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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 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 affected groups involved in ITS and transportation planning, design, funding, and implementation in the state.

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TXDOT ITS STRATEGIC PLAN 2013

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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.

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.

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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 are 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:

- 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.

CHAPTER 1:
INTRODUCTION

According to the Texas Department of Transportation (TxDOT) *2013–2017 Strategic Plan*, the State of Texas has as its mission to be "limited, efficient, and completely accountable" (*1*). As part of that statewide mission, the state places a focus on critical priorities, of which transportation and mobility for its citizens is one. This priority is a linchpin in the goal to foster opportunity and economic prosperity. The following sections highlight how intelligent transportation systems (ITS) fit within the overall framework of TxDOT's Strategic Plan and how this plan helps meet its statewide mission for Texas.

STATEWIDE MISSION AND VALUES

TxDOT's mission is to provide safe and reliable transportation solutions for the citizens of Texas (*1*). 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 (*1*). ITS are 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. For travelers, it:

- Helps them get to their destinations without getting lost.
- Alerts them to changing weather and traffic conditions that may impact their trip.
- Helps offer multimodal choices in congested corridors.
- Helps ensure a reliable trip.
- Even helps them evacuate 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 TxDOT attain its overall mission and vision in a cost-effective manner.

AGENCY GOALS

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 involving both travelers and transportation workers, and helping facilitate safe evacuation efforts in the event of emergencies. ITS in their 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 are 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.

AGENCY CAPABILITIES

The trend in managing the transportation infrastructure is reflected in the AASHTO Systems Operations and Management Guidance (*2*). This guidance reflects a set of strategies that an agency can use to anticipate and manage traffic congestion while minimizing the other unpredictable causes of service disruption, delay, and crashes (*2*). Related to this guidance is a tool under development for the Federal Highway Administration (FHWA) that an agency can use to determine its capability specifically related to traffic management (*3*). An agency that has mature capabilities in the arena of traffic management exhibits various characteristics that support this operational objective. Logically, ITS play a key role in developing these capabilities.

The following presents a brief list of specific capabilities involving ITS that can help TxDOT meet its vision.

- An agency's traffic management operations and maintenance (O&M) budget that includes ITS is one that is a performance-based, zero-based budgeting process to support continuous traffic management operations and maintenance based on expected performance outcomes.
- Traffic management capital improvement projects that include ITS are funded as an integral part of all projects, regardless of origin and support. These resources are also available for traffic management projects that do not involve major construction.
- Traffic management response plans are dynamically deployed and system-wide, 24/7 based on measured and predicted impacts, all of which are facilitated with ITS.
- Traffic management decisions are made using decision support systems relying on real-time data with predictive capabilities that are made possible with ITS technologies.
- New advanced systems and technology are deployed and can integrate seamlessly into existing systems.
- Deployed technological infrastructure is used to manage traffic, and system coverage is comprehensive with high levels of automation.
- ITS regional architectures are fully utilized, routinely updated, and are used as guidance in implementation.
- Measurement of traffic management performance is conducted on a continual and automated basis, and data acquisition includes all sources of data, both in the private and public sectors.

DOCUMENT PURPOSE

This document provides a framework to guide the development and deployment of an integrated statewide program for ITS. 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.

The TxDOT ITS Strategic Plan 2013:

- 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.

CHAPTER 2:
ITS STRATEGIC PLAN GOALS AND OBJECTIVES

The TxDOT ITS Strategic Plan supports the goals and objectives of the TxDOT agency Strategic Plan. It has the same four goals as the TxDOT Strategic Plan:

- Maintain a safe system.
- Address congestion.
- Connect Texas communities.
- Become a best-in-class state agency (*1*).

For some ITS objectives, specific strategies have been identified to further describe the objective.

The ITS Strategic Plan goals, objectives, and strategies are listed below. They have been prepared with input from both TxDOT agency staff and from partner agencies throughout the state.

TXDOT ITS STRATEGIC PLAN GOALS, OBJECTIVES, AND STRATEGIES

The following sections outline key objectives that fall under each of the four goals of the ITS Strategic Plan. Each objective also has a list of strategies that, when implemented, help TxDOT meet the higher objective and goal in support of the agency Strategic Plan.

Goal: Maintain a Safe System

The following objectives are integral to ITS playing a role in maintaining a safe system for the citizens of Texas.

- Objective: Deploy and operate ITS technologies and services to reduce crashes and fatalities.
    - Strategy: Deploy and operate ITS services that provide incident management, traffic control, emergency management, and other safety-related capabilities.
    - Strategy: Use ITS in high-accident locations and areas of high congestion to improve safety and increase traveler information.

- Strategy: Expand the use of ITS by TxDOT and their contractors in construction zones to reduce the potential for crashes and improve worker safety.
- Strategy: Incorporate the use of ITS systems and services in major evacuation efforts to both monitor events and share information with the public.

- Objective: Manage ITS infrastructure and services as an asset.
  - Strategy: Use ITS for data collection to support safety performance measures.
  - Strategy: Fill in critical gaps in ITS in TxDOT districts and along strategic routes using TxDOT, partner, or private-sector resources.

Goal: Address Congestion

Two primary objectives listed below can enable TxDOT to address congestion within the transportation network across the state.

- Objective: Deploy and operate ITS technologies and services to provide travel and traffic management services.
  - Strategy: Deploy and operate ITS services that provide pre-trip, en-route, and travel-demand management capabilities through public- and/or private-sector paths.
  - Strategy: Deploy and operate ITS traffic management services to effectively manage the capacity of the roadway system.
  - Strategy: Provide active management of traffic and other progressive solutions services that can improve travel reliability and predictability.

- Objective: Work cooperatively with regional partners to provide regional ITS solutions, systems, and staffing.
  - Strategy: Support ITS services that enable public transit.
  - Strategy: Develop standard ITS operating procedures and systems that are consistent with regional needs and that serve the TxDOT Strategic Plan.
  - Strategy: Assign adequate staff and equipment resources to traffic management and maintenance operations to provide effective working relationships and performance outcomes.

Goal: Connect Texas Communities

TxDOT can meet the goal of connecting Texas communities by meeting the three objectives described below.

- Objective: Deploy and operate strategic corridors and regions to enhance the economic development, mobility, and safety.
    - Strategy: Partner with private-sector, multimodal travel information providers to effectively reach different users in these strategic corridors.
    - Strategy: Provide interoperability of roadway toll revenue collections, including parking, within the state and between neighboring states.
- Objective: Deploy ITS in a cost-effective and beneficial manner that includes innovative services and technologies.
    - Strategy: Deploy compatible ITS software and systems to make operations seamless across district boundaries.
    - Strategy: Locate computer control elements of ITS technologies in larger urban centers that can provide supplemental staffing to rural districts.
    - Strategy: Incorporate automated and semi-automated decision support systems into the ITS software and systems.
- Objective: Deploy ITS systems and technologies that facilitate the efficient movement of freight and goods along strategic, high-volume freight corridors, including border crossings.
    - Strategy: Understand and address the freight community's needs for information.
    - Strategy: Deploy ITS to provide more seamless information to the freight community.

Goal: Become a Best-in-Class State Agency

To reach the goal of being a best-in-class state agency, TxDOT can work to achieve the three key objectives that follow.

