roadway flashing lights (16 percent). Some agencies also provide environmental sensors and implement specific signal plans for inclement weather.
- Corridor management strategies used by these agencies include cross-jurisdictions traffic signal coordination (65 percent), planned special events (42 percent), incident management (30 percent), transit operations (20 percent), and traffic responsive timing (15 percent). The use of these strategies is expected to increase in the near future.

- Less than 40 percent of these agencies archive data for future use. Archived data include traffic volumes, speed, phase/cycle lengths, lane occupancy, emergency signal preemption, turning movements, and vehicle classification.

TRANSIT MANAGEMENT

During the past decade, transit agencies rapidly expanded the number of buses with automatic vehicle location (AVL) technology, demand responsive service with computer-aided dispatch (CAD), and real-time monitoring of fixed route buses. Other findings from the survey include:

- Approximately a quarter of transit agencies have, or plan to have, traffic signal priority on fixed route buses.
- Staff of over 67 percent of transit agencies report observed incidents.
- The use of electronic fare collection on fixed-route buses has significantly increased, while electronic fare collection at rail stations has decreased significantly.
- Over 80 percent of transit agencies provide real-time traveler information through web pages, while 15 to 40 percent of agencies now provide real-time traveler information via mobile devices, e-mail alerts, and telephone (511 as well as non-511).
- A significant number of transit agencies (over 61 percent) have audio or video surveillance on fixed-route buses. A significant number of agencies also have audio or video surveillance at bus stops, rail stations, and bus depots.
- Over half of these agencies utilize data from AVL/CAD and automated passenger counting systems for planning purposes. Furthermore, over a third of these agencies use AVL and other data for providing flexible routing/scheduling, and coordination of passenger transfers between transit systems.
- Digital, analog, and trunked radio is the primary communications technology used by these agencies.
- Around 40 percent or fewer of the transit agencies archive information in real time. Archived information includes vehicle time and location, passenger count, and incidents.

ELECTRONIC TOLLING

Deployment of electronic toll collection capabilities at toll booths and toll collection in lanes has been high (95 percent and over 70 percent, respectively) since 2000. Both types of deployments have now reached nearly full coverage with deployment levels reaching 98 percent and 95 percent, respectively. These agencies mostly use proprietary transponder technology. Furthermore, up to a fourth of these agencies plan to change to newer technology during the next few years. About 9 percent of transit agencies use congestion pricing, and this number is also expected to double in the future.

PUBLIC SAFETY—FIRE-RESCUE

Over 60 percent of public safety and fire-rescue agencies currently use on-board navigation capability, 86 percent or more use CAD, 66 percent use signal preemption, and 42 percent use AVL technologies. A significant number of these agencies also participate in formal multi-agency coordination efforts for managing regional or statewide incident management programs. Over 55 percent of these agencies also share real-time or after-the-fact incident information with other fire-rescue or law enforcement agencies at the local level. Some of these agencies also share incident information with transportation agencies, but mostly after-the-fact data. Means used to provide this information include face-to-face contact, voice communication, data communication or multimedia. Around 65 percent of fire-rescue agencies also operate ambulances equipped with telemedicine capabilities, which include data to hospital and voice/video to hospital. Other elements these agencies use include:

- Monitoring of early warning systems to identify emergencies (62 percent).
- Integrated ITS and communications technology to coordinate with traffic management, transit, and other agencies (34 percent).
- Response routing systems to identify quickest and safest routes to incidents (34 percent).
- Ability to accept 911 calls (32 percent).
- Broadband connection to other public safety agencies and dispatch centers (63 percent).

PUBLIC SAFETY—LAW ENFORCEMENT

Over 90 percent of the law enforcement agencies use CAD, 50 percent or more use AVL, and about 18 percent use signal preemption. Up to a third of these agencies are also involved in multi-agency programs to manage incidents, mostly within the state. Like fire-rescue agencies, these agencies also share real time or after-the-fact incident data with other agencies. Methods used by law enforcement agencies to communicate with traffic management include face-to-face (28 percent), voice (46 percent), data (21 percent), and multimedia (11 percent) communications. Other elements in use by these agencies include:

- Monitoring of early warning systems to identify emergencies (53 percent).
- Integrated ITS and communications technology to coordinate with traffic management, transit, and other agencies (32 percent).
- Response routing systems to identify quickest and safest routes to incidents (20 percent).
- Ability to accept 911 calls (14 percent).
- Broadband connection to other public safety agencies and dispatch centers (53 percent).

TRAFFIC MANAGEMENT CENTERS

TMCs in the country support the following modes of operation:

- Arterial management only (30 percent).
- Freeway management and arterial management (24 percent).
- Freeway management, arterial management, and public safety (16 percent).
- Freeway management only (12 percent).
- Freeway management, arterial management, transit management, and public safety (6 percent).

Functions performed by TMCs on freeways include management (detection, verification, dispatch, and management), traveler information dissemination, special/planned event traffic management, network surveillance, work zone management, maintenance dispatch, performance monitoring and reporting, snow and ice removal, environmental monitoring, ramp management and control, lane management and control, and integrated corridor management. Functions performed by TMCs on arterials include traffic signal coordination and control, special event management, network surveillance and data collection, traveler information dissemination, incident management, evacuation management and traffic coordination, maintenance dispatch, network performance monitoring and evaluation, emergency services traffic control coordination, management of work zones, snow and ice removal, integrated corridor management, environmental monitoring, and lane management and control. In addition:

- Over 50 percent of TMCs have center-to-center communications via use of communications standards.
- About 22 percent TMCs have center-to-center-connections to private-sector information disseminators.
- Over 37 percent of TMCs utilize a decision support system for corridors, road weather management, incident management, emergency management, evacuation, or maintenance.
- About 50 percent of TMCs have implemented shared control of field devices with other agencies.

STATUS OF TRAFFIC SIGNALS

A 2012 report prepared by the National Transportation Operations Coalition (NTOC) provides the most recent assessment of practices of public agencies in the United States and Canada related to the status of traffic signal operations (*21*). Based on a self-assessment conducted by participating agencies, this report evaluates the practices in the following five categories:

- Management, which includes programmatic actions.
- Traffic Signal Operations, which deals with review and update of phasing and timing parameters, including coordination.
- Signal Timing Practices, which deals with the evaluation of the signal operations and use of practices that have shown to produce efficient operations.
- Traffic Monitoring and Data Collection that provide for the determination of traffic flow conditions to evaluate agency objectives.
- Maintenance, the objective of which is to maintain field infrastructure reliability.

This report shows minor overall improvements. However, only three categories—management, signal timing practices, and maintenance—showed minor improvement during the past few years. Signal timing practices improved the most (by 7 points). However, given that there are over 300,000 traffic signals in the U.S. and Canada (*21*), the impact of these would be significant. More specifically, the NTOC Report Card assesses the status of agencies in the five categories to be as follows:

Management

At present, agencies seldom document and share information about signal operations programs with employees, agency leadership, and the public. In addition, any outreach to the public, policymakers, and other partners occurs informally. Lastly, performance measurement rarely occurs.

Traffic Signal Operations

Agencies maintain information about signals and timing inventories in a central location, but infrequently update these data to reflect changes in traffic and land-use patterns. In addition, performance of traffic signal timings is not monitored on a regular basis, and plans are not in place for special events and emergencies.

Signal Timing Operations

Agencies do not generally document signal timing policies and practices. In addition, all signal timing parameters and controller features are not considered. The number of timing plans is also inadequate to cover all traffic demand conditions.

Traffic Monitoring and Data Collection

Agency performance in this category is the worst, with a grade of 'F'. Agencies lack real-time data collection needed to provide adequate information to the public or to allow quality checks to assess correct working order of equipment (i.e., sensors) and effectiveness of signal operations.

Maintenance

Because of inadequate staff or training resources, agencies cannot proactively maintain their signals, and maintenance is limited to only the most critical issues.

STATUS OF ITS COMMUNICATIONS INFRASTRUCTURE

The 2010 ITS Deployment Survey does not contain any significant information about communications infrastructure used by transportation agencies to support ITS. This section is based on a review of practices of departments of transportation (DOTs) in selected peer states, additional detail of which is available in Chapter 7.

Alaska DOT

Alaska DOT uses a mix of technologies to provide communications with field devices, which include road weather information systems (RWIS), portable and fixed DMS, CCTV cameras, weigh-in-motion (WIM) stations and traffic sensors. These communications technologies include telephone lines, microwave-based statewide communications network with 900 MHz wireless spectrum radios, satellite service, and cellular service.

Arizona DOT

Arizona DOT uses a mix of technologies for ITS needs. The statewide communications backbone consists of a dozen node buildings with a 10 gigabyte dual path to the TMC, consisting of 150 miles of department-owned fiber and some twisted pair cable. This communications backbone connects field devices, which include video cameras, dynamic message signs, freeway mainline detectors, and ramp meters. A current project is also connecting some traffic signals via fiber. The majority of rural DMS outside the Phoenix area are connected using old telephone lines. Arizona DOT is in the process of connecting these devices to a statewide microwave system run by DPS. This system includes 70 analog microwave sites across the state, consisting of three independent, but integrated loops. Arizona DOT is also considering the use of this system for rural RWIS. The department is also increasingly using wireless (i.e., 5.4 GHz) for DMS and CCTV cameras. In addition to the DOT communications infrastructure, agencies in Maricopa County have a Regional Community Network (RCN), which allows partner agencies to share their fiber and conduits.

Arkansas DOT

ITS infrastructure in Arkansas primarily consists of state-owned fiber on DOT right of way along most major interstate roads. This network is used to connect all but one district office and the field devices, which include DMS and CCTV cameras. Fiber connection to the one remaining district will be completed soon. The department also uses cellular-based wireless service for communicating with field devices where fiber does not exist.

Colorado DOT

ITS communications infrastructure in Colorado connects RWIS, DMS, CCTV cameras, and traffic sensors with two regional and the statewide TMC. This infrastructure includes fiber along I-70 from Kansas to the west, I-25 from Pablo to north of Denver (to be extended north to Cheyenne) and parts of SH 6 and SH 36. This infrastructure was developed with the aid of public-public and public–private partnerships. Colorado DOT's (CDOT's) current approach/direction is to install fiber where possible because of its reliability. However, the department uses cellular and telephone lines where it is challenging to install fiber due to mountainous terrain. Wireless, however, is not reliable because of high peaks and valleys. For this reason, the department plans to replace current Cisco wireless with fiber soon. CDOT also uses 800 MHz wireless communications with other agencies such as emergency management.

CDOT considers ITS communications infrastructure as a statewide strategic investment. The department has successfully created public–private partnerships where the department trades its right of way (ROW) in return for fiber ownership or use. CDOT recently obtained a Tiger Grant for sharing of metro fiber.

In 2010, CDOT entered into a public–private partnership agreement with Comcast. The agreement lets Comcast lease two of CDOT's existing single-mode fiber optic strands along the I-70 Corridor for 20 years, with rights to extend the agreement after the initial lease period. As part of the lease agreement, Comcast will maintain this portion of CDOT's fiber network through weekly inspection of the network's backbone, replace damaged or missing fiber markers, and clear/clean debris from network pull boxes and other access points. The estimated value of this benefit to Colorado taxpayers over the next 20 years is $14.5 million. Another example of such partnership is an agreement CDOT made with wireless operator Crown Castle International. Under this agreement the wireless operator is installing fiber on CDOT ROW along U.S. 6 and

SH 119 to provide wireless services to its customers. As part of this agreement, CDOT will own this fiber, have power provided to ITS equipment, and share space on 32 poles along the route to install ITS infrastructure (DMS, CCTV, RWIS, etc.) for providing ITS services. Furthermore, Crown Castle will maintain the fiber line for 20 years, including repairs and emergency response to outages. This aspect of the agreement is renewable through the partnership. As a result, CDOT will save $7 million required to build and maintain this communications infrastructure.

Delaware DOT

In Delaware, ITS communications infrastructure is used to connect DMS, CCTV cameras, automated traffic detectors, and other field devices to the statewide TMC, which is integrated with an emergency operation center. This communications infrastructure in the state includes more than 180 miles of fiber optic cable, 220 MHz and 800 MHz wireless radios, and cellular modems.

Florida DOT

Florida DOT (FDOT) has several regional TMCs with fiber-based communications to field devices. The fiber circuits in the network are gigabit Ethernet links. FDOT's strategic plan is to continue developing the statewide fiber optic network and its integration in support of district ITS initiatives. FDOT is also developing a wide-area network (WAN) for interconnecting regional TMCs (RTMCs) across the state and Turnpike. Some districts are already interconnected. The ITS WAN, which uses center-to-center communication, provides for RTMCs to share traffic information (i.e., during hurricane evacuation, to provide access to archived data service, etc.), remote ITS roadside device control, video images, and command/control sharing among the RTMCs. ITS WAN uses statewide microwave system (SMS) to provide statewide connectivity. SMS was recently upgraded from an analog to a digital system to support video and data sharing between operational RTMCs. This high-speed data network is capable of transmitting up to 33 Mbps between hub sites and up to 3 Mbps from remote sites to hub sites. The SMS can also support the transmission of multiple streams of Internet Protocol (IP)-based traffic information from remote field devices to RTMCs that are connected to the microwave system data network. The ITS WAN will also take advantage of FDOT's fiber optic facilities, where available, because of higher communication speeds supported by these links. The data servers for Florida's next-generation 511 system will be housed in a single location in Tampa, and will also be connected to the ITS WAN. FDOT road rangers (service patrol) use GPS and cell card-enabled laptop computers to directly enter incident information into the central system.

FDOT has a 30-year agreement with Lodestar, with exclusive rights for the first 15 years to market and sublease certain DOT properties, wherein Lodestar may enter into sublease agreements with wireless providers and provide FDOT with a percentage of the gross receipts derived from these subleases. This strategy encourages wireless service providers to collocate on towers located primarily on FDOT's limited-access rights of way instead of developing numerous new tower sites in local communities.

Georgia DOT

In the Atlanta metropolitan area, DOT fiber is mostly used for communications from TMC to all field devices (i.e., DMS and CCTV cameras), with a few short hops (i.e., across the freeway to cameras) being microwave. Climate-controlled hub buildings act as nodes for this communications network. Early rural ITS devices consisted of cameras along hurricane routes, with landline communications. Each land line required a monthly service charge of $54 plus long distance charges. Recently, GDOT has started converting to cellular modem-based communications using fixed IP addresses. Available 4G cellular service is anticipated to significantly improve speeds over dial-up connections, which only supports one image every 3–4 seconds. GDOT has already completed fiber in the metropolitan areas, and it does not plan to extend it because of high installation cost. It is envisioned that any additional needs will be filled using wireless.

Idaho DOT

Idaho communications infrastructure is a combination of technologies, and uses multiprotocol label switching (MPLS) architecture. It includes fiber owned by the department (in the Boise area and local fiber networks in some districts, mostly in the urban areas), and bandwidth purchased from a telecommunications consortium. Purchased service provides for statewide multi-cast video transfer/viewing needs and communications between headquarters (TMC) in Boise and district offices. Communications infrastructure also includes fiber owned by other public agencies (911 center, state police, and cities). In addition, the department uses 3G cellular services to DMS, HAR, and many RWIS at a cost of $40/month/site. DSL is also used where cellular coverage is not available. Future expansion of communications infrastructure is expected to be via expansion of local fiber in urban areas and purchase of service for long-haul communications needs.

New Mexico DOT

New Mexico DOT ITS infrastructure includes RWIS, DMS, pan-tilt-zoom (PTZ) cameras, HAR, and traffic sensors, primarily located in the Albuquerque area. The TMC is also located in Albuquerque. Communications infrastructure in the Albuquerque area is mostly fiber optic network that is owned and operated by the DOT. This network is divided into four legs along interstate highways. The DOT shares this network with the City of Albuquerque and Bernalillo County by allowing them to connect their respective ITS devices. New Mexico DOT also has access to both city-owned and county-owned communications infrastructure. A few installations outside the Albuquerque areas, outside of the DOT fiber network, and locations outside of the metropolitan area use Wi-Fi wireless and cellular communications. The department plans to add conduit and fiber installations on several roadway sections, and a fiber sharing agreement with another city.

Other States

Several other state DOTs, including Mississippi, Alabama, and Louisiana use fiber-based communications along major interstate highways. State laws in Mississippi do not allow public–private partnership on state-owned right of way or telecommunications easements. Alabama also does not allow the installation of telecommunications infrastructure on their ROW through public–private partnerships (PPPs) as this relaxation may require them to open their ROW to all providers. However, the state law allows Louisiana Department of Transportation and Development (LaDOTD) to enter into such partnerships to install a fiber optic infrastructure along interstate highways and to share tower space with private companies. As a result, LaDOTD has entered into P3 agreements since 2000, where LaDOTD receives compensation (cash, infrastructure such as dark fiber or conduit, or bartered telecommunications services) in exchange for allowing the use of their interstate ROW and towers. Agreements are entertained on a first-come first-served basis and pre-established conditions.

CHAPTER 6:
EMERGING TECHNOLOGIES AND NATIONAL TRENDS

In April 2011, TTI was offered the opportunity to try out a satellite communications technology being marketed for use in controlling dynamic message signs and portable changeable message signs (PCMS). The technology, provided by Rapid Alert Network (RAN), consists of a global positioning system antenna to provide location information about the sign it is attached to, a satellite communications antenna, and a small processing unit. The antennae are small and can be easily attached either permanently or with temporary straps to a sign. The processing unit accesses the sign power supply and then interfaces with the sign controller through a serial communications port.

SYSTEM INSTALLATION

For the TTI assessment, the antennae were temporarily attached to a National Transportation Communications for ITS Protocol (NTCIP) full-matrix portable changeable message sign that was located at the TTI proving grounds facility (see Figure 2). Precision Solar Controls, Inc. owned the signs, which were in TTI's possession for other sign testing purposes. Precision Solar Controls officials agreed to let the RAN technology be temporarily attached to the sign for testing purposes. Attachment occurred in early May 2011. A RAN representative was able to attach the system to the PCMS in about 20 minutes. Once the system was turned on, communication was established with the sign in approximately 1 minute.

Figure 2. Temporary Attachments of GPS and Satellite Communication Antennae to a Precision Solar Controls PCMS.

COMMUNICATIONS INTERFACE

A web-based interface provides user interaction with the sign. Security is handled through a simple log-in procedure once a system administrator has established a username and password. A user hierarchy can be established to allow different levels of control. The interface provides an automatic link to Google Maps™ with the current sign location (see Figure 3). The RAN technical representatives have indicated that it would be possible to use a different map database (such as Microsoft Bing™) for the interface if so desired.

Interaction with the PCMS is handled through the left side of the user screen. First, single or multiple signs are selected from the sign list (only one sign was evaluated as part of this assessment). Once a sign is selected, the user then types in the desired message text in the black window on the screen. The interface allows for up to three phases of information to be entered. Once the text is entered in the window, the user clicks the Send button. To end a sign message display, the user clicks the Clear or blank button. The "Loc?" button returns the current GPS coordinates of the sign. If the sign has been moved or reoriented and not reset, this query will return a warning message indicating that the sign or its orientation has been moved (see Figure 4).

All interactions with a sign are logged (see Figure 5). Researchers determined that the times recorded with respect to message submission and delivery to the sign appear to be accurate.

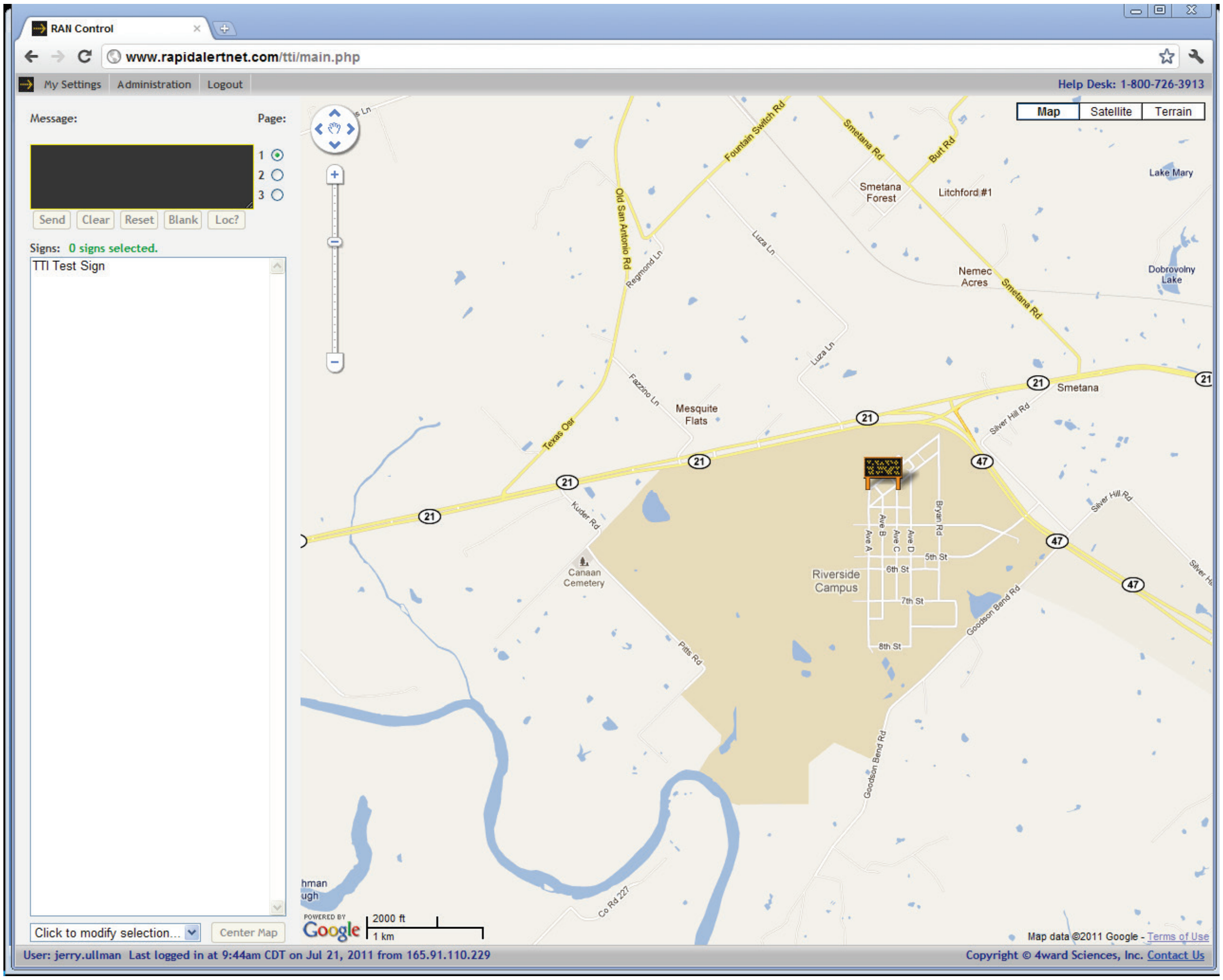


Figure 3. RAN Web Interface Screen.

