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16. Abstract

The state of the intelligent transportation systems (ITS) program in Texas is summarized and analyzed. The report first reviews the types of ITS deployments within each Texas Department of Transportation district. The methods used to plan, design, construct, operate and maintain, and evaluate ITS within each district are then discussed and critiqued.

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INTELLIGENT TRANSPORTATION SYSTEMS (ITS) IN TEXAS: DEPLOYMENT SUMMARY AND CASE STUDY OF DEPLOYMENT METHODOLOGIES

by

David T. Ory
Center for Transportation Research

William R. Stockton, P.E.
Texas Transportation Institute

C. Michael Walton, P.E.
Center for Transportation Research

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DISCLAIMERS

William R. Stockton, P.E. (Texas No. 41188)
Research Supervisor

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CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Recent advances in computing technology are drastically changing every facet of our lives. The arena of transportation is no exception. Personal cars are now being equipped with in-vehicle computers and a variety of safety monitoring equipment. Our roadways are being enhanced with sensing technology and dynamic message signs that convey real-time information. Our transit vehicles are being outfitted with electronic fare-collection devices to allow for more efficient operation. The use of such applications is referred to under the blanket name of Intelligent Transportation Systems, or ITS.

As defined by the United States Department of Transportation (USDOT), the goals of the ITS program are as follow:

"Increase operational efficiency and capacity of the transportation system;

- Enhance personal mobility and the convenience and comfort of the transportation system;
- Improve the safety of the nation's transportation system;
- Reduce energy consumption and environmental costs;
- Enhance the present and future economic productivity of individuals, organizations, and the economy as a whole;
- Create an environment in which the development and deployment of ITS can flourish" (1, p. i).

ITS incorporate a variety of technologies through a variety of applications. To better understand what applications fall under the umbrella of ITS, the National Architecture's User Services can be examined. The Federal Highway Administration (FHWA) and USDOT developed the National Architecture to provide structure and uniformity to ITS discussion and deployment. The User Services aspect of the Architecture is a finite, yet dynamic, listing of services that ITS provide to end users. The User Services, summarized in Table 1.1, demonstrate, in relatively simple language, the services ITS can provide.

Table 1.1: National Architecture User Services

Type of Service	User Services
Travel and Traffic Management	Pre-Trip Traveler Information
	En-Route Driver Information
	Route Guidance
	Ride Matching and Reservations
	Traveler Service Information
	Traffic Control
	Incident Management
	Travel Demand Management
	Emissions Testing and Mitigation
	Highway – Rail Intersection
Public Transportation Management	Public Transportation Management
	En-Route Transit Information
	Personalized Travel Security
	Public Travel Security
Electronic Payment	Electronic Payment Service
Commercial Vehicle Operations	Commercial Vehicle Administrative Process
	Automated Roadside Safety Inspection
	On-Board Safety Monitoring
	Commercial Vehicle Administrative Process
	Hazardous Material Incident Response
	Commercial Fleet Management
Emergency Management	Emergency Notification and Personal Security
	Emergency Vehicle Management
Advanced Vehicle Safety Systems	Longitudinal Collision Avoidance
	Lateral Collision Avoidance
	Intersection Collision Avoidance
	Vision Enhancement For Crash Avoidance
	Safety Readiness
	Pre-Crash Restraint Deployment
	Automated Vehicle Operation
Archiving Data	Archived Data Function

Source: The National ITS Architecture: A Framework for Integrated Transportation into the 21st Century, CD-ROM v 3.0, Market Packages (1), pp. 15–16.

The list can be described as dynamic because the above User Services are slowly expanding. As transportation professionals develop innovative ITS, such as those used for archiving data, new User Services are added to the list (2).

The research in this report focuses on the implementation of ITS rather than the benefits to end users. To that end, another aspect of the National Architecture, the Market Packages, is presented to provide further background. The Market Packages provide the link between the User Services and the actual equipment necessary to deploy ITS. As defined by the FHWA, the Market Packages were developed to

> Address the specific service requirements of traffic managers, transit operators, travelers, and other ITS stakeholders. To achieve an implementation orientation, the Market Packages were defined with enough granularity to support the specific benefits analysis and clear ties to transportation problems (3, p. 32).

The Market Packages are summarized in Table 1.2. The table organizes the Market Packages in the following areas: Advanced Public Transportation Systems (APTS), Advanced Traveler Information Systems (ATIS), Advanced Traffic Management Systems (ATMS), Advanced Vehicle Safety Systems (AVSS), Commercial Vehicle Operations (CVO), Emergency Management (EM), and Archiving Data (AD).

Table 1.2: National Architecture Market Packages

Market Packages	
APTS Advanced Public Transportation Systems	Transit Vehicle Tracking
	Transit Fixed-Route Operations
	Demand-Response Transit Operations
	Transit Passenger and Fare Management
	Transit Security
	Transit Maintenance
	Multi-Modal Coordination
	Transit Traveler Information
ATIS Advanced Traveler Information Systems	Broadcast Traveler Information
	Interactive Traveler Information
	Autonomous Route Guidance
	Dynamic Route Guidance
	ISP-Based Route Guidance
	Integrated Transportation Management/Route Guidance
	Yellow Pages and Reservation
	Dynamic Ridesharing
	In-Vehicle Signing
ATMS Advanced Traffic Management Systems	Network Surveillance
	Probe Surveillance
	Surface Street Control
	Freeway Control
	HOV Lane Management
	Traffic Information Dissemination
	Regional Traffic Control
	Incident Management System
	Traffic Forecast and Demand Management
	Electronic Toll Collection
	Emissions Monitoring and Management
	Virtual TMC and Smart Probe Data
	Standard Railroad Grade Crossing
	Advanced Railroad Grade Crossing
	Railroad Operations Coordination
	Parking Facility Management
	Reversible Lane Management
	Road Weather Information System
	Regional Parking Management
AVSS Advanced Vehicle Safety Systems	Vehicle Safety Monitoring
	Driver Safety Monitoring
	Longitudinal Safety Warning
	Lateral Safety Warning
	Intersection Safety Warning
	Pre-Crash Restraint Deployment
	Driver Visibility Improvement
	Advanced Longitudinal Control
	Advanced Lateral Control
	Intersection Collision Avoidance
	Automated Highway System
CVO Commercial Vehicle Operations	Fleet Administration
	Freight Administration
	Electronic Clearance
	CV Administrative Processes
	International Border Electronic Clearance
	Weigh-In-Motion
	Roadside CVO Safety
	On-Board CVO Safety
	CVO Fleet Maintenance
	HAZMAT Management
EM Emergency Management	Emergency Response
	Emergency Routing
	Mayday Support
AD Archiving Data	ITS Data Mart
	ITS Data Warehouse
	ITS Virtual Data Warehouse

Source: The National ITS Architecture: A Framework for Integrated Transportation into the 21st Century, CD-ROM v 3.0, Market Packages (1), pp. 15–16.

This report adheres to the language and organization of the National Architecture.

The User Services and Market Packages tables give a small indication of the overwhelming amount of new terminology and new technology that transportation professionals must learn. During the past few years, the ITS program has focused on research, development, and operational testing. Through the efforts of academics and other researchers, in coordination with the Intelligent Transportation Society of America (ITSA), ITS has continually demonstrated the ability to make a positive impact on the transportation system. As these encouraging results have begun to validate the use of ITS, the burden of knowledge and adaptation has slowly shifted from researchers to implementers (4). In many cases, the state departments of transportation (DOTs) have been handed the challenge of integrating ITS into their existing programs as well as becoming ITS leaders, or champions, in their regions. The research presented here provides an assessment of their struggles in approaching these tasks by utilizing a case study of a single state DOT.

1.2 PROBLEM STATEMENT

The ITS program in the United States is currently making the transition from research and testing to regional deployment. In many regions, the state DOT has been assigned the task of implementing many of these technologies. This research provides a summary of how these systems are being planned, designed, constructed, operated and maintained, and evaluated throughout one state DOT. Best practices are identified and nationally recommended practices are highlighted. Additionally, Problem Definitions of Lessons Learned are developed in each of these areas (planning, design, construction, operations and maintenance, and evaluation).

1.3 METHODOLOGY

The state of Texas is the case study for this research. The state is segmented into twenty-five Texas Department of Transportation (TxDOT) districts, each of which is responsible for ITS deployment in its region.

The primary information-gathering tool was a survey that was distributed to each of the TxDOT districts. The survey was dispersed primarily to the engineers in each region during the last few months of 1999 and the first few months of 2000. Additional information was obtained from phone interviews with the surveyed individuals.

1.4 CHAPTER SUMMARIES

Chapter 2 provides a brief summary of ITS deployment in Texas to establish the context of TxDOT's methodologies and struggles. All twenty-five TxDOT districts' programs and current and planned deployment are summarized.

Chapter 3 highlights the practices and struggles of the DOT districts in the areas of planning, design, construction, operations and maintenance, and evaluation. Best practices within the state are identified, and the practices of other state DOTs and recommended practices from academic and USDOT-sponsored literature are included in the discussion. This chapter also formulates a concise listing of Lessons Learned and Problem Definitions for key issues.

The fourth and final chapter provides a summary and conclusions.

CHAPTER 2: ITS IN TEXAS – SUMMARY OF PLANS, PROGRAMS, AND DEPLOYMENTS

The purpose of this chapter is to provide a basic understanding of the level of ITS deployment in Texas as a means of building a context for the discussion to follow in Chapter 3. This chapter presents a broad overview, rather than a detailed account, of ITS deployment in Texas. The authors intend this overview to help the reader understand the state's general ITS environment. The summary focuses on DOT deployments, but transit and city-deployed ITS are also mentioned. The information gathered for this chapter was obtained from published resources as well as through a survey (ITS Inventory Survey) distributed to DOT personnel. The survey (see Appendix A for a complete survey) is described in greater detail in Chapter 3.

2.1 GENERAL OVERVIEW OF ITS IN TEXAS

The state of Texas offers a diverse transportation environment rich in ITS application opportunities. The state boasts six large, metropolitan areas in Austin, Dallas, El Paso, Fort Worth, Houston, and San Antonio. In addition, the state has extensive port operations along the Gulf of Mexico, which include the Ports of Houston, Beaumont, Brownsville, Port Arthur, Galveston, and Corpus Christi—some of the largest ports, in terms of tonnage, in the United States (5). Also, the state shares a long international border with the Republic of Mexico and is a major thoroughfare for commercial vehicle traffic both heading north-south and east-west through, and destined for, Texas.

Within the TxDOT district structure, the majority of TxDOT districts house only one major city. For example, each of the six metropolitan areas mentioned previously has its own district by the same name. From this point forward, such names will be used in reference to the TxDOT districts rather than the cities themselves. Figure 2.1 shows the state segmented into TxDOT districts.

Figure 2.1: Texas Segmented into TxDOT Districts

Source: TxDOT Web Site (6)

The current state of ITS deployment in Texas is as diverse as the state itself. The district of San Antonio recently completed a federally funded Model Deployment Initiative (MDI), which provided the district with a mature traffic management center (TMC) as well as a host of other services. The Houston District also has a TMC in a permanent facility, and the districts of Fort Worth, Dallas, El Paso, and Austin have TMCs in various phases of development (7). In total, these six metropolitan areas have freeway management systems (FMS) covering 270 miles of highway with an additional 165 miles under construction. At a minimum, these systems perform incident detection and management and area-wide control and surveillance, as well as collecting data and disseminating traveler information. In terms of monetary expenditures, TxDOT allocated about $50 million in ITS projects during the 1999 fiscal year (7, 8).

In addition to freeway management, Texas also has a myriad of other ITS activities. Such programs as weather monitoring systems, international border operations, closed-circuit television (CCTV) surveillance in remote areas, rural traveler information, and a host of commercial vehicle operations (CVO) programs are underway across Texas (8).

The remainder of this chapter will summarize ITS activity in each TxDOT district. The districts (listed below with their TxDOT abbreviation for reference with Figure 2.1) will be separated into four different categories, namely: Metro, Border, Port, and Rural. The Metro districts will include the six metropolitan areas in Texas of Austin (AUS), Dallas (DAL), Fort Worth (FTW), El Paso (ELP), Houston (HOU), and San Antonio (SAT). The Border districts will include those regions sharing an international border with Mexico and include Odessa (ODA), Pharr (PHR), and Laredo (LRD) (El Paso is also a border district but will be placed in the Metro category). The Port districts will include those regions having a water border on the Gulf of Mexico and will include Corpus Christi (CRP), Yoakum (YKM), and Beaumont (BMT). Finally, the remaining districts will be lumped together in the Rural category. These districts include Abilene (ABL), Amarillo (AMA), Atlanta (ATL), Brownwood (BWD), Bryan (BRY), Childress (CHS), Lubbock (LBB), Lufkin (LFK), Paris (PAR), San Angelo (SJT), Tyler (TYL), Waco (WAC), and Wichita Falls (WFS).

2.2 Summary of Activity in Metro Districts

As mentioned previously, the Metro category will hold the districts commonly referred to as the "Big Six," namely Austin, Dallas, El Paso, Fort Worth, Houston, and San Antonio. As a means of providing background information for these districts, their population, daily vehicle miles, and aggregate number of vehicles are shown in Table 2.1.

