FRAMEWORK FOR THE
INTELLIGENT TRANSPORTATION SYSTEM (ITS) EVALUATION

ITS INTEGRATION ACTIVITIES

STRATIS

South Texas Regional Advanced Transportation Information System

Keeping South Texas Moving

by

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CHAPTER 1
INTRODUCTION

Intelligent Transportation Systems (ITS) represent a significant opportunity to improve the efficiency and safety of the surface transportation system. ITS includes technologies to support information processing, communications, surveillance and control, and more; typically performing these functions more quickly, efficiently, and reliably or providing a function that was not previously performed. A critical aspect of ITS which provides much of its capability is the *integration* of individual technologies or components of the ITS infrastructure to form a unified transportation management system (FHWA 1999).

The purpose of this investigation was to evaluate the experiences of the Texas Department of Transportation's (TxDOT) *South Texas Regional Advanced Transportation Information System (STRATIS)* - a recently developed traffic management center (TMC) in the Laredo District - in integrating existing field equipment including closed circuit television (CCTV) cameras, loop detectors/video identification vehicle detection systems (VIVDS), dynamic message signs (DMS), highway advisory radio (HAR), and train monitoring systems.

ITS Integration Defined

The concept behind ITS integration is that "linked" technologies working together provide more power and versatility for a region's transportation management capability than individual systems working separately. To be considered "integration", information must be: (1) transferred between ITS components and (2) used effectively by the recipient ITS component (FHWA 1999).

ITS Integration Links

Given this definition, performance measures to determine integration "success" consider selected interactions or linkages between ITS components rather than the level of function for individual ITS components. There are two types of possible integration links: (1) the integration between *different* components (e.g., arterial traffic condition information is used to support freeway management activities) and (2) the integration between elements of the *same* component (e.g., traffic signal timing information is shared along the length of an arterial that passes through multiple jurisdictions) (FHWA 1999).

ITS Integration Phases

Integrating ITS infrastructure components requires a higher level of coordination between different organizations than deploying systems in isolation. As a result, a three-phase process for ITS integration has evolved, with each phase requiring progressively greater levels of technical and institutional coordination: (1) shared infrastructure, (2) shared information, and (3) coordinated control.

- *Shared Infrastructure*. Sharing physical infrastructure refers to the joint use by different transportation agencies of the same equipment. Sharing infrastructure requires technical coordination to make certain that the equipment can be integrated and adheres to applicable ITS standards. Sharing infrastructure also entails institutional coordination, as agencies must work together to create a technically sound system that addresses each individual agency's needs (FHWA 1999).

- *Shared Information*. Sharing information refers to the transfer of data between agencies. The types of information that may be transferred include traffic conditions, incident information, incident response actions, traffic control actions, etc. Sharing information requires overcoming a more complicated set of technical and institutional barriers than those associated with sharing infrastructure. However, this increased level of coordination leads to an increased level of ITS efficacy (FHWA 1999).

- *Coordinated Control*. Coordinated control refers to the most complete type of integration; when one transportation agency uses shared information to make control decisions from a broader perspective than that of the individual agency. Where agencies merely sharing information may alter their control strategies based on data received from another agency, agencies coordinating control jointly plan and execute activities. Coordinated control requires overcoming the highest levels of technical and institutional barriers. While in all phases of integration, it is likely that the institutional impediments will prove more challenging than the technical ones, that fact is especially true when an agency must give up some of their decision making ability. However, as with the other phases, overcoming these barriers leads to proportionally greater levels of ITS efficacy (FHWA 1999).

ITS Integration Dimensions

With a focus on traffic management centers, (TMC), Cluett, et al (2006) describe the overall extent of integration in terms of the following five dimensions (see Figure 1):

1. *Physical Integration.* The agencies, organizations, and systems physically linked or co-located for the purpose of sharing data or information in support of traffic operations.

2. *Technical Integration.* The data and information communicated, exchanged, and shared through physical linkages among people, systems, and organizations, both within a TMC and between a TMC and other entities. This data and information exchange can be achieved through a range of means from verbal exchanges to automated electronic exchanges and decision support systems that integrate available information to enhance operational efficiency and effectiveness.

3. *Procedural Integration.* The development and use of policies, plans, and procedures that support integrated traffic operations in a TMC; the extent to which policies, plans and procedures are written down, made accessible to staff, reflect multi-agency interests and responsibilities, and are tested and reinforced with training and exercises; and the coordination of policies, plans and procedures across integrated agencies and organizations.

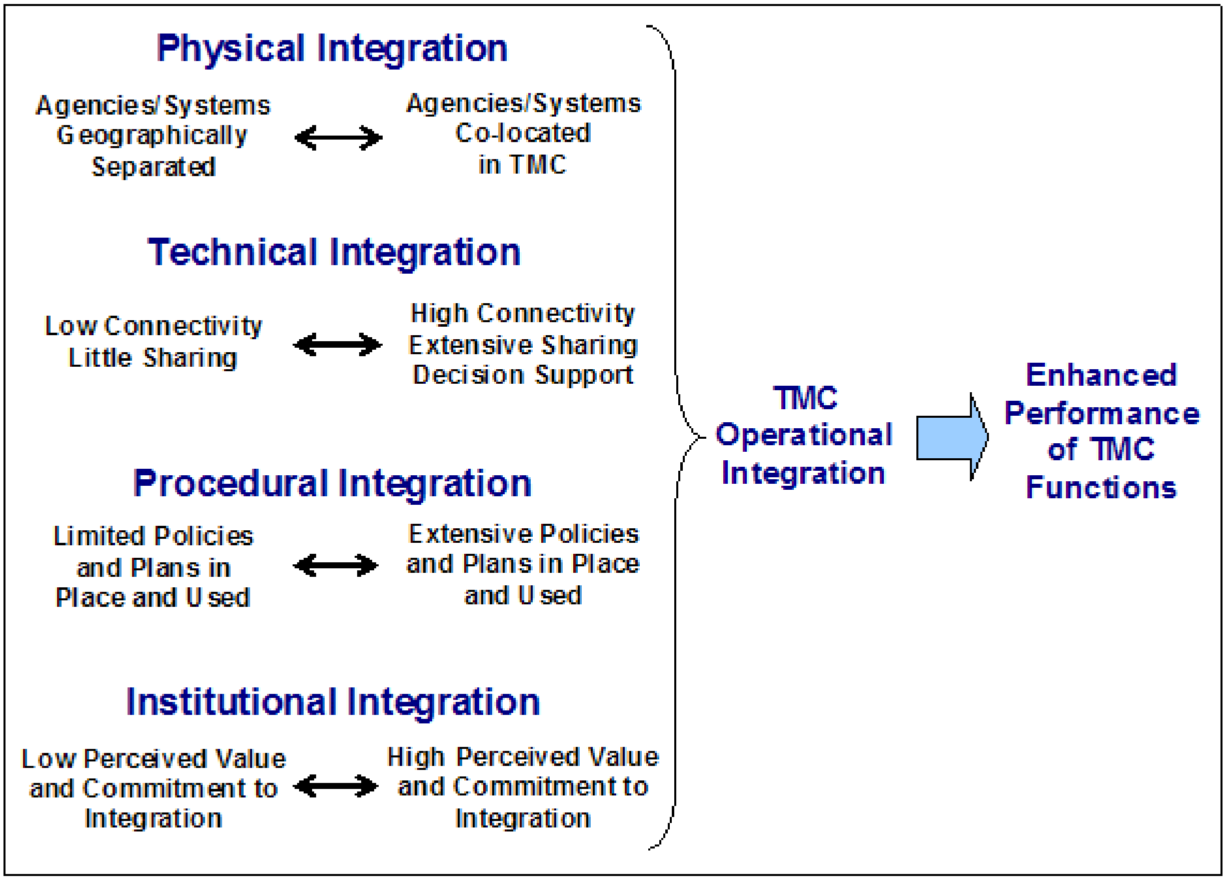

Figure 1. Component Effects of Integration Dimensions on TMC Functions

4. *Institutional Integration.* The level of commitment and partnership within and between participating organizations and agencies to achieve successful integration; leadership supporting the value of integration, and the willingness of partners to seek to collaborate to solve problems jointly; the clarity with which participant organizations' roles and responsibilities in support of integrated operations are spelled out and understood; the vertical and horizontal collaboration within and between agencies and organizations in support of TMC traffic operations; and agreements established among entities to support interaction and integration.