- Objective: Deploy equipment and staffing of ITS services in a cost-effective manner.

- Strategy: Continually evaluate the financial and service implications of alternative business models for ITS, including private-sector ownership and operations.
- Strategy: Provide dedicated funding for ITS so that operations and maintenance can be planned and costs are identified.
- Strategy: Develop a consistent performance monitoring system that computes operations, safety, and resource savings benefits of all TxDOT ITS deployments.

- Objective: Anticipate local and regional service needs and plan the services to accommodate those needs.
  - Strategy: Implement and operate communications systems that can be shared with partner agencies and that meet the requirements of ITS services as the marketplace develops.
  - Strategy: Provide a forum at the state and/or regional level for TxDOT and partner agency staff to share ITS knowledge, experience, and needs.

- Objective: Participate in connected vehicle and automated vehicle activities that will improve economic competitiveness for Texas.
  - Strategy: Participate in test beds, pilot programs, demonstration programs, and other venues that will allow Texas to effectively prepare for and engage in these transformational technologies.
  - Strategy: Identify and address institutional and policy issues that can facilitate successful ventures in the connected vehicle efforts.

RELATIONSHIP TO TXDOT AGENCY STRATEGIC PLAN

As noted earlier, the goals of the TxDOT ITS Strategic Plan are the same as the goals of the TxDOT Strategic Plan. The following four tables cross-reference the objectives between the two strategic plans (Table 1: safety objectives; Table 2: congestion objectives; Table 3: objectives for connecting Texas communities; and Table 4: objectives for becoming a best-in-class state agency).

Table 1. TxDOT Agency Safety Objectives and TxDOT ITS Safety Objectives.

	Maintain Safe System		Address Congestion	Connect Texas Communities	Become a Best-in-Class State Agency	
TxDOT Objectives / **ITS Objectives**	Reduce crashes and fatalities on the system through innovations, technology, and public awareness.	Maintain and preserve the transportation assets of the state of Texas.	Partner with local officials to develop and implement congestion mitigation plans in Texas.	Prioritize new projects that will increase the state gross domestic product (GDP) and enhance access to goods and services throughout the state.	Ensure the agency deploys resources responsibly and has a customer service mindset.	Focus on work environment, safety, succession planning, and training to develop a great workforce.
Deploy and operate ITS technologies and services to reduce crashes and fatalities.	**X**		**X**			
Manage ITS infrastructure and services as an asset.	**X**	**X**			**X**	

Table 2. TxDOT Agency Congestion Objectives and TxDOT ITS Congestion Objectives.

	Maintain Safe System		Address Congestion	Connect Texas Communities	Become a Best-in-Class State Agency	
TxDOT Objectives / **ITS Objectives**	Reduce crashes and fatalities on the system through innovations, technology, and public awareness.	Maintain and preserve the transportation assets of the state of Texas.	Partner with local officials to develop and implement congestion mitigation plans in Texas.	Prioritize new projects that will increase the state GDP and enhance access to goods and services throughout the state.	Ensure the agency deploys its resources responsibly and has a customer service mindset.	Focus on work environment, safety, succession planning, and training to develop a great workforce.
Deploy and operate ITS technologies and services to provide travel and traffic management services.	**X**		**X**			
Work cooperatively with regional partners to provide regional ITS solutions, systems, and staffing.			**X**			**X**

Table 3. TxDOT Agency Objectives and TxDOT ITS Objectives for Connecting Texas Communities.

	Maintain Safe System		Address Congestion	Connect Texas Communities	Become a Best-in-Class State Agency	
TxDOT Objectives / **ITS Objectives**	Reduce crashes and fatalities on the system through innovations, technology, and public awareness.	Maintain and preserve the transportation assets of the state of Texas.	Partner with local officials to develop and implement congestion mitigation plans in Texas.	Prioritize new projects that will increase the state GDP and enhance access to goods and services throughout the state.	Ensure the agency deploys its resources responsibly and has a customer service mindset.	Focus on work environment, safety, succession planning, and training to develop a great workforce.
Deploy and operate strategic corridors and regions with best-in-class levels of service to enhance the economic development, mobility, and safety.				**X**	**X**	
Participate in connected vehicle and automated vehicle activities that will improve economic competitiveness for Texas.	**X**		**X**	**X**	**X**	
Deploy ITS systems and technologies that facilitate the efficient movement of freight and goods along strategic high-volume freight corridors.	**X**			**X**		

Table 4. TxDOT Agency Objectives and TxDOT ITS Objectives for Becoming a Best-in-Class State Agency.

	Maintain Safe System		Address Congestion	Connect Texas Communities	Become a Best-in-Class State Agency	
TxDOT Objectives / **ITS Objectives**	Reduce crashes and fatalities on the system through innovations, technology, and public awareness.	Maintain and preserve the transportation assets of the state of Texas.	Partner with local officials to develop and implement congestion mitigation plans in Texas.	Prioritize new projects that will increase the state GDP and enhance access to goods and services throughout the state.	Ensure the agency deploys its resources responsibly and has a customer service mindset.	Focus on work environment, safety, succession planning, and training to develop a great workforce.
Deploy equipment and staffing of ITS services in a cost-effective manner.					**X**	
Deploy ITS in a responsible manner that includes innovative services and technologies.	**X**				**X**	
Anticipate customer service needs and plan the services to accommodate those needs.	**X**				**X**	**X**

CHAPTER 3:
ITS PRIORITIES

Researchers conducted initial and follow-up interviews with stakeholders in various regions across the state, including:

- TxDOT district staff from Austin, Beaumont, Bryan, Corpus Christi, Dallas, El Paso, Fort Worth, Laredo, Lufkin, Pharr, San Antonio, and Wichita Falls.
- City staff from Austin, Bryan, Kingsville, McAllen, San Antonio, Wichita Falls.
- Metropolitan Planning Organizations in Austin, Corpus Christi, Dallas-Fort Worth, Harlingen-San Benito, and Wichita Falls.
- Transit agencies in College Station, McAllen, and San Antonio.
- Other agencies involved in transportation, including police and fire departments, public works, DPS, and U.S. Customs and Border Protection.

During initial interviews, stakeholders were provided with maps showing current TxDOT ITS implementation and coordination. The current ITS implementation and coordination map shows four primary districts with 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 (see Figure 1). One candidate ITS scenario brought to stakeholders for consideration during follow-up interviews was consolidation of the operations of core TxDOT ITS functions into several primary traffic management centers (see Figure 2). This scenario was intended to serve as a starting point for discussions regarding potential regionalization of ITS across Texas.