Table 2.1: Metro Districts' Characteristics

District	Population[1]	Daily Vehicle Miles[1]	Vehicles[2]
Austin	1,211,461	26,026,270	971,792
Dallas	3,168,531	54,069,261	2,611,811
El Paso	719,889	10,567,193	432,608
Fort Worth	1,718,342	34,370,123	1,517,305
Houston	4,348,125	69,807,275	3,441,359
San Antonio	1,737,051	32,137,819	1,375,133

[1] – 1999 estimates, [2] – Data collected from 9/97 to 8/98
Source: Texas Department of Transportation (6)

The National Architecture's Market Packages segment ITS deployment into the following seven general categories: Advanced Public Transportation Systems (APTS), Advanced Traveler Information Systems (ATIS), Advanced Traffic Management Systems (ATMS), Advanced Vehicle Safety Systems (AVSS), Commercial Vehicle Operations (CVO), Emergency Management (EM), and Archiving Data (AD). This report will summarize ITS programs within Texas in these general categories, placing an emphasis on ATMS and ATIS, as those areas have traditionally been deployed by the state DOT.

2.2.1 Advanced Traffic Management Systems (ATMS)

The area of ATMS covers such ITS as freeway surveillance and control, incident management, electronic toll collection, railroad operations, parking facility management, and road weather information; a total of nineteen Market Packages make up the ATMS category (1). ATMS has stepped to the forefront in Texas as the western cities' ample freeways and lack of developed transit systems comprise an ideal environment for the use of such operating systems. The six Metro districts all have FMS and all have TMCs operating in either permanent or interim facilities. Table 2.2 summarizes the types of TMC operations and gives the moniker of each district TMC.

Table 2.2: Metro Districts' Traffic Management Centers

District	Program Name	TMC Structure	Details
Austin	None	Central Center (planned)	Opening date scheduled for 2001
Dallas	DalTrans	Central Center (planned)	TMC to link with TransVISION
El Paso	TransVista	Central Center (operational summer 2000)	Workstations will be provided for city personnel
Fort Worth	TransVISION	Central Center (operational Summer 2000), six satellite buildings	36,000 sq. ft facility currently under construction
Houston	TranStar	Central Center (operational), satellite buildings	$14 million, 54,000 sq. ft facility
San Antonio	TransGuide	Central Center (operational)	Model Deployment Initiative Project

Sources: Compiled from (8), (9), (10), (11), (12), (13)

As expected, the various regions have different levels of currently deployed FMS infrastructure. All the Metro districts, however, utilize fiber optic communications, cameras, and dynamic message signs (DMS) to monitor and manage their highway networks. Table 2.3 shows an inventory of these technologies in the Metro districts. For maps and graphics of the FMS in the Metro districts, please refer to Appendix B: Freeway Management System Coverage Graphics.

Table 2.3: Metro Districts' FMS Infrastructure Summary

District	Cameras	Dynamic Message Signs	Lane Control Signals	Notes
Austin[1]	1 ISDN, 25 Analog	2 operating, 50 being procured	53 heads @15 stations	Infrastructure currently in place on US 183 and IH 35
Dallas[2]	42 CCTV, 28 under construction	16 operating, 18 more planned	None, requested funding for 20 miles of LCS	Video detection currently used, 185 mile loop detector project is underway
El Paso[2]	34 CCTV, 20 more planned	13 operating, 30 to be added by 2002	163 heads @ 49 stations	Infrastructure in place along IH 10, US 54, and LP 375
Fort Worth[2]	40 CCTV, 14 Compressed Video	50 operating	244 heads	System is 47% complete
Houston[2]	194 CCTV, 40 more planned	77 operating, 56 to be added	40 heads @ 10 stations planned	Extensive AVI[4] system covering 227 miles of freeway
San Antonio[2,3]	100 CCTV on freeways, 3 at RR crossings, 4 at Alamodome	139 operating	687 heads @ 180 stations	98 miles under AVI control and 63 miles under freeway control

[1] – As of 6/11/99, Source: (10) [2] – Source: (8) [3] – Source: (13) [4] – Advanced Vehicle Identification

In addition to FMS, different ATMS strategies have emerged in particular districts. A summary of such applications, as they correlate to the ATMS Market Packages, is provided in Table 2.4. As the names of the Market Packages often do not clearly convey the types of technology they incorporate, a brief description is given for each Package. It should be noted that some of these applications, such as "Surface Street Control," are operated by cities within each district, rather than by the DOT.

Table 2.4: Metro Districts' ATMS Applications

Market Packages	Austin	Dallas	El Paso	Fort Worth	Houston	San Antonio
Network Surveillance	■	■	■	■	■	■
Traffic detectors, environmental sensors, and other surveillance equipment to feed data to TMC						
Probe Surveillance					■	■
Communication between vehicle and service provider or vehicle and roadway						
Surface Street Control	■	■		■	■	■
Traffic control systems to monitor and manage surface street traffic						
Freeway Control	■	■	■	■	■	■
Ramp control, lane control, and interchange control on freeways						
HOV Lane Management		■			■	
Coordinating freeway ramp meters and connector signals with HOV lane usage; HOV enforcement						
Traffic Information Dissemination	■	■	■	■	■	■
Ability to disseminate information from TMC to a variety of outlets (media, emergency management, etc.)						
Regional Traffic Control		■		■		
Integrating surface street control and freeway management, linking TMC						
Incident Management System	■	■	■	■	■	■
Managing the network when incidents occur with expected or unexpected events						
Traffic Forecast and Demand Management						
Algorithms, processing, and mass storage capabilities to support real-time assessment and forecasting						
Electronic Toll Collection		■			■	
Collecting tolls and identifying violators automatically						
Emissions Monitoring and Management						
Sensors to collect and monitor air quality for individual vehicles						
Virtual TMC and Smart Probe Data						
Distributed TMC over a wide area (statewide or multi-state), and using vehicles to probe network						
Standard Railroad Grade Crossing	■	■	■	■	■	■
Signs or flashing lights						
Advanced Railroad Grade Crossing						■
Information regarding train's arrival passed along to the driver						
Railroad Operations Coordination						
Strategic coordination with rail operations						
Parking Facility Management						
Enhanced monitoring and management of parking, including electronic fare and communication						
Reversible Lane Management		■			■	
Sensory functions that detect wrong-way vehicles and other surveillance capabilities						
Road Weather Information System			■			■
Information is monitored and analyzed to detect and forecast ice, fog, or other severe weather						
Regional Parking Information						
Parking facility management on a regional level						

Source: Adapted from The National ITS Architecture: A Framework for Integrated Transportation into the 21st Century, CD-ROM v 3.0, Market Packages (1), pp. 15–16; also (7), (8), (9), (10), (11), (14), (15).

Often, the Market Packages do not capture the richness and contrast of many ITS applications. Two applications can be summarized by one Market Package, but can be accomplished with slightly different tools. For example, different detection methods (loop, video, acoustic) and different camera types (CCTV, compressed video) can satisfy the same "Network Surveillance" Market Package. As a result, some of the more interesting methods used for ATMS will be discussed in greater detail.

In the area of incident management, the districts of Austin, Dallas, Fort Worth, and Houston operate courtesy patrol programs. These programs involve DOT personnel traveling along freeways assisting disabled vehicles and providing on-site traffic control during incidents. The programs have been very successful in building better relations with the traveling public (7).

In addition, the districts of Dallas, Fort Worth, Houston, and San Antonio all utilize ramp metering (16). The San Antonio District monitors pump stations to warn motorists of flooding on the freeways; El Paso is currently planning to deploy such a system (17).

While the great majority of ITS activity occurs at, and is the responsibility of, the individual district, TxDOT does support various aspects of ITS deployment at the state level. The primary means of such support comes through the TxDOT Traffic Operations Division (TRF) in Austin, which has contracted both Southwest Research Institute (SwRI) and Lockheed-Martin (L-M) to assist in systems integration at the statewide level. SwRI has been contracted to act as the statewide ITS systems integrator. In this position, SwRI assists all the TxDOT districts (but primarily the Metro districts) in developing software, managing communication infrastructure, developing ITS architectures, and any other issues dealing with software integration.

Lockheed-Martin has worked extensively in Houston (TranStar) and Fort Worth (TransVISION) over the past few years developing these cities' TMC software packages. L-M is now helping the Austin and El Paso Districts incorporate the software developed for TransVISION into their systems. The goal is to develop software components that can then be transferred easily to new TMCs. L-M also supports other systems integration work in Austin, Houston, Fort Worth, and El Paso.

In addition to utilizing SwRI and L-M, TxDOT's Traffic Operations Division (TRF) also assists statewide ITS deployment internally. The TRF group has developed ATMS software, which currently runs the TMCs in Austin and El Paso. This software is continually being updated and will be used to operate future TMCs in less-populated districts like Laredo and Amarillo. Innovations such as allowing portable DMS and CCTV cameras to communicate with the TMC are being incorporated into the software.

2.2.2 Advanced Traveler Information Systems (ATIS)

The ATIS Market Packages aim to provide timely information to travelers to help them make informed decisions. Such decisions may involve changing routes, changing modes, or deciding not to make the trip. Whereas ATMS allows traffic managers to gather information and more efficiently operate the transportation network, ATIS allows travelers to receive such information and make their own decisions.

Within the Metro districts, traveler information is being disseminated in a variety of ways, ranging from highway advisory radio (HAR) to sophisticated Web sites. In general, most districts have media agreements that allow local news stations to utilize images from the district's surveillance cameras for newscasts and Web site usage (7). The districts of Houston and San Antonio have comprehensive Web sites, while Austin provides still images from cameras on a news station's Web site (12, 13). Fort Worth and Dallas are developing a joint Web site, which will provide traffic information for both districts (8). Table 2.5 summarizes the ATIS Market Packages currently deployed in the Metro districts. Please note that a few of these Packages, such as "In-Vehicle Signing," are driven by the private sector, and the DOT has limited ability to encourage such deployment. However, the DOT does have the ability to deploy these technologies with its service vehicles or coordinate deployment with police or emergency vehicles. Such a strategy is used by San Antonio with in-vehicle signing technology (18).

Table 2.5: Metro Districts' ATIS Applications

Market Packages	Austin	Dallas	El Paso	Fort Worth	Houston	San Antonio
Broadcast Traveler Information	■	■	■	■	■	■
Near real-time dissemination of all types of traffic, transit, weather, and parking information						
Interactive Traveler Information					■	■
Request/response systems for all types of information, through any type of info. provider						
Autonomous Route guidance	■	■	■	■	■	■
Route guidance based on static, stored information, market-driven (Mapquest)						
Dynamic Route Guidance					■	■
Same as above, using dynamic information for route guidance purposes						
ISP-Based Route Guidance					■	■
Dynamic information obtained through an information service provider.						
Integrated Transportation Management/Route Guidance						
Allows TMC to continuously optimize control strategies using real-time information						
Yellow Pages and Reservations						
Making Yellow Pages available to driver						
Dynamic Ridesharing					■	
Ride-matching capability						
In-Vehicle Signing						■
Providing information inside the vehicle						

Source: Adapted from The National ITS Architecture: A Framework for Integrated Transportation into the 21st Century, CD-ROM v 3.0, Market Packages (1), pp. 15–16; also (7), (8), (9), (10), (11), (14), (15).

Again, a few of the more interesting ATIS programs will be discussed further, as the Market Packages often fail to capture the unique nature of many applications. In the area of "Interactive Traveler Information," the districts of Houston and San Antonio offer comprehensive Web sites, which provide a wealth of information including speed maps, travel times, incident maps, and route-building options (12, 13). San Antonio, as part of the MDI, has placed several information kiosks at transit stops, shopping malls, and universities, where travelers can obtain information and even print maps and narrative directions (18). In the area of "Dynamic Ridesharing," the Houston District is experimenting with a Smart Commuter program. This program attempts to lure single-occupancy-vehicle users into carpools by offering a ridesharing program, which searches for ideal carpooling matches (14).

2.2.3 Advanced Public Transportation Systems (APTS)

Although DOTs are not directly responsible for APTS applications, a summary of APTS will be provided here. A further discussion of the DOT's role in encouraging APTS deployment by the local transit agency and building toward an integrated system is provided in Chapter 3 of this report.

The general goal of APTS is to improve the overall level of transit service and to make transit operating agencies more efficient and cost-effective. Along these lines, typical APTS applications include tools to monitor transit vehicles for security and maintenance purposes, to provide timely information to transit users, and to facilitate quicker and more convenient fare collection (1). Table 2.6 summarizes APTS Market Package deployment within TxDOT's Metro districts.

Table 2.6: Metro Districts' Transit Agencies and APTS Applications

	DISTRICT (TRANSIT AGENCY)					
Market Packages	**Austin**	**Dallas**	**El Paso**	**Fort Worth**	**Houston**	**San Antonio**
	Capital Metro	DART	Sun Metro	The T	METRO	VIA
Transit Vehicle Tracking	■	■			■	■
Track vehicle for schedule adherence to update schedule in real time						
Transit Fixed-Route Operations		■				
Performs driver assignment/monitoring and schedules fixed-route services automatically						
Demand Responsive Transit Operations		■		■		
Automatic driver assignment and monitoring and vehicle routing and scheduling (CAD)						
Transit Passenger and Fare Management						
Management of passenger loading and fare payment on-board electronically						
Transit Security						■
On-board as well as public area monitoring						
Transit Maintenance				■		
Automatic maintenance and scheduling monitoring; on-board sensors						
Multi-Modal Coordination		■		■	■	■
Intermodal coordination between transit and traffic agencies						
Transit Traveler Information	■	■			■	■
Information at transit stops and on-board transit vehicles						

Source: Adapted from The National ITS Architecture: A Framework for Integrated Transportation into the 21st Century, CD-ROM v 3.0, Market Packages (1), pp. 15–16 also: (8), (15), (19), (20), (21), (22), (23).