5. *Operational Integration.* The ways in which data and information are shared and used by TMCs and related agencies, organizations, and systems to support traffic operations, integrated control of traffic systems, and shared decision-making with regard to TMC traffic functions.

Lessons Learned from ITS Integration

Through prior ITS integration and evaluation efforts in cities such as Houston, Texas; Phoenix, Arizona; Seattle, Washington; San Antonio, Texas; and in regions such as Southern California, New Jersey-New York-Connecticut, Gary-Chicago-Milwaukee, and Northern Virginia, a number of "lessons learned" have been identified with the intent of providing continuous improvement in ITS deployment and integration.

- *Benefit from Previous Experiences*. A review of previous ITS integration experiences can support future integration efforts. Prior successes help to demonstrate to decision-makers, including government officials and upper-level management personnel, the value in ITS integration efforts (Smith and Galanti 2002).

- *Involve Stakeholders*. Participation of stakeholders throughout the ITS integration process is universally cited as a major success factor. Three types of stakeholders have been identified as key: (1) early champions - those who may introduce the concept to a stakeholder organization, (2) local advocates - government officials or agency managers who encourage the program, and (3) proactive stakeholders - agency managers or government officials directly responsible for financial and executive decisions such as these. Stakeholder involvement from beginning to end will ensure that all participants share the same vision of the eventual system (FHWA 1999b).

- *Demonstrate Benefits*. It is important to demonstrate the benefits of the ITS integration to all stakeholders. Understanding the differences in technical knowledge of the stakeholders is crucial (Smith and Galanti 2002). Typically, planning personnel are the stakeholders most interested in cooperation and regional involvement but the operations personnel are the ones that will be utilizing the new system (FHWA 1999c). Planning personnel may not have the backgrounds necessary to fully understand the technical aspects of a complex integration architecture. Planning personnel need to understand who is involved with what parts of the project without delving deeply into the technical aspects of the integration program. Conversely, operations personnel need to understand the direct benefits to their work from the ITS integration efforts (Smith and Galanti 2002). It may also be useful to present only the benefits relevant to a particular user rather than all of the benefits of the project (FHWA 1999d).

- *Encourage Interagency/Multi-Jurisdictional Cooperation*. Interagency and multi-jurisdictional cooperation are essential to the success of the integration. ITS integration "coalition" can be formed using existing relationships and organizational umbrellas (FHWA 1999e) or may be newly established cross-cutting organizations, with representation from all stakeholders (DBH Consulting 2000). Once interagency, multi-jurisdictional relationships have been established, maintaining these relationships will benefit future projects and daily operations.

- *Involve Experienced Information Technology Professionals.* Significant value can be realized by involving experienced Information Technology (IT) professionals. One of the most significant benefits of including such expertise is the ability to shorten project length. However, experience has also shown that it is necessary to guard against over-reliance on "outside" IT professionals; ensuring that stakeholders remain sufficiently engaged to provide meaningful technical direction and that agency staff remain involved in every stage of the project (Smith and Galanti 2002).

- *Educate Users/Stakeholders*. At the initial stages of integration, many agencies report the need for further education and guidance (FHWA 1999c). Employees, uneducated about basic ITS concepts, can hamper development and implementation schedules (FHWA 1999d). It has been suggested that stakeholders use the system as it evolves; individuals may reach a comfort level with the National ITS Architecture only after having used it (FHWA 1999f).

- *Highlight Accomplishments*. A final lesson is the need for stakeholders to highlight accomplishments of the ITS integration. The public and even many involved within stakeholder organizations will have little knowledge of the capabilities of the newly integrated ITS. Stakeholders should make the benefits known to the public through sources such as the Internet, television reports, and other media outlets (DBH Consulting 2000). If the value of the integration effort is demonstrated properly, public support and the support of key decision-makers will increase, significantly enhancing approval for similar future endeavors (Smith and Galanti 2002).

Laredo's ITS Vision

The TxDOT, Laredo District, began deployment of ITS in 1996 and in 2003, completed a 7,000 square foot traffic management center (TMC) referred to as *STRATIS*, *South Texas Regional Advanced Transportation Information System*. *STRATIS* was developed to integrate existing field equipment including closed circuit television (CCTV) cameras, loop detectors/video identification vehicle detection systems (VIVDS), dynamic message signs (DMS), highway advisory radio (HAR), and train monitoring systems in the greater Laredo Region (see Figure 2).

Concurrently with the development of *STRATIS*, and in response to FHWA's final rule to implement Section 5206(e) of the TEA-21 which requires that ITS projects funded through the Highway Trust Fund conform to the National ITS Architecture and applicable standards, TxDOT initiated the development of the *Regional ITS Architecture* (Kimley-Horn and Associates, Inc. and ConSysTech Corp. 2002) and the *Regional ITS Deployment Plan* (Kimley-Horn and Associates, Inc. 2003) for the greater Laredo Region.

In general, an ITS architecture provides a framework for implementing ITS on a regional level, encourages interoperability and resource sharing, identifies applicable standards, and allows for cohesive long-range planning among stakeholders. An ITS deployment plan identifies and prioritizes projects that are needed to implement the ITS architecture on a short, medium, and long-term basis. The Laredo Regional ITS Architecture provides the framework and prioritized the key functions and services desired by stakeholders in the Region. Stakeholders include representatives from federal, state, and local transportation agencies, transit, police, fire, the U.S. Border Patrol, and private entities. Building upon the Laredo Regional ITS Architecture, the Laredo Regional ITS Deployment Plan identifies and prioritizes specific ITS projects and strategies to complete the architecture. Early development of this Plan supports a comprehensive, phased approach to Regional ITS deployment, with infrastructure incrementally built over a 20-year horizon and successfully integrated among key foundation systems in the Region. Early development of this plan also supports funding allocation decisions (Kimley-Horn and Associates, Inc. and ConSysTech Corp. 2002).