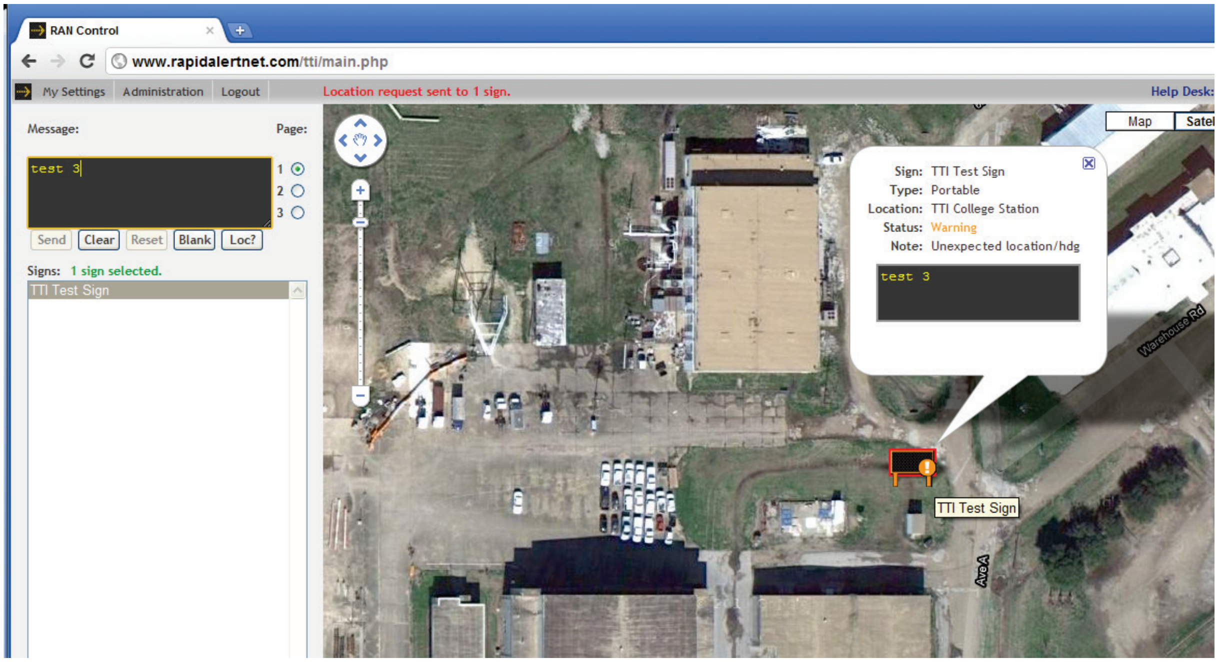
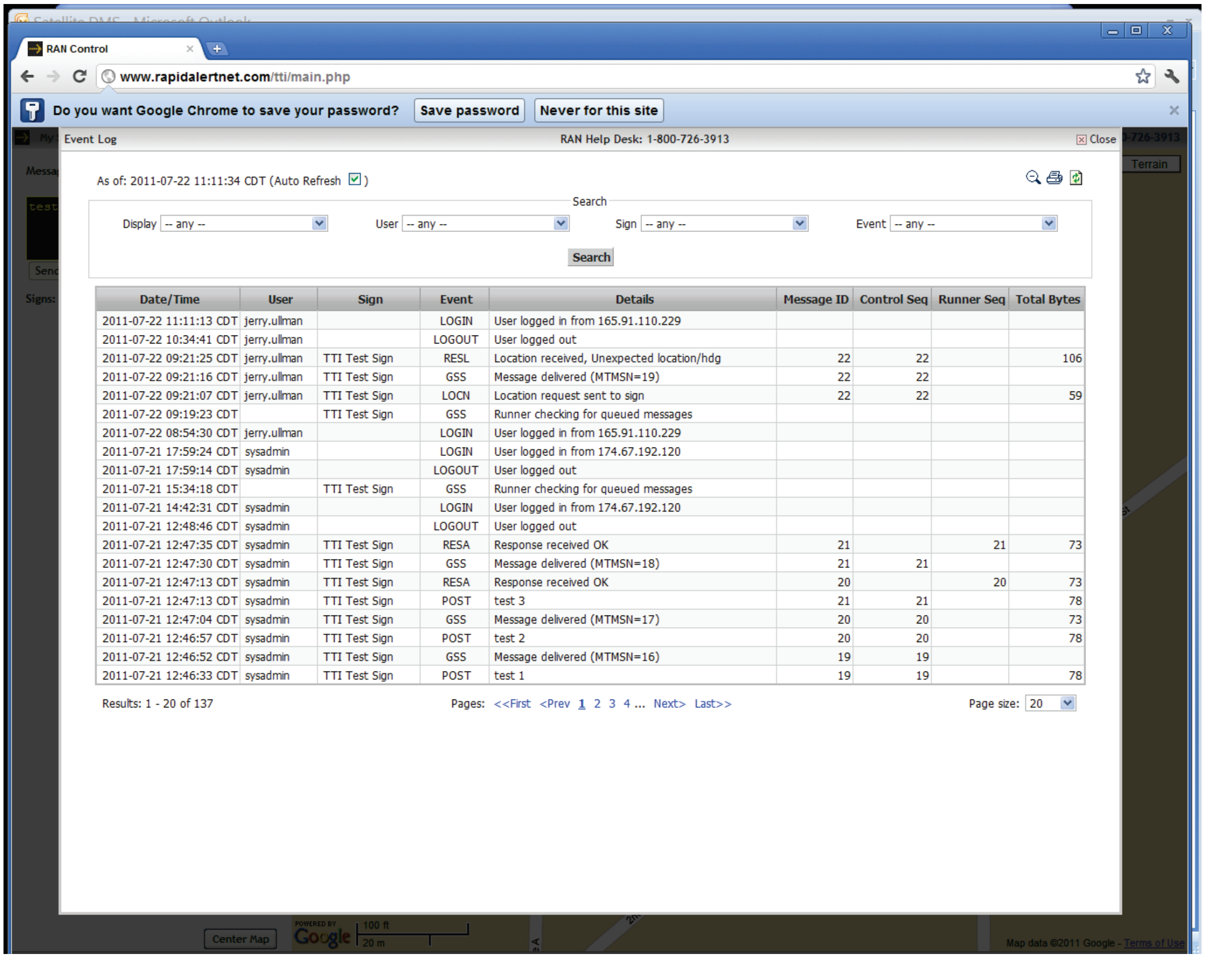


Figure 4. Sign Location or Heading Warning Message.

SYSTEM OPERATION

TTI staff interacted with the PCMS using the satellite system on a number of occasions between May and July 2011. No issues were encountered when attempting to log into the system or when logging out. Message entry and submission to the sign was straightforward and without any issue, as well. In an open-sky environment, such as exists at the TTI annex, message submission time to the sign was fairly quick, within 15 to 30 seconds in most cases. This communication time will increase as the amount of open sky is diminished, i.e., if the sign is located in an urban environment with tall buildings or a deep canyon/valley. For example, when TTI staff pulled the sign up next to the hangar, effectively cutting the amount of open sky accessible to the sign by half, the communication time to the sign increased to between 45 seconds and 1 minute. Further reduction of visible sky from the sign would likely yield further increases in communication time. Tall trees may also diminish communication time, although it was not possible for TTI to test that particular condition.

Overall, it appears the sign will be able to receive commands in all but the most constrained conditions. However, it should be noted that no testing was performed during heavy rain or other adverse weather conditions that typically interfere with satellite television feeds. Given that the data requirements for issuing commands to a sign and receiving responses is much smaller than that used for video broadcasting, weather may not have a major influence on the operation of the tested system. However, that remains to be verified under actual severe weather conditions.



Date/Time	User	Sign	Event	Details	Message ID	Control Seq	Runner Seq	Total Bytes
2011-07-22 11:11:13 CDT	jerry.ullman		LOGIN	User logged in from 165.91.110.229				
2011-07-22 10:34:41 CDT	jerry.ullman		LOGOUT	User logged out				
2011-07-22 09:21:25 CDT	jerry.ullman	TTI Test Sign	RESL	Location received, Unexpected location/hdg	22	22		106
2011-07-22 09:21:16 CDT	jerry.ullman	TTI Test Sign	GSS	Message delivered (MTMSN=19)	22	22		
2011-07-22 09:21:07 CDT	jerry.ullman	TTI Test Sign	LOCN	Location request sent to sign	22	22		59
2011-07-22 09:19:23 CDT		TTI Test Sign	GSS	Runner checking for queued messages				
2011-07-22 08:54:30 CDT	jerry.ullman		LOGIN	User logged in from 165.91.110.229				
2011-07-21 17:59:24 CDT	sysadmin		LOGIN	User logged in from 174.67.192.120				
2011-07-21 17:59:14 CDT	sysadmin		LOGOUT	User logged out				
2011-07-21 15:34:18 CDT		TTI Test Sign	GSS	Runner checking for queued messages				
2011-07-21 14:42:31 CDT	sysadmin		LOGIN	User logged in from 174.67.192.120				
2011-07-21 12:48:46 CDT	sysadmin		LOGOUT	User logged out				
2011-07-21 12:47:35 CDT	sysadmin	TTI Test Sign	RESA	Response received OK	21		21	73
2011-07-21 12:47:30 CDT	sysadmin	TTI Test Sign	GSS	Message delivered (MTMSN=18)	21	21		
2011-07-21 12:47:13 CDT	sysadmin	TTI Test Sign	RESA	Response received OK	20		20	73
2011-07-21 12:47:13 CDT	sysadmin	TTI Test Sign	POST	test 3	21	21		78
2011-07-21 12:47:04 CDT	sysadmin	TTI Test Sign	GSS	Message delivered (MTMSN=17)	20	20		73
2011-07-21 12:46:57 CDT	sysadmin	TTI Test Sign	POST	test 2	20	20		78
2011-07-21 12:46:52 CDT	sysadmin	TTI Test Sign	GSS	Message delivered (MTMSN=16)	19	19		
2011-07-21 12:46:33 CDT	sysadmin	TTI Test Sign	POST	test 1	19	19		78

Results: 1 - 20 of 137 Pages: <<First <Prev 1 2 3 4 ... Next> Last>> Page size: 20

Figure 5. Communication Event Log.

For the sign tested, interaction via the communication system was limited to text characters typed into the message window. The system did recognize both upper- and lowercase characters, but it was not possible to adjust message justification, font style or enhancements such as bold characters, or other features. TTI staff noted that the system did adjust to certain sign characteristics such as the number of characters that can be displayed on a line, and they automatically adjusted for this constraint when typing in messages. Furthermore, RAN representatives have indicated they are currently developing web-based controller interface functionality for line and page justification, message on and off time, and displaying messages stored in the sign memory (i.e., "canned" messages). They do not intend at this time to implement the graphics upload and download functionality in NTCIP 1203v2 due to bandwidth considerations. However, if customers want to use their own management systems, full functionality of all NTCIP attributes will be possible by interfacing RAN through the Application Program Interface (API) being developed by RAN. RAN representatives have worked with the Southwest Research Institute (SwRI) and with the Traffic Operations Division of TxDOT to implement the API with the TxDOT Lonestar™ software. At this point, SwRI and TxDOT will need to make some minor changes to Lonestar™ in order to integrate it fully with the RAN API.

Initial evaluations did uncover a potential problem with attempting to send multiple messages quickly in sequence, as might occur if a user did not type in a message correctly and quickly tried to resend a corrected version. When more than two messages had been sent prior to the sign receiving the first message, the queue of messages sometimes did not get sent in the accurate sequence. Furthermore, the sign did not appear to end up with the last message that was sent, but instead reverted to an earlier message. After TTI and RAN staff communicated about this particular glitch, RAN made a software change. Subsequent trials of rapidly sent multiple messages to the sign did not result in the same problem, suggesting that the software modification made by RAN was successful.

POTENTIAL USEFULNESS OF SATELLITE COMMUNICATIONS FOR DMS AND PCMS CONTROL

Based on the controlled-condition trials performed at the TTI proving grounds, the satellite communications system did appear to perform as intended. Installation of the system was fairly quick and straightforward. PCMS message entry and removal was likewise fairly easy. The one possible glitch with respect to the communications software was apparently resolved.

There are a number of situations in which it could possibly be beneficial to have satellite communications capabilities with DMS and PCMS in lieu of more traditional cellular communications. The most obvious of these are locations where cellular communication is unavailable or of poor quality. Lower-volume or functional classification roadways in many rural areas statewide fall into this category. If the need exists to deploy a PCMS on a facility of this type and have the capability to communicate with the sign remotely, a satellite-based system could be used for that purpose.

Another potential application would be in urban areas when high communication demands makes it difficult to gain access to the cellular network. Travelers in many urban areas have difficulty making cellular telephone calls during peak hours when on or near major freeways due to the volume of calls being attempted in that area. An alternative to cellular communications can be established for permanently installed DMS in urban areas, as PCMS deployments that offer cellular communications capabilities could be hampered during high-volume calling periods. This could be particularly problematic if such signs were deployed for traffic management during major emergencies such as hurricane or hazardous materials evacuations, or for special-event traffic management. Although satellite communications with the signs have not been evaluated in these high-cellular communication demand environments, it is likely that it would have more frequent and regular communication opportunities with the signs.

A third potential application would be to provide temporary remote communication capabilities to those PCMS that are not equipped for cellular communications at this time. TxDOT does own a number of PCMS that, due to cost considerations, do not have remote communication capabilities. A satellite communications system, especially one that can be easily attached to a sign when needed and then removed or moved to a different sign when not needed, could address an unmet need. Such an approach would likely require a few modifications to the system that was tested to allow it to be temporarily attached and removed from signs as needed.

Finally, a few districts currently own several NTCIP-compliant PCMS that were purchased without cellular modems due to cost and use trade-off considerations. Those districts may find it useful to have a RAN system in their possession to temporarily connect to a sign when necessary for real-time remote communication and operation of the sign. To be cost-effective, the frequency of use would need to be fairly low, such that the (assumed) higher per-communication message cost to and from the sign would still not exceed the typical monthly cellular communication plan for a sign. Presently, it is unclear how much a RAN system will cost for purchase and for communications.

Although satellite communications for DMS and PCMS may offer some advantages in certain situations, it is not yet clear how expensive such technology would be from an operations perspective. According to RAN representatives, the communications costs will likely depend on the amount of usage and number of devices deployed. It was noted that RAN itself is looking at a hybrid satellite/cellular communication setup where cellular is used when and where it is available and the system automatically switches to satellite when necessary. Such an approach would likely reduce communication costs, but by how much is not known. It is also not known whether widespread deployment of satellite communications devices will ultimately result in a situation similar to cellular communications during peak-period travel in urban areas.

EMERGING TRENDS

The following sections highlight emerging trends in technology that will likely have an impact on ITS deployment in the coming years.

Dark Fiber

The marketplace for fiber optic communications is changing. At this time companies are installing dark fiber in Texas and other locations in the United States. Some of these companies have installed connectivity that stretches from the East Coast to the West Coast and from the Gulf of Mexico to the Pacific Northwest. In Texas the major cities along I-35 and I-45 are key deployment sites.

The business model for this marketplace is to have dark fiber ready for a company or agency that needs the connectivity. The companies retain ownership of the fiber and provide technologies and services to meet the needs of the customers who would pay on a usage basis. One of the leading suppliers in Texas will soon have 9000 miles of fiber in place and connectivity to 60+ cities. Depending on the routing, proximity to transportation infrastructure, and cost, the use of these existing dark fibers could speed buildout of ITS where fiber is chosen as the deployment solution.

Cellphone App for Freight Pre-clearance and Toll Payment

Freight pre-clearance and toll payments are marketplaces that could experience transformational change through the use of smartphone technologies. Some private-sector organizations are currently providing products that enable cell phones to send bypass requests. The concept is for the driver’s cell phone to send a request a few miles prior to the pull out. When closer to the site, the application displays the driver’s instructions to either bypass the site or follow road signs to the station. For TxDOT these kinds of technologies could lower infrastructure costs and provide additional flexibility when managing truck fleets.

CHAPTER 7:
PEER STATE REVIEW

A key part of developing a statewide ITS strategic plan is to obtain and incorporate feedback from peer states about their ITS programs, ITS needs, and best practices. TTI researchers developed a questionnaire to serve as a guide during the interviews. This section describes the results of interviews that TTI researchers conducted in 12 peer states across the country. The research team selected these states based on geography, size, and common transportation operations and management issues. Researchers conducted the one-on-one interviews by telephone with key ITS personnel in each state.

TTI researchers interviewed ITS personnel from 12 states: Alaska, Arizona, Arkansas, Colorado, Georgia, Idaho, North Carolina, Ohio, South Dakota, Utah, Vermont, and Wisconsin. The following is a summary of the interviews from each state.

ALASKA

The current ITS infrastructure in Alaska consists of:

- Road weather information systems (RWIS) that measure surface/subsurface temperatures and water/snow levels through the use of pavement sensors, atmospheric sensors, and closed circuit cameras (CCTV).
- Weather information management systems.
- Weight restrictions decision making tool, which provides real-time and historical data, including temperature, rainfall, water locked in ice, soil substructure, and standing water level.
- Portable message boards, some equipped with IP addresses.
- Cellular modems.
- Satellite modems.
- A limited number of CCTV and traffic cameras (Fairbanks only).
- A limited number of permanent dynamic message signs (Anchorage only).
- A limited number of Wavetronix high definition (HD) speed sensors.
- An enforcement van.

The Alaska Department of Transportation and Public Facilities (Alaska DOT&PF) has several components in its ITS communications infrastructure, including direct dial capabilities from polling locations, a microwave-based statewide communications network that uses both dial-up modems and wireless spectrum radios, a limited number of PBX systems, seven geosynchronous satellites, and code division multiple access (CDMA) cell phones in some locations. Also, a new 511 system for the state is being developed (the current contract was being renegotiated at the time of the interview).

There is not a state TMC in Alaska, as the cities manage their own sign control. Alaska does not have travel-time information at this time, but plans to have that available in 1–2 years. Funding for ITS programs in Alaska mainly comes from federal monies. It cannot be used to hire staff but can be used to hire contractors for specific projects and/or activities.

The interviewee indicated that Alaska would like to enhance its current ITS program by:

- Continuing to develop the 511 system.
- Replacing RWIS with geographical information system (GIS).
- Adding a geo-referenced crash data system.
- Updating the current integrated traffic management system.
- Developing two ITS corridors.

ARIZONA

The ITS infrastructure in Arizona consists of:

- 65 DMS in Maricopa County.
- 200 PTZ cameras.
- 24 CCTV cameras.
- Approximately 200 ramp meters, with over 150 having communication to the TMC.
- Main lane sensors.
- RWIS at 18 rural sites.
- Dust detection system near the New Mexico border.
- Node buildings.
- 150 miles of fiber owned by the Arizona DOT (ADOT).
- Wireless connections to DMS and CCTVs.

Approximately 70 percent of the population in Arizona lives in the Phoenix area, specifically Maricopa County. Most of the ITS infrastructure in Arizona is either located within Maricopa County or Tucson. The statewide TMC is located in Phoenix at the Maricopa County Council of Governments (MAG). An additional TMC servicing the southern portion of the state is located in Tucson (STOC). The STOC is restricted to a 20-mile region around Tucson and does not operate on a 24/7 schedule like the statewide TMC.

At this time, ADOT funds all ITS projects and there are no public–private partnerships (which were prohibited until 2010). However, some partnering is occurring with local public agencies to share resources, i.e., one agency laying fiber in another agency's conduit. In 2004, voters approved a 0.5 percent tax increase, which will generate $146 million in additional funding for the ITS program in Arizona (over 20 years), with $10–$12 million allocated for the MAG region.

ARKANSAS

ITS infrastructure in Arkansas consists of:

- 41 existing DMS and nine more being installed.
- 30 CCTV cameras.
- 10 existing HAR locations and two being added on a construction project.
- Fiber.

The Arkansas State Highway and Transportation Department (AHTD) has state fiber on state right of way for communications to all district offices except one and along major interstate highways, including I-30, I-40, I-540 (I-49 corridor), and I-530. No fiber currently exists on I-55. In the near future, AHTD will have fiber to the one remaining district office. Fiber is used for communications to DMS and cameras and for research. AHTD also uses wireless communications with IP addresses where fiber does not exist. Depending on the location, either AT&T or Verizon service is used. The best service is approximately two bars of enhanced data rates for global evolution (EDGE). The cost for Verizon service is about $50/modem, and AT&T is comparable. In addition, a 511 system is being developed for the state.

AHTD has a Transportation Investment Generating Economic Recover (TIGER) Grant, along with Louisiana and Mississippi, as the lead agency to install ITS infrastructure on four bridge crossings along the Mississippi River south of Memphis. The infrastructure to be installed under two contracts will include DMS, cameras, HAR, river monitoring, and fiber connections. A third contract will verify data for monitoring purposes. Data will be transmitted to the TMC in Jackson, Mississippi. Arkansas does not have a TMC, but will have access to these data. A third contract will verify data for monitoring purposes.

COLORADO

ITS infrastructure in Colorado includes:

- 200 RWIS.
- 200 DMS.
- 400–500 CCTV cameras.
- Inductive loops and radar sensors.
- Fiber-based communications infrastructure.
- A statewide TMC located in Golden, and two smaller TMCs. The one in Glenwood Canyon monitors all devices on a 174 mi (280 km) stretch along I-70 in Northern Colorado.

Funding is always an issue, especially for hiring more full-time staff needed to support ITS. Currently, State funds (specifically the Highway User Trust Fund) support ITS (deployment, maintenance, and replacement).

Communications infrastructure is mostly fiber along I-70 from Kansas to Denver, along I-25 from Pueblo to north of Denver, and on parts of SH 6 and SH 36. Fiber infrastructure was developed through public–public and public–private and partnerships. A current TIGER Grant—an example of a public–public partnership—allowed the DOT to share its metro fiber. CDOT trades ROW `in exchange for fiber ownership or use. CDOT also uses 800 MHz communications to other agencies (i.e., emergency management). CDOT's current approach/direction to expanding communications infrastructure is to install fiber where possible. Some devices currently run on cellular communications and some run on telephone lines. It is challenging to install fiber in the mountainous terrain, but it is reliable. Wireless is not reliable and is challenging to install because of high peaks and valleys. The department plans to replace current Cisco wireless communications with fiber soon.

GEORGIA

Deployment of ITS in the Atlanta metro region began in the mid-1990s in preparation for the 1996 Olympic games. At that time, Federal funding was available for demonstration projects, so Georgia built the core ITS systems with expansion in mind. After the Olympics, the state began expanding the ITS infrastructure using the same architecture and fiber. It began servicing rural areas with ITS in the late 1990s by installing signs and cameras along hurricane evacuation routes. Telephone lines are proving to be costly for communication to rural ITS deployments, so the state is currently seeking alternative communication methods, such as deploying cellular modems with fixed IP addresses.

From 1996–2011, all ITS in Georgia was operated using an in-house software developed by TRW, named Navigator™. The software was updated to Navigator 2 in 2010, and a new web-based software by Delcan was introduced in 2011.

Georgia DOT (GDOT) has several ITS partnerships. GDOT is a member in the Traffic.com Transportation Technology Innovation and Demonstration (TTID) program, a federally funded program in 25 states. Through this program, GDOT allowed Traffic.com to install remote traffic microwave sensors (RTMS) along 80 miles of highway corridors. In exchange, GDOT has access to 80 solar-powered sensors that have been integrated into the ITS program at no cost to the state. GDOT has also partnered with INRIX for a demonstration project along the I-95 corridor, funded by the I-95 Corridor Coalition. Through this partnership, GDOT will integrate travel time data obtained from INRIX servers.

The annual budget for ITS in Georgia is divided between ITS operations, software and hardware, maintenance, and incident management. ITS operations has a $7 million annual budget to be used for supplies, materials, utilities, service fees, staff for TMCs, supervisors, and dispatchers. Expenses for software and hardware are allocated $1.5 million annually, maintenance of the ITS systems is budgeted for $3 million, and incident management (including 90 highway patrol officers) is allocated $7 million. According to the interviewee, capital funding for ITS projects is readily available through the Atlanta Regional Commission, the metropolitan planning organization (MPO). The MPO funds basic ITS operational improvements such as adding turn lanes or alleviating bottlenecks, striping, and signing.

In the future, GDOT plans to continue expanding the ITS infrastructure around the state and exploring alternative systems and products. It has plans to introduce speed harmonization on Loop 285 (65 miles) that will raise default speeds from 55 to 65 miles per hour.

IDAHO

ITS infrastructure in Idaho includes:

- 87 RWIS in the state, located predominantly in rural areas.
- 54 DMS.
- Five weigh-in-motion sites for collecting data in addition to WIM sites at ports of entry.
- Existing roadway sensors include automated traffic recorders, Wavetronix radars, inductive loops, and 10 Bluetooth-based systems for collecting travel time data. The department also has two portable Bluetooth-based systems for collecting travel time data in work zones.

The Idaho Department of Transportation (IDOT) has a statewide TMC that the Idaho Health and Welfare Department manages. IDOT pays them approximately $400K/year. The TMC provides 24/7 dispatching and operation of an ITS network of statewide elements between six districts. The department has just executed a contract to replace the old control-room system. This contract was selected using best value procurement. The new Delcan-developed system will have a web-based interface. The state also has a 511 system with information provided through telephone lines, a full-featured web page, and a web page for mobile devices.

Idaho's communications infrastructure is a combination of technologies and uses MPLS architecture. It includes fiber that the department owns (in the Boise area and local fiber networks in some districts, mostly in the urban areas), and bandwidth purchased from a telecommunications consortium. Purchased service provides 10 MB and 20 MB data transfer depending on traffic and need, especially driven by statewide multi-cast video transfer/viewing needs to allow several camera feeds simultaneously, and provides communications between headquarters (TMC) in Boise and the district offices. Bandwidth is sufficient for the needs. The infrastructure also includes fiber that the other public agencies own (911 center, state police, and cities). In addition to fiber, the department also uses 3G cellular services for communications to fixed devices (i.e., DMS, HAR, and many RWIS). DSL is also used where cellular coverage is not available. Verizon is the main provider and costs $40/month/site. Other cellular providers are also used. Future expansion of the communications infrastructure is expected to be via expansion of local fiber in urban areas and purchase of service for long-haul communications needs.

Sources of ITS funding in the state have included Grant Anticipation Revenue Vehicles (GARVEE) bonds, safety funds, and federal aid funds. The ITS program in Idaho has been primarily led by department headquarters in Boise, which prioritized and funded the projects. Starting in FY 2014, the department is shifting responsibility for identifying priorities, programming ITS projects, and deploying infrastructure to individual districts. ITS at headquarters will continue to oversee and allocate funds for 511 traveler information service and ITS maintenance on a statewide level. In March 2011, the state's ITS strategic plan was updated to accommodate these changes and to ensure a smooth transition as well as maintain consistency with statewide architecture after that.

NORTH CAROLINA

North Carolina operates ITS using state-owned, single-mode fiber optic cable to cover 95 percent of the state. In rural areas, wireless connections are available. At this time, most connections are center-to-field, but staff are working toward center-to-center with hardwire connections. There is one statewide TMC in Raleigh, North Carolina, and regional TMCs in Charlotte and Greensboro. Data are shared between several state agencies, including the highway patrol, emergency management, and major municipalities. North Carolina has several performance measures to evaluate the ITS program. They strive to reduce congestion and reduce clearance times while keeping safety first and foremost.

The ITS network in North Carolina is expanding. Several roadway construction projects currently under way will be installing additional ITS components and some areas qualify for Congestion Mitigation and Air Quality (CMAQ) funding as well. The state is exploring the possibility of public–private partnerships at this time. Operations and maintenance of the ITS program are outsourced. The 14 highway divisions fund their own ITS and utilize all available resources for the region.