Some of the more interesting APTS applications are currently being used in Dallas. The light rail system in Dallas is coordinated by a TMC-like control center, which monitors and dispatches vehicles. Also, computer aided dispatch (CAD) programs buttress para-transit and fixed-route services. The fixed-route buses have the ability to, time permitting, deviate from their route to pick someone up, typically a para-transit user. This program allows the para-transit service to interact more effectively with fixed-route operations, and it increases para-transit's overall efficiency (20).

2.2.4 Commercial Vehicle Operations (CVO), Emergency Management (EM), and Archiving Data (AD)

The area of Advanced Vehicle Safety Systems (AVSS) will not be covered in this section as those deployments are largely driven by the private sector, mainly automobile manufacturers. TxDOT has not been involved in the few areas, such as the building of automated highway systems infrastructure, where the local public sector can play a role. As a result, the remainder of the Metro discussion will focus on the relatively few deployments in the areas of CVO, EM, and AD.

In the area of CVO, El Paso is a participant in the U.S. Treasury North American Trade Automation Prototype (NATAP) demonstration project. The goal of this project is to utilize on-vehicle safety monitoring, cargo security devices, and Commercial Vehicle Information Systems and Networks (CVISN) messaging to develop a seamless international border. The project will assist daily commuters as well as commercial vehicle operators. On a statewide level, a strategic plan outlining possible ITS applications along IH-10, from New Orleans to San Antonio, has been developed. The plan focuses on "intermodal freight movement at strategic ports, efficiency of freight movement through the corridor, and rural ITS safety applications." (15, p. 494)

In the area of EM, the San Antonio District is stepping to the forefront with its LifeLink program. LifeLink allows for video conferencing between ambulance personnel and doctors at the nearby hospital. Video images of the entire patient allow doctors to assist ambulance personnel and better prepare the awaiting hospital for the arriving patient (18).

San Antonio and Houston are moving forward in the area of AD. In San Antonio, all gathered data are archived and made available to the public and research institutions. Currently, the Texas Transportation Institute (TTI) receives real-time data through the Internet (8). TTI also has a presence in TranStar in Houston, where it assists in maintaining the TranStar Web site and collects and manages large amounts of data. These data have been used extensively in research efforts (8).

2.3 SUMMARY OF ACTIVITY IN BORDER DISTRICTS

Activity along the international border between the United States and Mexico is an important aspect of the Texas transportation system. Four TxDOT districts, El Paso (ELP), Laredo (LRD), Odessa (ODA), and Pharr (PHR), make up this international border (see Figure 2.2). Since the El Paso District was discussed in the Metro section, the districts of Laredo and Pharr are discussed here. The Odessa District currently has no ITS applications and is not planning to have any in the future.

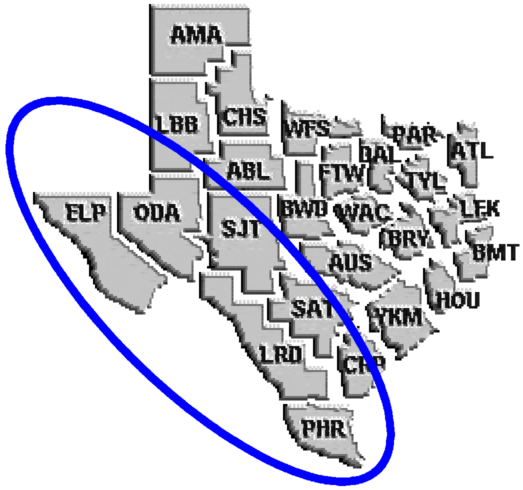


Figure 2.2: TxDOT Districts Located along the International Border with Mexico

Source: Adapted from TxDOT Web Site (6)

Tables 2.7 and 2.8 summarize the types of activity currently underway in Laredo and Pharr. General information about the districts is also provided in the tables.

Table 2.7: Laredo District ITS Summary

District	▪ Laredo (LRD)
Background	▪ The United States' busiest inland port, projected 21 million vehicles to cross in 2000; ▪ The cities of Laredo and Del Rio make up the majority of the district's 350,000 residents.
ITS Program	▪ Planning a regional architecture for the areas of Laredo, Del Rio, and Rio Grande Valley; ▪ Linked TMCs planned for the cities of Laredo (dubbed TransGateway) and Del Rio; ▪ Focus will be on commercial vehicle operations as well as flood-sensing, incident management, and signal pre-emption.
Operational Tests	▪ TRIBEX and NATAP operational tests (similar to El Paso) on Columbia-Solidarity Bridge.

Sources: (6), (8), (14), (15)

Table 2.8: Pharr District ITS Summary

District	▪ Pharr (PHR)
Background	▪ Pharr is located at the southern tip of Texas and is home to nearly 1 million residents. The city of Brownsville is located in the district.
ITS Program	▪ Currently developing a regional ITS plan.
Operational Tests	▪ Small freeway management system on US 83 utilizing a CCTV and DMS; ▪ Testing detectors (loop, infrared, acoustic) with TTI in an attempt to classify vehicles in order to award heavy trucks signal pre-emption to extend pavement life; ▪ Utilizing a weather monitoring system to warn causeway bridge crossers of brown pelican's (endangered species) presence.

Sources: (6), (7), (8), (14).

2.4 SUMMARY OF ACTIVITY IN PORT DISTRICTS

Another diverse aspect of the Texas transportation system is Texas' Gulf Coast. Five districts are located along the Gulf of Mexico and include Pharr (PHR), Corpus Christi (CRP), Yoakum (YKM), Houston (HOU), and Beaumont (BMT) (see Figure 2.3).

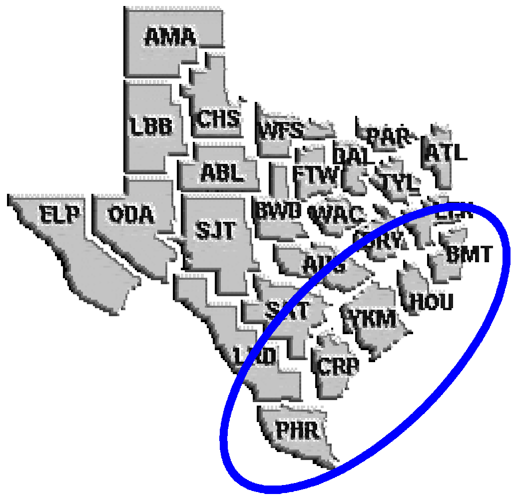


Figure 2.3: TxDOT Districts Located on the Gulf of Mexico

Source: Adapted from TxDOT Web Site (5)

Of these districts, Houston was discussed in the Metro section and Pharr in the Border section. In addition, the districts of Yoakum and Beaumont reported no ITS activity in their regions. As a result, the district of Corpus Christi (Table 2.9) is summarized in this section in a manner similar to the summaries of Laredo and Pharr.

Table 2.9: Corpus Christi District Summary

District	▪ Corpus Christi (CRP)
Background	▪ Population of near 550,000, popular tourist destination as well as a large port city.
ITS Program	▪ Developing a regional plan, which has been dubbed a regional ITS vision; ▪ This vision will form an ITS steering committee (with TxDOT personnel involved) that will work with the city of Corpus Christi; ▪ The goal will be to further develop pilot programs and to keep an urban and rural emphasis; ▪ Long-term goal is to use FMS to expedite hurricane evacuation procedures; ▪ The steering committee hopes to build a virtual FMS.
Operational Tests	▪ Currently experimenting with DMS and cameras and trying to build basis for virtual FMS; ▪ Also using video detection and HAR; ▪ APTS: Testing an Automated Dial-A-Ride (ADART) system, which automatically schedules pickup and provides transit driver with directions.

Sources: (6), (8)

2.5 Summary of Activity in Rural Districts

The remaining TxDOT districts are classified as Rural. Although FMS and other urban applications often dominate discussions regarding ITS, the rural field has come into its own in recent years. In essence, Rural ITS involve using ITS technologies in a rural setting.

In Texas, very little rural ITS activity is currently underway. The one exception to this general rule is the district of Amarillo, located in the northernmost panhandle section of Texas. As a result, this report will provide first a table (Table 2.10) detailing the activity in Amarillo, and then a table (Table 2.11) discussing the results of the ITS Inventory Survey as it pertains to the rest of the Rural districts.

Table 2.10: Amarillo District Summary

District	▪ Amarillo (AMA)
Background	▪ Population of near 350,000 and located on the panhandle of Texas; ▪ Region often experiences extreme weather events such as ice, snow, and tornadoes.
ITS Program	▪ Currently in the planning stage; ▪ District plans to bring DMS, cameras, and a small TMC; ▪ Initial goal of the program is to better communicate sudden changes in weather to travelers; ▪ Long-term plans will bring incident management to the urban sections of the city of Amarillo.
Operational Tests	▪ None at this time.

Sources: (6), (8)

Table 2.11: Rural District Summary

District	ITS Activity
Abilene	▪ Limited use of video detection;
Atlanta	▪ Video detection, desire for greater use of ITS in future years;
Brownwood	▪ No ITS;
Bryan	▪ No ITS, hope to bring rural applications and rail/signal applications in future years;
Childress	▪ No ITS;
Lubbock	▪ Did not respond to survey;
Lufkin	▪ No ITS;
Paris	▪ No ITS;
San Angelo	▪ Video detection;
Tyler	▪ Using DMS in coordination with Dallas District;
Waco	▪ No ITS;
Wichita Falls	▪ No ITS.

CHAPTER 3: DEPLOYMENT PROCESSES AND BARRIERS

The purpose of this chapter is to provide insight to the deployment processes at the district level within TxDOT. The methods of and challenges to planning, designing, constructing, operating and maintaining, and evaluating ITS are discussed. The basis for the discussion is a survey distributed to each of the twenty-five TxDOT districts during the winter of 1999–2000. These surveys were often followed up with telephone interviews.

The survey (see Appendix A for a complete survey) was separated into seven major sections, namely the following:

- Planning;
- Design;
- Construction;
- Evaluation;
- Barriers to Success;
- Cost;
- Existing and Planned Deployment Inventory; and
- Assistance.

The Planning portion of the survey inquires about how ITS is planned in the TxDOT districts. Questions regarding personnel and documents used for planning activities are included. The purpose of this section is to better understand the extent and process of planning activities in each district.

The Design section has a structure similar to the Planning section. Questions inquire about who designs the systems (in-house or through outsourcing) and to what extent vendors have been influential in the process.

The Construction section inquires about construction, procurement, and inspection procedures and issues.

The Evaluation section asks how individual components and complete systems are evaluated. Furthermore, this section requests that any documents or reports regarding evaluation be forwarded to the researchers.

The Barriers to Success portion inquires about specific issues in all areas of ITS deployment. This section is segmented into the areas of planning, design, construction, operations, maintenance, evaluation, and resources, and asks district personnel to respond to statements about their ITS programs. A typical statement in the planning section is "A lack of long-term goals has not allowed for a clear vision of deployment." The districts then labeled this statement as "A Major Concern," "A Concern," or "Not a Concern" with regard to their ITS programs. In addition to this classification, the respondents were asked to provide strategies for overcoming these issues.

The Cost and Existing and Planned Deployment Inventory sections ask the respondents to forward any cost information or inventory maps or lists.

Finally, the Assistance portion asks the respondents to discuss what types of information sharing would be most beneficial to their efforts and asks them how they see the ITS programs in their region developing in future years.

This chapter uses these responses to compare and contrast the districts' methods with one another and with the recommended practices of academic and USDOT-sponsored literature. Best practices are identified from this analysis.

Following the discussion of the deployment practices, a section is devoted to the Lessons Learned and Problem Definitions. This section will first highlight the key areas in which the districts have worked through major obstacles (Lessons Learned) and then develop clear Problem Definitions that outline areas where the districts are still struggling. The content of these sections is, again, based on the survey and telephone interviews.

The chapter is organized in a manner similar to Chapter 2. The TxDOT districts are separated into Metro, Border, Port, and Rural categories to better facilitate discussion.

3.1 METRO DISTRICTS' ISSUES, RECOMMENDED AND BEST PRACTICES

The TxDOT Metro Districts include Austin, Dallas, El Paso, Fort Worth, Houston, and San Antonio. Within the Metro district's grouping, the following discussion is divided into the areas of planning, design, construction, operations and maintenance, and evaluation.

3.1.1 Planning Issues

The ITS early-deployment planning (EDP) process has emerged as a crucial and relatively standard practice. Regional and statewide planning efforts across the country have been developed over the last decade, and many adhere to a similar format. The USDOT recommends working through the following procedure:

- What do we want to do?
  - Involve stakeholders / players;
  - Agree on operations and management goals;
  - Inventory existing conditions.
- How do we do it?
  - Stakeholders / players involved;
  - Develop regional framework;
  - Define operational requirements.
- How do we make it happen?
  - Part of transportation plan and transportation improvement program;

- Agree on regional technologies / responsibilities (24, pp. 3-1, 3-2).