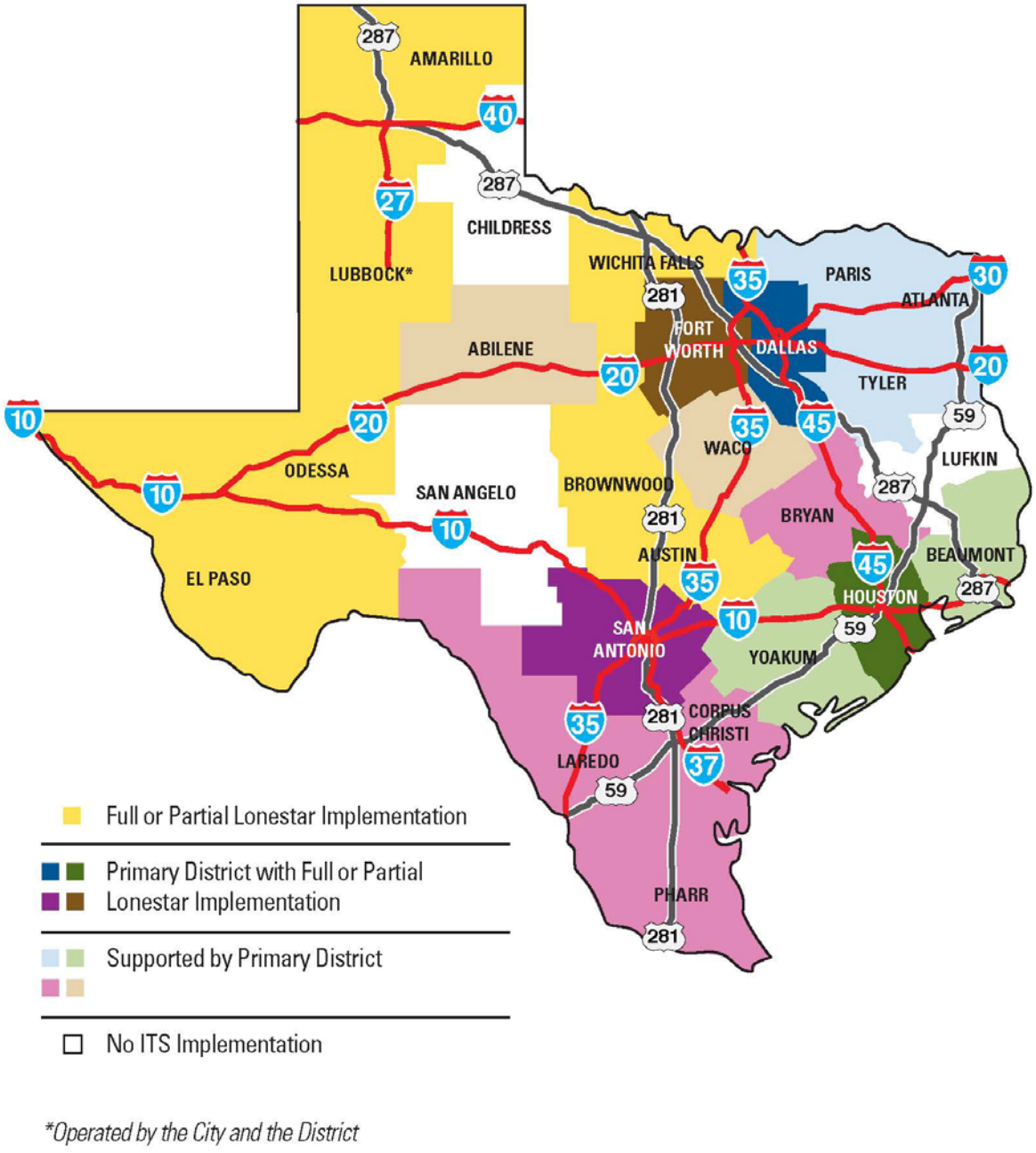

Figure 1. Current TxDOT ITS Implementation and Coordination.

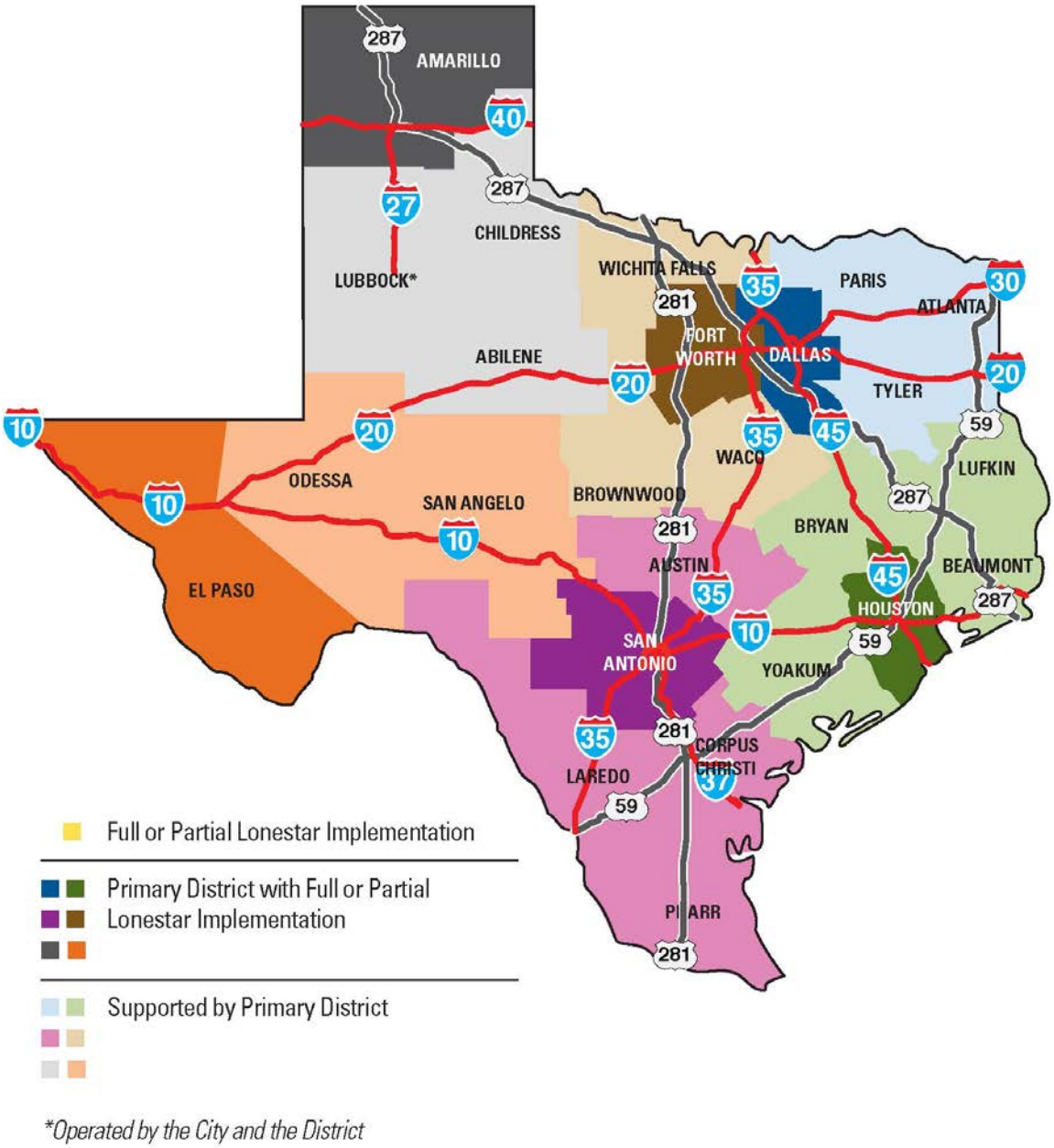

Figure 2. Potential TxDOT ITS Implementation and Coordination.

In the future scenario, primary traffic management centers 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 a

traffic incident, or a local special event), but the primary traffic management center would maintain responsibility for the day-to-day operation of the TxDOT ITS. TxDOT Traffic Operations Division (TRF) 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 nonroadway-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.