OHIO

Ohio Department of Transportation (ODOT) is divided into six ITS regions, each using camera, DMS, fiber, and wireless connections. The ITS "backbone" in Ohio has already been developed and installed, so the state is in "maintenance mode" with all equipment expanded and built to the fullest capacity. The ITS operating budget comes from gas taxes and state planning and research (SPR) funds. ITS platforms (NTCIP) are developed in-house. ODOT provides traveler information and traffic updates at buckeyetraffic.org.

Currently, Ohio leases fiber lines and conduit from AT&T/Time Warner. The service providers maintain the fiber line and cabinet. As a result, service fees have increased, but maintenance has decreased significantly. Leasing the fiber/conduit was more effective and a better use of limited funding and staff resources at ODOT. Sine wireless communications still exist, and the state uses 4G from Verizon to meet some needs.

ODOT is developing a statewide 511 system. The department plans to find corporate sponsorships to generate enough revenue to operate and maintain the system, making it no cost to the state. The corporate sponsors will maintain the rest areas/travel plazas in exchange for putting their logo on signs and related 511 information. There are no public–private partnerships at this time.

SOUTH DAKOTA

South Dakota is one of the most rural states in the country, with no large metropolitan areas and a small population, making travel time and congestion non-issues. Sioux Falls is the largest city in the state, with 150,000 people. ITS is at a limited intensity in South Dakota because they do not have the population or vehicle volume to support a more extensive program.

DMS are located statewide along the interstate and use fiber, hard line, cellular, and spread-spectrum radio connections. The fiber networks in the state are commercial, with the exception of Sioux Falls and Rapid City (the state owns the fiber networks in those two cities). Using commercial fiber along the interstates is more appropriate in South Dakota due to the low traffic volumes and little to no need for an extensive, state-owned fiber network. Traveler information systems have been very important in this state. The volume of web hits on the traveler information website and calls to the TMC increases significantly in the winter. South Dakota Department of Transportation (SDDOT) employs the C-Vision program through the

Federal Motor Carrier Safety program. C-Vision allows state and federal commercial vehicle ITS systems to be integrated and provides user services like electronic payments, auto permitting, and auto screening.

SDDOT implemented a 511 system in 2002. Users can subscribe to receive alerts via text or e-mail for certain sections of highway, different time intervals, etc. The DOT now outsources the services to Meridian. SDDOT partners with the South Dakota Trucking Association to meet the needs of the commercial trucking industry and improve commercial vehicle ITS.

In the future, the state plans to install 23 additional environmental sensors that can be used for weather and traffic, and use a high-resolution CCTV. South Dakota is also planning to implement variable speed limits on the interstate. This implementation could be important during winter-weather events, and the trucking industry is very supportive of this action.

Funding for ITS in South Dakota is available through the C-Vision program and budgeted into interstate projects. However, the DOT is searching for alternate funding sources, such as special programs, earmarks, and discretionary grants.

UTAH

Utah is a remote and rural state with 80 percent of the population living in an 80-mile stretch near Salt Lake City. One North–South freeway dissects the urban areas. When this freeway was reconstructed, the Utah Department of Transportation (UDOT) installed conduits with excess capacity along the route to use for trades and partnerships. When ITS was first established, UDOT created earmarks for ITS. Now that the system is mature and the DOT is pursuing only strategic installations, funding is not an issue for ITS. Bonding and taxing are not permitted for ITS projects, but there is a small discretionary fund available to pursue smaller projects.

Utah has a very robust fiber network, with UDOT installing fiber early and very aggressively. Fiber is reliable, has fast connections, facilitates readily available data sharing, and through agreements, there are no maintenance costs for the state. UDOT created a public–private partnership to allow access to right of way in return for use of fiber in other areas of the state. The state uses more fiber than it actually owns—the DOT owns 800 miles of fiber, but has acquired access to an additional 1000 miles through trades and partnerships. Spot installations are conducted if these fit with the overall goals of the DOT and the telecommunications company, but there must be a mutual benefit. Some of the benefits of using private fiber include:

- Immediate maintenance and repairs.
- Reliable security.
- Free exchange of data.
- The ability to connect several local partners to view cameras and signals.

Utah has many relationships with standard agreements and has found that most barriers associated with public–private partnerships are institutional. Partnerships have been able to facilitate high-speed communications to rural areas to connect schools, businesses, prisons, etc. The extensive fiber network has attracted higher quality businesses to more rural areas of the state where coverage is consistent and reliable.

Due to the extensive fiber effort, UDOT can communicate with and remotely control over 1400 traffic signals (the state has over 1700) across the state. Canyon locations can create unique traffic conditions that often occur far from the DOT headquarters. UDOT is able to communicate with devices (DMS, speed warning systems, etc.) located in these canyons through the fiber network.

VERMONT

ITS infrastructure in Vermont includes:

- RWIS.
- Weigh-in-motion systems.
- DMS.
- 511 system and website.
- Limited fiber network.
- Cellular modem connections.

The Vermont Agency of Transportation (VTrans) uses cellular modem to deploy its ITS components because it is readily available, and plans to install a fiber network have been delayed by politics. VTrans installed 14 miles of fiber as a proof of concept, and it is currently working with the private-sector to market right of way to install additional fiber connections. The RWIS use a broadband connection and have streaming videos available for police and emergency management to view. The cameras used cannot see the license plate due to major privacy concerns by the public in Vermont (state legislative approval is needed to view the license plates).

The DMS in the state show weather conditions and public safety messages. Travel time information is not necessary, but the new transportation bill requires that information. Thus, the DOT plans to make that available. The 511 website (www.511vt.com) has information about road construction, closures, and adverse driving conditions.

ITS is funded through state funding and operations, but the department is researching other STP funding alternatives. Vermont received the "Best of ITS" award for a small transportation operations center (TOC) at the 2011 ITS America World Congress.

WISCONSIN

ITS began in Wisconsin in 1993 with a Milwaukee-based system. The system expanded to Madison in 1996 and was deployed in urban centers. In 2000, the centers combined to create a single statewide ITS system and Wisconsin Department of Transportation (WisDOT) opened a statewide TMC in 2007. The statewide TMC monitors all ITS devices and has connectivity to border states to allow for data sharing, especially across highway corridors. Wisconsin is divided into five ITS regions, each with a dedicated staff person to act as a liaison for project delivery (rather than day-to-day operations). Each region is responsible for implementation, but the state TOC provides guidelines for design and construction of ITS components. A full-time ITS designer is on-site, and the control room is staffed 24/7 with 14 staff members.

The ITS system in Wisconsin is primarily fiber based. The system also includes 250 cameras, 575 detector stations, 125 metered entrance ramps, and 50 DMS. The state leases fiber and conduit to several agencies in major corridors, such as utility companies, the State Patrol, and neighboring states. The communications backbone in Wisconsin is self-sustained because revenue from fiber leases pays for the operation of WisDOT's fiber network.

WisDOT is not permitted to install new ITS devices unless these are part of a larger roadway project. This requirement has restricted the ability to expand the ITS system. Maintenance and monitoring of the system is outsourced via a statewide contract. Data management and planning have been outsourced through partnerships with state universities.

The contracts for maintenance and operations have been consolidated and make the prime vendor responsible for managing subcontractors (for 511, incident management, control room staff, Equal Employment Opportunity Commission [EEOC], etc.).

WisDOT has several goals for the ITS program, including expansion when available, focus on traveler information and improving mobility, and focus on incident management and developing partnerships with the State Patrol.

CHAPTER 8: FUNDING, PROCUREMENT, AND PARTNERSHIPS

The project team investigated the current TxDOT processes for ITS planning, design, specification, and procurement. The intent was to determine if changes in the existing process are viable and/or if new methods or improvements should be considered to deliver more timely and nimble ITS deployment when there is a clear technological and cost-effective advantage.

ALTERNATIVE CONTRACTING MECHANISMS

With respect to ITS procurement, several alternative contracting mechanisms might offer opportunities to optimize ITS operations in cost-effective ways. These mechanisms include job order contracting, comprehensive development agreements, and public–private partnerships.

Job Order Contracting

Job order contracting allows the governing agency (city officials or TxDOT) to provide the contractor with a contract that includes a negotiated and fixed price for the project. The approach encourages contractors to bid on a project based on the required labor, material, and procurement costs. The contractor is provided with work orders that include a specified completion date in an effort to ensure all tasks are completed in a modest amount of time, keeping the project on schedule (*22*). Currently, no major legal impediments exist with respect to job order contracting as long as TxDOT adheres to other restrictions and regulations that may impact the project. The following are best practices related to using this strategy:

- Utilize with projects that have a high user cost during construction or will significantly benefit users upon completion.
- Specifically define work restrictions in the contract that ensure regulations are followed.
- Assess the appropriateness of the technique prior to contract initiation.
- Ensure work schedule and incentives are in place to facilitate a successful project.
- Coordinate with multiple strategies if appropriate to optimize potential success (*22*).

Comprehensive Development Agreements

A comprehensive development agreement (CDA) allows a private company to perform different combinations of design, development, finance, construction, maintenance, repair, and operation. A CDA may be used for:

- Toll projects.
- Improvement projects that include both tolled and non-tolled lanes.
- Improvement projects in which a private entity has an interest in the project.
- Improvement projects financed wholly or partly with private activity bonds (*23*).

Public–Private Partnerships

States have increasingly turned to a variety of public–private partnerships mechanisms to finance transportation projects. These partnerships involve private-sector financing, construction, maintenance and/or operation of transportation projects. As of August 2012, 33 states and Puerto Rico have laws enabling PPPs for highways and bridges (*24*).

The potential opportunities for utilizing PPPs exist in many areas within the transportation program in general and can easily be expanded into the ITS realm. For example, Section 1201 of Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) requires states to provide real-time system management information for interstates by 2014 and other significant roadways by 2016 (*11*). Since a key component of this provision involves data, it is possible that a PPP might be a logical approach to leveraging private- and public-sector resources to meet the requirements and provide information to agencies and the traveling public. There might be similar opportunities within the purview of ITS as agencies consider alternatives to providing the ITS infrastructure for the transportation system. It is possible that many of these innovative finance mechanisms can be used to leverage resources for ITS projects in Texas.

ALTERNATIVE FUNDING OPTIONS

The funding of operations and maintenance of ITS infrastructure and system continues to be a continual challenge for TxDOT. Aside from the aforementioned contracting mechanisms, a variety of alternative funding options have potential to generate funding streams for ITS projects and systems. The following sections are some of these strategies. Many of these options would need to be approved prior to implementation to help maximize flexibility in financing transportation and, specifically, ITS improvements in Texas.

- Driver license surcharge: an additional fee charged at the time of application or renewal of a driver license dedicated solely to funding transportation (*25*).
- State sales tax on motor fuel: the application of the current state sales tax rate of 6.25 percent to gas and diesel purchases to be dedicated to transportation (*26*).
- Local option motor fuel tax: the levy of additional gas and diesel tax by local regions on local fuels to be dedicated to transportation (*27*).
- Increased statewide motor fuels tax: an increase in the state fuel taxes specifically dedicated to transportation (*28*).
- Index statewide motor fuels tax: the indexing of the state gas and diesel tax rate to either the highway cost index or consumer price index to keep pace with the rate of inflation and help meet funding shortfalls, which could be used to fund transportation (*29*).
- Increase state sales tax: an increase in the statewide sales tax dedicated to the highway fund to support transportation (*30*).
- Tax increment financing: the establishment of a special district or region associated with a roadway project where increases in property tax revenues are dedicated to service bonds on the project (*31*).
- Local option vehicle registration: the levy of an additional vehicle registration fee that would be collected and spent locally on transportation (*32*).
- Increase state vehicle registration: an increase in the state vehicle registration fee to be spent on transportation (*33*).
- Motor vehicle sales tax: an increase in the dedication of the motor vehicle sales tax dedicated to transportation (*34*).
- Vehicle miles traveled (VMT) fee: a fee charged to drivers based on the number of miles each vehicle travels, directly related to road usage (*35*).

Federal Funding

The U.S. DOT recently released its updated *ITS Strategic Research Plan* for 2010–2014 (*36*). Since the release of its predecessor document, the U.S. DOT has advanced research in its ITS program, primarily in the area of connected vehicle research (safety, policy, mobility, environment, road weather management, and connected vehicle technology), along with applied research initiatives in active transportation in demand management (ATDM), commercial vehicle information systems and networks (CVISN), and intelligent and efficient border crossings (*36*).

While it was originally assumed that the U.S. DOT's ITS research program would continue to receive the same level of funding as the previous year (2009) at $100 million, in FY 2012 ITS Research and Development received $86.4 million. The Presidential request for funding for FY 2013 for research and development for FHWA was $528.4 million with ITS Research and Development receiving $94.6 million (an increase of 9.5 percent). However, the Senate Committee on Appropriations recommended $429.8 million for transportation research, which is the same level as FY 2012 (*37*). The Office of Management and Budget has classified all research and development funds as sequestrable (*38*).

State Funding

Trends in ITS funding in individual states mimic those at the federal level. Trends indicate that fuel tax revenues continue to decline as a result of inflation, less driving by the traveling public, and the increase in fuel-efficient and alternative-fuel vehicles (*24*). With respect to how agencies manage ITS funds and budgets, a 2010 survey of ITS deployment that the Research and Innovative Technology Administration had conducted indicates that many states still maintain separate budgets for ITS deployments and related costs (*11*). Table 7 provides a summary of specific deployment trends across the United States. For this survey, RITA distributed nearly 1600 surveys to state and local transportation agencies in 108 metropolitan areas, with the average response rate being 85 percent.

Table 7. Agency ITS Funding, Budget Trends in the U.S. by Agency Type, 2010 (*11*).

	Number of Agencies				
ITS Funding and Budget Practices	**Freeway Management Agencies**	**Toll Collection Agencies**	**Traffic Management Centers**	**Arterial Management Agencies**	**Transit Management Agencies**
Separate Budget for ITS	83	39	134	76	26
Track Budget Separately for ITS Deployments	59	30	88	46	18
Track Budget Separately for ITS Operations and Maintenance	74	23	98	45	13
Track Budget Separately for Traffic Management or Operations Center	64	29	87	56	2

The National Conference on State Legislatures' report on *Transportation Funding and Finance* (*24*) highlights the following trends in funding and finance that impact an agency's ability to meet the demands of the transportation system:

- Revenues from fuel tax continue to decline for a variety of reasons, including inflation, lower VMTs, and the increased use of fuel-efficient and alternative-fuel vehicles.
- States are more frequently considering general funds as a source of transportation revenue.
- Some states are diverting transportation revenues to other budget categories to make up shortfalls.
- Tolling continues to increase in popularity as a source of revenue with more than 30 states having some form of tolling on its transportation facilities.
- States are continuing to try and save money through more efficient project completion and improved overall system performance.
- There is an increasing trend to borrow and leverage funds for transportation projects (*24*).

In recent years, local governments have stepped in to help with transportation funding as states are finding their resources constrained. Local governments now are typically a major source of transportation funding, providing about 30 percent of all highway funding (*24*). The federal program continues to be uncertain. As of July 2012, federal surface transportation programs have been reauthorized only for the next 27 months (*24*) and it is unclear what will happen at the termination of Moving Ahead for Progress in the 21st Century (MAP-21).

Alternative Transportation Funding Sources

In a recent study, the National Conference of State Legislatures found that many states are considering nontraditional sources of funding to meet their shortfalls in transportation. These sources include:

- Revenues leveraged by issuing bonds.
- Federal credit assistance.
- State infrastructure banks.
- Public and private partnerships (*24*).

Table 8 summarizes the variety of mechanisms that agencies can and are using to leverage traditional funding sources to meet shortfalls and accelerate transportation projects into reality.

MAP-21 has several provisions that directly impact these alternative funding sources and can offer alternatives to TxDOT with respect to project funding and finance. These measures include the following:

- Continues to provide the majority of federal-aid highway funds to the states through five core programs:
    - National Highway Performance Program.
    - Transportation Mobility Program.
    - National Freight Network Program.
    - Congestion Mitigation and Air Quality Improvement Program.
    - Highway Safety Improvement Program.
- Creates a new title called America Fast Forward, which strengthens the Transportation Infrastructure Finance and Innovation Program (TIFIA) program to leverage federal dollars farther than they have been stretched in the past.
- Removes barriers that previously limited states' flexibility to invest in projects that fit their specific needs and critical challenges.
- Establishes an outcome-driven approach and improves the statewide and metropolitan planning process to be performance-based and hold agencies accountable for improving the condition and performance of their assets.

- Includes reforms to help reduce project delivery time that include expanding the use of innovative contracting methods (*39*).

In Texas, legislation first passed in 2007, and subsequently was amended in 2011 and 2013, allows local governments (cities and counties) to set up Transportation Reinvestment Zones (TRZs). TRZs are an innovative financing method that leverages the real estate value created by transportation improvements, and is specifically designed to fund transportation infrastructure. TRZs are not a tax increase, but rather a mechanism to capture the property tax increment associated with increased property values resulting from transportation investment within the designated TRZ. TRZs allow local entities to sell bonds secured by the incremental tax revenues to fund the transportation project. Since 2009, the following Texas cities and counties have established TRZs and/or successfully funded projects:

- The City of El Paso successfully secured funding for its contribution to the regional Comprehensive Mobility Plan.
- The City of Socorro, the City of Horizon, and the County of El Paso each established TRZs to jointly fund a series of improvements along a common corridor.
- Hidalgo County established its TRZ No. 2 to fund the Hidalgo Loop project.

Tax Increment Reinvestment Zones (TIRZs) are very similar to tax increment financing (TIF) and special assessment districts (SADs), in that special areas are created and as property values increase in that area, the increased taxes are used exclusively in that area to fund improvements to infrastructure. Districts can be designated to receive either partial or full portions of the increased revenues.

Table 8. Transportation Finance Mechanisms (*40*).

Category	Funding Mechanism
State Bonding and Debt Instruments	Revenue Bonds General Obligation Bonds Hybrid Bonds
Public–Private Partnerships	Pass-Through Tolls / Shadow Tolling Availability Payments Design-Build-Finance-[Operate]-[Maintain] Delivery Models Build-[Own]-Operate-Transfer and Build-Transfer-Operate Delivery Models Long-Term Lease Concessions
Federal Debt Financing Tools	Grant Anticipation Revenue Vehicles (GARVEEs) Private Activity Bonds (PABs) Build America Bonds (BABs)
Federal Credit Assistance Tools	TIFIA State Infrastructure Banks (SIBs) Section 129 Loans
Federal-Aid Fund Management Tools	Advance Construction (AC) and Partial Conversion of Advance Construction (PCAC) Federal Aid Matching Strategies
Other Innovative Finance Mechanisms	Non-Federal Bonding and Debt Instruments Value Capture Arrangements such as TIF

As indicated in Table 8, states have been using a variety of public–private partnership mechanisms to finance transportation projects. These partnerships involve private-sector financing, construction, maintenance, and/or operation of transportation projects. As of August 2012, 33 states and Puerto Rico have laws enabling PPPs for highways and bridges (*24*).

The potential opportunities for utilizing PPPs exist in many areas within the transportation program in general and can easily be expanded into the ITS realm. For example, Section 1201 of SAFETEA-LU requires states to provide real-time system management information for interstates by 2014 and other significant roadways by 2016 (*11*). Since a key component of this provision involves data, it is possible that a PPP might be a logical approach to leveraging private- and public-sector resources to meet the requirements and provide information to agencies and the traveling public. There might be similar opportunities within the purview of ITS as agencies consider alternatives to providing the ITS infrastructure for the transportation system. It is possible that many of these innovative finance mechanisms can be used to leverage resources for ITS projects in Texas.

ITS ASSET MANAGEMENT

Recent TxDOT research presents guidance for asset management, which could readily be applied to ITS systems and equipment (*41*). The research presents a three-tiered structure to capture the evolving management strategies that TxDOT considers critical to guiding future asset management contractual activities. This structure can enhance the districts' flexibility to manage assets depending on the conditions and needs of each region. TxDOT's proposed three-tiered approach to asset management consists of:

- Total asset management for large urban areas encompassing multiple counties.
- Asset management of critical functions on a smaller regional scale.
- Asset management for specific types of assets.

Comprehensive Transportation Asset Management

Comprehensive transportation asset management, or total asset management, is focused on large urban areas encompassing multiple counties. It seeks to approach asset management on a large scale to take advantage of economies of scale and efficiency in contract management (*41*). The specific contracting strategies that are included under comprehensive transportation asset management are:

- Routine maintenance.
- Total asset management.
- Integrated asset management.

Asset Management of Critical Regional Functions

Asset management of critical functions on a smaller regional scale is intended to bundle critical functions across a region into one contract. An example might be to combine the maintenance of all roadside components (excluding the pavement) into one contract. The specific contracting strategies that are included under critical functions on a regional scale are as follows:

- Moderately bundled/activity-based.
- Significantly bundled.

- Partial competitive.[1]
- Jointly performed.
- Routine maintenance.
- Integrated.
- Framework (*41*).

Asset Management for Specific Types of Assets

Asset management for specific types of assets are very focused and may include items such as pavement markings or LED signal indicators and may be based on warranty specifications. The specific contracting strategies that are included in the specific assets category are as follows:

- Individual activity.
- Long-term separate.
- Framework (*41*).

Asset Management Strategies Defined

Contracting strategies are taken from TxDOT Project 0-6388 literature (*42*) and are defined as follows:

- **Jointly Performed Maintenance Contract Method:** In-house personnel perform a portion of a specific maintenance activity and the remainder is outsourced to a contractor, typically due to a lack of sufficient equipment or labor. For example, snow removal or small rehabilitation projects can be jointly performed.
- **Long-Term Separate Maintenance Contract Method:** A single maintenance activity is outsourced across many areas, regions, or even the entire county for a long duration,

---

[1] TxDOT does not currently use partial competitive contracts. However, the project team and the Project Monitoring Committee elected to include this strategy in the list of potential options in the event that TxDOT determines it is appropriate for specific investments.

typically more than 5 years, often because it is unique or risky. For example, it is common to outsource rest area maintenance for up to 10 years.

- **Framework Contract Method:** Several contractors are pre-approved and receive nominal contracts that make them eligible for award of maintenance projects. The method is often called a Multi-Agency Contract (MAC) and is used widely in the U.S. military. Some states use this model for traffic control contracts.
- **Moderately Bundled Activities Contract Method:** A few maintenance activities that are of a similar nature and have a compatible sequence of work are let out together, such as mowing, sweeping, and litter pick-up.
- **Partial Competitive Maintenance Contract Method:** A certain percentage of the in-house workforce is retained to perform various routine maintenance activities, while the rest of the activities are bid out. In this method, in-house forces can competitively bid against contractors for the work. Often, the scope of work is large and may include all maintenance activities or a very large bundle of activities.
- **Routine Maintenance Contract Method:** All routine maintenance activities are outsourced together as one contract. If a performance-based specification and lump-sum pricing are used, the method can be regarded as a Total Asset Management Contract Method. If a method-based specification and unit pricing are used, the method can be regarded as Significantly Bundled Activities Contract Method.
- **Integrated Maintenance Contract Method:** A combination of both routine and preventive maintenance activities are outsourced together as one contract. If a performance-based specification and lump-sum pricing are used, the method can be regarded as a Total Asset Management Contract Method. If a method-based specification and unit pricing are used, the method can be regarded as a Significantly Bundled Activities Contract Method.
- **Significantly Bundled Activities Contract Method:** Nearly all maintenance activities are let out together, other than a few activities that are special or unique. A method-based specification and unit price are required to implement this method. This contract method has also been called a General Maintenance Contract.
- **Total Asset Management Contract Method:** A strategic and systematic process of operating, maintaining, upgrading, and expanding physical assets effectively throughout

their life cycle. In the context of contracting, Total Asset Management involves outsourcing operations, maintenance, upgrades to, and expansion of a road asset. A performance-based specification and lump-sum pricing are required to implement this method. Florida calls this method Total Asset Maintenance Contracting and Texas calls this method Total Maintenance Contracting.

- **Alliance Contract Method:** A contractor is selected based entirely on qualifications and has the opportunity to gain or lose 15 percent of the contract value depending on performance. This method typically carries out performance-based specifications and uses cost plus fee as the pricing strategy.

Transportation revenues, which are traditionally derived from fuel taxes, motor vehicle fees, and tolls, have not kept pace with projected needs. In a report updated August 2012, the National Council on State Legislatures reported a cumulative nationwide shortfall has been estimated at $1 trillion through 2015 (*24*).

CHAPTER 9:
REGIONAL NEEDS MEETINGS WITH TXDOT STAFF AND STAKEHOLDERS

The project team developed a draft interview guide to be used to gather information from stakeholders regarding their needs for ITS, the issues related to architecture on a statewide and regional level, specific goals for operations, and information about partnerships and expectations, especially in the future. The draft interview guide was vetted through the project team and with the project director.

PHASE 1

The interview guide was submitted to the Institutional Review Board (IRB) at Texas A&M University as university research policy required. After the IRB approved the draft guide, researchers began contacting stakeholders in various regions across the state. In some instances, researchers actually met the interviewee in person; while in other instances, the guide was e-mailed to a stakeholder who then completed it and returned it to the researcher. The purpose of this activity was to test the guide to determine if the questions being asked were understandable and logical to the interviewee. Additionally, based on the responses received, researchers determined if the guide was yielding information that can be used to inform subsequent research in this project. This effort was a first step in establishing baseline information to be used for regional "needs" meetings.