On the national level, the *Oregon ITS Strategic Plan 1997 – 2017* (3), developed in October 1998, does the best job of illustrating this process while adhering to the National Architecture and is a good resource.

While the primary purpose of the planning process is to provide a solid vision and plan for deployment, other benefits gained from the process are often even more valuable. In a USDOT-sponsored report entitled *Discussion of Cross-Cutting Issues* (4), the benefits of bringing together various stakeholders are lauded. The paper reads,

> The regional planning process serves as a catalyst for getting jurisdictions to work together and is an effective tool for promoting continued interaction. It helps participants understand the ITS program, serves as the first opportunity by many to become aware of and involved with ITS, keeps representatives informed of ITS activities of other agencies, and keeps the need for integration present among representatives (4, p. 8).

The *Discussion of Cross-Cutting Issues* report is not alone in making this assessment. Many USDOT-sponsored efforts cite the planning process as a crucial first step in establishing inter-agency cooperation and developing a fully integrated ITS program (25, 26).

Of the six Metro districts within TxDOT, Austin, Dallas, El Paso, and Fort Worth have formal, regional plans, while Houston and San Antonio do not. Table 3.1 summarizes these plans and comments on the effectiveness of the plans in regard to the ITS planning process. The effectiveness is based on survey questions that inquired about how the district felt about to the long-term planning process and the relationships it has formed with the MPO and other organizations involved in ITS planning.

Table 3.1: Summary of Metro Districts' ITS Planning Documents

District	Planning Document	Date	Consultant	Effectiveness
Austin	Austin Area-Wide IVHS Plan and IH-35 Corridor Deployment Plan	Feb. 1998	CTR[1], Wilbur Smith	Low, document failed to provide guiding vision or build solid relationship with transit agency.
Dallas	Dallas Area-Wide Intelligent Transportation Systems Plan	July 1996	TTI[2]	High, survey responses indicated no concern over long-term planning.
El Paso	El Paso Regional ITS Plan	Dec. 1998	None (DOT and city)	Low – Medium, document established a solid vision but quickly became outdated from a technology point of view and failed to build relationship with transit agency.
Fort Worth	Fort Worth Regional Intelligent Transportation Systems Plan	Jan. 1999	TTI	High, survey responses indicated no concern over long-term planning and expressed great confidence in the document.
Houston	No Document	---	---	---
San Antonio	No Document	---	---	---

[1] – Center for Transportation Research at The University of Texas at Austin, [2] – Texas Transportation Institute
Sources: (14), (27), (28), (29).

Houston does not have a formal planning document and is concerned about its lack of vision. Houston personnel have, in the past, utilized consultants during the planning process for individual projects, and they think more time should have been devoted to planning in general. The Houston District heavily involved city, county, and transit agency personnel in the entire TranStar process. This multi-agency approach allowed for solid working relationships among the various groups.

The San Antonio District uses system architecture, traffic volumes, and general needs to drive the placement of future ITS deployment. The strong and consistent leadership in the San Antonio District has allowed for a clear vision of ITS goals.

3.1.2 Planning Lessons Learned and Problem Definitions

Through survey responses and telephone interviews, the Metro districts have provided a great deal of insight as to how they overcame certain obstacles. In the area of planning, the districts have recommended the following strategies to avoid pitfalls.

Lessons Learned:

- **The establishment of a clear vision is crucial to successful ITS deployment;**
- **Involvement of all stakeholders is essential to building an integrated ITS program;**
- **The development of a competent, long-range planning document greatly aids future deployment.**

While the districts have overcome many hurdles in the ITS planning process, difficulties are still present. Half of the Metro districts (Austin, El Paso, and Houston) mentioned concern over their current long-term plans. In some cases, the districts' deployments pre-dated the EDP process. Other times, early deployment plans were developed but did not suit the needs of the district and did not develop working relationships with key stakeholders (such as the transit agencies in Austin and El Paso). In both cases, a useful long-term plan was not developed, and the lack of a plan may impede future deployment. National experience has shown that a key component in building a successful ITS program is the establishment of a unified vision.

Problem Definitions: Long-term plans are not present or are not sufficiently serving the district.

3.1.3 Design Issues

For state DOTs, a primary concern regarding the design of ITS is the decision to outsource. Designing in-house allows the DOT to maintain more control of the system at a lower cost. However, it also requires the DOT design staff to learn the nuances of ITS, often through experience and sometimes through costly mistakes. Such a long learning curve may or may not be overcome through the use of consultants. Consultants may have the experience and knowledge to design ITS properly, but they may not, and if they do not, the DOT will be forced to deal with the resultant, inadequate product.

The USDOT report *Discussion of Cross-Cutting Issues* (4) cited the ability to train and develop a knowledgeable design staff as the key to successful ITS deployment. The same report found local transportation staff to be "in the most dire need of training." (4, p. 26)

The Metro TxDOT districts are facing similar dilemmas and are dealing with these issues in a variety of ways. Austin, Dallas, El Paso, and Houston all stated that a lack of knowledge in their design staff was a "Major Concern" or a "Concern." Furthermore, all the districts who have dealt with consultants (Austin, El Paso, Fort Worth, and Houston) mentioned that the inadequacy of the consultants' plans was a "Major Concern." Table 3.2 summarizes each district's design strategy and concerns.

Table 3.2: Summary of Metro Districts' Design Strategies and Concerns

District	Design Strategy	Strategies to Overcome Design Dilemmas
Austin	▪ Primarily utilize in-house resources; ▪ Use consultants for little more than drafting.	▪ Provide consultants with clear scope of work to build successful relationship; ▪ Design training should be tied to project cost rather than travel budget.
Dallas	▪ Only in-house resources to date.	▪ Issue is with rapidly changing nature of ITS technologies, not a lack of design staff knowledge.
El Paso	▪ Primarily in-house, has used consultants.	▪ Design staff has improved tremendously with experience; district now feels comfortable with staff.
Fort Worth	▪ In-house resources for all projects except software integration.	▪ In dealing with consultants, district learned that the technology best suited to fit local needs may not be the technology suggested by the consultant.
Houston	▪ In-house and consultants used for major projects.	▪ Consultant did not produce satisfactory designs; ▪ District thinks consultants need to train or hire personnel to develop a more competent staff.
San Antonio	▪ In-house.	▪ Keep design engineers involved in the planning process; ▪ Be very selective when choosing a consultant.

Sources: (30), (31), (32).

3.1.4 Design Lessons Learned and Problem Definitions

The Lessons Learned and Problem Definitions in the area of ITS design can be separated into two areas: in-house design and private consulting design.

In the area of in-house design, the districts were split on how comfortable they were with the ability of their design staffs. Austin and Houston were most concerned with the issue, while Dallas considered the dynamic nature of ITS technologies to be the main problem. In the area of Lessons Learned, the districts gave the following advice to help maintain a competent design staff.

Lessons Learned:

- **Keep the design staff involved in planning activities;**
- **Keep initial projects small so design staff can work through any initial problems.**

As mentioned above, the issue of not having a competent in-house design staff has not been resolved by all the districts, especially not by Austin and Houston. As a result, this area can still be considered a problem.

Problem Definition: Districts are struggling to hire, train, and retain quality ITS design staff.

The second area of ITS design involves working with private consulting firms. All the districts that have had experience with consultants (Austin, El Paso, Fort Worth, and Houston) have expressed major concerns over the quality of their work. The following Lessons Learned have been developed from their experiences.

Lessons Learned:

- **Provide consultants with a clear scope of work;**
- **Choose your consultant wisely, and monitor his work carefully.**

No Problem Definitions will be given for this area because the state DOT has limited ability to improve the quality of private consulting work.

3.1.5 Construction Issues

This report will narrow the arena of construction to exclude issues of procurement. The background needed to understand the institutional and regulatory environment of procurement has not been presented in this report so this report will focus on the relationship with DOT staff and construction contractors and on inspection issues. A good resource for those interested in procurement issues is *Innovative Contracting Practices for ITS* (33), written by L. S. Gallegos Associates.

The Metro TxDOT districts are dealing with three major issues pertaining to ITS construction:

- Finding good contractors knowledgeable in ITS;
- Holding these contractors responsible for the components they install; and
- Training and properly utilizing inspection staff.

Because each district has experienced different difficulties in construction issues, a brief paragraph will describe each district's problems and solutions.

The Austin District has had trouble in all of the above areas. It has had contractors provide poor-quality products and be released from their obligations before the low quality was detected. The district also has inspection staff who are new to ITS and who end up taking a lot of the Traffic Operations personnel's time discussing inspection. In dealing with the contractor and procurement issues, Austin recommends that a clear, detailed specification that includes provisions for enforcement be placed into each contract (30, 31).

The Dallas District has had relatively few problems in the area of ITS construction. Highway contractors have subcontracted experienced and adequate ITS contractors to install the ITS components. They did have concerns regarding the low-bid process but thought that more supervision by staff could eliminate any inadequate work. The Dallas District thinks it has experienced and well-trained ITS inspectors.

With its initial deployments in the mid-1990s, the El Paso District had difficulty dealing with large roadway contractors. Now, however, the contractors are subcontracting to knowledgeable ITS firms, and the problems have diminished substantially. In terms of inspection, the Transportation Operation group performs the inspection of the ITS components of roadway construction in coordination with the area engineer. The district feels comfortable with this arrangement and does not expect to adjust the strategy in the future.

The Fort Worth District has had trouble with large construction contractors dealing with ITS, and the Fort Worth personnel think it is the responsibility of the ITS inspectors to ensure that a quality product is produced. The ITS inspector in the Fort Worth District oversees ITS components placed in larger roadway construction projects as well as projects that involve only ITS. Another concern the district has about ITS construction is the use of the low-bid process. The district indicated that this often led to a low-quality product, and it offered the following recommendations and alternative strategies to overcome this problem:

- Qualify ITS/telecommunications contractors;
- Require ISO certification of major component manufactory;
- Proprietary purchase;
- Require extensive testing and training and longer warranties on major components.

The Houston District thought using subcontractors for ITS work and keeping ITS projects separate from roadway projects would be the best strategy for dealing with contractors. Houston did have problems in the area of inspection. For roadway projects with an ITS component, the roadway inspectors, rather than the ITS inspection staff, were often used. Again, keeping the projects separate could solve such problems.

The San Antonio District recommends using pre-qualified contractors for ITS work and continually training the inspection staff. The inspection staff remain in the construction division, but transportation personnel give them ample time to discuss issues.

3.1.6 Construction Lessons Learned and Problem Definitions

As the Metro districts continue to work with ITS projects, they are addressing many of the issues mentioned above. The following Lessons Learned summarize the recommendations of the districts.

Lessons Learned:

- **Keep initial ITS projects small;**
- **Work toward processes other than the low-bid process to ensure that quality components are being installed (pre-qualifying);**
- **Train and re-train ITS inspectors and allow them to monitor contractors' work carefully;**
- **Force contractors to test ITS components thoroughly and allow for adequate testing before acceptance;**
- **Force contractors/vendors to train and re-train operations and maintenance personnel.**

While the districts have overcome many of their construction concerns, problems still exist in this area. In general, the problems center on the low-bid process, which is not serving the needs of the districts. Fortunately, innovative programs, such as pre-qualifying contractors, are being used to overcome these problems.

Problem Definition: The low-bid process does not serve the needs of ITS projects.

3.1.7 Operations and Maintenance Issues

As the ITS in the Metro districts become more mature, an increasing emphasis is being placed on the operations and maintenance (O&M) of the systems. Before actual deployment, little was known about the cost or extent of O&M that would be needed for TMCs and other ITS deployments. TMCs all over the country are now faced with overwhelming O&M costs and little available funding (34).

Ginger Daniels of TTI produced a very comprehensive paper discussing the issues surrounding the O&M of ITS, specifically TMCs, entitled *Guidelines for Funding the Operations and Maintenance of Intelligent Transportation Systems* (34). The paper utilizes metropolitan TxDOT districts as its case study for analysis. The foci of the paper are twofold. First, realistic estimates of the costs of O&M for specific ITS infrastructures are developed. Second, the authors give a thorough overview of the issues and problems facing the O&M of ITS within current DOT policies. The cost tables are excellent and should be a constant reference for all ITS operators within Texas (34).

The report's analysis of O&M operations in Texas and across the U.S. also yielded some interesting results. A survey distributed across the U.S. by the researchers revealed that 50 percent of states reported their current ATMS operating ability to be fair to poor, and 70 percent expected their future maintenance functions to be fair to poor. Reasons cited for such poor performance and expectation centered primarily on funding issues. Generally, state DOTs lump ITS O&M expenses with other transportation O&M needs. And, in the face of deteriorating bridges and other infrastructure, ITS applications are often left out of the picture. Some states are beginning to find more innovative ways to fund O&M. One such method is to utilize contractors to maintain the state's equipment. This strategy utilizes the apparently more abundant contracting dollars, but risks the problem of having multiple vendors working on integrated systems (34). The San Antonio District is currently testing this strategy (8).