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 coordination exists with local agencies and partners. Doing so would make efficient use of resources and limited funding. Many of the responses to the proposed future scenario 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 wished 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 require budgets adequate for the ITS services they are providing.
- Funding and staffing limitations tempered the need for additional ITS services.

The following summarizes the other responses gathered from 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, training, and to whom operations and maintenance staff reports.
- Clear communication between partners is very important. A clear, detailed communication plan, or standard operating procedure manual, between the primary traffic management center 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 stakeholders 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 interviews, researchers also asked stakeholders what additional ITS services they would like if funding were 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 (DMS).
- 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 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.

CHAPTER 4:
NATIONAL TRENDS IN ITS STRATEGIES

CONNECTED VEHICLES

Over the past few years, the U.S. Department of Transportation (U.S. DOT) 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. This initiative parallels the ITS structure that was launched in the 1990s with 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 identifies 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 are as follows:

- Vehicle-to-vehicle safety.
- Vehicle-to-infrastructure safety.
- Real-time data capture.
- Dynamic mobility applications.
- Environment.
- Road weather (*4*).

Time Frame

Currently, the connected vehicle initiative is in the research stage and RITA is providing guidance. The high-level roadmaps that describe these initiatives typically run from 2010 to the beginning of 2015. For instance, the roadmap applications for the environment define foundational analysis in calendar year (CY) 2010–2012 and candidate application evaluation from CY 2012–2014. Each of the roadmaps 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 (*5*). The potential rule may set requirements for inclusion of vehicle-to-vehicle communications in new vehicles.

The connected vehicle initiative might also include requirements for 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 focuses on communicating traffic signal information to mobile devices (*4*). 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

At this time, 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. Department of Transportation (U.S. DOT) research program. For instance, Michigan is hosting a connected vehicle test bed in Detroit (*6*). 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.

511

Many states are currently providing 511-based traveler information. The U.S. DOT website (*7*) 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 3 shows the states that have implemented 511.

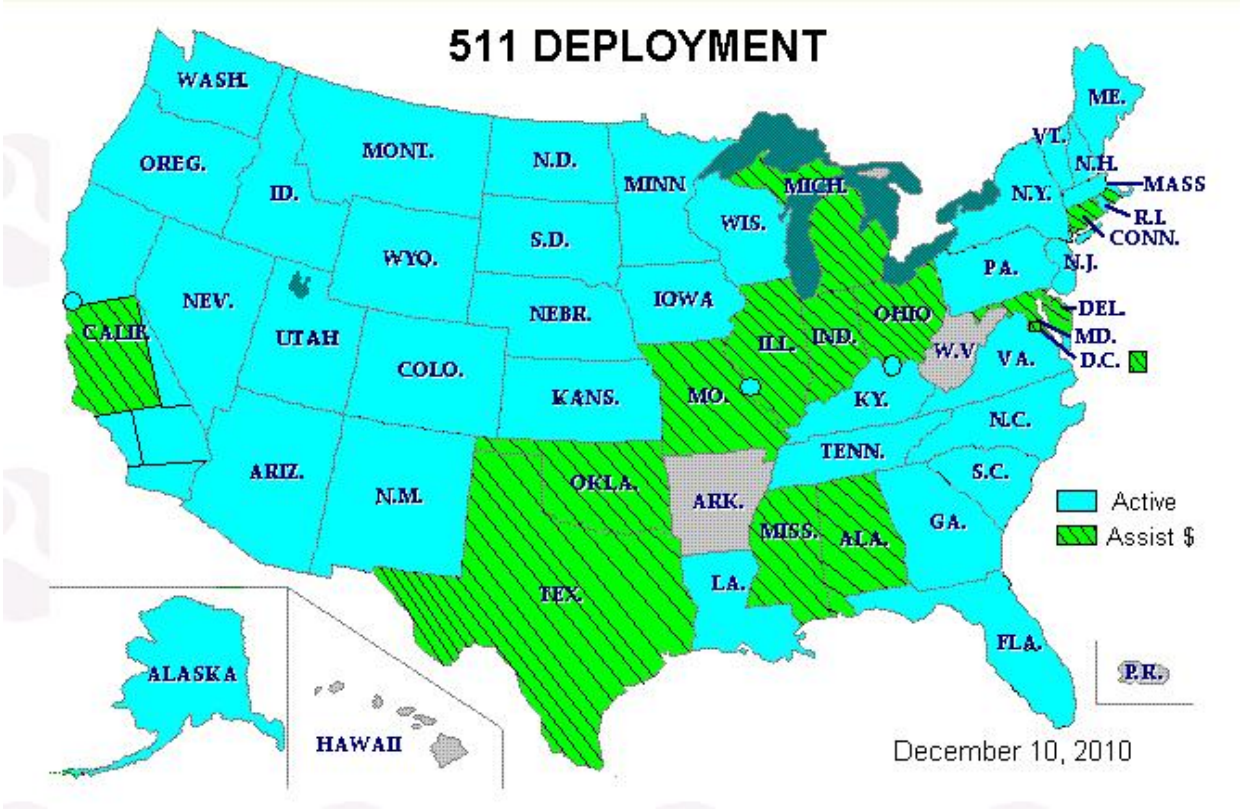

Figure 3. States with 511 Deployments (*7*).

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 the 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.

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).

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 deployed vehicle sensors and cameras, and they have distributed this information to the public. The business model has been as follows:

- Public-sector investment for performance monitoring and control.
- Public agencies distribute free information to travelers, other public agencies, and private information providers.

This approach has been used since the late 1960s and 1970s when FHWA began investing in the Urban Traffic Control System (UTCS) Project (*8*). However, private-sector companies have recently begun to provide increasing amounts of data with increasing accuracy. For example, INRIX® was spun out of Microsoft® research in 2004 (*9*), while NAVTEQ® began as a privately held company in 1985 and became a publicly held company in 2004 (*10*). AirSage® was founded in 2000 (*11*), and TomTom® was founded in 1991 (*12*).

Additionally, the growth of smart phones has provided an increasing number of opportunities to monetize transportation information and ways to engage travelers in gathering transportation information through social networking. The iPhone®, introduced in 2007, has accelerated this environment (*13*). Many of the traffic applications for mobile devices are supported on popular platforms including iPhone®, Android®, BlackBerry®, and others. For example, INRIX Traffic is supported on the iPhone®, iPad®, and Android® (*14*).

In a recent study, the Texas A&M Transportation Institute, 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. In this study, six private companies were surveyed, the results of which are presented in Table 5. Those companies surveyed were AirSage, American Trucking Research Institute (ATRI)®, INRIX, NAVTEQ, TomTom, and TrafficCast®.

Table 5. 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 commercial fleets, sensors, 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-points compared, accuracy.
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 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.

Overall, 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 that other agencies installed and maintained, and fixed sensors that the data provider installed and maintained. Across the providers, no one single data source model is in use. Correspondingly, no single business model exists. 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 its fleet arrangements for protection of its 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.

A number of 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.

FUNDING, PROCUREMENT, AND PARTNERSHIPS

The ability for an agency to sufficiently fund projects is a changing landscape in today's economy. DOTs across the country are grappling with this question, and changes in existing processes may be viable and/or new methods or improvements might need to be considered to deliver more timely and nimble ITS deployment when there is a clear technological and cost-effective advantage.