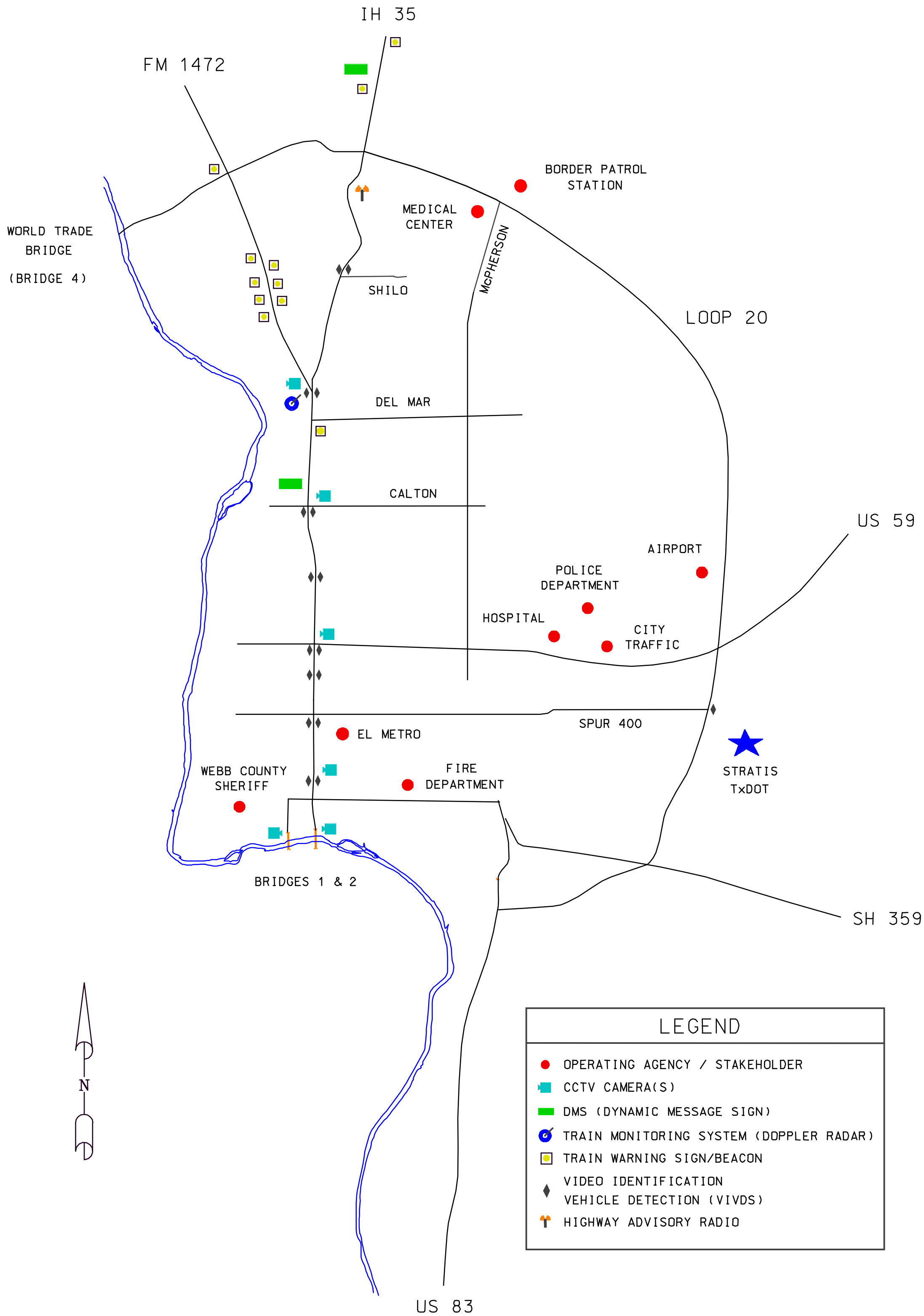

Figure 2. Existing ITS Infrastructure in the Laredo Region

Regional Integration and Interoperability

One of the primary purposes in developing an ITS Architecture for the Laredo Region was to ensure that while various agencies are deploying ITS components, some commonalties exist between them that allow and facilitate the exchange of data seamlessly and automatically. The data that is being collected and disseminated is valuable to many different agencies; therefore, an integration strategy was needed to ensure the data exchange is possible (Kimley-Horn and Associates, Inc. and ConSysTech Corp. 2002).

A key aspect of Laredo's ITS vision is to integrate systems both on an intra-regional and an inter-regional basis. Intra-regional integration can provide opportunities for enhanced information sharing that would, in turn, speed implementation of reactive and proactive operational plans, ensure provision of consistent traveler information, improve transit system operational performance and schedule adherence, and reduce congestion and improve safety during planned or unplanned roadway or border crossing closures. Similarly through enhanced information sharing, inter-regional integration can support larger-scale operations related to border crossing and homeland security activities or emergency evacuation.

Evaluation Objectives

As stated previously, *STRATIS* was developed to integrate existing field equipment including closed circuit television (CCTV) cameras, video identification vehicle detection systems (VIVDS), dynamic message signs (DMS), highway advisory radio (HAR), and train monitoring systems and warning signs/beacons. The objective of this project is to evaluate the success of these integration efforts, considering both intra-regional and inter-regional integration and quantitative and qualitative resulting benefits.

Report Organization

Following this introductory information, this report provides an overview of Laredo's ITS program (Chapter 2) including regional characteristics, stakeholders, and ITS components and integration. Chapter 3 provides a description of the evaluation methodology including methods to determine integration indicators describing the level or degree of integration achieved; integration outcomes including the evaluation strategy, the evaluation plan, and the various test plans used to establish resulting benefits; and any qualitative assessments provided by stakeholders. Evaluation results, including integration indicators, integration outcomes, and qualitative assessments are provided in Chapter 4. This report concludes with a summary of findings and recommendations (Chapter 5).

It should be noted that this evaluation effort was not intended as a critique of any of the parties involved. Rather, it was intended to identify key benefits resulting from the *STRATIS* integration, as well as any lessons learned. It is expected that the results presented in this report will be of use in future regional and national integration initiatives.

CHAPTER 2
LAREDO'S ITS PROGRAM

With its proximity to Mexico and major trade corridors, recent and significant growth in industry and employment, and extensive roadway network and transportation services, the Laredo Region shows significant potential for successful ITS deployment. This Chapter describes the region's characteristics, local stakeholders, and existing ITS components and integration.

Regional Characteristics

The Laredo Region extends south from the Texas Hill Country to the north bank of the middle Rio Grande River on the Mexican border and includes the counties of Webb, Dimmit, La Salle and Duval. Major cities within and immediately adjacent to the Region include the City of Laredo and Nuevo Laredo in Mexico. With a population of just under 200,000, the City of Laredo has been ranked as the second fastest growing city in the country, due to the passage of the North American Free Trade Agreement (NAFTA) and the consequent influx of major trade and industry to the Region (Kimley-Horn and Associates, Inc. and ConSysTech Corp. 2002).

Key industry stakeholders in the Region are Mercy and Doctor's Hospital, education facilities for school districts, Laredo Community College, Texas A&M International University, City of Laredo, Webb County, U.S. Border Patrol, and rail and trucking companies. Nearly 60 manufacturing or distribution facilities exist; major manufacturers include Sony, Rheem, and Modine. The Laredo Arena complex brings professional sports to the Region (Kimley-Horn and Associates, Inc. and ConSysTech Corp. 2002).

The City of Laredo is conveniently located on the Pan American Highway (which stretches from Canada into Central and South America), and currently serves as the principal U.S. port of entry into Mexico. The City of Laredo uniquely maintains two border crossings; one with the Mexican State of Tamaulipas at Nuevo Laredo, and one with Nuevo Leon at Columbia. Approximately 12,000 American and Canadian long-haul trucks cross the border daily. The border services an additional 9,000 local truck crossings per day (Kimley-Horn and Associates, Inc. and ConSysTech Corp. 2002).

The roadway network in the Region is well developed (see Figure 3). The primary facilities include I-35, U.S. 83, U.S. 59, State Highway 359, Loop 20, FM 1472, and Mexico's State Routes 2 and 85 (Pan American Highway) (Kimley-Horn and Associates, Inc. and ConSysTech Corp. 2002):

- I-35, beginning at the international border with Mexico at Laredo and terminating at Duluth, Minnesota, provides a direct freeway connection between Mexico and Canada. I-35 crosses the State of Texas serving cities such as Laredo, San Antonio, Austin, Waco, and Dallas. I-35 also serves as a major automobile route through Laredo, and connects to several pedestrian bridges and International Bridge No. 1 (Puente de las Americas Bridge).