Within TxDOT, ITS O&M budgeting has been approached like traffic control device O&M has. A routine budget is provided to the individual local districts. The TTI report concluded that the "final amount allocated to ITS/ATMS O&M depends on the district leadership and the individual working relationship among managers on the district level." (34, p. 55)

The survey for this research found similar results, in that O&M is considered one of the more pressing issues in the Metro districts. When asked in what area there is the greatest need for additional personnel, all six Metro districts indicated operations, maintenance, or both. Table 3.3 summarizes the greatest areas of concern for the Metro districts as well as their proposed solutions to overcome these problems.

It should be noted that the work of SwRI and L-M in association with TxDOT TRF, as discussed in Chapter 2, provides a tremendous amount of support to the Metro districts in working through and solving O&M issues.

Table 3.3: Summary of Metro Districts' O&M Concerns and Solutions

District	Primary Concerns	Proposed Solutions
Austin	▪ Need for standard operating procedure for FMS; ▪ Need for quicker processing of purchase requests; ▪ Change in accounting structure; ▪ ITS technician training.	▪ Separate operations and maintenance in a clear fashion within TxDOT accounting system; ▪ Establish comprehensive training course for ITS technicians.
Dallas	▪ None.	▪ Anticipates need for additional personnel as system matures.
El Paso	▪ Needs additional personnel in Operations and Maintenance.	▪ While personnel are available and easily trained, the resources are not available for the district to hire.
Fort Worth	▪ Experienced difficulty in operating software.	▪ Include user interface that district will be comfortable with in software specifications; ▪ Force vendor to offer initial and continuous training for the life of the software.
Houston	▪ None.	▪ None.
San Antonio	▪ Anticipates need for additional personnel in the future.	▪ Current practice of contracting out maintenance for video wall, LCS[1], AVI[2], and kiosks is working well.

[1] – Lane Control Signals, [2] – Advanced Vehicle Identification, Sources: (8), (30), (31), (32)

3.1.8 Operations and Maintenance Lessons Learned and Problem Definitions

The operations, management, and maintenance of ITS are quickly becoming the most important area of ITS deployment. For the TxDOT Metro districts, the following Lessons Learned should be noted.

Lessons Learned:

- **Plan for the financing of operations and maintenance before the project is constructed;**
- **Work toward more creative funding arrangements, such as contracting maintenance of various components.**

As mentioned above, the area of O&M is becoming the primary area of concern for all Metro TxDOT districts. When asked the question, "In what area is there the greatest need for additional personnel?", all six districts indicated operations, maintenance, or both. The districts also mentioned that they were struggling to fund the O&M needs in their districts properly and that they were having difficulty properly tracking these expenses within the TxDOT accounting structure.

Problem Definition: The current personnel levels and funding structure are not meeting the operations and maintenance needs of the districts.

3.1.9 Evaluation Issues

The evaluation of ITS projects is an important aspect of the overall deployment process. ITS evaluations should be done to

- "Understand the impacts;
- Quantify the benefits;
- Help make future investment decisions;
- Optimize existing system operation or design." (35, p. 3)

These processes follow an evolutionary pattern. Under the umbrella of "Understanding the Impacts," the first step is to "quantify the benefits" to demonstrate the worthiness of ITS to decision-makers. As ITS becomes accepted by decision-makers, their evaluation must continue in order to determine which ITS strategies are most beneficial. As preferred ITS applications emerge, their evaluation must continue to determine optimal design and operating strategies (35).

On the national level, many metrics have been developed which devise strategies for properly evaluating ITS. In general, they work from pre-established transportation goals (i.e., safety, mobility) set measures that relate to those goals (i.e., time savings) determine which data can properly enumerate those measures (i.e., average speed) and then determine methods for collecting data (e.g., radar guns). USDOT has established a few good measures that consist of relatively easily collected data that still have the ability to illustrate the success of ITS (36). These “few good measures” are

- Crashes,
- Fatalities,
- Travel time,
- Throughput,
- User satisfaction or acceptance, and
- Cost (36).

In 1999, Shawn Turner and Bill Stockton of TTI developed an evaluation metric specific to Texas, entitled *A Proposed ITS Evaluation Framework for Texas* (35). Because this report is intended to provide guidance in the area of evaluation for TxDOT districts, it will be reviewed in some detail here.

The report follows the established methodology of relating ITS benefits to established transportation goals and then develops measures to demonstrate progress toward these goals. The goals, in this case, are the Texas Transportation Goals. Table 3.4 lists the Texas Transportation Goals along with a partial listing of measures that relate to these goals.

Table 3.4: Texas Transportation Goals and Related Evaluation Measures

Texas Transportation Goal	Measures
Mobility and Accessibility	▪ **Travel time savings**[1] ▪ **Customer satisfaction**[1] ▪ **Vehicle operating costs**[1] ▪ Congestion levels ▪ Number of trips taken ▪ Percentage of population within “x” minutes travel of employment center
Effectiveness and Efficiency	▪ **Throughput**[1] ▪ Benefit/cost ratio ▪ Cost per new person-trip ▪ Vehicle-hours of delay ▪ Number of stops
Choice and Connectivity	▪ Ability to choose convenient alternative modes ▪ Intermodal transfer time ▪ Schedule adherence
Safety	▪ **Number and severity of crashes**[1] ▪ **Number of fatalities**[1] ▪ Number of vehicle thefts
Environmental and Social Sensitivity	▪ Mobile source emissions level ▪ Energy / fuel consumption ▪ Noise pollution
Economic Growth and International Trade	▪ **Travel time savings**[1] ▪ **Operating cost savings**[1] ▪ **Administrative and regulatory cost savings**[1] ▪ Manpower savings

[1] – Measure included in the USDOT “few good measures” list.
Source: Adapted from *A Proposed ITS Evaluation Framework for Texas* (35).

The framework developed in the TTI report recommends that the following steps be taken for the proper evaluation of ITS:

- Step 1: Identify Market Packages planned for deployment that will be evaluated;
- Step 2: Identify goals in which the Market Packages have expected benefits;
- Step 3: Cross-reference goals and select appropriate evaluation measures;

- Step 4: Based on local deployment, define specific data items and collection/estimation methods (35, pp. 22–23).

In addition to establishing these methodologies, the report also comments on the importance of taking data on "before" conditions. Often, the actual ITS serves to collect the data that are needed. Thus, taking traditional "before" measures is impossible. However, in the period of time during acceptance testing, "before" conditions data could and should be collected and archived properly. This will allow for proper calibration of simulation models, which could then be used for measuring the impacts of the ITS project as a whole (35).

A Proposed ITS Evaluation Framework for Texas is still in the development stage within TxDOT, and, as a result, districts have been evaluating ITS in a variety of ways. In addition to examining this type of system-wide evaluation, the following discussion will address the methods used to evaluate the performance of individual ITS components, such as loop detectors.

The Austin District is currently in the ideal situation for collecting "before" condition data. It has installed a significant amount of surveillance and detection infrastructure but has yet to come on-line with extensive information dissemination and incident management. Currently, staff are working on collecting "before" data and trying to determine the accuracy of the equipment. The Austin District has experienced a lot of difficulty with this task. The primary challenge has been attempting to validate data collected by loop detectors. This problem needs to be resolved before the district begins to develop system-wide evaluation procedures. The ultimate goal in the Austin District is to collect data that can easily be entered into a simulation model, such as CORSIM, for analysis (30). To date, no formal reports have been produced evaluating Austin's ITS.

The Dallas District is in a relatively similar stage of deployment as the Austin District, but it has not experienced the same problems with component evaluation. The district personnel stated that they had adequate testing procedures for ensuring that the components performed properly and mentioned that the project designer stayed with the project through its construction. In terms of system evaluation, the Dallas District has yet to perform any formal evaluation.

The El Paso District had difficulties with component performance with its initial systems, but it has had fewer problems with its more recent deployments. The district utilizes two full-time maintenance personnel to ensure that the components are operating properly. The overall system in El Paso is just now coming on-line, and, as a result, the district has yet to put a formal evaluation procedure in place.

The Fort Worth District is satisfied with its component evaluation strategies, which consist of using CCTV cameras and traffic counters to verify loop performance laser guns to check speed outputs and "light meters" to measure the intensity of DMS lights. Also, the district referenced the work done by Gerald Ullman of TTI, who developed guidelines for the use of lane control signals (LCS) by testing the effectiveness and comprehension of various LCS schemes in a laboratory setting (37). In terms of system-wide evaluation, the district is currently developing a Measure of Effectiveness (MOE) algorithm to use on its ITS. In addition, it uses courtesy patrol and incident management logbooks to evaluate how the system has improved the performance of the network.

The TranStar system in Houston, while a mature TMC, has also experienced problems in determining the reliability of individual components, and personnel said such issues were a "Major Concern" in their district. However, the district simply saw these problems as the nature of the available technology.

In terms of system-wide evaluation, the Houston District, although missing key elements of the system, was formally evaluated by TTI in 1997–98 (38). The study used basic measures to assess the impacts of the TranStar system. First, the congestion level in the area was assessed using advanced vehicle identification (AVI) data and TxDOT volume-roadway annual inventory files. Second, the TranStar agency managers were asked to assess the program by rating various deployments as they achieved, or failed to achieve, established goals. The report then quantified congestion benefits in dollar amounts using standard techniques. The goal was to establish a simple framework so that the TranStar system could be updated on an annual basis using similar methods (38).

In addition to the evaluation of the TranStar system as a whole, the HOV lanes in Houston have also been analyzed. TTI documented the benefits of the HOV system in a 1999 report (39). As analysis of HOV lanes is a well-documented and essentially separate field, the methodology of that report and other HOV reports will not be discussed in this research.

The San Antonio District has approached the issue of component evaluation in a very comprehensive and intelligent manner. It has three levels of measuring performance before it selects and approves the construction contract. First, the district tests vendor equipment it is interested in purchasing. Once the equipment has passed a laboratory test and is placed in the ground, the contractor is responsible for testing the component. The procedure and results of this testing must be documented, and the district is heavily involved in this testing process. Finally, the entire system is tested to ensure that the components are working with the system as a whole. The district would like to see more vendor equipment testing done at the state level through the Traffic Operations (TRF) division.

The San Antonio District has been evaluated by many entities as part of the MDI program. While a variety of reports have been produced that discuss the issues and difficulties faced with the MDIs, the one that speaks most directly to the issue of evaluation is the *Metropolitan Model Deployment Initiative: National Evaluation Strategy* (40), produced by the FHWA and USDOT in November 1998 (4, 25). This document evaluates all four MDI projects, which were developed in New York/New Jersey/Connecticut, Phoenix, Seattle, and San Antonio. The report evaluates the project by first separating the deployments into the following groups (* indicates San Antonio MDI included in the component):

- Traffic signal control*,
- Freeway management*,
- Incident management,

- Electronic toll collection,
- Emergency management*,
- Transit management*,
- Electronic fare payment,
- Railroad grade crossing*, and
- Traveler information systems*.

Within these categories, the deployments are evaluated in terms of six study areas: safety, energy and emissions, operational efficiency, benefit-cost ratio, customer satisfaction, and institutional benefits. An expert in each of these areas (personnel from USDOT, FHWA, Volpe Center, and Mitretek Systems) led the evaluation. Most often, the study areas used output measures from the “few good measures” list in addition to more qualitative assessments by the expert in each area (40).

Russell Henk et al. of TTI also analyzed the San Antonio system in a 1996 report entitled “Before-and-After Analysis of the San Antonio TransGuide System.” (41) This paper utilized accident data and video image measures of response time as inputs to the CORFLO simulator to produce a variety of evaluation measures (41).

In terms of applicability to TxDOT deployments, the TTI report *A Proposed ITS Evaluation Framework for Texas* (35) stands as an example of a best practice. The document relates the evaluation procedures to the National Architecture Market Packages and provides a variety of effectiveness measures, all of which relate directly to the established Texas Transportation Goals. In the field of component evaluation, the districts are encouraged to share successful and unsuccessful practices with one another in an effort to eliminate any future delays.

3.1.10 Evaluation Lessons Learned and Problem Definitions

To date, the Metro districts have addressed and largely overcome their obstacles related to component evaluation.

Lessons Learned:

- **Develop formal procedures for the evaluation of ITS components such as DMS, loop or other detectors, LCS, and cameras.**

In the area of system-wide evaluation, many districts are either struggling to develop robust evaluation procedures or have yet to address the issue of evaluation. A well-defined evaluation procedure will allow districts to justify ITS expenditures and eventually help the districts develop more efficient ITS operating strategies. The authors hope the report *A Proposed ITS Evaluation Framework for Texas* (35) will assist the Metro districts in accomplishing this task.

Problem Definition: There is not a well-defined methodology for the evaluation of ITS.

3.1.11 Resources Issues

Uniform within the six Metro districts is the need for more money for ITS activity as well as the need for more qualified personnel. While there is no real solution for not having an endless monetary supply, much research has been devoted to the need for more qualified personnel in the ITS field.

Traditionally, transportation professionals have had training rooted in civil engineering. While such training provides adequate background for all types of structural analysis and infrastructure management, civil engineers typically do not have the systems integration and electrical engineering background often necessary in the ITS field. As a result, USDOT initiated a series of reports entitled *Building Professional Capacity in ITS* (42). The goal of these reports was to assist transportation agencies in identifying training and education needs, and to provide guidelines for staffing ITS teams. The reports are a good source of information about what types of personnel are needed in the ITS field (42).