Appendix A provides a copy of this guide, which was divided into four sections of questions to obtain information about ITS needs, statewide versus regional issues, operational issues, and partnerships. The three columns on the right identified the target audience (TxDOT, partner, or both) for each question. During the interview/data collection process, however, there seemed to be some confusion about these instructions resulting in questions asked to or answered by an unintended audience. For example, the first question ("Does your agency have an ITS strategic plan?") was intended for TxDOT partners, but responses to this question were received from two TxDOT districts. When inappropriate, such responses can be ignored.

- Test interviews were conducted in the following locations: Dallas/Fort Worth Metroplex.
- Central Texas region—primarily Austin and surrounding areas.
- San Antonio.

- El Paso.
- Houston.
- Bryan/College Station.

Interviewees included staff from TxDOT districts, large and small cities, metropolitan planning agencies, transit agencies, and TMCs. Several unsuccessful attempts were made to reach personnel in smaller, rural areas. The research team has determined that it will be necessary to travel to some of those areas to meet face-to-face with agency staff to ensure that a rural perspective is included in the needs assessment. In addition to the TxDOT districts interviewed, specific agencies included:

- Capital Area MPO (CAMPO).
- El Paso MPO.
- North Central Texas Council of Governments (NCTCOG).
- Capital Mass Transit Authority (CMTA).
- TranStar and City of Houston Traffic & Transportation Division (TranStar).
- City of Round Rock (RR).
- City of Cedar Park (CP).
- City of San Antonio (CoSA).
- City of Georgetown (GT).
- City of Bryan (CoB).
- Bryan/College Station MPO (BCSMPO).
- City of College Station (CoCS).

Observations Regarding the Interview Guide

Overall, the instrument provided useful information. The information will enable researchers to get a clearer picture of the aspects of ITS deployment across the state. In some instances, it may be helpful to provide checklists where respondents could simply check the services provided. Regarding ITS needs, it may also be useful to provide a list and have respondents prioritize the list since that is also a research objective.

In some cases when the guide was e-mailed, it was apparent that respondents might not have fully understood some of the questions or the type of information being requested. In some cases, Yes or No answers were provided when specific information was requested. Once the guide is refined, it will be most beneficial to conduct all interviews in person or by telephone.

Except TranStar and TxDOT Houston, interviewers obtained specific answers to each question in the guide described earlier. However, interviews with TranStar and TxDOT Houston staff were conducted in a free form where the interviewer described the objective of the interview, described the general categories of questions, and allowed the interviewee to give a comprehensive reply, which one or two people then recorded. The following tables summarize information that TTI researchers obtained. In some cases, comments have been added below questions in the first column. These comments have not been vetted with the respondents and, because of the draft nature of the interview guide, may not accurately reflect their opinions. Also note that the purpose of this interview test procedure was to refine the interview itself and the sampling methodology, and not to review or analyze specific results.

PHASE 2

The project team continued to conduct statewide interviews with stakeholders regarding their needs for ITS, the issues related to architecture on a statewide and regional level, specific goals for operations, and information about partnerships and expectations, especially in the future. The interview guide was updated based on feedback from the panel. The following represents a summary of the interviews.

A key part of developing a statewide ITS strategic plan is to obtain and incorporate feedback from regional stakeholders about their issues and needs. In Phase I of this project, TTI researchers developed a questionnaire to serve as an interview guide during the information gathering process. The researchers then conducted a set of pilot interviews with selected stakeholders. Based on the experience gained with these initial interviews, researchers made a few minor revisions to the interview guide for use in the second round of the information gathering process during Phase II of the project that began in fiscal year 2012. This section describes the results of meetings and interviews that TTI researchers conducted to date in 20 TxDOT district-covered geographic regions. In total, TTI researchers held 50 information gathering sessions that included representatives from 84 stakeholder agencies, including all TxDOT district offices and some local area offices. Furthermore, some participating cities included representatives from several departments (i.e., traffic operations, planning, fire, and police). Table 9 summarizes this information by classifying stakeholder participation according to agency.

Table 9. Summary of Stakeholder Participation by Agency Type.

Region	TxDOT	MPO	City	County	Emergency Responder[1]	Transit	Other
Amarillo	●	●	●				
Atlanta	●	●	●	●	●	●	Arkansas DOT
Austin	●	●	●		●	●	
Beaumont	●						
Brownwood	●						
Bryan/College Station	●	●	●			●	
Childress	●						
Corpus Christi	●	●	●		●		
Dallas	●	●	●				
El Paso	●	●			●		
Houston	●	●	●			●	
Laredo/ Del Rio	●		●		●		USCBP[2] Laredo ISD
Lubbock	●	●	●	●		●	
Lufkin	●						
Paris	●	●	●				
Pharr	●	●	●				
San Angelo	●						
San Antonio	●	●	●		●	●	
Waco	●						
Wichita Falls	●	●	●				

1 Includes Emergency Operations, Police, Fire, and DPS; 2. United States Customs and Border Protection

A quick glance at this table reveals a high level of staff participation from TxDOT districts, MPOs, and cities. The interview process continued throughout the fiscal year 2012 to fill any remaining holes in regional stakeholder participation.

INFORMATION GATHERING PROCESS

TTI researchers conducted the information gathering efforts using two different formats:

- One-on-one interviews with individual agencies, including TxDOT districts. These interviews were either conducted in person or over the phone. In some cases, an interview with a non-TxDOT agency also included TxDOT staff from the local district or area office. Furthermore, in some of these interviews, researchers followed the interview guide by asking each interviewee all questions one by one. In other cases, the interviewee chose to use a free form format for providing the desired information, and responded to follow-up questions as appropriate.

- Workshop-style group meetings with regional stakeholders. These meetings provided participants opportunities to respond to interview questions in an open format.

As part of this stakeholder needs assessment process, researchers conducted 41 one-on-one interviews with individual agencies and nine group meetings with stakeholders from multiple agencies, all of which are formally scheduled. In most cases, project information was e-mailed to the stakeholders prior to the meeting. The researchers shared the interview notes with the project panel. Furthermore, information obtained from the stakeholders were consolidated into the following categories, and evaluated:

- Status and uses of ITS deployment in the region.
- Regional ITS-related issues and needs identified by stakeholders.
- Existing and future relationships between stakeholders in the region.
- ITS funding.
- Any staffing and technical issues.

STATUS OF REGIONAL ITS IN TEXAS

The following sections summarize the information gathered from meetings and interviews with the stakeholders in various regions.

Strategic Plans and Regional Architectures

During the interview process, researchers asked non-TxDOT stakeholders if their agencies have developed ITS strategic plans. Some agencies indicated that they do not have a strategic plan, while some referred to regional ITS architectures. Several stakeholders indicated that their agency has a strategic plan and provided various levels of details. The following paragraphs provide information about these agencies, and include additional information about Austin and Laredo plans readily available on the internet.

- Austin-area Incident Management for Highways (AIM High), which is a coalition of 19 regional agencies, developed a strategic plan in 2010. Available on the internet, the plan:

- Defines incident management.
- Lists goals and objectives.
- Identifies stakeholders, resources, and challenges.
- Recommends incident management tools and strategies.
- Identifies incident management requirements.
- Outlines next steps.

- The City of Laredo has a local ITS Master Plan, which follows the regional architecture and is available on the internet. The plan provides the ITS Vision, Mission, and Requirements. It also identifies existing ITS deployment, including field equipment and communications infrastructure, and provides recommendations for future ITS deployment (system concepts, project concepts, and telecommunications infrastructure). The document also discusses consistency with the regional ITS architecture.
- The City of McAllen has a 5-year ITS plan to expand signal optimization and communications, but it is not funded. The plan does not include expansion to uniform 311 functions, but it should. Also, it does not follow the regional architecture because technology advances have made some deployments feasible, which were not thinkable when the architecture was developed. Furthermore, ITS deployments in the valley follow known needs in each agency.
- The City of San Antonio has a plan, but it is not detailed. It was developed in 1997 and identifies existing deployments and future needs to deploy devices and warning systems, and integration with TxDOT. However, the city's day to day decision-making and ITS expansions are based on internal policies and funding.
- The City of Del Rio does not have any ITS. However, any deployment will be consistent with the regional architecture as are other existing deployments in Del Rio.
- The Laredo District development plans are consistent with the regional architecture.
- The Sherman-Denison MPO does not have one, but the agency's needs mirror those of TxDOT.
- The San Antonio Police Department has standard operating procedures, which are shared with partner agencies, but cannot be shared with the public.

- VIA Metropolitan Transit's plan is consistent with ITS regional architecture for the San Antonio region.
- Other agencies identified to have a strategic plan include Corpus Christi Regional Transit Authority, Corpus Christi MPO, TranStar, and Austin District's ITS deployment plan.
- The Waco District response indicated that the Waco region is a conduit between Dallas and San Antonio, and should be involved in strategic planning related to this corridor.
- NCTCOG does not have a strategic plan, but has strategic corridors. The strategic corridors and strategic initiatives would hopefully fit into the state strategic plan.
- The City of Garland has a strategic plan for our traffic management system.

TxDOT developed its regional ITS architectures seven to 10 years ago. The architecture development process identified needs of regional stakeholders and recommended near-term, mid-term, and long-term projects to satisfy these needs. The agency responsible for funding each project identified whether funding was available at the time. Interviews with stakeholders reveal that little to no effort has been made since then to update the regional ITS architectures. El Paso stakeholders indicated that their outdated ITS architecture does not address cross-cutting issues such as active traffic management and connected vehicles. A similar comment from Houston suggested the need to develop a new or updated vision to accommodate connected vehicles.

Despite considering themselves important partners in the process, non-TxDOT stakeholders think that leading the effort to keep these documents up-to-date is TxDOT's responsibility. The regional architectures also recommended the development of formal cooperation agreements between regional partners. However, only a few formal agreements have been executed, and most key regional stakeholders (i.e., TxDOT district, city, and MPO) have continued to work together informally.

SNAPSHOT OF ITS DEPLOYMENT IN VARIOUS REGIONS

Although a detailed inventory of ITS in various regions is of interest, in many cases stakeholders were only asked to provide, or volunteered, this information to facilitate the regional issues and needs assessment process. Therefore, the information that stakeholders provided and which is summarized here is not a complete picture. It lacks information about ITS deployment and functions in larger urban areas (i.e., Houston and Dallas). Nonetheless, the information received does provide a picture of the state of ITS deployment in Texas. The following is a list of ITS elements identified by stakeholders. Table 10 further summarizes the information by listing only those deployments identified by three or more regions:

- Surveillance cameras of various types,
- Portable and permanent dynamic message signs.
- Detector (loops, microwave, video, Bluetooth, etc.).
- Weather stations.
- Flood, ice, and fog detection systems.
- Closed-loop, central, or adaptive signal control.
- Computer-aided dispatch for transit and emergency vehicles.
- Security cameras, AVL devices, data terminals, and GPS on buses.
- Mobile data terminals and AVL on transit and emergency vehicles.
- Traffic signal preemption.
- Wired (including fiber) and wireless (Wi-Fi and radio-based) communications.
- Weigh-in-motion stations.
- Highway advisory radio.
- Warning systems (signal ahead, speed on curves, and school zones).
- Technology for information dissemination to users, including e-mail, text, and reverse-911.

As illustrated in Table 10, most of the deployment information provided came from rural and smaller urban regions. CCTV cameras and dynamic message signs (permanent and portable) are the most prevalent ITS elements in such regions across Texas. In addition, several regions also reported deployment of emergency signal preemption and flood detection/warning systems. Lastly, ITS technologies deployed by transit and police agencies include vehicle location devices, mobile data terminals and computer-aided dispatch. In addition, one smaller district listed several ITS elements of local benefits. These include advance warning of signal ahead, radar-based speed signs in school zones, and radar-based speed warning on curves.

Table 10. Summary of ITS Deployment by Device/System.

ITS Device/System	Regions
CCTV Cameras	Amarillo, Atlanta, Brownwood, Corpus Christi, Dallas, Laredo, Lubbock, Lufkin, Paris, Waco, Wichita Falls
Permanent DMS	Amarillo, Atlanta, Beaumont, Brownwood, Bryan, Corpus Christi, Laredo, San Antonio, Waco, Wichita Falls
Signal Preemption	Atlanta, Brownwood, Laredo, Lubbock, Lufkin, Paris, Wichita Falls
Portable DMS	Beaumont, Brownwood, Childress, Lufkin, San Angelo
AVL and GPS (Transit/School Bus)	Austin, Corpus Christi, Laredo, Lubbock, San Antonio
Mobile Data Terminals (Transit)	Corpus Christi, Pharr, San Antonio, Wichita Falls
CAD (Transit and Police)	Corpus Christi, Paris, Pharr, San Antonio
Flood Detection/ Warning Systems	Amarillo, Beaumont, Laredo, Wichita Falls

REGIONAL ISSUES AND ITS NEEDS

The following subsections summarize key points from stakeholders in each region.

Amarillo Region

The city of Amarillo serves as a hub for shopping and medical needs of smaller communities, some of which are located in adjacent states (New Mexico, Kansas, and Colorado). Recurring congestion is not an issue in the city, though road construction and maintenance activities do cause congestion and rear-end crashes. Bad weather (snow and ice) also affects traffic flow. In addition, flooding is an issue at some underpasses. TxDOT is the main driving force for all ITS activities in the region and coordinates with emergency management and other agencies. ITS infrastructure in the region includes flood warning systems (consisting of signs accompanied by flashing beacons that direct drivers to exit prior to downstream flooded underpasses), and dynamic message signs, which provide information about construction, weather events, and incidents. The stakeholders had two concerns about DMS messages.

- The first concern was that the signs are difficult to read. This concern may be the result of aging signs. A related concern was about the legibility of signs with recently raised speed limits. It was suggested that human factors studies may be needed to determine the efficacy of current DMS designs for higher speed limits.

- The second issue is about the effectiveness (intelligence) of messages for long-distance drivers. Stakeholders agreed that a sign telling drivers about an incident 30–40 miles ahead is not useful in helping them decide what to do unless additional information is provided that helps them to decide whether to proceed or change their plans.

Amarillo stakeholders indicated the need for enhanced traveler information that provides additional information about the expected impact of an incident and how long it will take to clear. Using such information, users can decide to proceed, stop in Amarillo (which has the capacity to accommodate people and vehicles), or return/postpone the journey. Stakeholders also indicated the need to coordinate with adjacent states, especially to facilitate commercial traffic. It should be noted that no significant ITS infrastructure has been deployed in the region since the development of the regional architecture. Stakeholders identified lack of funding as the root cause.

Atlanta Region

Similar to the Amarillo region, TxDOT is the primary driving force behind ITS deployments in the Atlanta region. ITS in the region includes DMS, surveillance cameras, ice detection systems on bridges, dynamic speed warning systems for curves, LED-based message boards to provide supplemental information about traffic control or closed ramps, and dynamic speed warning systems in school zones. Key points raised by the stakeholders include the following items.

- There are significant trucks carrying hazardous materials through the city because of a lack of a designated route. It is not desirable for these vehicles to be caught in traffic for a significant period of time.
- TxDOT views DMS and cameras as useful ITS for hurricane evacuation in the district. The Texarkana Office of Emergency Management (OEM) indicated that the city serves as a sister city to Port Arthur for providing shelter during weather emergencies. The MPO and other stakeholders from the City of Texarkana, however, do not see any significant impact of hurricanes on the city itself.
- The TxDOT district would like to install additional cameras on major highways.

- The TxDOT district does not have TMC functionality because they are not using Lonestar™ software.
- Adaptive systems that cities used are seen as helping to minimize the need for staff.
- Regional stakeholders coordinate with stakeholders in Arkansas and Louisiana, especially during incidents and weather events. They indicated the need to develop formal communications protocols with them.
- TxDOT staff has an interest in finding ways to encourage local partners to share the cost of ITS infrastructure.
- District staff feel that the division could take a more proactive role in addressing their needs and that communications between them should be improved.
- District staff would also like TxDOT to resume the yearly ITS conference as a means of information exchange.
- There are concerns that only a few individuals possess all of the institutional ITS knowledge/expertise. Any informal relationships with local partners that they have developed could be jeopardized if they no longer worked there.
- OEM indicated that incidents on the Texas side can and do back up traffic into Arkansas and affect long-distance travelers as well as 2500 people from Arkansas and Oklahoma employed at the Red River Army Depot located west of the city. Providing timely and accurate information to them requires additional DMS to the west through the boundary of Bowie County, interstate traveler information, and more proactive coordination between Texas and Arkansas DOTs.
- OEM would like traveler information systems to include tornado warnings, and that information comes from the National Weather Service in Shreveport. OEM is also concerned that regionalization of ITS functionality may compromise the efficient dissemination of such information to motorists.

Austin Region

The following list provides a summary of key points raised by stakeholders in the Austin region.

- TxDOT does not have a consistent policy across the state, and various regions and regional issues are unique because of their needs and different level of maturity. Also, it is not clear whether the division or the district leads.
- Funding dictates which goals are achieved.
- Working relationships are established at the lower levels.
- Emergency management teams (i.e., police) would like access to ITS infrastructure and additional information (i.e., video feed in addition to a call) to allow more efficient incident management. They would also like an improved process for the deployment of secondary responders and equipment needed for clearing incidents.
- Dedicated funding is needed for ITS.
- The transit agency needs vehicle location and historical data for planning purposes.
- The cities of Cedar Park and Round Rock indicated the need for:
    - Surveillance systems.
    - Better communications (i.e., fiber).
    - Better management of school zone beacons.
    - Signal performance improvement and measurement.
    - Reliable current and historical data.

Beaumont Region

The following is a summary of issues and needs that the Beaumont District staff identified.

- There were initial communications issues with the Lonestar™ system, but these were resolved. The Beaumont District believes that TxDOT's Traffic Operations Division (TRF) did not provide troubleshooting staff or procedures to fix the problems, some of which are still occurring with some of the equipment.
- The district does not have dedicated ITS staff, and it is not practical to send someone from the signal shop 30 miles away for problem-solving. They do not feel comfortable calling the Houston District ITS staff for help.

- District staff like the idea of uniformity and standards, but the system has to work. They also like the idea of regional or central control because they do not have expertise in-house. However, they need appropriate support from TRF if this arrangement will be the norm.
- There is a need to provide information on the web in addition to DMS. They have started displaying travel times obtained using Bluetooth devices and expect this information to be useful during the Neches River bridge reconstruction project, which will last for 3 years.
- There is a need to provide critical travel time information and related information to long-distance drivers (i.e., motorists headed to Beaumont from Houston) as well as those on their way from Beaumont to Houston (e.g., one lane closed on I-10 in Houston).
- The district needs a better mechanism for obtaining incident information. Currently, it comes from TxDOT staff on the ground. They are uncomfortable posting and clearing information that comes from non-TxDOT sources.
- The Beaumont District should have access to regional information management system (RIMS) for posting incident information. BMT wants TranStar to post DMS 24/7. Otherwise, maintenance staff has to drive to the office to be able to do so if the need occurs after-hours.
- The district would like adaptive signal control at isolated signals with significant variations in traffic and truck demand at various approaches, but the Synchro they are installing does not have the ability to accomplish this.
- The district has radar detectors on the interstate, but they would like more. They also need queue warning systems at problem locations. They have flood gauges, but no RWIS.
- In the future, the question remains whether TRF will have a design group responsible for all ITS design from Austin.
- Communications platforms need to progress. The district needs to be able to use different types of technologies/alternates (Twitter, Facebook, text, etc.) to convey information to different age groups. They also need to be able to provide traveler information for truckers (e.g., trucking HAR or Citizens Band [CB] radio alerts).

- There might be a need for TRF to provide safety-related functionality such as queue warning and curve warning in Lonestar™. Right now, the core packages are CCTV, DMS, and some travel time.

Brownwood Region

The following is a summary of issues and needs that the Brownwood District staff identified.

- Operation on I-20, the only site of existing ITS in the district, is affected by incidents, ice, and snow. The operations can be improved by monitoring speed and volume data, installing a vehicle rollover detection system, expanding ITS deployment (DMS and CCTV) west to the district boundary, and coordinating between adjacent districts along the corridor.
- Coordination between various TxDOT departments (information technology [IT], Procurement, etc.) needs to be improved for a more efficient ITS deployment. For their system, design to deployment took 5 years.
- Procurement policies should change to make the process more efficient and able to accommodate upgrades for technologies that have become obsolete during the process.
- The yearly ITS technical conference should be resumed. It provided a means for information exchange, but has not been held since 2007.
- The current America's Missing: Broadcast Emergency Response (AMBER) Alert system is inefficient in terms of steps and the time it takes to initiate from San Antonio to display alerts in the field. Any statewide ITS function such as this should be centralized under an ITS Division in Austin to provide uniformity and efficiency. This center should be able to plot coverage area and automate posting of alerts.

Bryan Region

Comments received from the Bryan region are summarized below.

- From the MPO perspective, the current ITS deployment has a regional focus provided through the Bryan/College Station Mobility Initiative (BCSMI). Data needs include:
    - Accident data to identify hot spots.

- Traffic counts.
- Origin-destination (O-D) data from archived data used for bicycle and pedestrian planning.
- Data for freight planning.

- The region needs traveler information for special events. Hazardous material and truck movement data are important issues.
- The City of Bryan provides event-based traveler information in the form of press releases that people can access via social media and smart phones to get information on road closures and power outages.
- Since Bryan is a rural district, the TxDOT focus is on statewide issues. The district looks to TRF to continue to provide a consistent policy and oversight. District-wide issues include high loads (such as campers) utilizing historic railroad underpasses. This issue arises because typical navigation software does not include warnings for non-truck high loads. Currently, the Bryan District focuses on providing traveler information (wildfire, AMBER and Silver Alerts, and Public Service Announcements) through the TxDOT statewide website as well as the three DMS located in the district.
- The district is also working on a project to use the TxDOT administrative network for access to remote offices, which will have radio communication to field master. Key district needs include remote access to signal systems and field equipment, regional partnerships in urban areas, CCTV cameras for monitoring travel conditions, and queue warning at construction sites. There is also a need for the regional agencies to better operate traffic signals at regional boundaries, as well as the ability to remotely detect and close/open high-water crossings.
- The City of College Station is responsible for traffic signals, but does not have proactive management capability given the fact that it is understaffed. The city provides press releases, tweets, and advisory warning signs with beacons for weather-related issues. The region has a Bluetooth test bed to provide arterial speeds along several arterials. The city needs more system detectors, communications to solo units, and PTZ cameras. They would also like to have access to TxDOT cameras and message boards.
- Texas A&M Transportation Services provides game day and other special event information through a web page. It also provides real-time bus arrivals and bus capacity

information to Google Maps™. Additional information to the campus community includes mobile website with smart phone app, website, tweets, buses as probe vehicles in network, and RSS feeds. It would be beneficial for Transportation Services to get yearly data from the city to allow route planning, real-time information about city road conditions, and signal priority.

Childress Region

The district does not experience any significant congestion or incidents on I-40 within the district boundary. There is not enough hotel capacity on I-40 in the district, and road closure information for long-distance travelers is important. Also, there is significant truck traffic on US 287 that can use travel information. Currently, the district uses portable DMS to warn interstate motorists about road closures in New Mexico. It is desirable to install a permanent DMS for providing road closure information to westbound traffic near the Oklahoma state line and a few DMS on US 287. It would also be beneficial to install CCTV cameras at permanent DMS locations.

Corpus Christi Region

Issues and ITS uses/needs in the Corpus Christi region are summarized below.

- There is a need to share data between TxDOT and the MPO.
- Funding for projects determines who takes the leading role, and all agencies are equally affected by the lack of funding. However, stakeholders see ITS continuing to be priority.
- TxDOT does not have sufficient staff for 24/7 ITS operations and would like TransGuide to provide after-hour monitoring of cameras.
- Nueces County would like to view feeds from the city’s emergency operations center. The City of Corpus Christi would like to obtain real-time data and disseminate this to the public.
- TxDOT would like communications capability to traffic signals to allow remote troubleshooting and management.

Dallas Region

Views of three regional stakeholders are summarized below.

- TxDOT's focus is at the regional level, but statewide guidelines dictate equipment procurement and deployment. TxDOT has a consistent policy across the state and between regions, and TRF provides direction through the implementation of statewide policies. The district's goal is to provide timely, accurate, and relevant information to the traveling public. Performance goals include scanning all facilities for incidents at 30-minute intervals during the off-peak hours.
- There is a need for two-way flow of information between the division and the districts, particularly at district boundaries. The division should facilitate sharing of information between districts. There is also a need for communications with external entities (i.e., local tolling agency).
- TxDOT needs additional staff to operate and manage the current ITS system.
- TxDOT needs short-term additional funding to complete the field installations in area priority corridors. Long-term funding is needed to maintain the existing ITS system.
- The focus of NCTCOG is on the regional level because 97 percent of trips originate and end within the Dallas–Fort Worth region. The region has strategic corridors, and it hopes that these corridors and strategic initiatives are incorporated into the statewide strategic plan.
- NCTCOG needs volume, speed, and vehicle classification data for performance monitoring and modeling to aid in decision-making. Data are also needed for adjustment in managed lane prices based on the usage of lanes.
- Regional safety needs include quick notification of incidents to first responders and the traveling public, along with quick incident clearance to reduce secondary collisions and minimize travel delays. Other needs include:
    - Filling gaps in the existing ITS communications infrastructure.
    - Improving communications between TxDOT, and local and regional partners.
    - Leveraging of transportation resources by creating or enhancing public–private partnerships.