State Funding

Trends in ITS funding in individual states mimic that 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 (*15*). With respect to how agencies manage ITS funds and budgets, a 2010 survey of ITS deployment by the Research and Innovative Technology Administration indicates that many states still maintain separate budgets for ITS deployments and related costs (*16*). Table 6 provides a summary of specific deployment trends across the U.S. For this survey, researchers distributed nearly 1600 surveys to state and local transportation agencies in 108 metropolitan areas with the average response rate being 85 percent.

Table 6. Agency ITS Funding, Budget Trends in the U.S. by Agency Type, 2010 (*16*).

	Number of Agencies				
ITS Funding and Budget Practices	**Freeway Management Agencies**	**Toll Collection Agencies**	**Transportation 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* (*15*) 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 various 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 for 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 (*15*).

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 (*15*). The federal program continues to be uncertain. As of July 2012, federal surface transportation

programs have been reauthorized only for the next 27 months (*17*) 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

A recent study of the National Conference of State Legislatures found that many states are considering nontraditional sources of funding to meet their shortfalls in transportation. These sources including leveraging revenues by issuing bonds, federal credit assistance, state infrastructure banks, and public and private partnerships (*18*). Table 7 provides a summary of the variety of mechanisms that agencies can and are using to leverage traditional funding sources to meet shortfalls and accelerate transportation projects into reality.

Table 7. Transportation Finance Mechanisms (*18*).

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	Transportation Infrastructure Finance and Innovation Act (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 Tax Increment Financing (TIF)

MAP-21 has a variety of 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:

- Continue 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 (CMAQ).
    - Highway Safety Improvement Program.
- Create a new title called America Fast Forward, which strengthens the TIFIA program to leverage federal dollars farther than they have been stretched in the past.
- Remove barriers that previously limited states' flexibility to invest in projects that fit their specific needs and critical challenges.
- Establish an outcome-driven approach and improve the statewide and metropolitan planning process to be performance-based and hold agencies accountable for improving the condition and performance of their assets.
- Include reforms to help reduce project delivery time that include expanding the use of innovative contracting methods (*19*).

In Texas in 2007, the 80th Legislative Session passed SB 1266. This bill allowed the establishment of Transportation Reinvestment Zones (TRZs). Cities and counties are authorized to designate TRZs to fund road projects. TRZs are not a tax increase; funding is captured from increased property values within the designated TRZ. El Paso has used TRZs as a funding source to complete projects recommended in the Comprehensive Mobility Plan.

Tax Increment Reinvestment Zones (TIRZs) are very similar to tax increment financing and special assessment districts (SAD) in that special areas are created. 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.

As indicated in Table 7, states are gradually using a variety of public–private partnership (PPP) mechanisms to finance transportation projects. These partnerships involve private-sector financing, construction, maintenance, and/or operation of transportation projects. States have increasingly turned to PPPs, which involve the private sector in project financing, construction, maintenance, or operation. As of August 2012, 33 states and Puerto Rico have laws enabling PPPs for highways and bridges (*15*).

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 (Safe Accountable Flexible Efficient Transportation Equity Act: A Legacy for Users) requires states to provide real-time system management information for interstates by 2014 and other significant roadways by 2016 (*20*). 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. Similar opportunities might exist 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 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 receives work orders that include a specified completion date in an effort to ensure all tasks are completed within a modest amount of time, keeping the project on schedule (*21*). 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 high user costs 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 (*21*).

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, or improvement projects financed wholly or partly with private activity bonds (*22*).

Public–Private Partnerships

States have increasingly used various 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 (***Error! Bookmark not defined.***).

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 (*20*). 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 is 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 discuss 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 (*23*).
- 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 (*24*).
- Local option motor fuel tax: the levy of additional gas and diesel tax by local regions on local fuels to be dedicated to transportation (*25*).
- Increased statewide motor fuels tax: an increase in the state fuel taxes specifically dedicated to transportation (*26*).
- 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 (*27*).
- Increase state sales tax: an increase in the statewide sales tax dedicated to the highway fund to support transportation (*28*).
- 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 (*29*).
- Local option vehicle registration: the levy of an additional vehicle registration fee that would be collected and spent locally on transportation (*30*).
- Increase state vehicle registration: an increase in the state vehicle registration fee to be spent on transportation (*31*).

- Motor vehicle sales tax: an increase in the dedication of the motor vehicle sales tax dedicated to transportation (*32*).
- Vehicle miles traveled (VMT) fee: a fee charged to drivers based on the number of miles each vehicle travels, directly related to road usage (*33*).

ITS Asset Management

Recent TxDOT research presents guidance for asset management, which could readily be applied to ITS systems and equipment (*34*). 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.

CHAPTER 5:
STATUS OF REGIONAL ITS IN TEXAS

This chapter presents a summary of the status of ITS and the inventory of devices in various regions across the state. While the information does not provide extreme detail, it does provide a picture of the state of ITS deployment in Texas in 2013.

CURRENT ITS DEPLOYMENT AND COORDINATION

The following is a list of ITS elements that stakeholders from across the state have identified that are categorized as ITS. Table 8 further summarizes this device-related information by listing those deployments present in 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, automatic vehicle location (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.

The information provided in Table 8 mostly reflects those deployments in rural and smaller urban regions, though many of these devices are present in larger urban areas. CCTV

cameras and dynamic message signs (permanent and portable) are the most prevalent ITS elements in such regions across Texas. Several regions also reported deployment of emergency signal preemption and flood detection/warning systems. Lastly, ITS technologies that transit and police agencies deploy 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 8. Summary of ITS Deployment by Device/System.

ITS Device/System	Regions
CCTV Cameras	Amarillo, Atlanta, Brownwood, Corpus Christi, Dallas, Houston, Laredo, Lubbock, Lufkin, Paris, Waco, Wichita Falls
Permanent DMS	Amarillo, Atlanta, Beaumont, Brownwood, Bryan, Corpus Christi, Dallas, Houston, Laredo, San Antonio, Waco, Wichita Falls
Signal Preemption	Atlanta, Brownwood, Laredo, Lubbock, Lufkin, Paris, Wichita Falls
Portable DMS	Beaumont, Brownwood, Childress, Dallas, Houston, 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

All but three districts have either full or partial implementation of TxDOT's Lonestar™ system. A significant number of districts operate standalone systems, with the City of Lubbock running the Lubbock system. Additionally, larger districts are supporting various smaller districts across the state. This support may take many forms, but the intent is to help facilitate ITS deployment and operations when the smaller districts may not be able to offer 24/7 operations.

REGIONAL ITS NEEDS SUMMARY

The following are specific needs that TxDOT and other regional stakeholders identified as capable of enhancing current ITS operations. These needs are 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 4 provides a distribution of need types that the stakeholders identified. Of the identified needs, 81 percent fell into *Travel and Traffic Management* and *Institutional* categories. The following subsections summarize the specific needs.

Traffic Signal Needs

Table 9 lists the types of signal-related needs that stakeholders identified 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. Multijurisdictional signal coordination typically applies to urban areas with more than one signal owner/operator (in this case, Texarkana, Bryan/College Station, and Houston).