In the TxDOT Metro districts, the problem is not identifying what types of personnel are needed, but having the ability to hire such personnel in the face of higher-paying competition in the form of consulting firms. While most surveyed districts mentioned the need for more funding, the districts more uniformly mentioned the need for additional personnel. While hiring additional personnel is often a monetary issue, some strategies documented in literature attempt to overcome this problem.

A USDOT-sponsored report, *Intelligent Transportation Systems (ITS) Program: Analysis of USDOT-Sponsored Reports on Non-Technical Issues* (26), did offer some recommendations to USDOT on such matters. It recommended that USDOT "should encourage the inclusion of ITS-related subjects and subject matter into existing curricula through any means at its disposal." (26, p. 76) TxDOT is a major presence in two of the nation's leading transportation engineering schools, The University of Texas at Austin and Texas A&M University. Perhaps some of the ample funding TxDOT provides these schools for research could be put into educating students about the technical and institutional issues of ITS. While there is no guarantee that these students would then take this knowledge to a TxDOT job, a few might, and the overall benefits might be worth the relatively small investment such a program would require.

Another recommendation in the above report was that USDOT "gather and analyze data to measure the level of public support for ITS, including willingness to pay, in order to come to an informed decision regarding appropriate strategies for ITS development." (26, p. 82) Perhaps further promotion of Texas' diverse ITS program would generate greater public support and perhaps even a willingness to pay among the public.

3.1.12 Resources Lessons Learned and Problem Definitions

The majority of Lessons Learned relating to resources, such as the importance of carefully planning for the monetary allocation of operations and maintenance, have already been mentioned in other sections. The one Lesson Learned not covered in previous areas pertains to the use of creative financing through partnering agreements.

Lessons Learned:

- **Search for public and private partners to ease the financial burden of ITS.**

The Metro districts are still struggling to overcome their need for more funding and additional personnel. With the exception of the San Antonio District, all the Metro districts said additional funds were needed to adequately deploy ITS in their regions. Furthermore, additional staff are needed to maintain the ITS currently deployed.

Problem Definition: Metro districts are in need of additional full-time personnel to help manage, operate, and maintain their ITS and are in need of additional funds to deploy needed ITS in their regions.

3.2 BORDER DISTRICTS' ISSUES, RECOMMENDED AND BEST PRACTICES

This report segmented TxDOT districts located along the U.S.–Mexico border because of the special opportunities available in these regions. Every day, hundreds of personal and commercial vehicles cross the border and enter border cities. In addition to managing this traffic, the districts must deal with a variety of national and international agencies, including officials from Mexico.

When speaking of current deployments and best practices regarding to ITS at international border crossings, one must first speak about Texas. Texas Border districts have emerged as the national leaders in border ITS applications. As such, the districts of El Paso, Laredo, and Pharr should be applauded for their efforts.

As discussed in Chapter 2, Laredo is developing a regional ITS vision, which includes the cities of Laredo and Del Rio. The district is including a wide variety of public- and private-sector entities in the project, including national government organizations and trucking associations.

On a smaller scale, the Pharr District is following in the intelligent footsteps of its neighboring district, Laredo. Pharr has already tested small ITS deployments and is now beginning to formulate a formal ITS plan.

In general, the two districts are approaching ITS in an intelligent, rational manner with federally funded operational tests and planning programs that take a regional approach and include a variety of stakeholders.

3.2.1 Border Districts' Lessons Learned and Problem Definitions

The Border districts have been deploying ITS in a competent manner thus far and have learned the following lessons.

Lessons Learned:

- **The use of federally funded operational tests can jumpstart an ITS program;**
- **ITS in a rural setting can, and should, take an integrated, regional approach.**

The problems still prevalent in the Border regions involve the myriad institutional issues involving agencies from both the U.S. and Mexico. These institutional issues must continue to be addressed and overcome for the ITS program in the area to flourish.

Problem Definition: Institutional/jurisdictional issues continue to exist along the U.S.–Mexico border.

3.3 PORT DISTRICTS' ISSUES, RECOMMENDED AND BEST PRACTICES

In many respects, Port regions face challenges similar to those of their Border counterparts. They must deal with a large volume of commercial traffic originating from an isolated source, and they must contend with a variety of agencies, both public and private. With ITS applications, again, many similarities are present. Both Border and Port regions hope to make crossing the gateway from the port or border a seamless process and may engage many similar technologies to do so. Port regions, however, have not benefited from the extensive operational tests that have recently emerged along our international borders. A few projects have been launched to better exploit the opportunities available at ports because it is predicted that marine trade will triple during the next twenty years (14).

An example of a marine ITS freight application is underway in Seattle, Washington. The project is a partnership among Sea-Land, Port of Tacoma, Washington Trucking Association, and the Puget Sound Regional Council. The project will tag 10,000 containers and trailers with disposable electronic seals. The tags will contain the "manifest information, gate release/arrival times, route plans, and other information that will allow the containers/trailers to be used as a traffic probe for freight planning purposes." (14, p. 340) Other elements of the system are Internet traffic updates and video surveillance at port gates. The ultimate goal of the project is to "allow freight information to flow in advance of the physical movement of freight, and for this information to arrive at every checkpoint along the way in advance of the truck conveyance." (14, p.338)

As discussed in Chapter 2, no ITS activity is reported in the Port districts of Beaumont and Yoakum, and ITS activity in Corpus Christi is centered on traffic management and does not involve any port organizations other than refinery fire personnel. However, Corpus Christi is exploiting its location along the Gulf of Mexico and hopes to use ITS to help evacuate citizens when a hurricane is near the coast. In Houston, the Port Authority is investigating ways to scan container tags automatically and is in the process of updating its computer systems (43). However, there is no formal working relationship between the state DOT and the Port Authority, as far as ITS are concerned in either Corpus Christi or Houston.

3.3.1 Port Districts' Lessons Learned and Problem Definitions

To date, very few Port districts are involved with ITS. As a result, few lessons can be developed other than one from the work in Corpus Christi, which has demonstrated the following.

Lessons Learned:

- **Freeway management systems can be planned to perform unconventional services, such as expediting hurricane evacuation procedures.**

The key problem that still exists in the port region is the lack of coordination between state DOT ITS personnel and port authorities. Other than refinery emergency personnel, the Port Authority in Corpus Christi does not play a role in the ITS program. Although Houston is categorized as a Metro district in this report, it also demonstrates this negligence. While the city, county, and transit agency play a large role in the TranStar system, the Port Authority is not involved.

Problem Definition: There is a lack of working relationships between DOT ITS personnel and regional port authorities.

3.4 RURAL DISTRICTS' ISSUES, RECOMMENDED AND BEST PRACTICES

As TMCs emerge across the country, ITS are often most closely associated with urban traffic management. Such an association is unfortunate because some of the more interesting and useful ITS projects occur in the rural environment. In recent years, rural ITS programs have gained more recognition on the national level because major projects are being deployed. These projects cover a broad array of purposes, from communicating bad weather warnings to commercial vehicles, to alerting tourists to the location of the nearest fast-food restaurant.

To assist in the deployment of rural systems, the FHWA and USDOT have organized rural ITS into seven clusters (14). These clusters include the following:

- Traveler Safety and Security – Alerting drivers to hazards; includes area-wide dissemination and particular site warnings and advisories;
- Emergency Services – Improving emergency response in remote locations;
- Tourism and Traveler Information Services – Providing travelers unfamiliar with the area with information;
- Public Traveler Services/Public Mobility Services – Improving the accessibility of transit services to rural residents;
- Infrastructure Operations and Maintenance – Technologies that improve these operations by detecting severe weather or failure during construction and maintenance;

- Fleet Operations and Maintenance – Improvements to vehicles such as snowplows, rural transit vehicles, and law enforcement;
- Commercial Vehicle Systems – A myriad of applications that improve everything from scheduling to safety to locating (14, pp. 242–243).

In addition to such organizational assistance, a wealth of other information regarding rural ITS projects is available from USDOT. Other useful reports include the *U.S. Department of Transportation ITS Projects Book* (14), which outlines projects completed to date and gives useful cost and contact information. Additionally, the Advanced Rural Transportation Systems Compendium has summarized more than 200 low-cost and low-technology ITS applications in rural settings in its publication entitled *Technology in Rural Transportation: Simple Solutions* (44). Finally, Mitretek's report, *Intelligent Transportation Systems Benefits: 1999 Update* (45), contains a section that summarizes some of the reported benefits of these rural systems.

While rural activity is blossoming in some states, it is still rather scarce in Texas. As stated in Chapter 2 of this report, the survey for this research revealed very little ITS activity taking place in rural Texas, with only one district undertaking a formal planning process and only a handful of districts engaging in any type of deployment.

Although the level of activity in Texas was uniformly low, the attitudes toward ITS varied greatly. A few engineers in rural districts responded to the survey or phone interview with excitement and energy about ITS. They mentioned that ITS do not play a prominent role today, but that they hoped the future would bring ITS applications. Often, these districts engage in small ITS projects such as video detection. In general, the districts desired more information about rural ITS applications and placed a heavy emphasis on having an established evaluation methodology to develop benefit-cost ratios to validate ITS.

An example of such a district is San Angelo. The San Angelo District has experienced many problems with the operations and maintenance of its video detection system, and these incidents have soured its attitude toward ITS. The district cited the lack of an established evaluation methodology, which would lead to a realistic benefit-cost ratio, as the primary reason to avoid future ITS applications. The authors hope the evaluation discussion in this report can aid this district.

While some districts struggled with small ITS deployments, other districts had seemingly little interest in ITS. Typically, district personnel said that low traffic volumes did not warrant the use of ITS in their regions.

The question for these districts to answer is whether any ITS applications can be useful in their districts. And, to answer this question honestly, the decision-makers in rural communities must continue to educate themselves about the possibilities of ITS. In the case of rural ITS, Rural TxDOT districts may have to look beyond the state borders for information and guidance. The surveys revealed that a primary source of information about ITS was neighboring, more populated districts. While such information-sharing is important, districts must continue to look outside the borders of Texas as well. The tailored nature of rural ITS applications makes a broader information base even more important.

As an alternative to district-level deployment, TxDOT may want to take action at the state level. Currently, the state of Arizona is moving toward building an integrated statewide system that incorporates many of its rural areas (46). In the survey for this research, one Rural district stated its desire for such a program in Texas.

3.4.1 Rural Districts' Lessons Learned and Problem Definitions

The Amarillo district has benefited from its formal planning process, and that process can be considered a Lesson Learned.

Lessons Learned:

- **Follow the formal ITS planning process in rural regions.**

Concerning the problems present in the rural communities, the key need is for a common vision among Rural districts. As discussed in some detail previously, there is a wide variety of opinions and attitudes regarding ITS among TxDOT's Rural district personnel. While a handful of districts are excited about and experimenting with ITS applications, many districts think ITS are tools exclusively for urban use. Presently, such ITS applications as communicating serious weather conditions to travelers and improving the operation of highway–rail intersections are making rural communities safer. TxDOT leadership is needed to bring similar programs to Texas. With any new innovation, a leader or champion is needed to carry the program forward in the early stages of deployment. Such champions are needed to push rural ITS forward in Texas. In the future, a lack of interest in ITS may hinder the development of statewide traveler information and safety programs.

Problem Definition: Great disparities are present in Rural decision-makers' attitudes and interest in ITS; few local ITS champions exist in Rural districts.

Those districts that have experimented with ITS expressed concern about evaluating their systems. Rural districts typically have much smaller budgets than their Metro counterparts and, as a result, have fewer funds to use on experimental programs. Without a robust evaluation methodology translating directly to a solid benefit–cost ratio, Rural districts may continue to be wary of ITS. Again, it is hoped the *A Proposed ITS Evaluation Framework for Texas* (35) report assists the districts in developing evaluation procedures.

Problem Definition: There is not a well-defined methodology for the evaluation of ITS.

3.5 SUMMARY

This chapter has demonstrated the wide variety of techniques and approaches being used to deploy ITS in Texas. These techniques are often in line with the recommended procedures of USDOT. Furthermore, the chapter has brought forth many of the issues the ITS program has overcome and many it is still dealing with. The authors hope this discussion will allow decision-makers to better understand the issues and concerns currently present in the TxDOT districts, and that districts new to ITS can learn from the experiences of their peers.

CHAPTER 4: SUMMARY AND CONCLUSIONS

4.1 SUMMARY

The three objectives of this report are as follows: summarize ITS activity in Texas, discuss the issues prevalent in all aspects of ITS deployment in Texas, and develop formal Lessons Learned and Problem Definitions, which capture the primary difficulties in dealing with these issues.

The level of ITS activity in Texas was found to be diverse and growing. For organizational purposes, the TxDOT districts were segmented into the following four categories: Metro, Border, Port, and Rural. The Metro districts include the districts commonly referred to as the "Big Six:" Austin, Dallas, El Paso, Fort Worth, Houston, and San Antonio. The Border districts share an international border with Mexico and include Laredo, Odessa, and Pharr. The Port districts are located on Texas' Gulf coast and include Corpus Christi, Yoakum, and Beaumont. The remaining districts are lumped together in the Rural category. These districts are: Abilene, Amarillo, Atlanta, Brownwood, Bryan, Childress, Lubbock, Lufkin, Paris, San Angelo, Tyler, Waco, and Wichita Falls.