- The City of Garland has a local focus. It is not clear how ITS can benefit the city as it means different things to different people. The city's ITS services include:
  - A coordinated traffic signal system.
  - Motorist information on a cable TV station (construction project information and real-time cameras at selected locations).
  - Construction information on the web.

A web-based train-monitoring system is being implemented at this time. The city also provides a signal preemption system for fire and rescue vehicles.

El Paso Region

El Paso region stakeholders identified the following issues and needs.

- The ITS architecture has not been kept current, and it does not include active traffic management, connected vehicles, and other cross-cutting issues. Emergency responder needs include:
  - Incident monitoring.
  - The ability to safely and quickly stabilize incidents.
  - Notification of closed roads.
  - Communications with regional partners.
  - Access to TxDOT DMS and cameras.
  - Updates to TxDOT's incident management plan.
- TxDOT needs include archived incident data to allow evaluation of ITS and operations in incident response and clearance, the ability to disseminate information and alerts to a wider audience, automated incident detection, and faster incident clearance.
- The MPO needs include:
  - Archived data.
  - A tool for combined viewing of archived and real-time data.
  - Increased DMS and HAR coverage in the region.
  - More efficient tools for information dissemination to public.

Houston Region

Comments received from Houston region stakeholders include the following issues.

- Since 2005, hurricane evacuation has become one of the key needs of the region.
- TRF seems to have a lack of urgency, manpower, and/or expertise to provide timely support to the district. Additionally, the division takes too much time for approval/response.
- There is a need for TRF to understand the day-to-day needs of the district and be responsive to incorporating these needs in the system software.
- The Lonestar™ software does not provide drivers for technology demonstrated to be useful in Houston.
- The district needs the Lonestar™ software to integrate modules that individual districts developed for use by other districts and to be able to accomplish this integration quickly. There is also a need to investigate better ways of communication.
- TxDOT's focus is rural, which is different from the needs of Houston.
- TxDOT is too big to be handled statewide. Regional ITS is more manageable.
- About 12 years ago, TxDOT ITS funding was eliminated, and Houston had to find other sources of funds, with Houston-Galveston Area Council (HGAC) providing this funding.
- There is a need for innovative funding to be supported by a statewide plan.
- The district needs to view regional ITS as multimodal, including the TxDOT vision.
- A primary need includes ways and/or policies to form nontraditional partnerships, which currently is not possible. As an example, the University of Houston wanted access to the TxDOT fiber to link various campuses, and in return they would maintain the infrastructure. However, TxDOT rejected the proposal on the grounds that this use of the fiber was not for transportation.
- There is a need for standards to be flexible enough to meet regional needs. For example, Houston's standards (for equipment, software, and operational procedures) do not need to be the same as that of West Texas.
- There is a need for a different vision to accommodate vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), etc.

- A primary concern is the need for streamlined inter-local agreements to share data and infrastructure between stakeholders in general and state and locals in particular (by getting legislative issues out of the way).
- The state needs to lead rural ITS with regional ITS focused on regions with input/agreement from the regions on ITS functionality along major corridors connecting them.
- From Houston METRO's perspective, TxDOT is a key, strategic, regional partner. They should show leadership in the ITS arena and serve in a role to coordinate among all regional agencies as needed. They should also provide a base level of expertise and capability to facilitate multi-agency projects.
- Houston METRO also is of the opinion that TxDOT should maintain ITS as a core business function and not abdicate traffic operations to the private sector in whole or in part.

Laredo Region

Comments provided by stakeholders from the Laredo region are listed below.

- The focus of ITS in the region is local with some (i.e., 211) services having a regional focus. Statewide issues seldom dictate local deployments, and there is little communication with other districts.
- Cross-border traffic is important.
- The region's emergency operations center needs to have access to all data, including video.
- There is a need to have regional policies on how to implement and operate ITS technology to cope with staff turnover.
- There also needs to be periodic updates to ITS architecture.
- The district needs guidance on the use of TxDOT video feeds for 911 services.
- Local police would like the ability to post messages on DMS after hours when TxDOT cannot. Another primary need of law enforcement agencies is better coordination for events and emergencies.
- There is a need for memoranda of understanding (MOUs) and mechanisms to ensure that local agencies getting state funds maintain their ITS equipment to the highest standard.

- Advance train detection systems are needed to identify and provide information to the public and emergency/incident management agencies about blocked roads.
- Policies and procedures are needed to allow public–private partnerships where each agency receives something in return. In the past, some potential partnerships did not succeed because of constraints.

Lubbock Region

In the geographical context, the Lubbock region is similar to Amarillo because the city of Lubbock also caters to the shopping, media, and education needs of a 1.5 million strong community, spread across a 150-mile radius. Similarly, congestion is not an issue. However, there are slight differences in the roles of the City of Lubbock and TxDOT in terms of existing ITS. The following bullets summarize this information.

- Most ITS needs are in the city, with isolated needs such as highway underpasses prone to flooding. The city has significant ITS infrastructure including surveillance cameras, traffic signals, and a reasonably good communications infrastructure.
- There is a need to provide economic security by facilitating commercial traffic through this energy and agricultural heartland.
- Enforcement of overweight trucks is an issue for TxDOT.

Lufkin Region

Lufkin is a rural district with ITS needs primarily tied to hurricane evacuations in coordination with local stakeholders and the adjacent Houston and Beaumont Districts. The district has surveillance cameras (PTZ and snapshot) and portable DMS to satisfy its dynamic needs (see Table 10). On rare occasions, this infrastructure has been used for incidents (i.e., a fire). The district would like additional surveillance cameras and is looking for regional or division support for day-to-day operations with the ability to occasionally view camera feeds. At any given time, 20 to 30 percent of the equipment may not be in operation. The current strategy is to check/fix equipment before the hurricane season starts.

Paris Region

The perspectives of Paris region stakeholders are listed below.

- Currently the region has no video surveillance. The district is spread out, and the lack of communication makes it difficult to get video to the district office. It is possible to get video to a local office and then to the district using the business network. Currently, staff can accomplish this for video image vehicle detection system (VIVDS). The district does not have the Lonestar™ software that was promised. Therefore, messages on four DMS are posted using Skyline software. Alerts are posted from Dallas via dial-up connection.
- US 75 experiences significant north–south traffic volume, with 18 percent freight traffic destined for the Midwest. There is more north–south truck traffic on US 75 than on I-35. If there is a choice, truck drivers prefer US 75.
- Incidents on US 75 can be an issue. In recent months, there have been two 18-wheeler collisions, and one of them blocked a northbound lane for a considerable time.
- There is no local congestion, but traveler information for southbound traffic could be beneficial due to congestion in McKinney north of Plano. Congestion information systems would allow southbound drivers to decide if taking an alternate route (US 82 to SH 289 to I-35) would be better at times.
- Integration of separate police and fire dispatch in the region can be beneficial.

Pharr Region

ITS applications in the Pharr region are local in the valley, with emergency evacuations potentially having regional impacts. Needs identified by stakeholders identified such needs as coordination between agencies for incident management, temporary closure of roads to divert traffic, congestion management, and means (GPS and communications) for better traffic signal system management.

San Angelo Region

The San Angelo region does not have any significant ITS infrastructure. The only needs identified are information systems for warning about ice, incidents, and low-water crossings. TxDOT identified that the only ITS need in its jurisdiction is DMS. There were plans to install some DMS with help from Austin, but they did not materialize.

San Antonio Region

Information obtained from stakeholders in the San Antonio region is summarized below.

- To provide effective service, the San Antonio Police Department needs remote monitoring and means for adjusting traffic signal timings, and accurate information about flooding and other incidents. Coordination with TxDOT via co-location at TransGuide is very helpful.
- ITS helps City Public Works to be responsive even with staff shortages. The department needs better information about incidents and changes to signal timings to respond to incidents. The Department needs include surveillance data, speed and volume data, and a centralized signal system with two-way communications to field devices.
- San Antonio-Bexar County MPO needs data for planning purposes for incidents, including alternate routes for events and parking management. The MPO is willing to purchase such data from private providers, but all of the desired data (i.e., origin-destination) are not currently available.
- TxDOT district staff identified the following issues and needs:
  - Their goal is sharing information, but regional plans do not specify types of data to be shared.
  - The district focus is on regional issues. Statewide issues are only related to AMBER and Silver Alerts.
  - There is uncertainty about the cost-effectiveness of private data.
  - District needs include surveillance and management, information dissemination via DMS and web, incident management, high-water detection, and providing alerts.
- VIA Metropolitan Transit stated that their scope is regional. The agency provides trip-related information to clients through a website and Interactive Voice Response system. In the future, the agency desires to provide additional information including AVL information, schedule adherence information, and route status information.

Waco Region

Waco is currently installing DMS, Bluetooth radios, speed detection, and other ITS infrastructure on I-35 as part of a construction project. There is a desire to install signs and CCTV cameras in Fort Hood and Killeen to upgrade the district’s closed-loop systems. They are also interested in mechanisms to learn about what adjacent districts are doing in the ITS arena.

Waco is a conduit for traffic flow on I-35, and it should be included in any corridor-level strategic planning.

Wichita Falls Region

In the Wichita Falls region, TxDOT has several CCTV cameras and DMS. The city and TxDOT routinely share feeds from TxDOT cameras. However, there is no technical mechanism for restricting camera control. At times, multiple people start to simultaneously exercise camera control. In such cases, the telephone is used to establish the priority user. City police have after-hour control of cameras. The area office uses video feeds to monitor work zones. In the event of no other needs, the DMS are used for alerts and public service messages. TxDOT would like to add a few more DMS, particularly one near the border with the Childress District for better coordination with that district for handling emergencies, which occur four to five times a year. The city would like to have video detection at intersections as well as height-detection systems to prevent cases of trucks hitting low-clearance bridges.

EXISTING PARTNERSHIPS AND FUTURE EXPECTATIONS

The following is a summary of information supplied by stakeholders about existing partnerships and future roles.

Amarillo Region

In the Amarillo region, TxDOT coordinates emergency management and gives the city after-hours access to cameras. However, the control capability is limited. Stakeholders believe that the public sector will provide data to the private sector for dissemination to the public and not the other way around.

Atlanta Region

In the Texarkana area, stakeholders from Texas coordinate with their counterparts at the Arkansas DOT and Texarkana, Arkansas. In addition, TxDOT coordinates with regional stakeholders for incident management and hurricane evacuations, including staff at the TMC in Shreveport, Louisiana, and the Arkansas Statewide TMC in Little Rock. The district also works with local cities and has implemented signal preemption using city funding. District staff members have a desire to provide cities access/control to their field devices in the future. More proactive future coordination between Texas and Arkansas DOTs can produce traveler information systems to meet the needs of regional travelers residing in Arkansas, but working in Texas, or vice versa.

Austin Region

As part of AIM High, a coalition of 19 regional stakeholders, the Austin District and the Austin Police Department are involved in an incident management program. Also, TxDOT requires an agreement with any regional agency needing to use TxDOT right of way. The district staff members believe that in the future, ITS leader(s) will emerge from agencies that have money. Furthermore, the Austin District's role will be corridor traffic management, but without funding for ITS, it will not remain a priority. Also, TxDOT's strategy will determine if expertise will remain at the regional level or the statewide level.

The view of the Austin Police Department is that TxDOT funding is a must, and other partners are not likely to do anything without that money. Cities in the region have good relationships with TxDOT, but they take a lead in deploying their own local ITS. The City of Cedar Park expects TxDOT to take an even bigger role but will maintain ITS as a priority in the absence of TxDOT funding. Capital Metro funds its own ITS and has partnered with the City of Austin to provide transit signal priority (TSP) for bus rapid transit (BRT) service. Capital Area MPO freely shares data with other public and private partners. However, the agency may start charging for large data requests from the private sector.

Beaumont Region

The district communicates with contacts with counterparts in the Louisiana DOT Baton Rouge area to provide information via e-mail about road closings near the border. They also coordinate with the Neches River bridge construction contractor. They have choices for cities: Beaumont and Port Arthur.

The regional MPO does not allow CMAQ funding to be spent on preliminary engineering studies (e.g., collection of data and preparation of optimized signal timings), which have significant costs associated with them. MPOs elsewhere allow this use of CMAQ funds. If the local MPO were to remove this self-imposed rule, the cities of Beaumont and Port Arthur would benefit.

Brownwood Region

The district has a good relationship with TRF, which has been responsive to its needs. The TxDOT Eastland area office also has good relationships with the county and DPS for responding to incident management. TxDOT signed cooperation agreements with these agencies several years ago. TxDOT provided video decoders to these agencies to enable them viewing access to the department's CCTV cameras located on I-20. In the future, more private involvement is expected, particularly the use of cellular phone towers along the interstate for gathering information.

Bryan Region

The MPO view is that it can take a leadership position, but TxDOT will continue to operate limited-access facilities. The agency does not envision the use of private data because it considers establishment of public–private partnerships to be difficult.

The view from the City of Bryan is that TxDOT should continue to take a leadership role as in the past, but it may not be able to do so. The city is willing to provide financial contributions to achieve regional goals, and it expects to sign a fiber-share agreement with TxDOT.

TxDOT's view is that regional partners have a vested interest and shared role in ITS deployment. An existing initiative is attempting to define a framework for local partnerships. Furthermore, leadership is dictated by available funds, and local partners will have to provide funds if TxDOT funding is eliminated. The district also expects improved two-way district-to-division and district-to-district communications. The division is also expected to facilitate communications between adjacent districts.

The City of College Station does not expect to use private data. Furthermore, the city expects its role to increase but anticipates that it will not have its own funds to support this role. Other sources of funding, such as from the MPO, will be needed.

Texas A&M University Transportation Services is working to collaborate with the cities, especially city police. It is possible that the MPO can take the lead, but TxDOT is the only agency expected to take that role in the future.

Corpus Christi Region

In the Corpus Christi region, TxDOT has information-sharing agreements with the City of Corpus Christi, DPS, and the City of Port Aransas, and it shares video feeds from its cameras with the city Emergency Operations Center (EOC), San Antonio TransGuide, and DPS. However, TxDOT does not actively participate in EOC operation. Furthermore, Metro COMM consolidates city and countywide radio communications, including 911 police dispatch. Corpus Christi Regional Transportation Authority provides ridership data to MPO. The city is working to provide video feeds from its cameras to the public and contractors. A new regional level EOC will serve DPS, Coast Guard, and TxDOT.

Stakeholders believe that ITS will continue to be a priority, but future funding will determine who takes a leading role. Also, TxDOT is discussing the possibility of sharing data with the MPO.

Dallas Region

TxDOT's view is that DalTrans will operate as a regional TMC, and the district is looking to expand its partnerships with other agencies to share resources and maximize ITS coverage. NCTCOG's view is that TxDOT will continue to be a regional partner even if it reduces funding. Furthermore, the region is committed to operate the transportation system efficiently and will look for other funding sources.

The City of Garland does not see any private role. In addition, the city does not know what role it can play in regional ITS operations. The city sees NCTCOG in a leadership role if TxDOT is not able to continue that responsibility. It also expects TxDOT to work with local agencies to develop solutions to real operational problems and develop a spirit of cooperation. Furthermore, the city is willing to share data with others.

El Paso Region

DPS and the Office of Emergency Management expect TxDOT to maintain a leadership role in the region while providing access to ITS infrastructure. These agencies have good relationships with TxDOT and ask TxDOT to disseminate information via DMS and HAR. Combined, both agencies provide incident management in the city and county and expect TxDOT to provide training in hazardous material response.

The TxDOT district expects the MPO to lead in planning and funding of regional ITS deployment with division guidance in the area of standardization, expertise, and statewide best practices. The district also expects centralized off-peak operation through the regional center and envisions that it will continue to work with partners via video share agreements.

MPO agrees with TxDOT about its increased future role. Because of its inability to procure and deploy, it expects to outsource these functions to the city and TxDOT. MPO also expects TxDOT to continue sharing data, provide prior planning to identify border issues, and keep the architecture current.

Houston Region

TxDOT is an important partner and key component of the regional operational concept. TxDOT's Houston District emphasizes regional partnerships, and its operations touch and affect all regional partners. TxDOT guidance to other agencies is huge and it is unimaginable that TxDOT would step back. However, if TxDOT stops funding, already existing local collaboration and cooperation will increase. The City of Houston is willing to cover freeways and toll roads at the local level, but absence of TxDOT leadership will create gaps. Furthermore, it is expected that TxDOT will be more open to ideas from local agencies. TxDOT's statewide lead in ITS should focus on rural links connecting metropolitan areas (like Houston and Dallas) with input from those districts on what ITS functionality to provide. TRF should also provide guidance on interstate and regionally significant routes to meet the 1201 Rule. ITS deployments needed under this rule are not in the current ranking for HGAC's funding program, and there is not CMAQ funding for them. Additionally, TRF could help in procuring statewide communications infrastructure, including brokering for the districts.

Laredo Region

TxDOT takes a lead in deploying regional ITS, and no agency is likely to lead if TxDOT is unable to do so. However, the lead agency (i.e., County Sheriff) for emergency management is different depending on the location. TxDOT allows local cities, law enforcement, and 911 service access to view feeds from its cameras with limited control. TxDOT has an MOU with the City of Del Rio about the proper use of cameras. It is expected that the current partnerships will continue, but there may be new partnerships in the future. For instance, the City of Del Rio is talking to electronic board owners to display emergency messages. The use of radio stations for information dissemination and using cable companies for access to public channels are other possibilities.

Lubbock Region

In Lubbock, the city Traffic Department coordinates with city fire and police departments. The Police Department has after-hours control of the city TMC. The city and TxDOT are equal partners, where TxDOT pays the city for managing its TMC and traffic signals. The city would like TxDOT to continue providing funding and other support but does not want Austin to dictate those arrangements. Stakeholders also indicated that emergency management is a public rather than a private function and should remain the same.

Lufkin Region

The TxDOT Lufkin District works with local partners. It is necessary to maintain the ability to be responsive. TxDOT staff believes that the cities of Lufkin and Nacogdoches may be willing to share the cost of resources, but other smaller communities do not have the resources to do so. Like many other regions, the district sees the role of the division as a resource.

Paris Region

TxDOT is the current leader in ITS, and there is no local entity that would pick up the slack if TxDOT is no longer the lead. However, there is not much ITS in the region. There might be a redistribution of MPO responsibilities, but the decision has to be a part of the yearly work plan and approved by FHWA and Federal Transit Administration (FTA) to ensure that any new responsibilities do not go beyond the mandate.

Pharr Region

The region has no plans for a local TOC/TMC and expects the regional center in San Antonio to remotely manage ITS infrastructure in the region. All partners are willing to enter into information-sharing agreements.

San Antonio Region

San Antonio Police share information with regional partners and expect more shared facilities in the future. The City of San Antonio uses the TxDOT Lonestar™ system to share video and data. In the future, TxDOT will manage smaller centers and integrate with transit, police, and fire on incident management. No other agency can assume TxDOT's position as the leader in ITS. VIA Metropolitan Transit is willing to use other resources if TxDOT cannot maintain its current lead. However, relationships between agencies are not expected to change even though consistent and predictable funding is no longer a given.

Wichita Falls Region

The City of Wichita Falls has a formal cooperation agreement with the local TxDOT district and a good relationship with Austin in terms of support received from them. The city has contracted with United State Geological Survey (USGS) to provide several flood detection systems that are maintained by USGS. The MPO does not directly deal with ITS, but facilitates cooperation. The district has made attempts to coordinate with Oklahoma and has established lines of communications. There is nothing to coordinate with the Childress District. Like other smaller districts, Wichita Falls expects control of ITS infrastructure to transfer to Fort Worth in the near future.

FUNDING AND STAFFING

Stakeholders reported several traditional sources of funds available depending on the agency and the size of metropolitan area. These sources include funds from bonds, American Recovery and Reinvestment Act (ARRA), district/department maintenance, Category 1, STP-MM, TxDOT local funds, General City funds, FEMA, Department of Homeland Security, advance transportation district, sales tax, and federal earmarks. The general sentiment is that over time, funding has become tight and dedicated funding for ITS ceased to exist. A perusal of regional ITS architecture reveals that in most cases (especially for rural districts), a majority of projects identified in the ITS deployment plans were never implemented due to lack of funds. As for dedicated staffing, information provided by TxDOT districts shows that most of them and several other agencies do not have staff dedicated for ITS. There are some exceptions, which include a few cities (i.e., cities of McAllen, San Antonio, and Wichita Falls) and emergency management or transit agencies, which have dedicated staff for ITS functions.

REGIONAL ITS NEEDS SUMMARY

Meetings and interviews with regional stakeholder identified a total of 236 needs across Texas. These needs were classified into the following categories.

- Travel and Traffic Management.
- Institutional.
- Funding.
- Information Management.
- Commercial Vehicles.
- Other (communications, public transportation, etc.).

Types of needs in the *Travel and Traffic Management* category include:

- More cameras or DMS.
- Signal preemption.
- Access to cameras belonging to another agency.
- Improved information sharing between partner agencies.
- Faster incident identification and clearance.
- Improved information dissemination to work zone management.
- Data.
- Coordination of signals across jurisdictional boundaries.

Needs classified as *Institutional* include:

- Improved cooperation between regional stakeholders (including formal agreements).
- Regional architecture updating.
- Development of consistent policies.
- Improved communication between TxDOT division and districts.
- Improved communications between districts, especially those along key corridors.
- Improved processes for faster and more efficient ITS deployments.

Funding needs include additional and/or dedicated funding for deployment, operations, and maintenance of ITS. Archived data needs were pooled under *Information Management*. The needs such as truck weight and height enforcement were categorized as *Commercial Vehicle* needs. Lastly, other needs included communications infrastructure, maintenance, emergency management, and public transportation.

Figure 6 provides a distribution of need types identified by the stakeholders. It should be noted that 81 percent of identified needs fell into *Travel and Traffic Management* and *Institutional* categories. The following subsections provide summaries of specific needs that the stakeholders identified.

Traffic Signal Needs

Table 11 lists the types of signal-related needs identified by stakeholders in different regions. A review of this information indicates that these needs are not specific to district size/region, but are fairly spread across the state. Signal operations are a local decision and funding comes from local funds. Some regions may need assistance from the state to integrate systems and provide funding in the future. Multi-jurisdictional signal coordination typically applies to urban areas with more than one signal owner/operator (in this case, Texarkana, Bryan/College Station, and Houston).

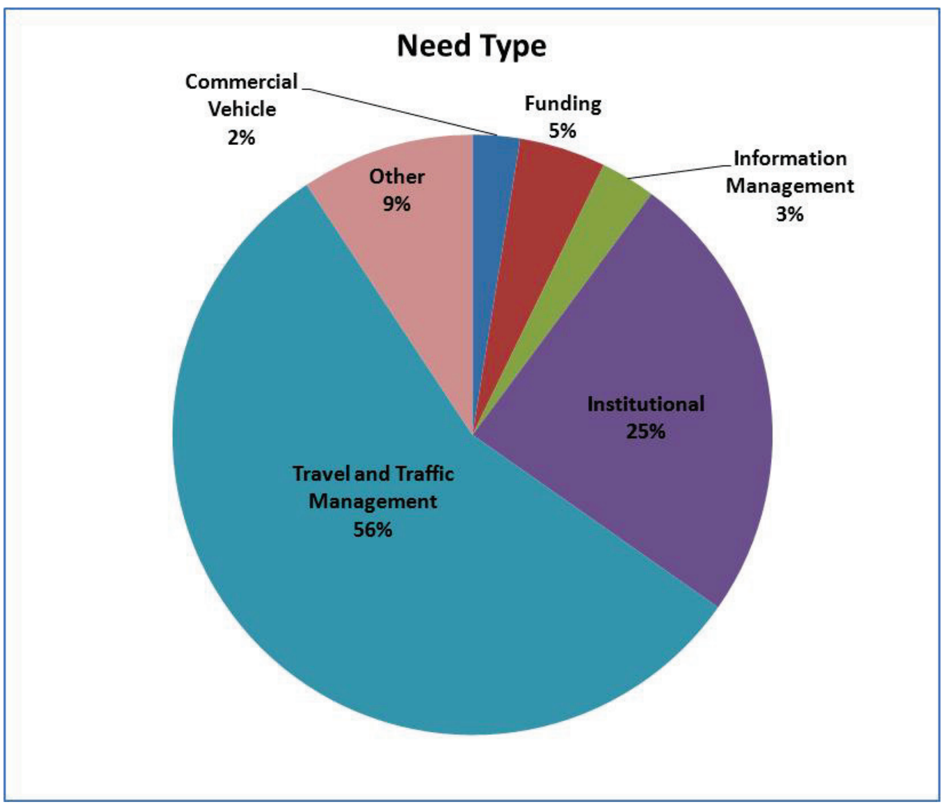


Figure 6. Distribution of Need Types.

Table 11. Needs Related to Traffic Signals.

Need	Region
Multi-jurisdictional/interoperable traffic signal operation	Atlanta, Bryan, Houston
Traffic signal coordination	Austin, Bryan, Pharr
Communications to remote traffic signal locations	Bryan, Corpus Christi
Video access/camera feeds from signalized intersections	Bryan, Laredo
Transit signal priority	Lubbock
Complete centralized signal system	San Antonio
Better closed-loop traffic signal system	Pharr, Waco
Traffic signal timing optimization	Beaumont, Wichita Falls

DMS Needs

Table 12 summarizes DMS needs that various regions identified. The need for additional DMS is more of a rural district issue where DMS is the primary ITS deployment. Replacement and upgrade of old technology is also a key need.

Table 12. DMS Needs.