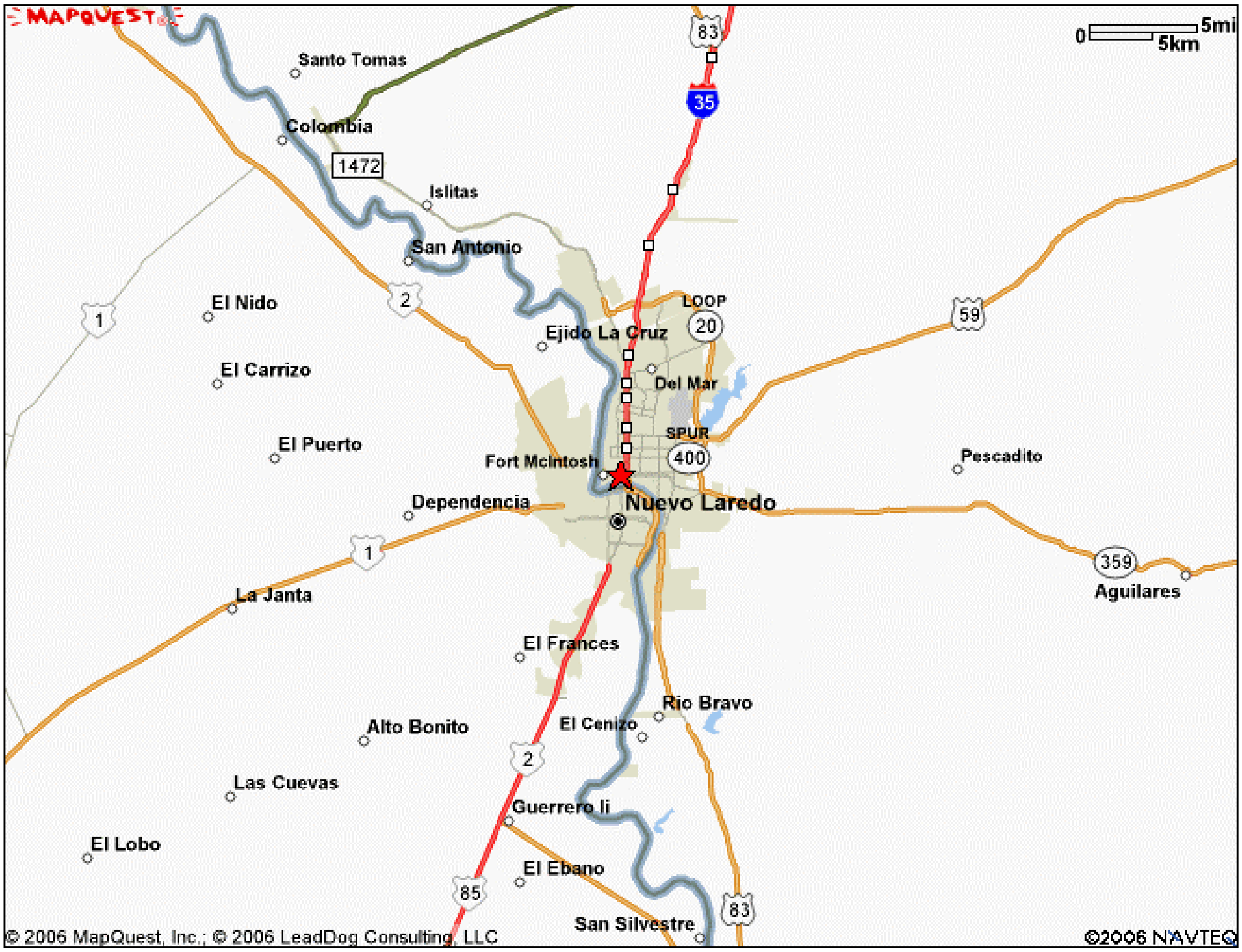

Figure 3. Roadway Network in the Laredo Region

- Providing a similar north-south route, U.S. 83 parallels the Texas-Mexico border before directing northward through Oklahoma, Kansas, Nebraska, and South and North Dakota into Canada.

- U.S. 59 is a principal highway that travels through the entire eastern area of the state of Texas in a generally north-south direction between the cities of Texarkana and Laredo. U.S. 59 is part of a major NAFTA trade corridor and carries a significant amount of truck traffic. U.S. 59 connects Laredo to cities such as Victoria, Corpus Christi (through U.S. 44), and Houston.

- Highway 359 crosses Webb and Duval counties, both part of the Laredo Region, and serves as an alternate to U.S. 59.

- Loop 20 is a recently completed, circumferential route in the City of Laredo, which bypasses downtown and provides access to Texas A&M International University, Laredo International Airport, Casa Blanca Lake, and the Texas Department of Transportation (TxDOT) District Office. Loop 20 is considered a primary alternate route for incidents on I-35, U.S. 83, U.S. 59, and State Highway 359.

Numerous other state highways and farm-to-market roadways traverse the Laredo Region. A key farm-to-market route, FM 1472, connects to several toll bridge crossings leading into Mexico near Laredo (Kimley-Horn and Associates, Inc. and ConSysTech Corp. 2002).

There are two key roadways on the Mexico side that are important for the Laredo Region:

- Mexico S.R. 2, which follows the Rio Grande south into Matamoros; and
- Mexico S.R. 85, which extends I-35 into Mexico City. Also called the Pan American Highway, Mexico S.R. 85 connects to Monterrey and South America (Kimley-Horn and Associates, Inc. and ConSysTech Corp. 2002).

The City of Laredo operates a fixed-route transit system called El Metro that serves the metropolitan area. Outside of the city, transit services are somewhat limited, but there are demand-responsive (or paratransit) services available through El Aguila. El Lift is a special transportation service offered by the City of Laredo providing curb to curb, on demand transportation service to disabled citizens unable to use conventional public transportation (Kimley-Horn and Associates, Inc. and ConSysTech Corp. 2002).

Stakeholders

The Laredo *Regional ITS Architecture* (Kimley-Horn and Associates, Inc. and ConSysTech Corp. 2002) generally identified a diverse group of stakeholders from federal, state, and local transportation agencies, transit, police, fire, the U.S. Border Patrol, and private entities (see Table 1). A subset of these stakeholders participated in the STRATIS integration (see Table 2).

Table 1. Laredo Region Stakeholders

Agency	Agency
• Businesses and Other Private Entities	• Other TxDOT Regions
• City/Community Parking System Operators	• Private Ambulance Services
• City of Laredo	• Private ISPs
• City of Laredo/Webb County	• Private Mayday Providers
• City/County Public Safety	• Private Shippers
• City/County/State Public Safety	• Private Tow/Wrecker
• County Road and Bridge	• Private Travelers
• Courtesy Service Patrol Provider	• Private Vehicle Owners
• DPS	• Railroad Operators
• DPS Division of Emergency Management	• Regional Hospitals
• El Aguila	• TAMIU
• El Metro	• Traveler Telecommunications System Providers
• Financial Institutions	
• Independent School Districts	• TxDOT
• Local Media	• TxDOT Motor Carrier Division
• NOAA	• US Border Patrol
• Other States DOTs	• US Customs

Table 2. Laredo Region Stakeholders Participating in *STRATIS* Integration

Agency
Businesses and Other Private Entities
• Time Warner Company
City of Laredo
• City of Laredo, Administration
• City of Laredo, Airport
• City of Laredo, Bridge
• City of Laredo, Engineering/Public Works
• City of Laredo, MPO
• City of Laredo, Traffic Safety
City/County Public Safety
• City of Laredo, Police Dept.
• City of Laredo, Police Dept., Traffic Enforcement Unit
• City of Laredo, Police Dept., Ordinance Unit
• City of Laredo, Fire Dept.
• City of Laredo, Fire Dept., EMS
• City of Laredo, Fire Dept., HAZMAT
• Webb County, Constable, Precinct 1
• Webb County, Sheriff's Dept.
• Webb County, Emergency Management
County Road and Bridge
• Webb County, Administration
• Webb County, Engineering
• Webb County, Planning
DPS
• Texas Dept. of Public Safety, Highway Patrol
El Aguila
• Webb County, Rural Transit (El Aguila)
El Metro
• City of Laredo, Transit, El Metro
• City of Laredo, Transit, El Metro, Operations
Independent School Districts
• Laredo Independent School District
Other TxDOT Regions
• TxDOT, Headquarters, Public Transportation
• TxDOT, Headquarters
• TxDOT, Headquarters, TRF-TM
Traveler Telecommunications System Providers
• City of Laredo, Telecommunications Dept. (INET)
TxDOT
• TxDOT, Laredo District
• TxDOT, Laredo Area Office
• TxDOT, Laredo Maintenance Office
US Border Patrol
• U.S. Dept. of Homeland Security, Border Patrol
US Customs
• US Customs and Border, Port of Entry
Other
• Texas Commission on Environmental Quality
• Federal Highway Administration, Texas Division
• Federal Highway Administration, Southern Resource Center
• Federal Motor Carrier Safety Administration, Texas Division
• Federal Motor Carrier Safety Administration, Southern Service Center

ITS Components

Again, as part of the Laredo *Regional ITS Architecture* (Kimley-Horn and Associates, Inc. and ConSysTech Corp. 2002), a comprehensive inventory of existing, planned, and future ITS components was developed. “Planned” was defined as having funding identified; “future” was defined as not yet having funding identified. Table 3 provides a comprehensive list of the existing, planned, and future ITS components in the Laredo Region.

This investigation considered a subset of these components, qualified as those components: (1) in existence at the time of this investigation (i.e., not “planned” or “future”), and (2) directly interfacing with *STRATIS* (including *STRATIS*). Key ITS components considered in this investigation were identified as supporting traffic management, emergency management, maintenance and construction, and archived data management.