The Metro districts were all found to have significant ITS deployments. Each district either has or is developing a comprehensive FMS and, in general, has included transit agencies and emergency personnel in its efforts. In addition to FMS, the districts are exploring more innovative ITS such as demand responsive transit in Dallas, commercial vehicle electronic clearance operational tests in El Paso, and ambulance-doctor video conferencing in San Antonio.

The Border districts are also heavily involved in ITS. The Laredo District, home of North America's busiest in-land port, is currently engaged in an operational test to evaluate CVO electronic clearance and is developing linked transportation management centers in the cities of Laredo and Del Rio. Also, the Pharr District is currently working on a Regional ITS Plan in the hopes of developing a TMC.

The Port districts are less active than the Metro and Border districts but do have some interesting programs underway. The Corpus Christi District is developing an FMS, which, in addition to managing the freeway networks, will expedite hurricane evacuation.

The districts in rural Texas are lagging behind their urban counterparts in ITS deployment, but there are signs of progress. The Amarillo District has developed an ITS Regional Plan to address its need for a rural weather monitoring system. Other districts have expressed interest in ITS and have been experimenting with video detection.

The second objective of the report was to provide a summary of the more prevalent issues affecting ITS deployment within TxDOT. Again, this discussion was aided by separating the districts into the categories of Metro, Border, Port and Rural.

The issues the Metro TxDOT districts were currently dealing with pertaining to ITS deployment were separated into the categories of planning, design, construction, operations and maintenance, and evaluation. The report provides a summary of the way each district approaches the above areas of ITS deployment. When appropriate, academic and USDOT-sponsored literature was used to provide a basis for discussion.

Additionally, best practices were identified in some areas, as warranted. In general, it was found that districts new to ITS were most concerned with planning and construction, while the more mature districts focused more on operations and maintenance. However, all the districts were wary of future operations and maintenance problems.

Significantly briefer discussions were provided for the Border, Port, and Rural districts. The Border section focused on the positive approaches the districts are taking toward ITS by developing a regional plan and utilizing federal operational tests as a means of encouraging ITS deployment. The Border regions are a good example of intelligent deployment practice within the state and nationwide.

Because little activity is currently present in the Port and Rural districts, this section of the report provided information regarding operational tests and rural applications, as well as useful resources to aid in future deployments. It is hoped that this section will act as an informational source for these districts.

In addition to this discussion of deployment methodologies, Chapter 3 provided a short list of Lessons Learned and Problem Definitions that summarize the more pressing needs of the ITS program at both the state and district level. The Lessons Learned highlight the key areas in which the districts have worked through major obstacles, and the Problem Definitions outline areas where the districts are still struggling. The Lessons Learned and Problem Definitions are segmented into the four general categories of Metro, Border, Port and Rural.

- Metro Districts' Lessons Learned and Problem Definitions:

Planning Lessons Learned

- The establishment of a clear vision is crucial to successful ITS deployment;
- Involvement of all stakeholders is essential to building an integrated ITS program;
- The development of a competent, long-range planning document greatly aids future deployment.

Planning Problem Definitions

- Long-term plans are not present, or are not sufficiently serving the district.

Design Lessons Learned

- Keep the design staff involved in planning activities;
- Keep initial projects small so design staff can work through any initial problems;
- Provide consultants with a clear scope of the work;
- Choose a consultant wisely and monitor his work carefully.

Design Problem Definitions

- Districts are struggling to hire, train, and retain quality ITS design staff.

Construction Lessons Learned

- Keep initial ITS projects small;

- Work toward processes other than the low-bid process to ensure that quality components are being installed (pre-qualifying);
- Train and re-train ITS inspectors and allow them to monitor contractors' work carefully;
- Force contractors to test ITS components thoroughly and allow for adequate testing before acceptance;
- Force contractors/vendors to train and re-train operations and maintenance personnel.

Construction Problem Definitions

- The low-bid process does not serve the needs of ITS projects.

Operations and Maintenance Lessons Learned

- Plan for the financing of operations and maintenance before the project is constructed;
- Work toward more creative funding arrangements such as contracting maintenance of various components.

Operations and Maintenance Problem Definitions

- The current personnel levels and the funding structure are not meeting the operations and maintenance needs of the districts.

Evaluation Lessons Learned

- Develop formal procedures for the evaluation of ITS components such as DMS, loop or other detectors, lane control signs (LCS), and cameras.

Evaluation Problem Definitions

- There is not a well-defined methodology for the system-wide evaluation of ITS.

Resources Lessons Learned

- Search for public and private partners to ease the financial burden of ITS deployment.

Resources Problem Definitions

- Metro districts are in need of additional full-time personnel to help manage, operate, and maintain their ITS, and they are in need of additional funds to deploy needed ITS in their regions.

- Border Districts’ Lessons Learned and Problem Definitions:

Lessons Learned

- The use of federally funded operational tests can jumpstart an ITS program.
- ITS in a rural setting can and should take an integrated, regional approach.

Problem Definitions

- Institutional/jurisdictional issues continue to exist along the U.S.–Mexico border.

- Port Districts’ Lessons Learned and Problem Definitions:

Lessons Learned

- Freeway management systems can be planned to perform unconventional services, such as expediting hurricane evacuation procedures.

Problem Definitions

- There is a lack of working relationships between DOT ITS personnel and regional port authorities.

- Rural Districts’ Lessons Learned and Problem Definitions:

Lessons Learned

- Follow the formal ITS planning process in rural regions.

Problem Definitions

- Great disparities are present in rural decision-makers’ attitudes and interest in ITS; few local ITS champions exist in Rural districts;
- There is not a well-defined methodology for the evaluation of ITS.

4.2 CONCLUSIONS

In general, the context of the Texas Department of Transportation provides a diverse ITS environment in which each district is given considerable leeway in deciding what’s best for its region. This has led to a variety of practices and approaches in dealing with a variety of issues. Such an environment is beneficial because each region can experiment on its own and share its knowledge with other districts and TRF personnel. In this strategy, best practices are bound to emerge, albeit through some iterative and costly processes.

The opportunity for future ITS applications in Texas is great. Many urban areas are just beginning to understand the powerful benefits of providing timely and useful information to travelers and management personnel. Partnering agreements and integration efforts are continually improving the urban systems. The border regions are making impressive strides as well, which may lead to a safe and seamless border with

Mexico. And the diverse rural environment is ripe with potential, just waiting to be identified and filled with ITS applications.

APPENDIX A
SURVEY FORM

ITS Inventory Survey

I. Purpose

The purpose of this survey is to assist TxDOT in the development of a comprehensive Intelligent Transportation System (ITS) inventory of current and planned deployments in each TxDOT district. This inventory will then be used to update TxDOT's ITS Deployment Plan and Strategy. It will also aid in identifying resources or expertise that could be valuable in other districts in future deployments.

II. Planning

Does your district have a position whose primary responsibility is ITS planning (i.e., separate from a roadway/general planning or ITS design group)?

Who is the appropriate district contact for ITS planning?

Is there a document unique to your district that guides ITS deployment or outlines goals (short- and long-term) of your district's ITS program? Are copies of these documents readily available?

Do any TxDOT individuals or documents (e.g., TxDOT's ITS Deployment Strategy) assist the district in planning? If so, whom or what?

Do outside consultants aid in the planning process or have they in the past?

Do ITS vendors aid in the planning process?

Other comments about the planning aspect of ITS:

III. Design

Is there a separate district contact that is in charge of the design of ITS systems?

Is the design of any specific ITS system done "in-house" at the district level?

If so, are any guiding documents/handbooks/manuals used in the design process?

Which consulting firms have been used to design your district's ITS systems?

Have specific ITS vendors been influential or helpful in the design process? If so, which vendors, and in what capacity have they been of assistance?

IV. Construction

Who (person or group) in your district is responsible for overseeing the construction of ITS systems?

Would a training program for ITS inspection benefit the inspectors in your district? Or would additional inspection staff be more beneficial?

Have any contractors been especially good or poor at installing ITS components?

Other comments about the construction of ITS systems:

V. Evaluation

What method, if any, do you use to evaluate the performance of ITS components? The means evaluating not the ITS system but individual components, e.g., testing the accuracy of loop detectors in measuring occupancy or speed.

Is there a specific mechanism used for evaluating the success of ITS systems/projects?

Have any reports been produced which evaluate the impact of individual ITS projects in your district?

Have consultants been hired to assist in the evaluation process? If so, who has been hired, and have reports been produced?

Have other TxDOT personnel or the use of documents aided in this process?

Are the reports outlining the process used in evaluation, and are the specific reports on evaluating projects readily available?

VI. Barriers to Success

During the deployment process, many obstacles appear which hinder the success of ITS. In this section of the survey, we wish to identify those specific Barriers to Success. Such barriers can be present at any point in the deployment process, from planning to operations. We ask that you reply to the below Barriers to Success in three ways:

1. Please rate each barrier according to how it has affected your district by circling a “major concern,” “a concern,” or “not a concern.” Any additional comments are also very much appreciated.

2. After discussing each barrier, please provide any strategies or mechanisms for overcoming, or attempting to overcome the specific barrier.

3. Last, and most importantly, please provide any additional Barriers to Success that your district has experienced with the deployment of ITS.

Planning Barriers

1. A lack of long-term goals has not allowed for a clear vision of deployment.

Major Concern / A Concern / Not a Concern

Strategy for dealing with above barrier:

2. We simply were not aware of many ITS applications during the early stages of the planning process.

Major Concern / A Concern / Not a Concern

Strategy for dealing with above barrier:

3. Conflicts with the metropolitan planning organization (MPO) or other organizations have hindered the planning process.

Major Concern / A Concern / Not a Concern

Strategy for dealing with above barrier:

4. Political opposition to ITS has hindered deployment.

Major Concern / A Concern / Not a Concern

Strategy for dealing with above barrier:

5. The lack of mainstreaming of ITS into the general planning process has not allowed ITS to become a viable option.

Major Concern / A Concern / Not a Concern

Strategy for dealing with above barrier:

Design Barriers

6. There is a lack of knowledge on the part of our staff in the area of ITS design.

Major Concern / A Concern / Not a Concern

Strategy for dealing with above barrier:

7. Designs presented by consultants have been inadequate and have caused the district to spend additional time adjusting plans.

Major Concern / A Concern / Not a Concern

Strategy for dealing with above barrier:

Construction Barriers

8. General contractors are not knowledgeable enough to allow ITS components to be placed in a larger construction project.

Major Concern / A Concern / Not a Concern

Strategy for dealing with above barrier:

9. Contractors hired specifically for ITS projects have not provided a quality product.

Major Concern / A Concern / Not a Concern

Strategy for dealing with above barrier:

10. There are no contractors in our area who are capable or willing to build ITS.

Major Concern / A Concern / Not a Concern

Strategy for dealing with above barrier:

11. The construction inspectors on staff are not knowledgeable enough to inspect ITS projects properly.

Major Concern / A Concern / Not a Concern

Strategy for dealing with above barrier:

12. The inspectors and construction division end up taking much of the traffic division's time in discussing construction.

Major Concern / A Concern / Not a Concern

Strategy for dealing with above barrier:

13. There is no mechanism available for forcing contractors to be responsible for the quality of the ITS component. A project is often accepted before adequate testing can be done to ensure the quality of the product.

Major Concern / A Concern / Not a Concern

Strategy for dealing with above barrier:

Evaluation Barriers

14. Once the components are in the ground, there is no way to test the reliability of the parts (e.g., loops) without extensive effort on the part of the traffic division.

Major Concern / A Concern / Not a Concern

Strategy for dealing with above barrier:

15. We have no set methodology for evaluating projects in order to improve the quality of the next deployment.

Major Concern / A Concern / Not a Concern

Strategy for dealing with above barrier:

Operations Barriers

16. The technology is not accurate enough to provide the robust results necessary to validate ITS.

Major Concern / A Concern / Not a Concern

Strategy for dealing with above barrier:

17. The available software packages are full of bugs and hard to operate.
Major Concern / A Concern / Not a Concern

Strategy for dealing with above barrier:

18. Our staff is not knowledgeable enough to run the systems efficiently.
Major Concern / A Concern / Not a Concern

Strategy for dealing with above barrier:

Resource Barriers

19. We lack the financial resources necessary to deploy ITS adequately.
Major Concern / A Concern / Not a Concern

Strategy for dealing with above barrier:

20. We lack the personnel necessary to deploy and maintain ITS adequately.
Major Concern / A Concern / Not a Concern

Strategy for dealing with above barrier:

21. In what area is there the greatest need for additional personnel (e.g., planning, design, construction, operations, maintenance, evaluation)?

Please provide a list of other Barriers to Success your district has encountered in trying to deploy ITS.

VII. Cost

We are aware that many ITS applications are placed in larger projects and are not monitored individually. However, any cost information you can provide about ITS deployments would be greatly beneficial. Any budget or cost information for past, current, or future deployments in the following categories is appreciated:

- Planning
- Design
- Construction
- Operations
- Maintenance
- Evaluation
- Personnel

Note: Please take Operations to be the operating cost of the ITS systems (i.e., phone line cost, extra electricity cost if discernable) and for personnel; only the cost of personnel dedicated completely to ITS operations is desired.