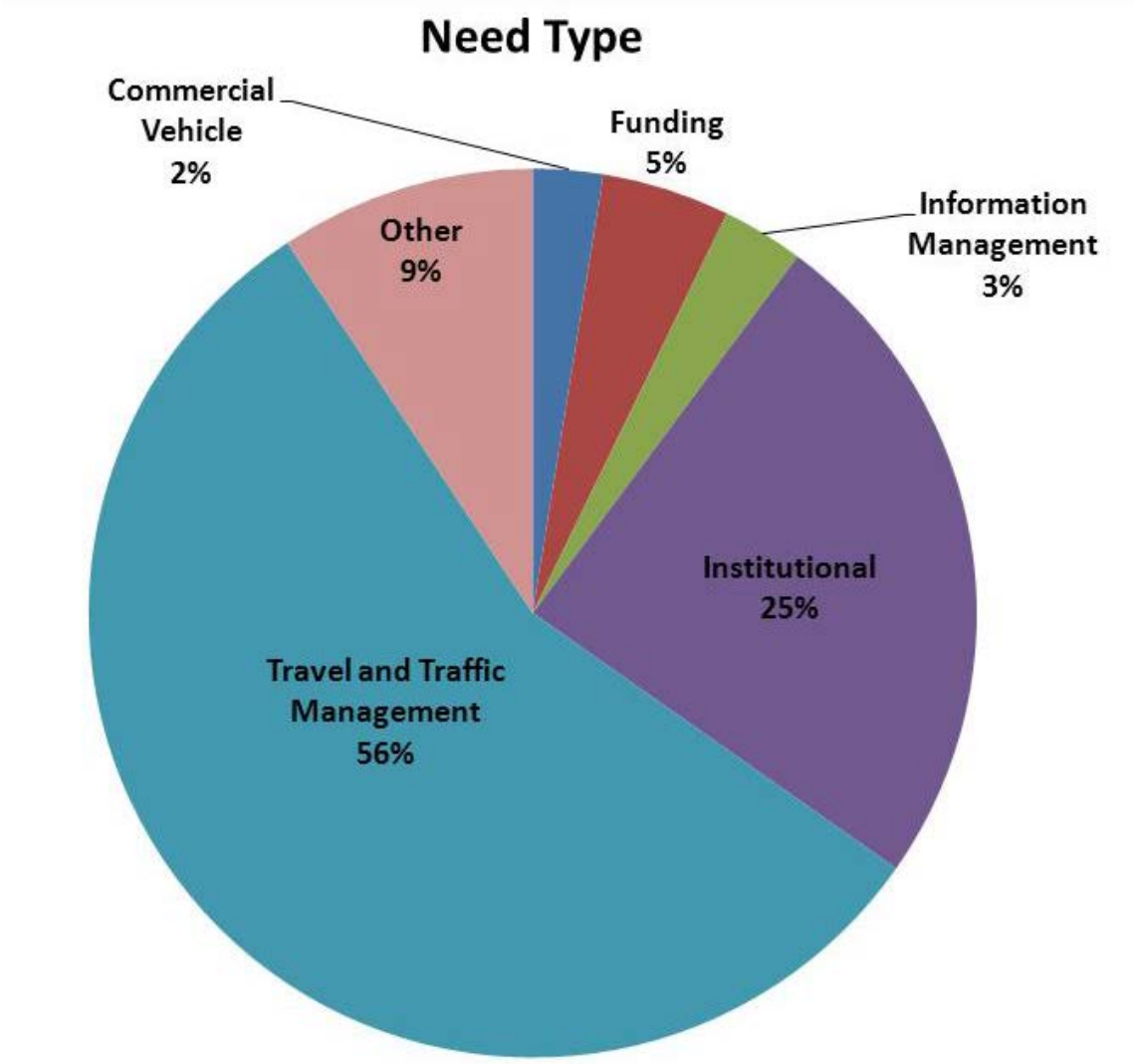

Figure 4. Distribution of ITS Need Types.

Table 9. Needs Related to Traffic Signals.

Need	Region
Multijurisdictional/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 10 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 10. 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 11 lists various regions' needs that involve cameras and video. Similar to DMS needs, the need for new or additional video cameras is also a key rural need. Furthermore, access to partner agencies' videos is primarily an urban-area need.

Table 11. 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 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 12 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 12. 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	Atlanta, Austin, Laredo
Access to reliable real-time traffic information, including incidents	Austin
Reduce incident clearance times	El Paso
Automatic detection of congestion and incidents	Beaumont, El Paso
Manage incidents across agencies	Austin

Traveler Information Needs

As shown in Table 13, traveler information needs are primarily in areas along major highways and interstate highways. 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 13. Traveler Information Needs.

Traveler Information Need	Region
Useful information for interstate or long-distance travelers	Amarillo, Atlanta, Childress, Lubbock, Paris
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 14 lists the institutional needs of various regions. A glance at this table reveals that institutional needs are statewide. The needs for improved cooperation between regional partners, dedicated funding for ITS, improved relationships between TxDOT's Traffic Operations Division and districts, and consistent ITS policy, strategy, and vision are the greatest. A few regions indicated the need for updated regional ITS architectures, but there is no statewide consensus on this issue.

Table 14. 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 15 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 and in I-35 and I-45 regions.

Table 15. Identified Regional Data Needs.

Data Need	Region
Archived data, including automated archiving	Austin, Bryan, El Paso, Houston, Laredo
Congestion, origin-destination (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 regionwide real-time and archived data	El Paso

Commercial Vehicle Needs

The data in Table 16 show that commercial vehicle needs are primarily in locations along major highways and interstate highways.

Table 16. Commercial Vehicle Needs.

Commercial Vehicle Need	Region
Travel information for trucks, including multistate 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 17 lists the need for private data. According to these data, stakeholders feel that, at present, there is not much need for private data. Only San Antonio region stakeholders are considering the use of such data.

Table 17. Needs for Private Data.

Private Data Need	Region
Considering the use of private data	Capital Area Metropolitan Planning Organization (CAMPO), San Antonio MPO
May start charging private entities	CAMPO
No plans or not decided	Bryan-College Station (BCS) MPO, City of College Station
Public-to-private flow of data only (Amarillo)	Amarillo
Cannot accept ITS devices from private entities	United States Customs and Border Protection
No private entity role in emergency management	Lubbock
Desire for statewide roadway performance data	San Antonio
Anticipate more private involvement like the use of cellular phone towers for gathering data along interstate highways	Brownwood

Special Texas Border Needs

Table 18 lists the special needs of the Texas–Mexico border region.

Table 18. Unique Needs of the 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 their local jurisdiction. In the future, MPOs could be potential leaders with expanded roles and experience.

CHAPTER 6:
ANTICIPATED ITS SERVICES

Through the initiatives of the U.S. Department of Transportation, the ITS technical area has developed a framework for describing ITS concepts including:

- The institutional considerations for ITS (e.g., institutions, policies, funding mechanisms, and processes that are required for effective implementation, operation, and maintenance).
- Transportation solution subsystems and interfaces.
- The communications required to exchange information between systems to support the transportation solutions.