Traffic Management

Through its integration efforts, *STRATIS* is intended to support a variety of traffic management activities including:

- *Network Surveillance and Control*. At the start of this investigation, the TxDOT Laredo District had 9 video surveillance cameras strategically located at high accident and/or high traffic volume interchanges, with plans for 15 additional CCTVs installed as part of several construction projects along I-35 and Loop 20. These projects also provided for additional loop detector installations (beyond the current 24 systems) and various access/upgrades to Video Imaging Vehicle Detector Systems (VIVDS) at approximately 18 intersections (Aldape 2005). The traffic volume, speed, and occupancy data provided by the loop detectors and VIVDS supports the development and implementation of control plans for signalized intersections. The video surveillance provided by the CCTV supports traffic and incident management efforts.

- *Traffic Information Dissemination*. The TxDOT Laredo District utilizes dynamic message signs (DMS) and highway advisory radio (HAR) to provide traffic information. At the start of this investigation, the TxDOT Laredo District had 7 DMS and 2 HAR systems. Eight additional DMS were installed along I-35 as part of several vicinity construction projects (Aldape 2005). These signs are used to alert motorists of roadway conditions. In addition, these signs are used for coordinated bridge control to support safer and more efficient traffic management at the bridges. HAR utilizes the automobile’s AM band for broadcasting en-route information about weather, roadway conditions, construction, closures, detours, and other information. In the Laredo Region, HAR stations are strategically located near the airport and international border crossings.

- *Incident Management*. *STRATIS* relies upon the same technologies for surveillance, control, and traffic information dissemination to provide incident management support. Incidents are detected and verified using the loop detectors, VIVDS, and CCTV. Incident information is provided to appropriate agencies (e.g., Texas Department of Public Safety, City of Laredo Fire Department, City of Laredo Police Dispatch, etc.) Incident information is provided to the public using DMS and HAR systems.

Table 3. Existing, Planned, and Future ITS Components by Stakeholder

Agency

Businesses and Other Private Entities

City and Community Parking System Operators
- Parking Management Systems

City of Laredo
- Airport PD
- Archived Data Management System
- Arena Parking Management
- Bridge System
- Bridge System Field Equipment
- Bridge System Trade Tag
- Bridge System Web Site
- Emergency Comm. Center
- Equipment Repair
- Field Equipment
- Fire/EMS/HAZMAT Vehicles
- Police Vehicles
- PWD
- PWD Vehicles
- TMC
- Trade Tag System
- Traffic Safety Department
- Webpage

City of Laredo/Webb County
- Emergency Ops. Center (EOC)

City/County Public Safety
- Public Safety Dispatch
- Public Safety Vehicles

City/County/State Public Safety
- Laredo Regional Incident and Mutual Aid Network

Commercial Vehicle Operators
- Operator Systems
- Vehicles

County Road and Bridge
- Equipment Repair
- Maintenance/Construction Vehicles

Courtesy Service Patrol Provider

DPS
- Communications Service
- Electronic Screening Stations
- Highway Patrol Vehicles
- License and Weights Division
- PS Regional Disaster Communications Committee

DPS Division of Emergency Management
- State EOC

El Aguila
- Transit Dispatch
- Transit Vehicles

Agency

El Metro
- Fixed-Route Transit Dispatch
- Kiosks
- Paratransit Dispatch
- Paratransit Vehicles
- Transit Vehicles
- Transit Webpage
- Traveler Card

Financial Institution

Independent School Districts
- District Dispatch
- District Vehicles

Local Media
- Print and Broadcast Media

NOAA
- National Weather Service

Other States DOTs
- Other States Credentials Administration and Safety Information Exchange

Other TxDOT Regions
- Other TxDOT Region TMCs

Private Ambulance Services
- Private Ambulance Dispatch Center

Private ISPs
- Private Sector Traveler Information Services

Private Mayday Providers
- Private Vehicle Emergency Systems

Private Shippers

Private Tow/Wrecker
- Private Tow/Wrecker Dispatch

Private Travelers
- Private Traveler
- Private Traveler Personal Computing Devices

Private Vehicle Owners
- Private Vehicles

Railroad Operators
- Rail Cars
- Rail Operations
- Railroad Wayside HRI equipment

Regional Hospitals

TAMIU
- TAMIU Archive
- TAMIU Archived Data User System

Traveler Telecommunications System Providers
- Telco 511 Call Routing

Table 3. Existing, Planned, and Future ITS Components by Stakeholder

Agency

TxDOT

- 511 System
- Area Construction Vehicles
- Area Office
- BRINSAP - Bridge Inventory Inspection System
- County Maintenance Section Storage Facility
- County Maintenance Sections
- County Maintenance Vehicles
- Courtesy Service Patrol Archive
- Courtesy Service Patrol Dispatch
- Courtesy Service Patrol Vehicles
- Crash Records Information System
- Credentials Administration and Safety Information Exchange
- District Shop
- Highway Condition Reporting System
- Laredo Archived Data Management System
- Laredo CCTV
- Laredo District Webpage
- Laredo DMS
- Laredo Field Sensors
- Laredo HAR
- Laredo TMC - STRATIS
- Laredo Toll Tag Readers
- Laredo Traffic Signals
- Over-dimension Vehicle System
- Rest Areas/Visitor Centers/Service Plaza Kiosks
- Texas Transportation Commission
- Tourist Bureau
- Work Zone Field Equipment

Agency

TxDOT Motor Carrier Division

- TxDOT Motor Carrier Routing Information

US Border Patrol

- US Border Patrol Air Operations
- US Border Patrol CVO Inspectors
- US Border Patrol Dispatch Center
- US Border Patrol Stations
- US Border Patrol Vehicles

US Customs

- US Customs Dispatch Center
- US Customs Product Manifest System

- *Rail Operations Coordination*. Intended to provide strategic coordination between rail operations and traffic management centers, *STRATIS* receives train schedules, maintenance schedules, and any other forecast events which will result in highway-rail intersection (HRI) closures. This information is used to develop advanced traffic control strategies or delivered as enhanced traveler information.

Emergency Management

STRATIS is intended to support efficient dispatch of emergency vehicles by providing safe and efficient routes based on real-time traffic information. Emergency services and public safety agencies in the Region are concurrently looking to technology to improve emergency management (e.g., the City of Laredo Fire Mobile Data System incorporates Mobile Data Terminals in fire vehicles to provide communications with the computer-aided dispatch (CAD) system).

Maintenance and Construction

To ensure a minimal traffic impact from work zones, *STRATIS* is intended to remotely monitor and support work zone activities, controlling traffic through DMS; work zone speeds and delays are provided to the motorist prior to the work zones.

Archived Data Management

The Texas Agricultural and Mining International University (TAMIU) is the designated repository intended to collect and archive traffic, roadway, and environmental information from *STRATIS* for use in off-line planning, research, and analysis. This data can be used directly by operations personnel or it can be made available to other data users and archives in the region.

ITS Integration

Recall that the concept behind ITS integration is that "linked" technologies working together provide more power and versatility for a region's transportation management capability than individual systems working separately. As such, it is important to consider not only the individual ITS components within the Laredo Region but also how they are integrated. To be considered "integration", information must be: (1) transferred between ITS components and (2) used effectively by the recipient ITS component (FHWA 1999). Figures 4 through 12, taken from the Laredo *Regional ITS Architecture* (Kimley-Horn and Associates, Inc. and ConSysTech Corp. 2002) depict the *STRATIS*-related ITS components and their linkages; solid lines represent existing linkages, dashed or dotted lines represent planned or future linkages not considered as part of this investigation. Table 4 provides a condensed summary of these linkages.

To support effective integration of each of the ITS components into a cohesive transportation management system, Advanced Traffic Management System (ATMS) software was developed by TxDOT's Traffic Operations Division for use by *STRATIS*.