VIII. Existing and Planned Deployment Inventory

We would like to obtain any maps, charts, or tables that have been developed to keep track of ITS deployment. An example may be a map or table summarizing the location of all deployed variable message signs or video cameras. Summaries of current and planned infrastructure are desired. Electronic copies of documentation (AutoCad, Microstation, etc.) would be greatly appreciated.

IX. Assistance

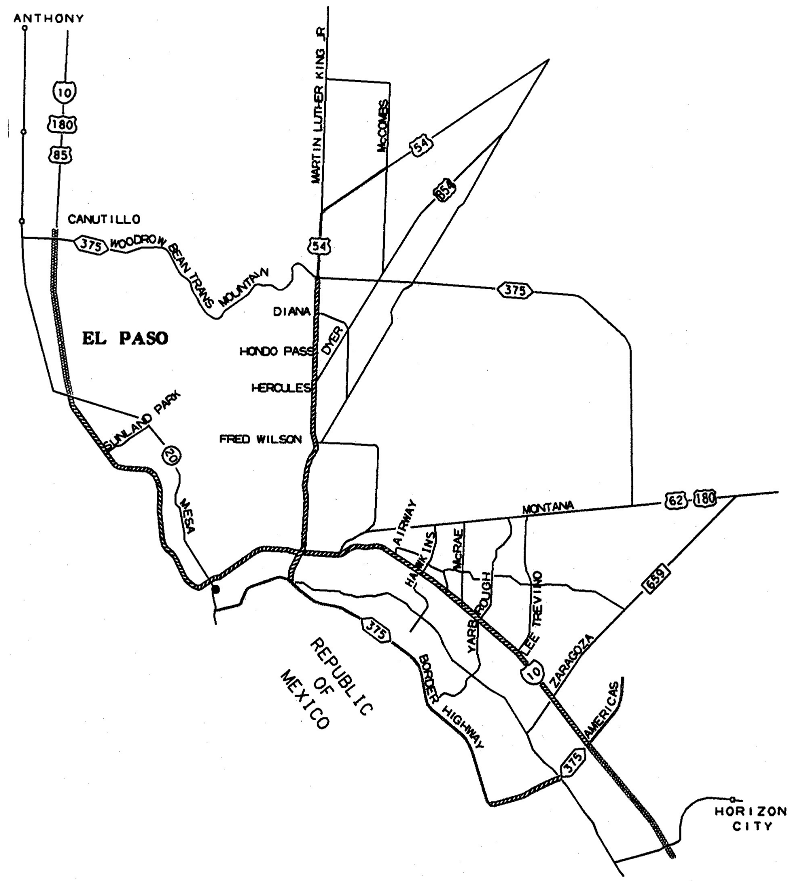
What type of information-sharing would most help your district better deploy and evaluate ITS?

What role do you think ITS will play in future years in your district? What role would you like to see it play?

Other comments:

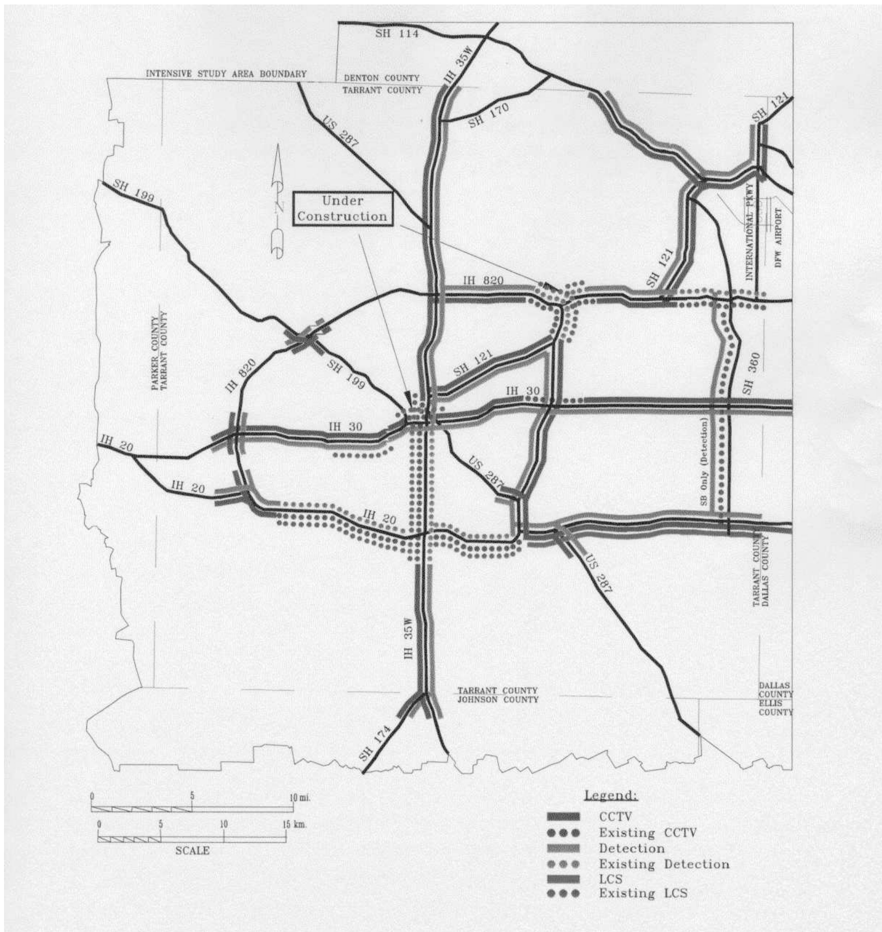
APPENDIX B
FREEWAY MANAGEMENT SYSTEM COVERAGE GRAPHICS

EL PASO



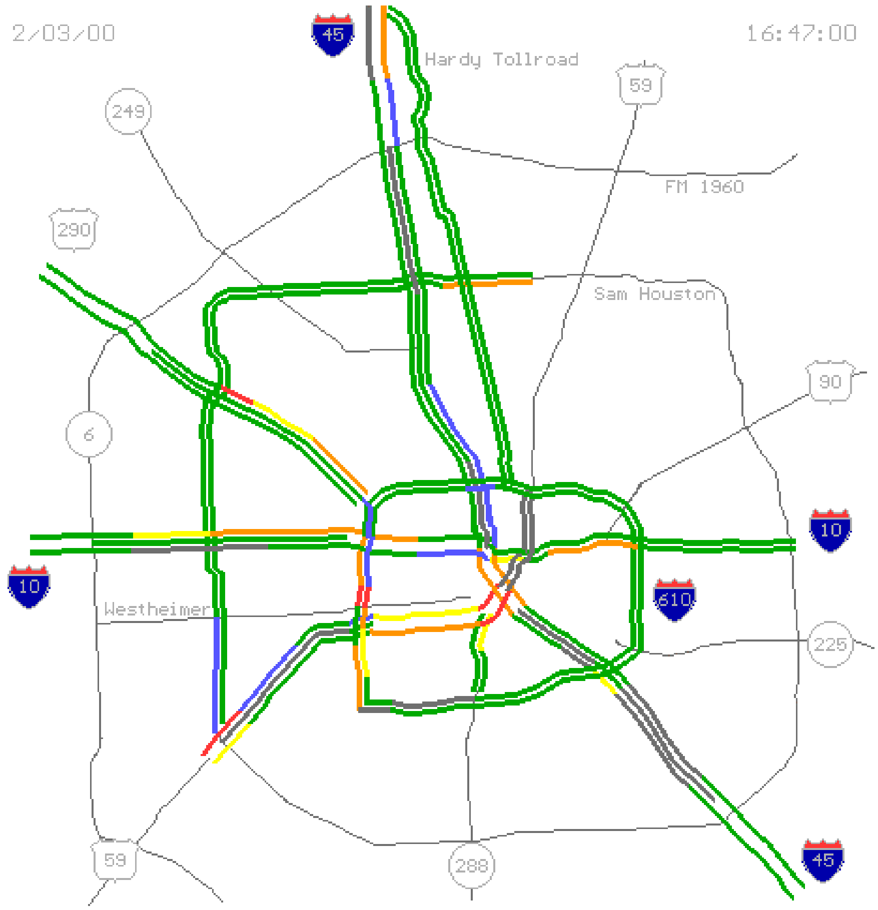
Source: TxDOT El Paso District

FORT WORTH



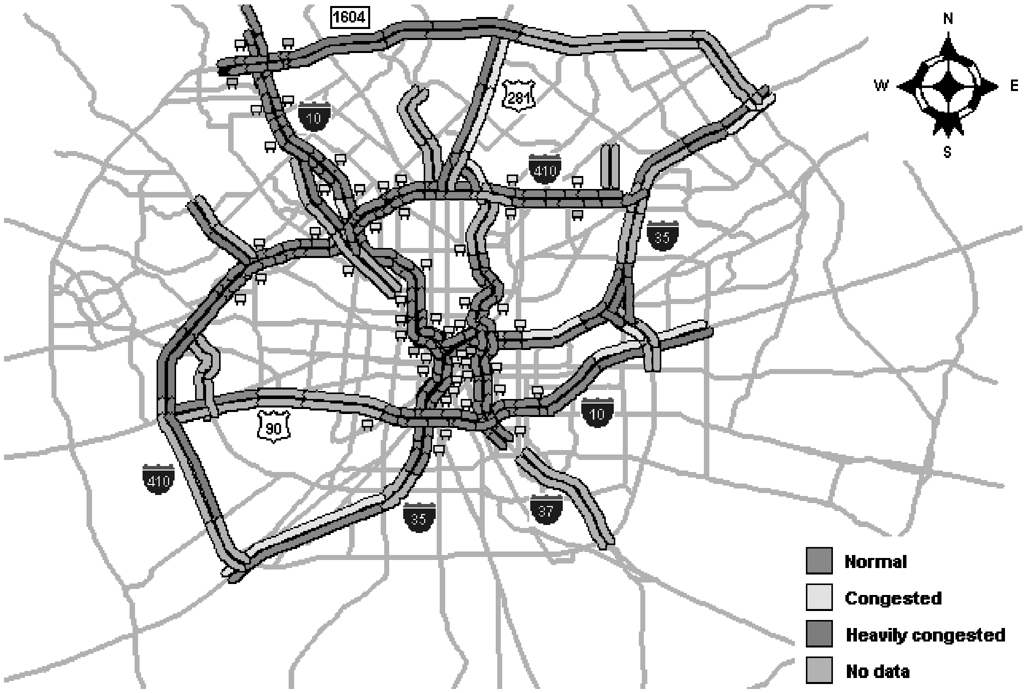
Source: Fort Worth Regional ITS Plan (29)

HOUSTON



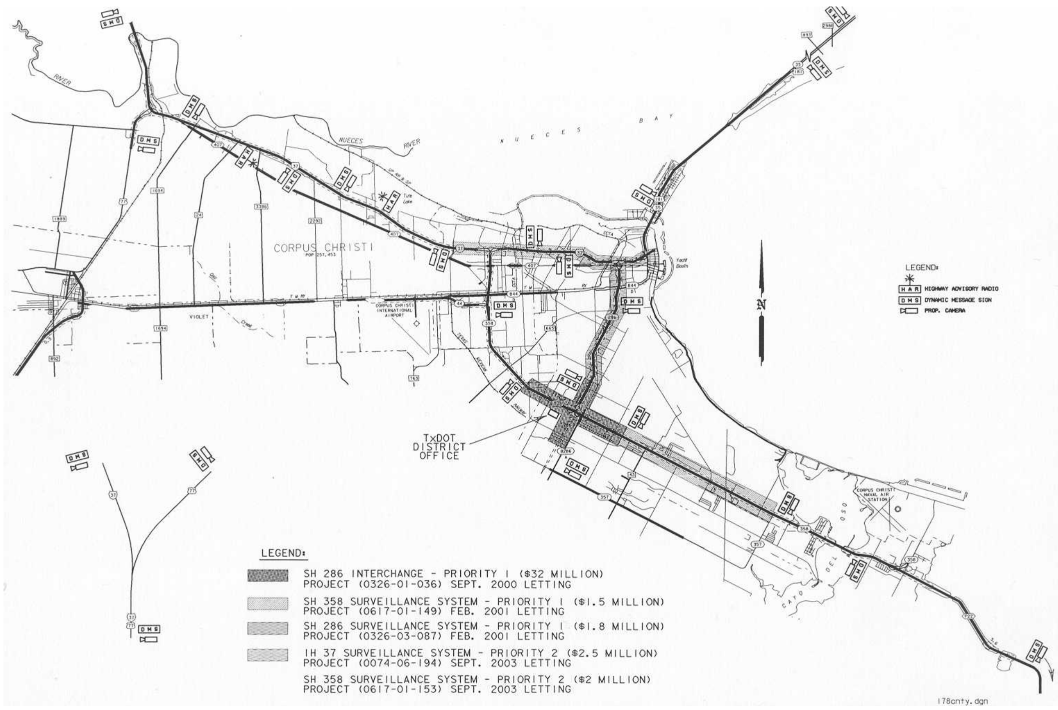
Source: TranStar Web site (12)

SAN ANTONIO



Source: TransGuide Web site (13)

CORPUS CHRISTI



Source: TxDOT Corpus Christi District

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