DMS Need	Region
More DMS	Atlanta, Austin, Beaumont, Brownwood, Childress, Paris, San Angelo, Waco, Wichita Falls
Upgrade/equipment	Amarillo, Austin, San Antonio
Ability to disseminate information for non-TxDOT facilities	Bryan/College Station, San Antonio
Access to DMS	Houston
Operate DMS by partner when TxDOT is unavailable	Laredo
Portable DMS	Laredo

Camera and Video Needs

Table 13 lists various regions' camera- and video-related needs. Similar to DMS needs, the need for new or additional video cameras is also a key rural need. Furthermore, access to a partner agency's videos is primarily an urban-area need.

Table 13. Camera- and Video-Related Needs.

Camera and Video-Related Need	Region
More cameras or increased surveillance	Atlanta, Austin, Brownwood, Childress, Laredo, Lufkin, Paris, Pharr, San Antonio , Wichita Falls
Access to TxDOT's or other agency's cameras/video feeds	Austin, Beaumont, Bryan, Corpus Christi, Dallas, Houston, Laredo, San Antonio
Camera/video feeds from signalized intersections	Bryan, Laredo
District ability to control cameras under regional control	Lufkin
Camera images at remote locations	Rural districts

Incident Management Needs

Table 14 provides a summary of incident management needs. These needs are in mid-size urban areas with growing congestion and include improved incident management and incident clearance, as well as traveler information.

Table 14. Incident Management Needs.

Incident Management Need	Region
Improved incident management, including traveler information	Atlanta, Austin, Corpus Christi, Laredo, San Angelo
Data integration needs with other stakeholders	Austin, Atlanta, Laredo
Access to reliable real-time traffic information including incidents	Austin
Reduced incident clearance times	El Paso
Automatic detection of congestion and incidents	Beaumont, El Paso
Manage incidents across agencies	Austin

Traveler Information Needs

Table 15 shows that traveler information needs are primarily in areas along major highways and interstates. Furthermore, all northern regions identified the need for information to help long-distance or interstate travelers. This need is consistent with needs for ITS hardware (DMS, signals, cameras) upgrades, and expansion. The needs are also consistent with current ITS efforts, which include I-35 smart corridor, I-45 hurricane evacuation, and integrated corridor management (ICM).

Table 15. Traveler Information Needs.

Traveler Information Need	Region
Useful information for interstate or long-distance travelers	Amarillo, Atlanta, Childress, Paris, Lubbock
Travel-time information systems	Austin, Bryan, Dallas, Laredo
Inform travelers about weather situations (ice, snow, fires, hurricane evacuation, etc.)	Amarillo, Atlanta, El Paso, San Antonio
Traveler information for special events	Bryan
Travel information for rail	Laredo

Institutional Needs

Table 16 lists the institutional needs of various regions that are also common throughout the state. The greatest needs are for improved cooperation between regional partners, dedicated funding for ITS, improved relationships between TRF and districts, and consistent ITS policy, strategy, and vision. A few regions indicated the need for updated regional ITS architectures, but there is no statewide consensus on this issue.

Table 16. Institutional Needs.

Institutional Need	Region
Improved cooperation and communications/agreements between regional partners and between regions along corridors.	Amarillo, Atlanta, Brownwood, Bryan, Dallas, Houston, Laredo, Lubbock, Pharr, San Antonio
Dedicated ITS funding	Atlanta, Austin, Corpus Christi, Houston, Laredo, Lubbock, San Angelo, Wichita Falls
Improved TxDOT district–division relationship	Atlanta, Austin, Dallas, Houston, Laredo, Lufkin
Consistent ITS policy/strategy/vision	Austin, Houston, Laredo, San Antonio, Waco
Sharing/leverage of resources and funding	Dallas, Laredo
More private and nontraditional partnerships	Houston, Laredo
Updated regional architecture	Bryan, El Paso, Pharr, Wichita Falls
Centralization of statewide functions (AMBER Alerts) and rural ITS, coordinated with linked larger districts	Brownwood, Houston
Improved departmental (IT, procurement, etc.) processes, and procurement policies to allow faster ITS deployment.	Brownwood, Houston
Improved coordination for traveler information between Texas and Oklahoma	Atlanta
TxDOT train partners on Hazmat response, etc.	El Paso

Data Needs

Table 17 lists data needs that regional stakeholders identified. These needs are primarily a mid- to large-urban area issue. Stakeholders listed various intended purposes for data. Data archiving is a need along border regions, as well as along I-35 and I-45.

Table 17. Identified Regional Data Needs.

Data Need	Region
Archived data, including automated archiving	Austin, Bryan, El Paso, Houston, Laredo
Congestion, O-D, accident and other data	Austin, Bryan, Dallas, El Paso, San Antonio
Data for operations and planning	Bryan, Corpus Christi, Paris
Local and cross-border sharing of data/information	Laredo, San Angelo
Tool to view region-wide real-time and archived data	El Paso

Commercial Vehicle Needs

The data in Table 18 show that commercial vehicle needs are primarily in locations along major highways and interstates.

Table 18. Commercial Vehicle Needs.

Commercial Vehicle Need	Region
Travel information for trucks, including multi-state travel	Amarillo, Atlanta, Beaumont, Childress, Lubbock, Paris
Truck weigh stations and enforcement for overweight trucks	Amarillo, Lubbock
Improved freight movement and planning	Austin, Bryan
Better handling of non-truck high loads at underpasses	Bryan
Traveler information about blocked railroad tracks to motorists and school buses, especially when fire trucks are involved	Laredo
Over-height truck detection systems	Wichita Falls

Private Data Needs

Table 19 lists the need for private data. According to these responses, stakeholders feel that at this time, there is not much of a need for private data. Only the San Antonio region stakeholders are considering the use of such data.

Table 19. Needs for Private Data.

Private Data Need	Region
Considering the use of private data	CAMPO, San Antonio MPO
May start charging private entities	CAMPO
No plans or not decided	BCSMPO, City of College Station
Public-to-private flow of data only (Amarillo)	Amarillo
Cannot accept ITS devices from private entities	USCBP
No private entity role in emergency management	Lubbock
Desire for statewide roadway performance data	San Antonio
Anticipate more private involvement like use of cellular phone towers for data along interstates	Brownwood

Special Texas Border Needs

Table 20 lists the special needs of the Texas–Mexico border region.

Table 20. Unique Needs of Texas–Mexico Border.

Topic	Need Related to Texas–Mexico Border
Roadway–Rail Interface	Railroad detection and preemption
	Information to emergency responders about blocked railroad tracks
	Information to motorists and school buses about blocked railroad tracks
Border Crossing	Better tracking/recording of wait times at crossings
	Tracking of commercial vehicles into the United States
	Hazmat crossing information

FUTURE LEADERSHIP

Funding and resources dictate an agency's role in a region, including leadership. Stakeholder expectation is for TxDOT to continue in a leadership role, particularly from a regional and interstate/long-distance travel and emergency evacuation perspective. Local entities will continue to install ITS to meet local needs using local and regional funding, and some are willing to take a leadership role if TxDOT is not able to do so. However, they will only be able to do this within local jurisdictions. In the future, MPOs could be potential leaders with expanded roles and experience.

CHAPTER 10: DRAFT VISION FOR ITS IN TEXAS

The research team developed a draft set of ITS plan elements for consideration by the Project Monitoring Committee and for use in building consensus with TxDOT local partners. The material is structured around the goals and objectives of the TxDOT *2013–2017 Strategic Plan* (*43*). The TxDOT agency goals of the plan are to maintain a safe system, address congestion, connect Texas communities, and become a best-in-class state agency. The ITS needs that TxDOT and its partner agencies pointed out during earlier stages of this project were aligned with the TxDOT *2013–2017 Strategic Plan*.

The ITS plan elements contained in this document were derived from stakeholder interviews and represent their assessment of current needs and the future direction of ITS in their operating venues. Additional ITS elements have been included based on ITS technology trends and assessments that were performed in the earlier phases of the research project.

The funding conditions described in the following section constrain the draft ITS plan elements. The partner agencies understand the reality of the existing funding. This common perception of the fiscal environment helps ensure that the ITS investment is highly effective, limited in size and scope, and stimulates ingenuity in the delivery of ITS services.

OVERVIEW INFORMATION

Transportation revenues, which are traditionally derived from fuel taxes, motor vehicle fees, and tolls, have not kept pace with projected needs. Recent reports indicate a cumulative nationwide shortfall has been estimated at $1 trillion through 2015 (*24*). The Presidential request for funding for FY 2013 for research and development for FHWA was $528.4 million with ITS Research and Development receiving $94.6 million (an increase of 9.5 percent over the previous year). However, the Senate Committee on Appropriations recommended $429.8 million for transportation research, which is the same level as FY 2012 (*44*).

Trends in ITS funding in individual states mimic those at the federal level. These indicate that fuel tax revenues continue to decline as a result of inflation, less driving by the traveling public, and the increase in fuel-efficient and alternative-fuel vehicles (*24*). With respect to how agencies manage ITS funds and budgets, a 2010 survey of the Research and

Innovative Technology Administration on ITS deployment indicates that many states still maintain separate budgets for ITS deployments and related costs (*11*).

The National Conference on State Legislatures' report on *Transportation Funding and Finance* (*24*) highlights the following trends in funding and finance that impact an agency's ability to meet the demands of the transportation system:

- Revenues from fuel tax continue to decline for a variety of reasons, including inflation, lower VMs, and the increased use of fuel-efficient and alternative-fuel vehicles.
- States are more frequently considering general funds as a source of transportation revenue.
- Some states are diverting transportation revenues to other budget categories to make up shortfalls.
- Tolling continues to increase in popularity as a source of revenue with more than 30 states having some form of tolling on their transportation facilities.
- States are continuing to try and save money through more efficient project completion and improved overall system performance.
- There is an increasing trend to borrow and leverage funds for transportation projects (***Error! Bookmark not defined.***).

In recent years, local governments have stepped in to help with transportation funding as states are finding their resources constrained. Local governments now are typically a major source of transportation funding, providing about 30 percent of all highway funding (***Error! Bookmark not defined.***). The federal program continues to be uncertain. As of July 2012, federal surface transportation programs have been reauthorized only for the next 27 months (*45*), and it is unclear what will happen at the termination of MAP-21.

States have increasingly used a variety of public–private partnerships to finance transportation projects. These partnerships involve private-sector financing, construction, maintenance, and/or operation of transportation projects. As of August 2012, 33 states and Puerto Rico have laws enabling PPPs for highways and bridges (*24*). Transportation Reinvestment Zones, legalized in Texas in 2007, are a funding mechanism in which funding is captured from increased property values within the designated TRZ and designated for road projects. Furthermore, Tax Increment Reinvestment Zones are very similar to tax increment financing and special assessment districts, in that special areas are created and as property values increase in that area, the increased taxes are used exclusively in that area to fund improvements to infrastructure. Districts can be designated to receive either partial or full portions of the increased revenues.

The potential opportunities for utilizing PPPs exist in many areas within the transportation program in general and can easily be expanded into the ITS realm. For example, Section 1201 of SAFETEA-LU requires states to provide real-time system management information for interstates by 2014 and other significant roadways by 2016 (*11*). Since a key component of this provision involves data, it is possible that a PPP might be a logical approach to leveraging private- and public-sector resources to meet the requirements and provide information to agencies and the traveling public. There might be similar opportunities within the purview of ITS as agencies consider alternatives to providing the ITS infrastructure for the transportation system. It is possible that many of these innovative finance mechanisms can be used to leverage resources for ITS projects in Texas.

Regional stakeholders (municipalities, MPOs, transit agencies, etc.) across the state continue to see TxDOT as a leader with respect to ITS. From the perspective of ITS architectures, non-TxDOT stakeholder agencies believe that TxDOT is responsible for keeping them current, despite considering themselves important partners in the process. Furthermore, most key regional stakeholders work together informally even though regional architectures recommend the development of formal cooperation agreements between regional partners. From a technical perspective, stakeholders also look to TxDOT to identify technologies, approaches, and products that can be implemented on a broad basis.

Across the state of Texas, agencies have deployed a variety of ITS elements and will continue to deploy more as needs evolve and resources are available. These elements include:

- Surveillance cameras of various types.
- Portable and permanent dynamic message signs.
- Detectors (loops, microwave, video, Bluetooth, etc.).
- Weather stations.
- Flood, ice, and fog detection systems.
- Closed-loop, central or adaptive signal control.

- Computer-aided dispatch for transit and emergency vehicles.
- Security cameras, AVL devices, data terminals, and GPS on buses.
- Mobile data terminals and AVL on transit and emergency vehicles.
- Traffic signal priority and preemption.
- Wired (including fiber) and wireless (Wi-Fi and radio-based) communications.
- Weigh-in-motion stations.
- Border wait time measurements systems.
- 511 (in Dallas).
- Integrated corridor management and decisions support systems (in Dallas).
- Highway advisory radio.
- Warning systems (signal ahead, speed on curves, and school zones).
- Technology for information dissemination to users, including e-mail, text, and reverse-911.

TXDOT OBJECTIVES AND STRATEGIES

This section structures the draft recommendations to be included in TxDOT's ITS strategic plan consensus process in the context of the goals and objectives of the TxDOT *2013–2017 Strategic Plan*.

Goal: Maintain a Safe System

- Objective: Reduce crashes and fatalities on the system through innovations, technology, and public awareness (page 4 of the TxDOT *2013–2017 Strategic Plan* [*43*]):
    - Reduce rear-end collisions caused by queues on freeways.
    - Reduce collisions caused by wrong-way driving.
    - Reduce collisions at signalized intersections.
    - Reduce run-off-the-road collisions.
    - Reduce collisions caused by impaired drivers.
    - Reduce collisions during inclement weather conditions.
    - Reduce collisions at rural high-speed, unsignalized intersections.
    - Reduce pedestrian collisions.

- Reduce bicycle collisions.
- Reduce crashes at highway rail grade crossings, and reduce first-responder arrival time on routes through rail crossings.
- Improve commercial vehicle operations and safety.
- Reduce collisions in construction/maintenance zones for workers and for travelers.
- Reduce secondary incidents during incidents.
- Reduce collisions related to Energy Zone operations.

* Objective: Maintain and preserve the transportation assets of the state of Texas (page 4 of the TxDOT *2013–2017 Strategic Plan* [43]):

  - Employ an asset management approach for managing the deployment and replacement of ITS field devices, including dynamic message signs, and traffic surveillance system.
  - Develop statewide communication architecture and backbone for connecting routes of significance.
  - Establish a statewide managed funding strategy for TxDOT ITS.
  - Provide standard functional requirements for ITS field devices and services for all TxDOT districts.
  - Provide for the statewide use of a standardized TMC software for core functions.
  - Support and facilitate deployment of interfaces to regional software modules for TxDOT and all partners.
  - Develop a system for capturing and retaining data to support planning, operations, and management of the transportation system.
  - Improve interoperability of ITS services through the development of statewide uniform device standards and specifications.
  - Deploy ITS services in Texas energy zones that assist in managing distressed pavement and potentially provide a funding mechanism to recover costs incurred.

Goal: Address Congestion

- Objective: Partner with local officials to develop and implement congestion mitigation plans in Texas (page 4 of the TxDOT *2013–2017 Strategic Plan* [*43*]):
  - Improve reliability and predictability of travel time on major freeways and at international borders.
  - Reduce congestion-related delays by decreasing queues and spillback from connecting urban freeways.
  - Manage traffic at interchange entrance ramps to improve mainline throughput and traffic flow.
  - Balance demand throughout a regional network by better coordination of freeway management with arterial roadways.
  - Actively manage the freeway network to smooth flow and maximize capacity in urban corridors.
  - Promote and facilitate the development of regional, multi-jurisdictional traffic signal operations.
  - Improve coordination of regional agencies that are implementing managed lanes and tolling.
  - Encourage active demand management for transit with additional real-time information.
  - Improve interstate coordination of transportation operations.
  - Provide real-time information about road and lane closures due to construction, traffic incidents, weather, and other events.
  - Promote the safe and smooth flow of traffic through rural construction and maintenance zones.
  - Provide effective video coverage.
  - Provide remote access to field devices.
  - Provide consistency of responses across all districts.
  - Develop process and procedures for quantifying the costs and benefits associated with ITS deployments.
  - Support the development of regional, multimodal operations.

- Support effective traveler information.
- Enhance incident management.

- Objective: Enhance the use of partnerships (page 4 of the TxDOT *2013–2017 Strategic Plan* [*43*]):
  - Streamline processes and procedures for facilitating traffic management activities in the region—develop clear formal policies and consistent application.
  - Retain ability of local agencies/districts to utilize systems to make local decisions.

Goal: Connect Texas Communities

- Objective: Prioritize new projects that will increase the state gross domestic product (GDP) and enhance access to goods and services throughout the state (page 4 of the TxDOT *2013–2017 Strategic Plan* [*43*]):
  - Develop statewide communication network plan for routes of significance.
  - Provide system and technology to promote the safe and effective evacuation during natural and man-made disasters.

- Objective: Enhance the economic competitiveness of the state of Texas (page 4 of the TxDOT *2013–2017 Strategic Plan* [*43*]):
  - Ensure efficient landside access to intermodal, port, airport, and truck terminal facilities.
  - Ensure the efficient intermodal transfer of people and goods.
  - Improve predictability of commercial travel and delivery times.
  - Expedite permitting and clearance of commercial vehicles at weigh- and agricultural-inspection sites to keep commerce moving.
  - Provide safe and efficient access to major activity centers such as tourist attractions, state and national parks, and other points/areas of interest.
  - Ensure sufficient, sustainable funding of ITS for deployment and maintenance.

Goal: Become a Best-in-Class State Agency

- Objective: Ensure the agency deploys its resources responsibly and has a customer service mindset (page 4 of the TxDOT *2013–2017 Strategic Plan* [*43*]):
  - Provide best-in-class support to local communities and district to facilitate attainment of local goals and policies.
  - Develop a comprehensive performance evaluation and reporting program to improve public support of DOT activities.
  - Develop a strategic research and development program to provide the development and deployment of innovative technologies.
  - Develop testbeds and model deployment for innovative programs of national interest, including connected vehicles, active traffic and demand management, and integrated corridor management.
- Objective: Focus on work environment, safety, succession planning, and training to develop a great workforce (page 4 of the TxDOT *2013–2017 Strategic Plan* [*43*]):
  - Increase the professional capacity for public and private sectors to support deployments.
  - Ensure that TxDOT has the proper staffing to properly maintain and use deployed systems to their maximum potential.

TXDOT ITS OBJECTIVES AND STRATEGIES

This section restates the candidate recommendations from Section 3, and it adds information concerning where they were identified by TxDOT and its partner city, county, metropolitan planning organization, and other key collaborators during previous stakeholder interviews. It also contains an identification of related ITS service packages that apply to those strategic plan elements (*46*).

1. ***<u>TxDOT Goal</u>: Maintain a Safe System***

1.1. <u>TxDOT Objective</u>: Reduce crashes and fatalities on the system through innovation, technology, and public awareness. The following candidate ITS strategic plan elements support this objective.

1.1.1. Reduce rear-end collisions caused by queues on freeways.

- Amarillo, Austin, and Houston. The Houston area emphasized that this is an urgent need.
- National ITS Architecture service packages that support the objective of reduction of secondary accidents include:
  - ATMS12-Roadside Lighting System Control.
  - ATMS22-Variable Speed Limits.
  - ATMS24-Dynamic Roadway Warning.
  - AVSS03-Longitudinal Safety Warning.
  - AVSS07-Driver Visibility Improvement.
  - AVSS08-Advanced Vehicle Longitudinal Control.
  - AVSS12-Cooperative Vehicle Safety Systems.

1.1.2. Reduce collisions caused by wrong-way driving.

- Fort Worth, Houston, San Antonio.
- National ITS Architecture service packages that support the objective of reduction of crashes due to driver errors and limitations include:
  - ATMS12-Roadside Lighting System Control.
  - ATMS13-Standard Railroad Grade Crossing.
  - ATMS14-Advanced Railroad Grade Crossing.
  - ATMS19-Speed Warning and Enforcement.
  - ATMS24-Dynamic Roadway Warning.
  - AVSS01-Vehicle Safety Monitoring.
  - AVSS02-Driver Safety Monitoring.
  - AVSS03-Longitudinal Safety Warning.
  - AVSS04-Lateral Safety Warning.
  - AVSS05-Intersection Safety Warning.
  - AVSS07-Driver Visibility Improvement.
  - AVSS08-Advanced Vehicle Longitudinal Control.
  - AVSS09-Advanced Vehicle Lateral Control.
  - AVSS10-Intersection Collision Avoidance.
  - AVSS12-Cooperative Vehicle Safety Systems.
  - CVO08-On-board Commercial Vehicle Operations (CVO) Safety.
  - MC05-Roadway Automated Treatment.

1.1.3. Reduce collisions at signalized intersections.

- Statewide, cities, and counties (looking to TxDOT to lead).

- National ITS Architecture service packages that support the objective of reduction of crashes at intersections include:
  - ATMS12-Roadside Lighting System Control.
  - AVSS02-Driver Safety Monitoring.
  - AVSS03-Longitudinal Safety Warning.
  - AVSS05-Intersection Safety Warning.
  - AVSS08-Advanced Vehicle Longitudinal Control.
  - AVSS09-Advanced Vehicle Lateral Control.
  - AVSS10-Intersection Collision Avoidance.
  - AVSS12-Cooperative Vehicle Safety Systems.

1.1.4. Reduce run-off-the-road collisions.

- National ITS Architecture service packages that support the objective of reduction of lane departure crashes include:
  - ATMS12-Roadside Lighting System Control.
  - ATMS22-Variable Speed Limits.
  - AVSS02-Driver Safety Monitoring.
  - AVSS04-Lateral Safety Warning.
  - AVSS07-Driver Visibility Improvement.
  - AVSS09-Advanced Vehicle Lateral Control.
  - AVSS12-Cooperative Vehicle Safety Systems.
  - MC05-Roadway Automated Treatment.

1.1.5. Reduce collisions caused by impaired drivers.

- Related to wrong-way driving.
- National ITS Architecture service packages that support the objective of reduction of crashes due to driver errors and limitations include:
  - ATMS12-Roadside Lighting System Control.
  - ATMS13-Standard Railroad Grade Crossing.
  - ATMS14-Advanced Railroad Grade Crossing.
  - ATMS19-Speed Warning and Enforcement.
  - ATMS24-Dynamic Roadway Warning.
  - AVSS01-Vehicle Safety Monitoring.
  - AVSS02-Driver Safety Monitoring.
  - AVSS03-Longitudinal Safety Warning.
  - AVSS04-Lateral Safety Warning.
  - AVSS05-Intersection Safety Warning.
  - AVSS07-Driver Visibility Improvement.
  - AVSS08-Advanced Vehicle Longitudinal Control.
  - AVSS09-Advanced Vehicle Lateral Control.
  - AVSS10-Intersection Collision Avoidance.
  - AVSS12-Cooperative Vehicle Safety Systems.

- CVO08-On-board CVO Safety.
- MC05-Roadway Automated Treatment.

1.1.6. Reduce collisions during inclement weather conditions.

- National ITS Architecture service packages that support the objective of reduction of crashes due to road weather conditions include:
  - ATMS12-Roadside Lighting System Control.
  - ATMS22-Variable Speed Limits.
  - ATMS24-Dynamic Roadway Warning.
  - AVSS03-Longitudinal Safety Warning.
  - AVSS04-Lateral Safety Warning.
  - AVSS05-Intersection Safety Warning.
  - AVSS07-Driver Visibility Improvement.
  - AVSS08-Advanced Vehicle Longitudinal Control.
  - AVSS09-Advanced Vehicle Lateral Control.
  - AVSS10-Intersection Collision Avoidance.
  - AVSS12-Cooperative Vehicle Safety Systems.
  - MC05-Roadway Automated Treatment.

1.1.7. Reduce collisions at rural high-speed, unsignalized intersections.

- Rural districts.
- National ITS Architecture service packages that support the objective of reduction of crashes at intersections include:
  - ATMS12-Roadside Lighting System Control.
  - AVSS02-Driver Safety Monitoring.
  - AVSS03-Longitudinal Safety Warning.
  - AVSS05-Intersection Safety Warning.
  - AVSS08-Advanced Vehicle Longitudinal Control.
  - AVSS09-Advanced Vehicle Lateral Control.
  - AVSS10-Intersection Collision Avoidance.
  - AVSS12-Cooperative Vehicle Safety Systems.

1.1.8. Reduce pedestrian collisions.

- Austin, San Antonio, Wichita Falls.
- Houston has installed in-pavement lighting.
- National ITS Architecture service packages that support the objective of reduction of crashes involving bicyclists and pedestrians include:
  - ATMS12-Roadside Lighting System Control.
  - ATMS13-Standard Railroad Grade Crossing.
  - ATMS14-Advanced Railroad Grade Crossing.
  - ATMS19-Speed Warning and Enforcement.
  - ATMS26-Mixed Use Warning Systems.
  - AVSS01-Vehicle Safety Monitoring.

- AVSS03-Longitudinal Safety Warning.
- AVSS04-Lateral Safety Warning.
- AVSS05-Intersection Safety Warning.
- AVSS07-Driver Visibility Improvement.
- AVSS08-Advanced Vehicle Longitudinal Control.
- AVSS09-Advanced Vehicle Lateral Control.
- AVSS10-Intersection Collision Avoidance.
- AVSS12-Cooperative Vehicle Safety Systems.