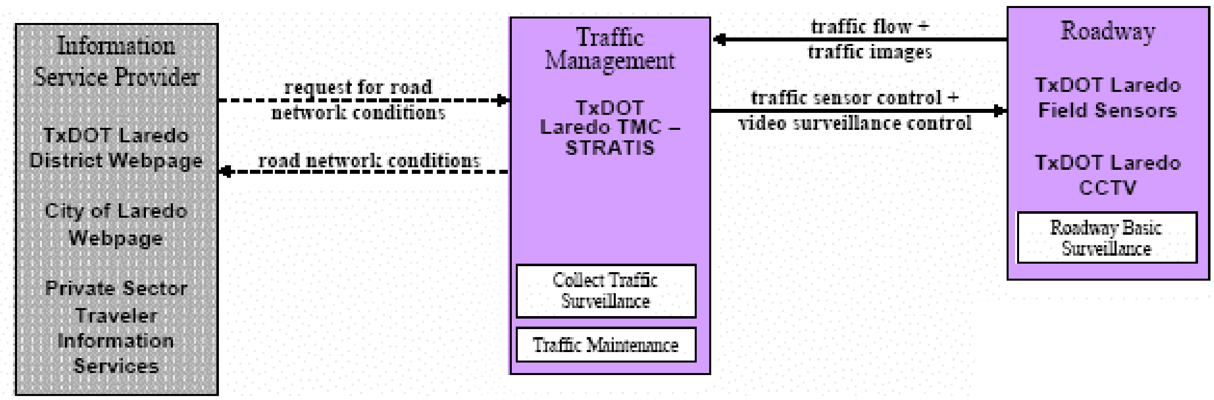

Figure 4. ATMS01: Network Surveillance

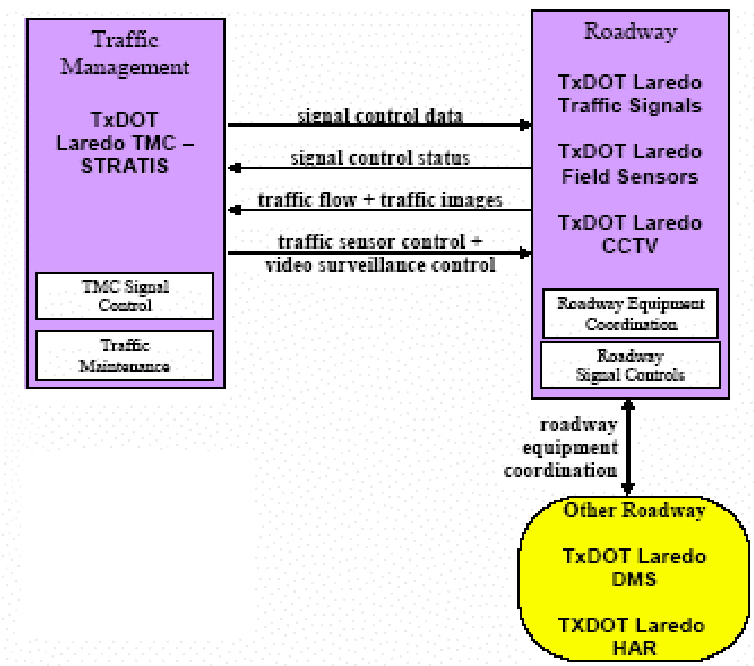

Figure 5. ATMS03: Surface Street Control

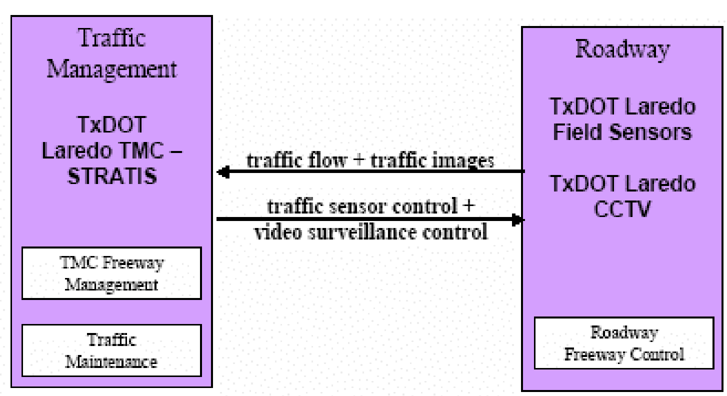

Figure 6. ATMS04: Freeway Control

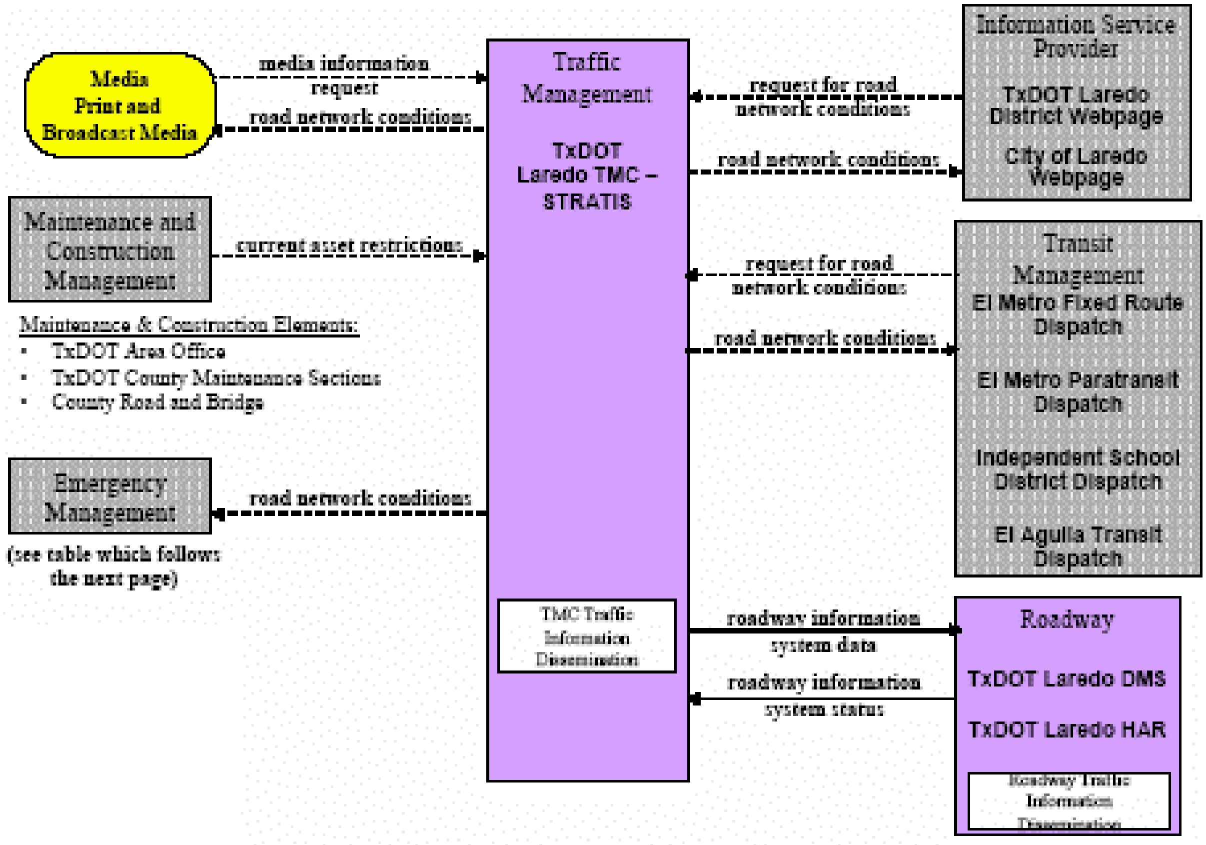

Figure 7. ATMS06: Traffic Information Dissemination