USING THE NATIONAL ITS ARCHITECTURE

The National ITS Architecture aligns very well with the goals of both the TxDOT Strategic Plan and the TxDOT ITS Strategic Plan. The National ITS Architecture can be approached from several starting points. One of those starting points is a planning perspective. The National ITS Architecture website has a tab labeled "architecture use," which has a subordinate menu called "planning." The planning page shows a graphic illustrating the use of the National ITS Architecture in the transportation planning environment (http://www.iteris.com/itsarch/html/archuse/planning.htm). Clicking on the "regional goals" graphic element navigates to a page where planning goals are identified. See http://www.iteris.com/itsarch/html/archuse/goals.htm. These National ITS Architecture goals are very similar to the TxDOT ITS Strategic Plan goals as shown in the following table.

Table 19. Alignment of National ITS Goals with TxDOT ITS Goals.

TxDOT ITS Strategic Plan Goals	National ITS Architecture Goals
Maintain a safe system	Improve the safety of the transportation system
Address congestion	• Enhanced mobility, convenience, and comfort for transportation systems users • Reduce environmental impacts • Increase operational efficiency and reliability of the transportation system
Connect Texas communities and increase the State GDP	• Support regional economic productivity and development • Enhance the integration in the connectivity of the transportation system
Become a best-in-class state agency	All of the goals listed for planning in the National ITS Architecture

The following sections describe the TxDOT ITS Strategic Plan goals in the context of the National ITS Architecture framework. Much more detail is provided in the National ITS Architecture, and is applicable for developing specific ITS programs and projects. In addition, the Architecture is appropriate for compliance with the FHWA Rule and Federal Transit Administration (FTA) Policy on ITS. These directives require that ITS projects carried out using funds made available from the Highway Trust Fund and the Mass Transit Fund conform to the National ITS Architecture and applicable standards (*35*).

ITS STRATEGIC PLAN GOAL: MAINTAIN A SAFE SYSTEM

Through the use of traffic management services, emergency management services, and commercial vehicle operations, safety can be enhanced. The National ITS Architecture identifies a number of specific operational targets that are appropriate for a safety goal (*36*). These include:

- Reduce incident notification time.
- Reduce incident clearance time.
- Increase the number of ITS-related assets.
- Increase the number of road miles that ITS cover.
- Reduce crashes at intersections.
- Reduce crashes due to road weather conditions.
- Enhance the safety of workers.

The TxDOT ITS Strategic Plan has two objectives that encompass these specific operational outcomes, namely:

- Deploy and operate ITS technologies and services to reduce crashes and fatalities.
- Manage ITS infrastructure and services as an asset.

The National ITS Architecture identifies many service packages that TxDOT can pursue to improve safety, including:

- ATMS08 Traffic Incident Management System.
- ATMS15 Railroad Operations Coordination.
- ATMS09 Transportation Decision Support and Demand Management.
- ATMS03 Traffic Signal Control.
- ATMS01 Network Surveillance (*37*).

As connected vehicle technologies mature, TxDOT will also be able to participate in the infrastructure elements of the Intersection Collision Avoidance Service (AVSS10). In addition to the traffic management services listed in the National ITS Architecture, Roadway Service Patrols (National ITS Architecture Service EM04) can be added to assist with management of incidents and reduce the likelihood of secondary crashes.

The effectiveness of TxDOT ITS for enhancing safety, mobility, and other needs are also dependent on the extent of coverage within a region. Continuing to fill the gaps in field equipment deployments such as CCTV cameras, sensors, and dynamic message signs can enhance effectiveness.

For the widening of I-35 in Central Texas around Waco, TxDOT is using ITS technologies to forecast travel time through construction zones and to warn about end-of-queues (*38*). Expanded use of these technologies and of more conventional ITS construction services, such as MC10 Maintenance and Construction Activity Coordination, are consistent with the TxDOT safety goal.

The National ITS Architecture also has services that are appropriate for evacuation. These include EM09 Evacuation and Reentry Management, and EM08 Disaster Response and Recovery.

ITS STRATEGIC PLAN GOAL: ADDRESS CONGESTION

The National ITS Architecture identifies operational targets for addressing congestion and increasing operational efficiency and reliability of the transportation system. These include:

- Decreasing the seconds of control delay per vehicle on arterial roads.
- Reducing delay associated with incidents.
- Reducing the time needed for responders to arrive on-scene after notification.
- Reducing the person hours (or vehicle hours) of delay associated with traffic incidents.
- Reducing carbon dioxide emissions.
- Ensuring that HOV lanes carry a targeted number of persons.
- Reducing the buffer index on the freeway system during peak and off-peak hours, etc.

The TxDOT ITS Strategic Plan has two objectives that encompass these specific operational outcomes, namely:

- Deploy and operate ITS technologies and services to provide travel and traffic management services.
- Work cooperatively with regional partners to provide regional ITS solutions, systems, and staffing.

To achieve these operational targets, the National ITS Architecture identifies service packages that TxDOT can pursue to improve congestion, including traveler information services and traffic management services. These services include:

- ATIS01 Broadcast Traveler Information.
- ATIS02 Interactive Traveler Information.
- ATIS06 Transportation Operations Data Sharing.
- ATIS07 Travel Services Information and Reservation.
- ATIS08 Dynamic Ridesharing
- ATMS01 Network Surveillance.
- ATMS03 Traffic Signal Control.
- ATMS04 Traffic Metering.
- ATMS05 HOV Lane Management.

- ATMS07 Regional Traffic Management.
- ATMS08 Traffic Incident Management System.
- ATMS16 Parking Facility Management.

ITS STRATEGIC PLAN GOAL: CONNECT TEXAS COMMUNITIES

The National ITS Architecture identifies operational targets for connecting communities to enhance economic vitality, increase accessibility and mobility of people and freight, and enhance the connectivity of the transportation system. These include:

- Reducing the person hours (or vehicle hours) of delay.
- Providing freight operators with traveler alerts and alternate routes.
- Decreasing average crossing times at international borders.
- Reducing the average monetary cost of congestion per capita.

The TxDOT ITS Strategy has the following three goals that address these performance targets:

- Deploy and operate strategic corridors and regions with best-in-class levels of service to enhance the economic development, mobility, and safety.
- Participate in connected vehicle and automated vehicle activities that will improve economic competitiveness for Texas.
- Deploy ITS systems and technologies that facilitate the efficient movement of freight and goods along strategic, high-volume freight corridors.

ITS STRATEGIC PLAN GOAL: BECOME A BEST-IN-CLASS AGENCY

To become a best-in-class agency, the TxDOT ITS Strategic Plan emphasizes

- Setting up cost-effective performance targets for ITS.
- Using innovative services and technologies.
- Providing service that meets the needs and expectations of travelers.

The ITS Strategic Plan lists the following goals:

- Deploy equipment and staffing of ITS services in a cost-effective manner.
- Deploy ITS in a responsible manner that includes innovative services and technologies.
- Anticipate customer service needs and plan the services to accommodate those needs.

CHAPTER 7:
CANDIDATE ITS ARCHETYPE

As TxDOT moves forward with securing the role of ITS as a critical element of transportation operations, one possible enhancement to the current statewide approach is to expand the concept of having primary traffic management centers in major metropolitan areas supporting smaller districts. This concept assumes that at some point in the future, every district will have some ITS implementation. The following sections highlight some of the major concepts that might enable this archetype to become a reality. It is important to note that this is just one way by which ITS can be managed in the future, and other archetypes could also be developed that optimize resources and the overall network.