1.1.9. Reduce bicycle collisions.

- Wichita Falls.
- National ITS Architecture service packages that support the objective of reduction of crashes involving bicyclists and pedestrians include:
  - ATMS12-Roadside Lighting System Control.
  - ATMS13-Standard Railroad Grade Crossing.
  - ATMS14-Advanced Railroad Grade Crossing.
  - ATMS19-Speed Warning and Enforcement.
  - ATMS26-Mixed Use Warning Systems.
  - AVSS01-Vehicle Safety Monitoring.
  - AVSS03-Longitudinal Safety Warning.
  - AVSS04-Lateral Safety Warning.
  - AVSS05-Intersection Safety Warning.
  - AVSS07-Driver Visibility Improvement.
  - AVSS08-Advanced Vehicle Longitudinal Control.
  - AVSS09-Advanced Vehicle Lateral Control.
  - AVSS10-Intersection Collision Avoidance.
  - AVSS12-Cooperative Vehicle Safety Systems.

1.1.10. Reduce crashes at highway rail grade crossings, and reduce first responder arrival time on routes through rail crossings.

- Rail monitoring systems provide warning of blocked crossings for first responders and allow adjustment of traffic signal timings based on train arrival patterns.
- National ITS Architecture service packages that support the objective of reduction of first responder arrival time include:
  - ATMS08-Traffic Incident Management System.
  - EM01-Emergency Call-Taking and Dispatch.
  - EM02-Emergency Routing.
  - EM03-Mayday and Alarms Support.
  - EM04-Roadway Service Patrols.
- National ITS Architecture service packages that support the objective of reduction of crashes at railroad crossings include:
  - ATMS13-Standard Railroad Grade Crossing.

- ATMS14-Advanced Railroad Grade Crossing.
- AVSS02-Driver Safety Monitoring.
- AVSS05-Intersection Safety Warning.
- AVSS12-Cooperative Vehicle Safety Systems.

1.1.11. Improve commercial vehicle operations and safety.

- Hazmat-related incident response, clean up, and related traffic detour.
- Promote real-time traffic monitoring of inter-region, interstate, and international freight corridors.
- Data for freight planning.
- Austin, Beaumont, Bryan, El Paso, Laredo, Houston, Texarkana.
- Speed warning systems on ramps—Houston.
- Border wait time measurement systems—El Paso, Laredo, Pharr.
- Alternate freight routes—US 75 through Paris region is an equally, and often preferred, alternate to I-35 for Midwest traffic.
- Adaptive signal control to promote truck movement—Beaumont.
- Traveler information for trucks (Beaumont, Childress) and high loads (Bryan, Wichita Falls).
- Enforcement—Lubbock.
- Strategic corridors—Amarillo, Dallas, Houston, Lubbock, Waco.

1.1.12. Reduce collisions in construction/maintenance zones for workers and for travelers.

- Waco District/I-35 construction project and other major reconstruction projects such as IH-635 in Dallas.
- National ITS Architecture service packages that support the objective of reduction of crashes and fatalities in work zones include:
  - ATMS12-Roadside Lighting System Control.
  - MC09-Work Zone Safety Monitoring.

1.1.13. Reduce secondary incidents during incidents.

- Statewide, national, all districts and regions.
- National ITS Architecture service packages that support the objective of reduction of secondary crashes include:
  - ATMS12-Roadside Lighting System Control.
  - ATMS22-Variable Speed Limits.
  - ATMS24-Dynamic Roadway Warning.
  - AVSS03-Longitudinal Safety Warning.
  - AVSS07-Driver Visibility Improvement.
  - AVSS08-Advanced Vehicle Longitudinal Control.
  - AVSS12-Cooperative Vehicle Safety Systems.

1.1.14. Reduce collisions related to Energy Zone operations.

- The objective is to mitigate fatigued drivers who are also driving on degraded pavements.
- National ITS Architecture service packages that support the objective of reduction of crashes due to unsafe drivers, vehicles, and cargo include:
  - AVSS01-Vehicle Safety Monitoring.
  - AVSS02-Driver Safety Monitoring.
  - AVSS03-Longitudinal Safety Warning.
  - AVSS04-Lateral Safety Warning.
  - AVSS05-Intersection Safety Warning.
  - AVSS08-Advanced Vehicle Longitudinal Control.
  - AVSS09-Advanced Vehicle Lateral Control.
  - AVSS10-Intersection Collision Avoidance.
  - AVSS12-Cooperative Vehicle Safety Systems.
  - CVO08-On-board CVO Safety.
  - MC05-Roadway Automated Treatment.

1.2. <u>TxDOT Objective</u>: Maintain and preserve the transportation assets of the State of Texas. The following candidate ITS strategic plan elements support this objective.

1.2.1. Employ an asset management approach for managing the deployment and replacement of ITS field devices, including dynamic message signs and traffic surveillance system.
- Austin, San Antonio.

1.2.2. Develop statewide communication architecture and backbone for connecting routes of significance.
- Local agencies are unable to access this communication.

1.2.3. Establish a statewide managed funding strategy for TxDOT ITS.
- Statewide—all districts.
- Fort Worth.
- Establish traffic operations performance measures for district engineers (DEs) (include in annual reviews just like pavement scores).
- Encourage the supplemental use of district funds to support operations—goes back to the “core business” question.

1.2.4. Provide standard functional requirements for ITS field devices and services for all TxDOT districts.
- TxDOT, Houston.

1.2.5. Provide for the statewide use of a standardized TMC software for core functions
- TxDOT, Beaumont, Bryan, Corpus Christi, Laredo, Lufkin, San Antonio.
- Promotes regional traffic management (one district manages other districts). Makes efficient use of staffing resources.

1.2.6. Support and facilitate deployment of interfaces to regional software modules for TxDOT and all partners.

- Dallas, Houston.
- Personal traffic information, route builders, historical data/travel time reliability.
- Dallas Decision support system.

1.2.7. Develop system for capturing and retaining data to support planning, operations, and management of the transportation system.

1.2.8. Improve interoperability of ITS services through the development of statewide uniform device standards and specifications.

- Especially useful for sharing of video. Cited as an objective in most regions.

1.2.9. Deploy ITS services in Texas Energy Zones that assist in managing distressed pavement and potentially provide a funding mechanism to recover costs incurred.

- TxDOT is investigating road user charges and roadway monitoring systems for deployment in the Texas energy zones.
- National ITS Architecture service packages that support the objective of managing distressed pavement include:
  - CVO06-Weigh-In-Motion.
  - MC12-Infrastructure Monitoring.
- National ITS Architecture service packages that support the objective of variable pricing include:
  - ATMS10-Electronic Toll Collection.
  - ATMS25-VMT Road User Payment.

2. ***<u>TxDOT Goal</u>*****: *Address Congestion***

2.1. <u>TxDOT Objective</u>: Partner with local officials to develop and implement congestion mitigation plans in Texas. The following candidate ITS strategic plan elements support this objective.

2.1.1. Improve reliability and predictability of travel time on major freeways and at international borders.

2.1.2. Reduce congestion-related delays by decreasing queues and spillback from connecting urban freeways.

2.1.3. Manage traffic at interchange entrance ramps to improve mainline throughput and traffic flow.

- Houston—ramp metering.

2.1.4. Balance demand throughout a regional network by better coordination of freeway management with arterial roadways.

- The Dallas integrated corridor management project involving TxDOT, local cities, and the DART transit agency has this as one of its objectives.
- National ITS Architecture service packages that support the objective of freeway and arterial management include:
  - ATMS01-Network Surveillance.
  - ATMS02-Traffic Probe Surveillance.

- ATMS03-Traffic Signal Control.
- ATIS01-Broadcast Traveler Information.
- ATIS02-Interactive Traveler Information.
- ATIS04-Dynamic Route Guidance.
- ATIS09-In Vehicle Signing.
- ATIS10-Short Range Communications Traveler Information.
- ATMS04-Traffic Metering.
- ATMS06-Traffic Information Dissemination.
- ATMS18-Reversible Lane Management.
- ATMS22-Variable Speed Limits.
- ATMS23-Dynamic Lane Management and Shoulder Use.

2.1.5. Actively manage the freeway network to smooth flow and maximize capacity in urban corridors.

- Emerging on nationwide basis.
- El Paso and other urbanized areas.

2.1.6. Promote and facilitate the development of regional, multi-jurisdictional traffic signal operations.

- Texarkana and other urbanized areas.

2.1.7. Improve coordination of regional agencies that are implementing managed lanes and tolling.

- National trend/emerging.
- Austin, San Antonio.
- NCTCOG—to support pricing.
- San Antonio: How to communicate I-35 is congested and provide information about use of SH 130.

2.1.8. Encourage active demand management for transit with additional real-time information.

- Next Bus, dynamic ride-sharing, park-n-ride availability.
- El Paso.
- Transit agencies.

2.1.9. Improve interstate coordination of transportation operations.

- El Paso with the State of New Mexico, Panhandle, Beaumont, Texarkana.
- Federal requirement.

2.1.10. Provide real-time information about road and lane closures due to construction, traffic incidents, weather, and other events.

- Federal requirement for 23 CFR 511.

2.1.11. Promote the safe and smooth flow of traffic through rural construction and maintenance zones.

2.1.12. Provide effective video coverage.

- Video coverage at strategic bottlenecks in rural locations with remote access by local partners (support for evacuation, etc.).
- Provide more extensive video coverage between major metropolitan/remote locations.
    - Atlanta, Brownwood.

2.1.13. Provide remote access to field devices.

- Beaumont, Corpus Christi, Pharr, etc.
- Federal requirement for 23 CFR 511.

2.1.14. Provide consistency of responses across all districts.

- Develop statewide standard operating procedures to ensure consistency of management responses and actions during similar situations.
- DMS messages, Emergency messages.
- AMBER/Silver/Blue Alerts.

2.1.15. Develop process and procedures for quantifying the costs and benefits associated with ITS deployments.

2.1.16. Support the development of regional, multimodal operations.

- Promote and encourage multimodal travel.
- Develop regionally accepted system performance standards and measures that will drive transportation resource investment decisions.
- Promote the establishment of regional operating organizations to develop regional collaboration closely linked to the MPO transportation planning and decision process creating stronger linkage between operations and planning.

2.1.17. Support effective traveler information.

- Deploy systems to support provision of 23 CFR Section 511 requirements.
- Federal requirement.
- Develop statewide standards for disseminating travel information on roadside communication devices.
    - DMS messages, Emergency messages.
    - AMBER/Silver/Blue Alerts.
- Facilitate the dissemination of information about border wait times.
    - El Paso, Laredo.
- Provide pre-trip planning services to assist in route, mode, and departure time decisions.
    - Dallas, Houston.

2.1.18. Enhance incident management.

- Enhance the ability of regions to detect, verify, respond to, and clear traffic incidents through effective communication and coordination between local governments, public safety officials, and transportation system operators.
    - San Antonio—increased sharing with smaller communities along I-35.
    - Bryan.

- Improve and enhance the prediction of impacts of traffic incidents and the effects of management responses.
- Provide warning of queues to reduce the frequency of secondary collisions during incident conditions.
  - National interest.

2.2. Enhance the use of partnerships.

2.2.1. Streamline processes and procedures for facilitating traffic management activities in region—develop clear formal policies and consistent application.

- Model MOUs for agency cooperation.
- Formulate data-sharing agreements with international partners to share real-time and other mutually beneficial information such as wait times, major incidents around ports, CCTV snapshots, evacuation-related information, planning data, etc. within region and between regions (El Paso, Laredo, Pharr, San Angelo, San Antonio, Waco).
- San Antonio—TxDOT and City of San Antonio finalizing agreement.
- Fiber-use agreements.
- CCTV and DMS use by local agencies/police.
- Active participation in emergency operations (El Paso).
- Leveraging resources (Dallas, Houston, Laredo).

2.2.2. Retain ability of local agencies/districts to utilize systems to make local decisions.

3. <u>TxDOT Goal</u>: Connect Texas Communities

3.1. <u>TxDOT Objective</u>: Prioritize new projects that will increase the state GDP and enhance access to goods and services throughout the state. The following candidate ITS strategic plan elements support this objective.

3.1.1. Develop statewide communication network plan for routes of significance that connect Texas communities.

- Austin, San Antonio, Waco.
- Local communities need TxDOT to provide backbone so that they can link communities together across jurisdictional boundaries.

3.1.2. Provide system and technology to promote safe and effective evacuation during natural and man-made disasters.

- Provide pre-trip planning information for evacuation conditions.
  - Beaumont, Corpus Christi, Paris, Pharr, San Antonio.
- Provide traffic management during evacuation conditions.
  - Beaumont, Corpus Christi, Paris, Pharr, San Antonio.
- Provide route guidance information and information on traffic/travel conditions and weather including winds, rainfalls, and storm surges.
- Provide reliable surveillance at critical junctions along strategic evacuation routes.

    - Beaumont, Corpus Christi, Paris, Pharr, San Antonio.
  - Provide accurate and timely traveler information regarding incidents on evacuation routes.
  - Share emergency information among local and regional TMCs and emergency management facilities.
    - Beaumont, Corpus Christi, Paris, Pharr, San Antonio, border regions.

3.2. Enhance the economic competitiveness of the state of Texas.

3.2.1. Ensure efficient landside access to intermodal, port, airport, and truck terminal facilities.

- Border Safety Inspection Facilities (BSIF) being implemented at several land ports of entry.
- El Paso, Laredo, Pharr.

3.2.2 Ensure the efficient intermodal transfer of people and goods.

3.2.3 Improve predictability of commercial travel and delivery times.

- Border wait time studies in El Paso, Laredo, Pharr.

3.2.4 Expedite permitting and clearance of commercial vehicles at weigh- and agricultural-inspection sites to keep commerce moving.

3.2.5 Provide safe and efficient access to major activity centers such as tourist attractions, state and national parks, and other points/areas of interest.

- San Antonio, including tourist traveler information.

3.2.6 Connected vehicles—competition with fuel.

3.3 Ensure sufficient, sustainable funding of ITS for deployment and maintenance.

3.3.2 Leverage resources of regional partners.

3.3.3 Promote public–private partnerships to leverage financial and human resources.

3.3.4 Promote the use of regional transportation reinvestment districts to provide resources for ITS deployments.

4. ***<u>TxDOT Goal</u>: Become a Best-in-Class State Agency***

4.1 <u>TxDOT Objective</u>: Ensure the agency deploys its resources responsibly and has a customer service mindset. The following candidate ITS strategic plan elements support this objective.

4.1.1 Provide best-in-class support to local communities and districts to facilitate attainment of local goals and policies.

- Strengthen lines of communications between TxDOT districts for sharing ideas and inter-district coordination.
  - Austin, Bryan, Paris.
- Ensure timely delivery support and new service to regional partners (including districts).
  - Beaumont, Lubbock, Paris.

4.1.2 Develop a comprehensive performance evaluation and reporting program to improve public support of DOT activities.

- New MAP-21 requirements (yet to be determined).

4.1.3 Develop a strategic research and development program to provide the development and deployment of innovative technologies.

- Become a pioneer in connected vehicles research and development.
- Position TxDOT to influence the process to address Texas' need in the initial concept development process.

4.1.4 Develop testbeds and model deployment for innovative programs of national interest, including connected vehicles, active traffic and demand management, and integrated corridor management.

- Try new devices and strategies as they come to market.
- Spur growth in small, high-tech industries.

4.2 <u>TxDOT Objective</u>: Focus on work environment, safety, succession planning, and training to develop a great workforce. The following candidate ITS strategic plan elements support this objective.

4.2.1 Increase the professional capacity for public and private sector to support deployments.

- Ensure that TxDOT staff members have adequate training to address constantly changing technology.

4.2.2 Ensure that TxDOT has the proper staffing to properly maintain and use deployed systems to their maximum potential.

- Ensure availability of support through easy access to redundant capabilities within a region.
- Provide access to highly trained technical personnel to support maintenance and adding functionality.
    - Houston, Paris, San Antonio.

CHAPTER 11: FOLLOW-UP INTERVIEWS WITH TXDOT STAFF AND STAKEHOLDERS

Researchers conducted follow-up interviews with TxDOT staff and other regional stakeholders. Using information gathered from previous stakeholder interviews, researchers developed a sample ITS archetype, presented it to stakeholders, and discussed their concerns and perspective relative to their region. This section summarizes the results of follow-up interviews.

Stakeholders were provided with maps showing current and potential TxDOT ITS implementation and coordination. Figure 7 shows the current ITS implementation and coordination map with four primary districts having full or partial Lonestar™ implementation, 11 other districts supported by the primary districts, seven districts with ITS implementation, and three districts with no ITS implementation.

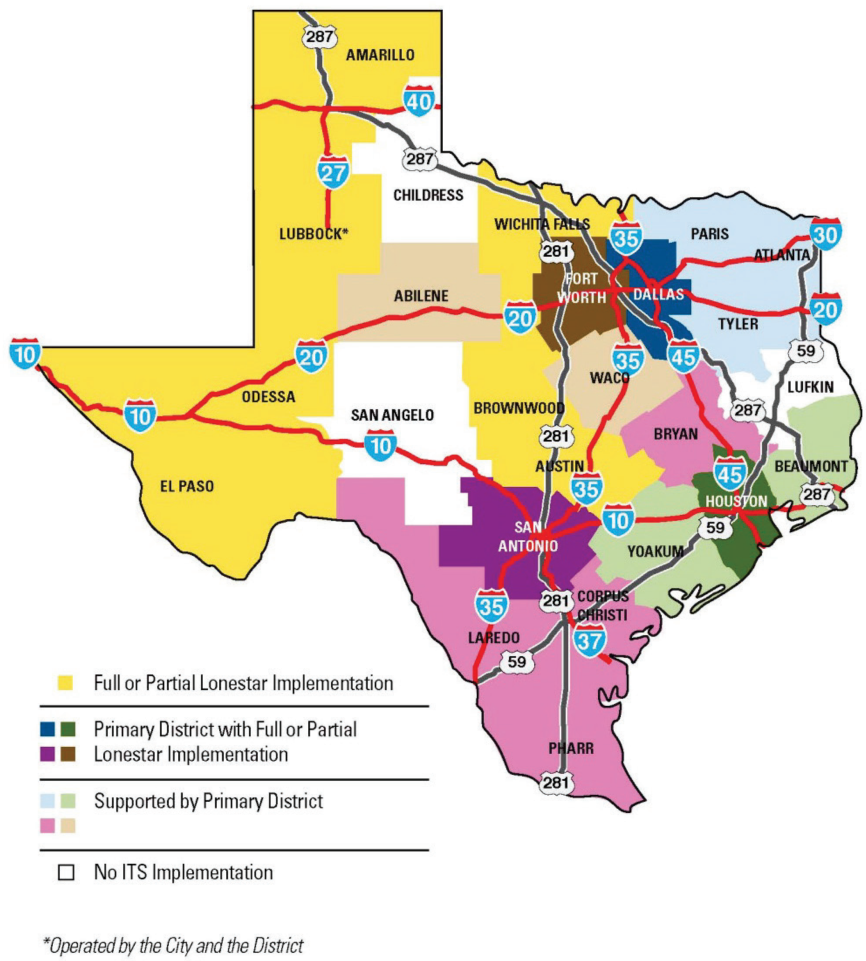


Figure 7. Current TxDOT ITS Implementation and Coordination.

One candidate ITS scenario brought to stakeholders to consider is consolidation of the operations of core TxDOT ITS functions into several primary TMCs (see Figure 8).

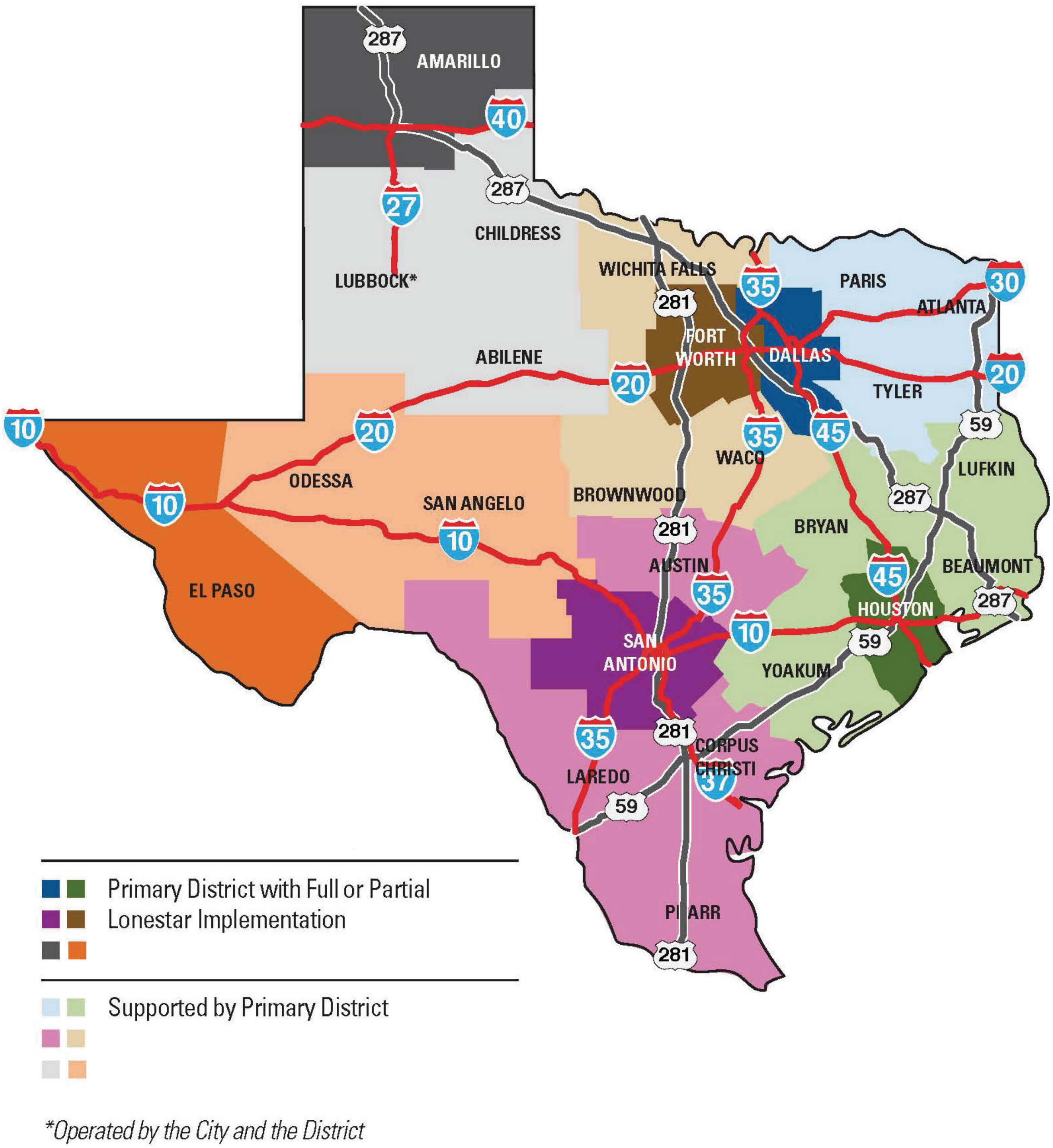


Figure 8. Potential TxDOT ITS Implementation and Coordination.

In the future scenario, primary TMCs would be located in strategic metropolitan areas (e.g., Dallas, Fort Worth, Houston, San Antonio, El Paso, and Amarillo) and would assume responsibility for operating ITS devices on state-supported highway/freeway facilities and neighboring districts, primarily after hours or as preferred by the districts. Local TxDOT district traffic management personnel would have the ability to remotely operate the ITS devices within their districts for specific traffic management purposes (such as local support of traffic incident, or local special event), but the primary TMC would maintain responsibility for the day-to-day operation of the TxDOT ITS. TxDOT Traffic Operations Division would be responsible for overseeing TxDOT's ITS programs, projects, equipment, and agreements statewide. With this role for TxDOT, local partners would be responsible for developing pre-trip planning and non-roadway-based traveler information systems (such as 511, social media, etc.). Local partner agencies would also be responsible for maintaining their current responsibilities for operating and maintaining traffic signal systems and other traffic management systems; developing, operating, and maintaining their own ITS/traffic management infrastructure; and maintaining transit ITS. Stakeholders at the follow-up interviews were asked several questions about this scenario, including:

- Would this be effective for your region?
- Is there a different way to structure it that would be more beneficial to you?
- How do you see your organization fitting into this structure?
- What would be your preferences in how this structure functions?

There was a general consensus among stakeholders to move primary centers to urban areas, in terms of equipment and after-hours staffing capability, as long as there is coordination with local agencies and partners. Doing so would make efficient use of resources and limited funding. Many of the responses were similar to those received in the previous interviews:

- Agencies found their existing ITS infrastructure to be useful to accomplish a number of ITS services.
- Agencies with ITS infrastructure desired to fill in the gaps in their deployment and complete the build-out of their systems.
- Many agencies did not have dedicated funding for ITS, and they desire budgets adequate for the ITS services they are providing.
- The desire for additional ITS services is tempered by funding and staffing limitations.

The following summarizes the other responses gathered from follow-up interviews with respect to consolidating core ITS functions and the example business scenario:

- Local needs should be the local partner's responsibility, particularly in matters regarding prioritizing local work zones or incidents, how video data can be shared, and operations and maintenance staff chain of command.
- Clear communication between partners is very important. A clear, detailed communication plan, or standard operating procedure manual, between the primary TMC and local partners should be in place, and it should clearly define when and under what circumstances local staff will take "control" of ITS systems, as well as agreements for two-way communication.
- The Traffic Operations Division must have enough staff in place if it plans to approve and handle all ITS procurement activities.