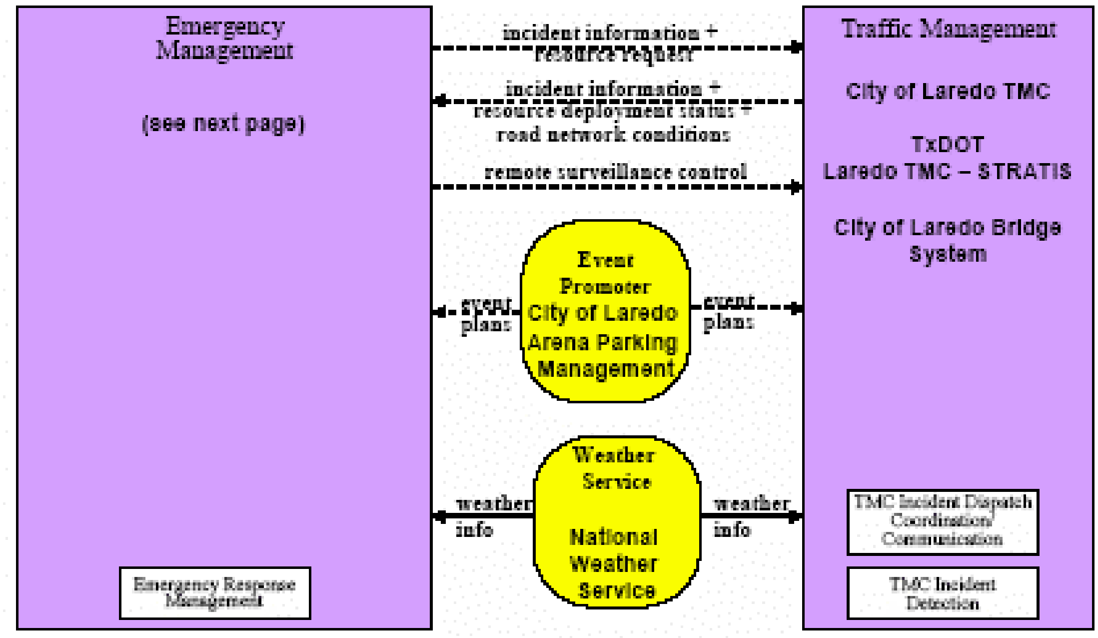

Figure 8. ATMS08: Incident Management System

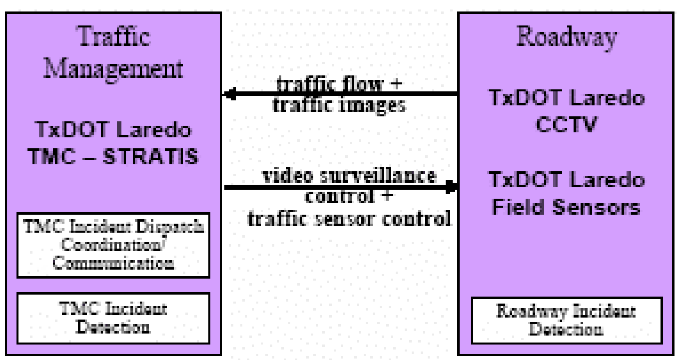

Figure 8. ATMS08: Incident Management System (Continued)

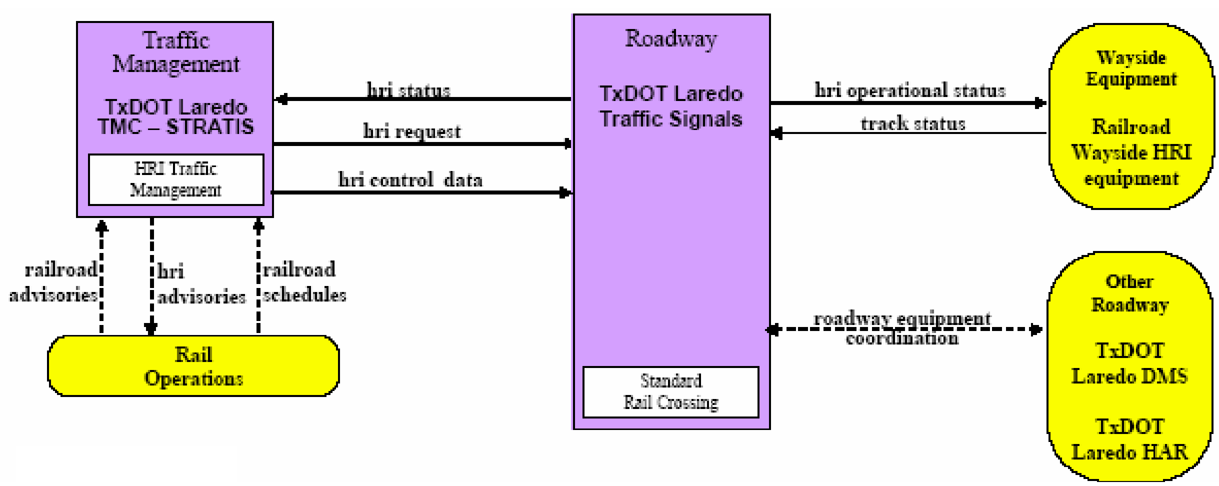

Figure 9. ATMS13: Standard Railroad Grade Crossing/ATMS15: Railroad Operations Coordination