CONCEPT OF OPERATIONS

The concept of the archetype illustrated in Figure 2 is that TxDOT would consolidate the operations of core ITS functions into several primary TMCs. These primary TMCs would generally be located in strategic major metropolitan areas. These primary centers would assume responsibility for operating ITS devices on state-supported highway/freeway facilities and state-supported routes of significance in the major metropolitan areas, as well as the ITS devices in neighboring TxDOT districts. Operation of neighboring districts would primarily be after-hours or as preferred by the districts. TxDOT would operate these primary centers 24 hours per day, seven days per week, and 365 days per year. These primary TMCs would support the following core ITS functions:

- The operation of permanent DMS and other en-route traveler information systems.
- Freeway surveillance and traffic sensors systems.
- Traffic signal systems (if appropriate).
- Data archiving and performance measurement/reporting.
- Operation of dynamic traffic control devices, such as ramp meters and lane control signals.
- Operation of active transportation and demand management (ATDM) technologies.
- Work-zone and construction-related ITS systems.

- Weather-responsive traffic management (such as winter weather events, or hurricane evacuations).
- Coordination and potential sharing of assets (e.g., fiber).
- Implementation of pre-approved signal plans for local partners when appropriate.
- ITS performance monitoring and reporting.

At the local level, 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 a traffic incident, or a local special event), but the primary TMCs would maintain responsibility for the day-to-day operation of the ITS systems. Each primary traffic management center would work with local districts and local partners to develop traffic management response plans and standard operating procedures for common traffic management situations for the ITS systems within their area. To the extent possible, these response plans would be consistent with policies and operating philosophies of individual districts and local entities. Primary TMC operators would have override capability of locally implemented responses to support high-priority regional or statewide traffic management objectives, unless the local and primary centers (e.g., hurricane evacuation, major corridor incidents that span jurisdictions) otherwise agreed.

Each primary traffic management center would be responsible for posting standard messages for statewide alerts (e.g., AMBER, Silver, Blue) on dynamic message signs within their purview. The operations of the state-managed dynamic message signs should follow usage policies and standards established by the Traffic Operations Division. Each primary traffic management center would also be responsible for providing traffic management support during all traffic incidents on state-supported facilities in accordance with the agreed-upon traffic management plan established by local districts and entities. They would also be responsible for maintaining the ITS devices within their control.

Each primary management center would use the TxDOT statewide Lonestar™ Traffic Management software system for the smaller districts within their region. Each primary center would support a center-to-center connection with the TMCs of local entities to which they connect within their region and maintain a center-to-center connection with neighboring supported centers to ensure coordination of inter-regional or statewide traffic management responses. Local entities would have the ability to share video to and from the primary TMCs.

These primary TMCs may establish policies on what TxDOT video can be shared with local entities.

Each primary traffic management center would operate and maintain a regional data warehouse for archiving ITS operation data or have an arrangement with a local agency to do so. The data from each primary center would be made available to district and local entities to support their long-range and operational planning activities. Local entities would develop their own system to augment the data retained by the regions.

A statewide communication infrastructure would be developed for coordination between primary TMCs and to support the installation of ITS devices and equipment along routes of major significance. This would include rural interstates, major U.S. and state highways, hurricane evacuation routes, etc. This infrastructure could also be used to support traffic signal operations in local districts and transportation needs of local partners.

OPERATIONS AND MAINTENANCE PERSONNEL

Within the context of the candidate archetype, each primary TMC would have a person responsible for regional TMC operations. Primary TMC directors would report to a designated individual within the Traffic Operations Division. These primary TMC operations leaders would be responsible for:

- Developing a staffing plan for operating and maintaining the ITS systems within the region.
- Coordinating with district and local entity personnel to ensure that their ITS traffic management needs are met.
- Coordinating the programming of capital projects for new system deployments or expansions with area MPOs.
- Developing standard operating procedures and coordinated traffic management response plans with local entities.
- Developing an operating and maintenance budget for ITS systems within the region, including provisions for any leased communications services.

- Developing comprehensive replacement plans and a responsive and preventative maintenance program for all the ITS devices supported by the primary center.
- Coordinating with local entities in the development of regional ITS architectures.

To ensure adequate staffing, some district personnel currently performing ITS operations and maintenance functions would be transferred to the primary centers.

Primary centers would be housed administratively under TRF and would be responsible for developing standard operating procedures for coordinating activities of local partners during hurricane and other emergency events. These centers would coordinate the development of their operating procedures with TRF, which would then have oversight responsibility during evacuations and other emergencies of regional significance.

ROLE OF THE TRAFFIC OPERATIONS DIVISION

As part of the candidate archetype, TxDOT's Traffic Operations Division (TRF) would be responsible for overseeing TxDOT's ITS programs, projects, equipment, and agreements statewide as well as for developing and maintaining statewide ITS architecture governing the design, deployment, operations, and maintenance of TxDOT's primary TMCs. TRF would develop, install, and maintain a communication infrastructure that permits regional centers to share data and operations, and the communications network would be used to support center-to-field communications with ITS device deployed on routes of significance throughout the state.

TRF would be responsible for developing, operating, and maintaining a centralized website for disseminating regional and statewide traveler information, which would include a whole host of information sources. Local agencies could continue to host and provide regional websites that include the input of TxDOT. Furthermore, TRF would establish operation performance standards for ITS devices and would be responsible for monitoring system performance to ensure that devices conform to these operational standards.

TRF would manage a centralized ITS construction, maintenance, and operations budget and would be responsible for the design, review, and approval of ITS plans, specifications, and estimates (PS&E). However, districts would continue to be responsible for the construction of highway projects with ITS elements and would coordinate submittals review and approval with TRF. Construction of large-scale ITS deployment would continue to be supported through local Surface Transportation Program (STP)/Congestion Mitigation and Air Quality Program funding

programs, and the participation of regional centers in model deployments would be coordinated through TRF.

TRF would be responsible for developing and managing local operational and/or funding agreements between the primary centers and local entities, and also provide administrative support to each of the regions. It would be responsible for developing and maintaining an inventory management/asset management system that the primary centers would use, and also for providing a training program for ensuring that primary center staff members have the knowledge, skills, and ability to perform their duties effectively. Finally, TRF would be responsible for identifying and coordinating the development of new systems and system modifications to address the needs of individual regions, and developing and implementing policies related to sharing resources (including data, personnel, communications, and equipment) with local partners.

ROLE OF DISTRICTS

Local districts have a role to play as well in the candidate archetype. They would work to identify needs and operational issues that could potentially be addressed through ITS deployments and coordinate with local partners to ensure that ITS projects are identified and needs are addressed and then incorporated into the short-range (TIP) and long-range planning processes. Local districts would incorporate ITS and communications infrastructure needs into highway construction projects and continue to operate and maintain traffic signal systems and other traffic management systems that the primary centers would manage.

ROLE OF LOCAL PARTNERS

Under this candidate archetype, local partners would be responsible for developing pre-trip planning and nonroadway-based traveler information systems (such as 511, social media, etc.). They would maintain their current responsibilities for operating and maintaining traffic signal systems and other traffic management systems in accordance to current TxDOT policies, and also be responsible for developing, operating, and maintaining their own ITS/traffic management infrastructure. Local partners would also be encouraged to coordinate operations and share information with regional centers.

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