Many stakeholders felt that regionalization made sense for their area/district because there would be more consistency and potentially more cost savings, which would ultimately lead to more funding for ITS. However, several people raised concerns and had questions about the proposed regionalization, such as:

- Will there be the ability to "customize" systems for local needs?
- How will resource allocation remain equitable?
- How will the duplication of efforts be addressed (i.e., websites, etc.)?
- Will there be a centralized 511 system for the state?
- How will the distance from a primary TMC affect the supported districts?
- How will hurricane evacuation situations be handled?
- Will the proposed alignment be reviewed to consider local needs? For instance, San Antonio would support Laredo and Austin. Austin has very different needs than Laredo, and already operates a 24/7 TMC.
- How will different agencies work together?
- How will this affect the traveling public?

- How will regional centers be able to respond without knowledge of local issues/roadways/networks, etc.?
- How will regionalization be handled if it does not make sense in my area?

During the follow-up interviews, researchers also asked stakeholders what additional ITS services they would like if funding was not a concern. There was an overall willingness to consider additional ITS services throughout the state, and many regions would like to expand their ITS system. ITS “wish list” responses included:

- Dedicated funding for ITS implementation.
- Regional training and workshops for ITS implementation.
- Seamless ITS infrastructure throughout corridors, especially those identified as routes of significance.
- Additional dynamic message signs.
- Upgrade and/or replace aging equipment.
- Expansion of video and camera monitoring area to provide full coverage.
- Addition of a high-speed communications network.
- Real-time transit monitoring system.
- Variable speed-limit system.
- Regional traffic signal management system.
- The ability to provide traveler information via mobile devices.
- Upgrade and reestablish the Highway Advisory Radio (HAR) system.
- The ability to stream videos.
- Queue/congestion warning system in work zones to prevent secondary crashes.
- Full integration with other agencies, especially other local partners.
- Improve low-water crossing warning systems.
- Signal priority equipment.
- Co-locate agencies.
- Increase dedicated ITS staff.

During the follow-up interviews, stakeholders did not mention connected vehicle initiatives as an ITS strategy they plan to pursue or implement in their regions. As noted in

Chapter 4, connected vehicle technology is an emerging trend in ITS, which presents an opportunity for TxDOT (Central Offices, not a particular district) to champion this technology in the state if they hope for connected vehicle activities and initiatives to take place.

CHAPTER 12: DEVELOPMENT OF THE ITS STRATEGIC PLAN FOR TEXAS

The development of the ITS strategic plan was a multi-year effort that included an overview of ITS around the United States, an assessment of the state of the ITS industry, a peer state review, market research, and several rounds of consensus-building interviews with stakeholders across the state.

This first major effort of this project includes a review of state trends in ITS strategic planning as part of the assessment of the state of the ITS industry. As part of this review, the researchers collected information from each state and summarized the experiences from 27 states. They also examined a U.S. DOT report that documents best state practices related to ITS strategic planning. After reviewing these documents the researchers created summaries of key information including the following:

- Key information about ITS strategic planning including the types of stakeholders who were involved and the time horizon of the planning activity.
- Overall scope of the public outreach activities performed by the states, including ITS websites, implementation of 511 services, and branding of the ITS initiative.

The second major effort was a review of ITS initiatives in other states, the federal and private-sector research initiatives that are emphasizing connected vehicles, and the emerging state of ITS technologies, which allow the TxDOT planning process to identify evolving trends in ITS services and investments. The research identified several categories of services and project types that served as a foundation for discussion with stakeholders while developing the statewide ITS strategic plan.

A key part of developing a statewide ITS strategic plan is to obtain and incorporate feedback from peer states about their ITS programs, ITS needs, and best practices. TTI researchers developed a questionnaire to serve as a guide during the interviews. The project team conducted the one-on-one interviews over via telephone with key ITS personnel from peer states across the country—Alaska, Arizona, Arkansas, Colorado, Georgia, Idaho, North Carolina, Ohio, South Dakota, Utah, Vermont, and Wisconsin. The research team selected these states based on geography, size, and common transportation operations and management issues.

Next, the project team investigated the current TxDOT processes for ITS planning, design, specification, and procurement. The intent was to determine if changes in the existing process are viable and/or if new methods or improvements should be considered to deliver more timely and nimble ITS deployment when there is a clear technological and cost-effective advantage.

The funding of operations and maintenance of the ITS infrastructure and system continues to be a continual challenge for TxDOT. A variety of alternative funding options have potential to generate funding streams for ITS projects and systems. Many of these options would need to be approved prior to implementation to help maximize flexibility in financing transportation and specifically ITS improvements in Texas. With respect to ITS procurement, several alternative contracting mechanisms might offer opportunities to optimize ITS operations in cost-effective ways. These mechanisms include job order contracting, comprehensive development agreements, and public–private partnerships.

The project team developed a draft interview guide to be used to gather information from stakeholders regarding their needs for ITS, the issues related to architecture on a statewide and regional level, specific goals for operations, and information about partnerships and expectations, especially in the future. The draft interview guide was vetted through the project team and with the project director and submitted to the Institutional Review Board at Texas A&M University as university research policy required.

After the IRB approved the draft guide, researchers began contacting stakeholders in various regions across the state. In some instances, researchers actually met the interviewee in person; while in other instances, the guide was e-mailed to a stakeholder, who then completed it and returned it to the researcher. The purpose of this activity was to test the guide to determine if the questions being asked were understandable and logical to the interviewee. Additionally, based on the responses received, researchers determined if the guide was yielding information that can be used to inform subsequent research in this project. This effort was a first step in establishing baseline information to be used for regional "needs" meetings.

Another key part of developing a statewide ITS strategic plan is to obtain and incorporate feedback from regional stakeholders about their issues and needs. In Phase I of this project, TTI researchers developed a questionnaire to serve as an interview guide during the information gathering process. The researchers then conducted a set of pilot interviews with selected stakeholders. Based on the experience gained with these initial interviews, researchers made a few minor revisions to the interview guide for use in the second round of the information gathering process during Phase II of the project.

The second round of the information gathering process began in FY 2012. TTI researchers conducted numerous meetings and interviews in geographic regions covered by 20 TxDOT districts. In total, TTI researchers held 50 information gathering sessions that included representatives from 84 stakeholder agencies, including all TxDOT district offices and some local area offices. Furthermore, some participating cities included representatives from several departments (i.e., traffic operations, planning, fire, and police).

Using information gathered from previous stakeholder interviews, researchers developed a sample ITS archetype, presented it to stakeholders, and discussed their concerns and perspective relative to their region during follow-up interviews with TxDOT staff and other regional stakeholders. Stakeholders were provided with maps showing current and potential TxDOT ITS implementation and coordination.

There was a general consensus among stakeholders to move primary centers to urban areas, in terms of equipment and after-hours staffing capability, as long as there is coordination with local agencies and partners. Doing so would make efficient use of resources and limited funding. Many stakeholders felt that regionalization made sense for their area/district because there would be more consistency and potentially more cost savings, which would ultimately lead to more funding for ITS. However, several people raised concerns and had questions about the proposed regionalization. During the follow-up interviews, researchers also asked stakeholders what additional ITS services they would like if funding was not a concern. There was an overall willingness to consider additional ITS services throughout the state, and many regions would like to expand their ITS system.

CHAPTER 13: FINAL REMARKS

The purpose of this research was to provide a framework to guide the development and deployment of an integrated statewide program for intelligent transportation systems. ITS are a critical component of the transportation infrastructure that helps ensure the system operates in the most efficient way possible every day and night, and during all types of situations and weather conditions. It helps travelers:

- Get to their destinations without getting lost.
- Know about changing weather and traffic conditions that may impact their trip.
- Make multimodal choices in congested corridors.
- Plan a reliable trip.
- Even evacuate safely in times of emergency.

Thus, ITS is an essential element of the TxDOT value system that needs to be sustainable into the future to help the department attain its vision and goals in a cost-effective manner.

The Texas Transportation Commission, TxDOT, and the broad community of ITS providers, stakeholders, and agency partners will use the plan developed in this project to promote the development, deployment, and use of ITS statewide. If this plan is to succeed, it needs the cooperation of all affected groups involved in ITS and transportation planning, design, funding, and implementation in the state. The TxDOT ITS Strategic Plan 2013, which is Volume 2 of this report and an outcome of this project:

- Provides concise ITS strategic plan goals and objectives for TxDOT.
- Highlights the ITS priorities from the regional and local perspective.
- Summarizes national trends in ITS strategies.
- Presents a status report on regional ITS in Texas.
- Introduces anticipated ITS services that TxDOT may need in the future.
- Presents a candidate ITS archetype as potential guidance for moving forward with ITS across the state.

Initially, the researchers evaluated the presence of intelligent transportation systems for all 50 states and five U.S. territories. Of the 55 locations studied, evidence of statewide ITS architecture was found in 36. The research team then conducted interviews with stakeholders in various regions across Texas, including TxDOT district staff, municipal staff, representatives from metropolitan planning organizations, transit agencies, and other agencies involved in transportation. Stakeholders were provided with maps showing current and potential TxDOT ITS implementation and coordination.

Using information gathered from previous stakeholder interviews, researchers developed a sample ITS archetype, presented it to stakeholders, and discussed their concerns and perspective relative to their region. One candidate ITS scenario brought to stakeholders to consider is consolidation of the operations of core TxDOT ITS functions into six primary TMCs. Stakeholders at the follow-up interviews were asked several questions about this scenario, including:

- Would this be effective for your region?
- Is there a different way to structure it that would be more beneficial to you?
- How do you see your organization fitting into this structure?
- What would be your preferences in how this structure functions?

There was a general consensus among stakeholders to move primary centers to urban areas, in terms of equipment and after-hours staffing capability, as long as there is coordination with local agencies and partners. Doing so would make efficient use of resources and limited funding.

Many stakeholders felt that regionalization made sense for their area/district because there would be more consistency and potentially more cost savings, which would ultimately lead to more funding for ITS, though many questions remained regarding how the proposed regionalization would be implemented. During the follow-up interviews, researchers also asked stakeholders what additional ITS services they would like if funding was not a concern. There was an overall willingness to consider additional ITS services throughout the state, and many regions would like to expand their ITS system.

TxDOT has four primary goals related to meeting its mission. These goals are: maintain a safe system, address congestion, connect Texas communities, and become a best-in-class state agency. The agency cannot hope to successfully meet these goals without ITS in its arsenal of strategies to advance transportation across the state. For example, maintaining a safe system translates into reducing crashes and fatalities, reducing the likelihood of crashes and those involving transportation workers, and helping facilitate safe evacuation efforts in the event of emergencies. ITS in its various forms can help address these safety challenges.

Congestion continues to grow on Texas' urban and suburban roadways. Regions can work to grapple with this problem by deploying ITS solutions that help optimize the existing infrastructure and make the most of every square foot of pavement and every installed device that helps manage traffic. Furthermore, ensuring that ITS is part of the connectivity between communities can help foster collaboration and efficient use of the infrastructure along major corridors that serve key regions of the state and beyond.

Finally, incorporating ITS into every aspect of TxDOT's traffic management approach helps ensure that every tax dollar from the citizens of Texas is used to optimize the valuable assets in the transportation system. It will also help TxDOT be a forward-thinking and proactive agency that promotes the development and deployment of innovative traffic management concepts and technologies to take Texas into the future and meet the challenges and demands of a growing population. This ITS Strategic Plan can help advance TxDOT in achieving its strategic plan both now and in the future.

REFERENCES

1. Dankocsik, C., M. Zarean, D. Register, and K. Timpone. *Best Practices of Rural and Statewide ITS Planning.* Report No. FHWA-OP-02-037. Washington, DC: Federal Highway Administration, U.S. Department of Transportation, 2002.

2. Gordon, R.L. and W. Tighe. *Traffic Control Systems Handbook.* Report No. FHWA-HOP-06-006. Washington, DC: Federal Highway Administration, U.S. Department of Transportation, 2005.

3. "INRIX Secures $10 Million in Oversubscribed Series B Round." INRIX Press Release, May 2006. URL: http://www.inrix.com/pressrelease.asp?ID=9, Accessed August 2013.

4. "NAVTEQ History." NAVTEQ Corporate Website. URL: http://corporate.navteq.com/company_history.htm. Accessed August 2013.

5. "AirSage Company Overview." AirSage Corporate Website. URL: http://www.airsage.com/site/index.cfm?id_art=46580&actMenuItemID=22145&vsprache/EN/AIRSAGE___COMPANY_OVERVIEW__.cfm. Accessed August 2013.

6. "TomTom History." TomTom Corporate Website. URL: http://corporate.tomtom.com/history.cfm. Accessed August 2013.

7. Ricknäs, M. "iPhone Timeline." *ITWorld* Website, June 9, 2008. URL: http://www.itworld.com/iphone-timeline-080609. Accessed August 2013.

8. "INRIX Traffic for iPhone, iPad and Android." INRIX Corporate Website. URL: http://www.inrixtraffic.com/. Accessed August 2013.

9. Brydia, R. *Task Report #2—Develop Private Sector Marketplace Review from Contract for Private Sector Data for Performance Management*." College Station, TX: Texas A&M Transportation Institute, The Texas A&M University System, unpublished.

10. Middleton, D. *Synthesis of TxDOT Uses of Real-Time Commercial Traffic Routing Data*. College Station, TX: Texas A&M Transportation Institute, The Texas A&M University System, unpublished.

11. *Real-Time System Management Information System*. Fact Sheets on Highway Provisions. Washington, DC: Federal Highway Administration, U.S. Department of Transportation.

URL: http://www.fhwa.dot.gov/safetealu/factsheets/realtimesmi.htm. Accessed October 25, 2012.

12. "Discussion regarding providing traffic data in Texas." INRIX Meeting Notes. Austin, TX: Texas Department of Transportation, 2011, unpublished.
13. "Discussion regarding providing traffic data in Texas." NAVTEQ Meeting Notes. Austin, TX: Texas Department of Transportation, 2011, unpublished.
14. Turner, S. "Commercial Traveler Information on Four Selected Links on I-35 in Austin, TX." College Station, TX: Texas Transportation Institute, 2011.
15. *Connected Vehicle.* Washington, DC: Research and Innovative Technology Administration, U.S. Department of Transportation. URL: http://www.its.dot.gov/connected_vehicle/connected_vehicle.htm. Accessed August 2013.
16. Intelligent Transportation Systems Joint Program Office Website. Washington, DC: Research and Innovative Technology Administration, U.S. Department of Transportation Federal Highway Administration. URL: http://www.its.dot.gov/. Accessed August 2013.
17. Harding, J. *V2V*. Washington, DC: National Highway Traffic Safety Administration, U.S. Department of Transportation, 2011. URL: http://www.nhtsa.gov/DOT/NHTSA/NRD/Multimedia/PDFs/Public%20Paper/Presentations/2009%20Meetings/Harding2009Hyundai.pdf. ***Author: Is 2011 or 2009 correct? Accessed August 2013.
18. *Connected Vehicle Applications.* Washington, DC: Federal Highway Administration and Research and Innovative Technology Administration, U.S. Department of Transportation. URL: http://www.its.dot.gov/research/v2i.htm, 2011. Accessed August 2013.
19. Krueger, G. *VII Michigan Test Bed Program Concept of Operations*. Lansing, MI: Michigan Department of Transportation, 2005. URL: http://www.michigan.gov/documents/MDOT_VII_Concept_of_Operations_139651_7.pdf. Accessed August 2013.
20. *2010 Deployment Tracking Survey Results*. Intelligent Transportation Systems Website. Washington, DC: Research and Innovative Technology Administration, U.S. Department of Transportation. URL: http://www.itsdeployment.its.dot.gov/. Accessed October 2012.

21. *National Traffic Signal Report Card Technical Report.* Washington, DC: National Transportation Operations Coalition, Institute of Transportation Engineers. URL: http://www.ite.org/reportcard/TechnicalReport.pdf. Accessed August 2013.

22. *Construction Contracting Options.* College Station, TX: Texas A&M Transportation Institute. URL: http://mobility.tamu.edu/mip/strategies_pdfs/construction-improvements/technical-summary/construction-contracting-options-4-pg.pdf. Accessed November 2012.

23. *Comprehensive Development Agreements (CDA).* College Station, TX: Texas A&M Transportation Institute. URL: http://mobility.tamu.edu/mip/strategies_pdfs/financing/technical_summary/Comprehensive-Development-Agreement-2-Pg.pdf. Accessed November 2012.

24. *Transportation Funding and Finance.* Washington, DC: National Conference of State Legislatures, 2012. URL: http://www.ncsl.org/issues-research.aspx?tabs=951,72,117#951. Accessed October 2012.

25. *Driver License Surcharge.* College Station, TX: Texas A&M Transportation Institute. URL: http://mobility.tamu.edu/mip/strategies_pdfs/financing/technical_summary/Drivers-License-Surcharge-2-Pg.pdf. Accessed November 2012.

26. *State Sales Tax on Motor Fuel.* College Station, TX: Texas A&M Transportation Institute. URL: http://mobility.tamu.edu/mip/strategies_pdfs/financing/technical_summary/Fuel-Sales-Tax-2-Pg.pdf. Accessed November 2012.

27. *Local Option Motor Fuel Tax.* College Station, TX: Texas A&M Transportation Institute. URL: http://mobility.tamu.edu/mip/strategies_pdfs/financing/technical_summary/Fuel-Tax-Local-Option-2-Pg.pdf. Accessed November 2012.

28. *Statewide Motor Fuels Tax.* College Station, TX: Texas A&M Transportation Institute. URL: http://mobility.tamu.edu/mip/strategies_pdfs/financing/technical_summary/Fuel-Tax-Statewide-2-Pg.pdf. Accessed November 2012.

29. *Index Statewide Motor Fuels Tax.* College Station, TX: Texas A&M Transportation Institute.

URL: http://mobility.tamu.edu/mip/strategies_pdfs/financing/technical_summary/Indexed-Fuel-Tax-2-Pg.pdf. Accessed November 2012.

30. *State Sales Tax.* College Station, TX: Texas A&M Transportation Institute. URL: http://mobility.tamu.edu/mip/strategies_pdfs/financing/technical_summary/State-Sales-Tax-2-Pg.pdf. Accessed November 2012.

31. *Tax Increment Financing.* College Station, TX: Texas A&M Transportation Institute. URL: http://mobility.tamu.edu/mip/strategies_pdfs/financing/technical_summary/Tax-Increment-Financing-2-Pg.pdf. Accessed November 2012.

32. *Local Option Vehicle Registration.* College Station, TX: Texas A&M Transportation Institute.
URL: http://mobility.tamu.edu/mip/strategies_pdfs/financing/technical_summary/Vehicle-Registration-Fees-Local-Option-2-Pg.pdf. Accessed November 2012.

33. *State Vehicle Registration Fees.* College Station, TX: Texas A&M Transportation Institute.
URL: http://mobility.tamu.edu/mip/strategies_pdfs/financing/technical_summary/Vehicle-Registration-Fees-Statewide-2-Pg.pdf. Accessed November 2012.

34. *Motor Vehicle Sales Tax.* College Station, TX: Texas A&M Transportation Institute. URL: http://mobility.tamu.edu/mip/strategies_pdfs/financing/technical_summary/Vehicle-Sales-Tax-2-Pg.pdf. Accessed November 2012.

35. *Vehicle Mileage (VM) Fee.* College Station, TX: Texas A&M Transportation Institute. URL: http://mobility.tamu.edu/mip/strategies_pdfs/financing/technical_summary/VM-Fee-2-Pg.pdf. Accessed November 2012.

36. ITS Joint Program Office. *Transforming Transportation through Connectivity: ITS Strategic Research Plan, 2010–2014 (Progress Update, 2012).* Report No. FHWA-JPO-12-019. Washington, DC: Research and Innovative Technology Administration, U.S. Department of Transportation, October 2012.

37. Sargent, J.F. *Federal Research and Development Funding: FY2013.*
Report No. R42410. Washington, DC: Congressional Research Service, June 2012.
URL: http://www.fas.org/sgp/crs/misc/R42410.pdf. Accessed October 2012.

38. *OMB Report Pursuant to the Sequestration Transparency Act of 2012 (P.L. 112–155).* Executive Office of the President of the United States, Washington, DC. URL: http://www.whitehouse.gov/sites/default/files/omb/assets/legislative_reports/stareport.pdf. Accessed October 2012.

39. *Summary of Moving Ahead for Progress in the 21st Century (MAP-21).* U.S. Senate Committee on Environment and Public Works Website. URL: http://epw.senate.gov/public/index.cfm?FuseAction=Files.View&FileStore_id=6d1e2690-6bc7-4e13-9169-0e7bc2ca0098. Accessed October 25, 2012.

40. *Transportation Governance and Finance: A 50-State Review of State Legislatures and Departments of Transportation.* Washington, DC: National Conference of State Legislatures, 2012. URL: http://www.ncsl.org/documents/transportation/FULL-REPORT.pdf. Accessed October 2012.

41. Kuhn, B., D. Jasek, J. Carson, L. Theiss, P. Songchitruksa, J. Perkins, Y. Yang, and J. Mwakalonge. *Asset Management Guidebook for Safety and Operations.* Report No. FHWA/TX-12/0-6390-P1. College Station, TX: Texas A&M Transportation Institute, July 2012.

42. Menches, C.L., N. Khwaja, and J. Chen. *Synthesis of Innovative Contracting Strategies for Routine and Preventive Maintenance Contracts.* Report No. FHWA/TX-10/0-6388-1, Austin, TX: Center for Transportation Research, February 2010.

43. *2013–2017 Strategic Plan*. TxDOT Website. Austin, TX: Texas Department of Transportation. URL: http://www.txdot.gov/about_us/strategic_plan.htm***received an error at this site***. Accessed November 2012.

44. Sargent, J.F. *Federal Research and Development Funding: FY2013.* Report No. R42410. Washington, DC: Congressional Research Service, June 2012. URL: http://www.fas.org/sgp/crs/misc/R42410.pdf. Accessed October 2012.

45. *Moving Ahead for Progress in the 21st Century.* MAP-21 Website. Washington, DC: Federal Highway Administration, U.S. Department of Transportation. URL: http://www.fhwa.dot.gov/map21/. Accessed October 2012.
46. *National ITS Architecture*. National ITS Architecture Website. Washington, DC: Research and Innovative Technology Administration, U.S. Department of Transportation. URL: http://www.iteris.com/itsarch/index.htm. Accessed November 2012.

APPENDIX: ITS STRATEGIC PLAN AGENCY INTERVIEW GUIDE

INTERVIEW GUIDE

Consider the following cross-cutting issues as you answer the questions below:

- Freight movement.
- Traveler information – this will differ, maybe statewide information or regional.
- Work zone (major construction projects).
- Emergencies, e.g., hurricane evacuation, wildfires.
- Border issues.
- Infrastructure management.
- Tolling.
- Active traffic demand management.
- Safety, e.g., connected vehicles.

ITS Needs	Audience		
	All	TxDOT	Partners
Does your agency have an ITS strategic plan?			✓
What transportation problems are you trying to solve with ITS?	✓		
What ITS services does your agency provide?	✓		
What information needs do you have?	✓		
Which agency takes the lead on ITS deployment?	✓		
What functions do you need ITS information to perform?	✓		
What needs are core?	✓		
What needs are secondary?	✓		
What operational needs are/can be addressed by ITS?	✓		
What management needs are/can be addressed by ITS?	✓		
What safety needs are/can be addressed by ITS?	✓		
Is there a need for archived ITS data? Why or why not?	✓		
Who procures/maintains/controls ITS equipment?	✓		
Can you prioritize your ITS needs in term of immediate, short-term and long-term?			✓
Architecture/Statewide/Regional Issues			
How is current infrastructure incorporated into ITS plans? Is it consistent between regional ITS architecture and actual deployment?	✓		
How do the cross-cutting issues relate to regional architecture?	✓		
What direction is your agency pursuing with regard to cross-cutting issues?	✓		
From your perspective, are you more focused on regional issues or statewide issues? How do statewide issues affect your ITS deployment?	✓		

From your perspective, does it appear that TxDOT has a consistent policy across the state and between the regions?	✓		
Considering your goals, how does ITS help you meet those goals?			✓
Does your agency have any plans for supplementing and/or replacing traveler information with private sector data?	✓		
What do specialized groups (e.g. freight, tourism, etc.) need to know about traveler information?	✓		
Operations			
What will be your agency's role in regional operations?	✓		
How are operations currently funded?	✓		
How will operations be funded in the future?	✓		
Partnerships/Expectations			
How will partnerships with TxDOT look in the future, especially in light of TxDOT's reduced funding?	✓		
If TxDOT eliminates funding, will ITS still be a priority for your agency?			✓
If TxDOT is no longer the lead agency, who will take the lead?	✓		
How does your agency deal with TxDOT when deploying ITS on TxDOT ROW?			✓
What are your agency's expectations of TxDOT in terms of ITS?			✓
What is the role of the Traffic Operations Division within your district?		✓	
Who leads ITS efforts (district or division)?		✓	
Moving forward, how can TxDOT change current practices and still meet statewide ITS goals?		✓	
Please describe any policies your agency may have with regard to sharing information with other agencies.	✓		
Please describe any policies your agency may have with regard to sharing information with the private sector	✓		
Other			
How does your ITS strategic plan relate to the development of an ITS strategic plan for the state of Texas?			✓