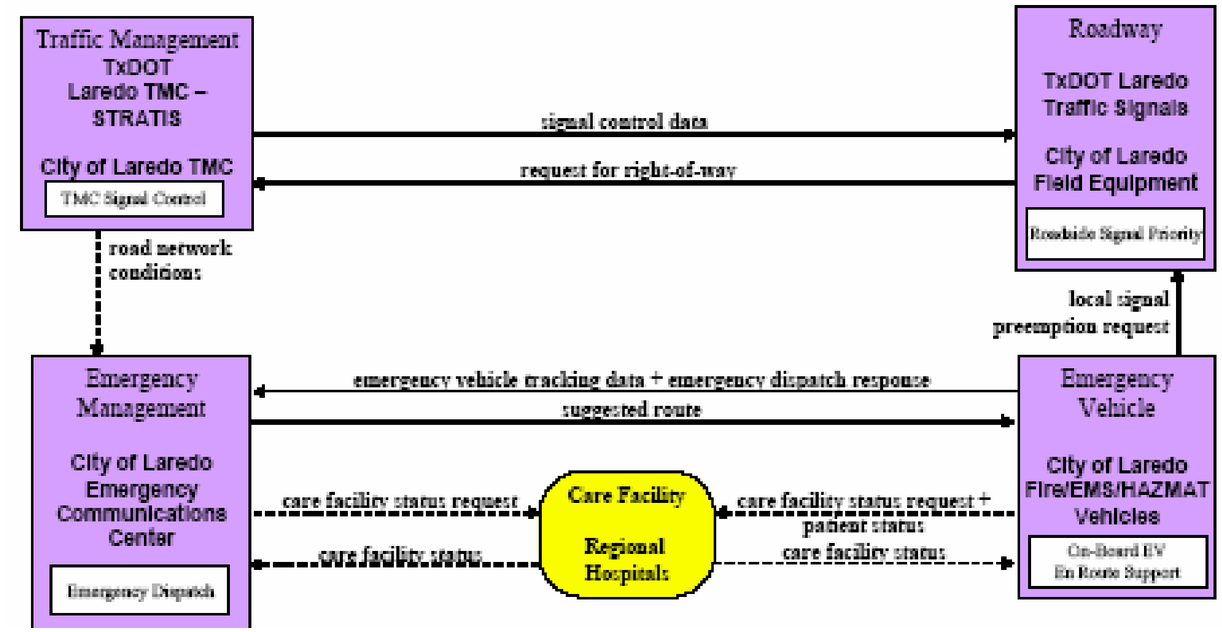

Figure 10. EM02: Emergency Routing

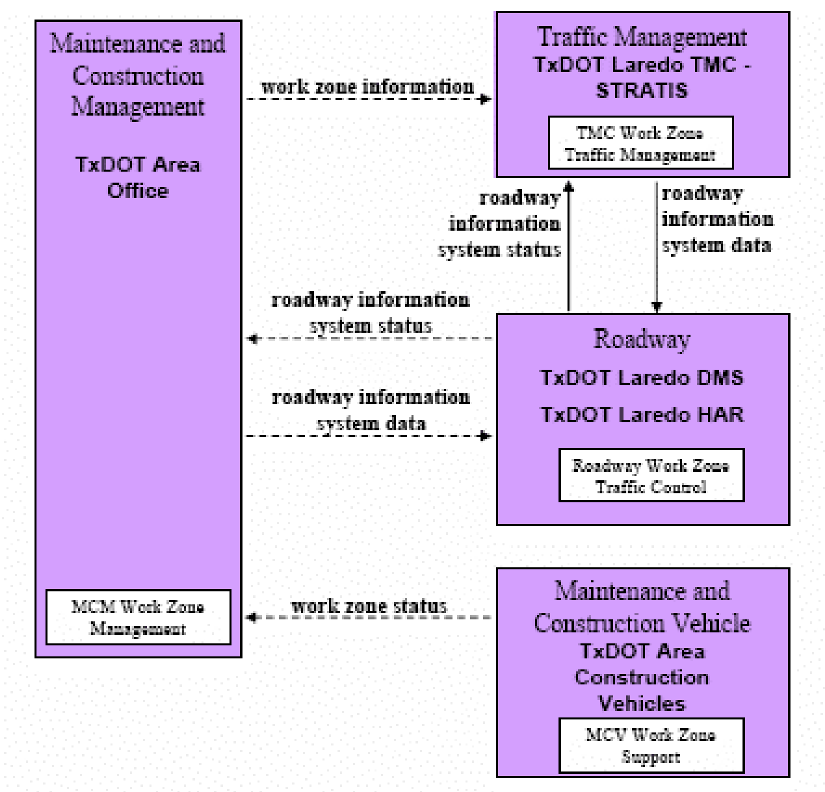

Figure 11. MC08: Work Zone Management

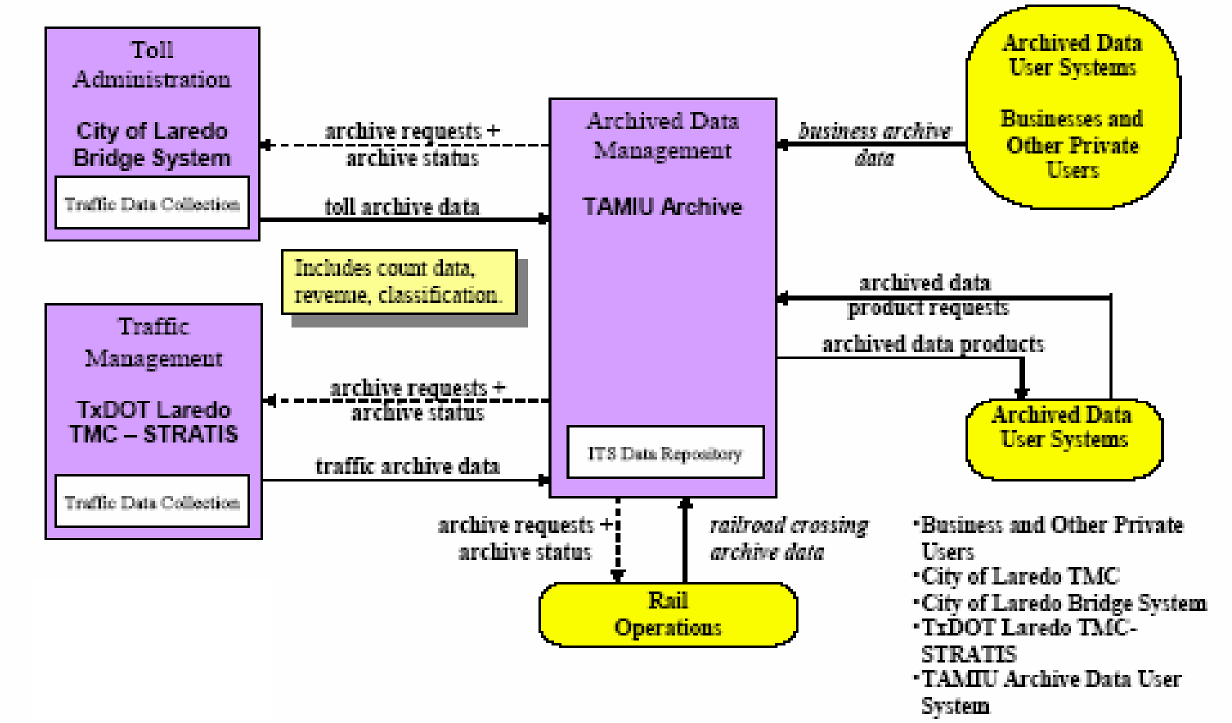

Figure 12. AD01: ITS Data Mart

Table 4. Existing STRATIS Linkages

COMPONENTS	Information **from** STRATIS	Supported Market Packages									Information **to** STRATIS	Supported Market Packages								
		ATMS01: Network Surveillance	ATMS03: Surface Street Control	ATMS04: Freeway Control	ATMS06: Traffic Information Dissemination	ATMS08: Incident Management System	ATMS13/15:Standard Railroad Grade Crossing/ Railroad Operations Control	EM02: Emergency Routing	MC08: Work Zone Management	AD01: ITS Data Mart		ATMS01: Network Surveillance	ATMS03: Surface Street Control	ATMS04: Freeway Control	ATMS06: Traffic Information Dissemination	ATMS08: Incident Management System	ATMS13/15:Standard Railroad Grade Crossing/ Railroad Operations Control	EM02: Emergency Routing	MC08: Work Zone Management	AD01: ITS Data Mart
National Weather Service											Weather information					✓				
TAMIU Archive	Traffic archive data									✓										
TxDOT Laredo CCTV	Traffic video surveillance control	✓	✓	✓		✓					Traffic images	✓	✓	✓		✓				
TxDOT Laredo DMS	Roadway information system data				✓				✓		Roadway information system status				✓				✓	
TxDOT Laredo Field Sensors	Traffic sensor control	✓	✓	✓		✓					Traffic flow	✓	✓	✓		✓				
TxDOT Laredo HAR	Roadway information system data				✓				✓		Roadway information system status				✓				✓	
TxDOT Laredo Traffic Signals	Signal control data		✓					✓			Signal control status		✓							
	HRI request HRI control data						✓				HRI status						✓			

CHAPTER 3
EVALUATION METHODOLOGY

When evaluating the experiences of TxDOT's *STRATIS* TMC in integrating existing field equipment including closed circuit television (CCTV) cameras, loop detectors/video identification vehicle detection systems (VIVDS), dynamic message signs (DMS), highway advisory radio (HAR), and train monitoring systems, two general approaches were taken:

1. the level or degree of integration achieved by *STRATIS* was determined using methods recommended in *Measuring ITS Deployment and Integration* (FHWA 1999), and

2. the integration outcomes (i.e., improvements in safety, traffic congestion and delay, etc.) were determined using methods recommended in the *TEA-21 ITS Evaluation Guidelines* (FHWA 1999g).

Each of these methodologies is described below. In addition to each of these methods, stakeholder surveys solicited more qualitative information regarding the integration process and perceived benefits.

Integration Indicators

The method presented in *Measuring ITS Deployment and Integration* (FHWA 1999) represents a very useful tool for tracking the deployment and integration of ITS technologies. Although this methodology was developed using the framework of the Metropolitan ITS Infrastructure, the close relationship between that infrastructure and the more comprehensive National ITS Architecture makes it easy to apply the methodology under either framework.

The first step in measuring integration is to determine the links between components required to provide integrated ITS operation. An extensive list of possible interactions was defined in *Measuring ITS Deployment and Integration* (FHWA 1999) through analyses of data flows in the National ITS Architecture (see Figure 13). This list does not present all possible information transfers. These interactions, or links, were selected as possible ITS integration indicators for two reasons; the links are already (1) commonly defined and (2) periodically measured.

As mentioned previously, there are two types of possible integration links: (1) between *different* components (e.g., linkage "2" in Figure 13) and (2) between elements of the *same* component (e.g., linkage "26" in Figure 13). Also mentioned previously, a three-phase process for ITS integration has evolved, with each phase requiring progressively greater levels of technical and institutional coordination: (1) shared infrastructure, (2) shared information, and (3) coordinated control. The methodology presented in *Measuring ITS Deployment and Integration* (FHWA 1999) considers only the latter two phases when measuring existing integration: (1) shared information and (2) coordinated control. Information sharing is defined as the transfer of information from one element to another, where the recipient element can use the information to structure its response to changing travel conditions more efficiently. Information exchange is measured with a "flow" metric, which considers how much of available information is being exchanged to other components. Coordinated control identifies the manner and use of information that is transferred to the recipient element (FHWA 1999).

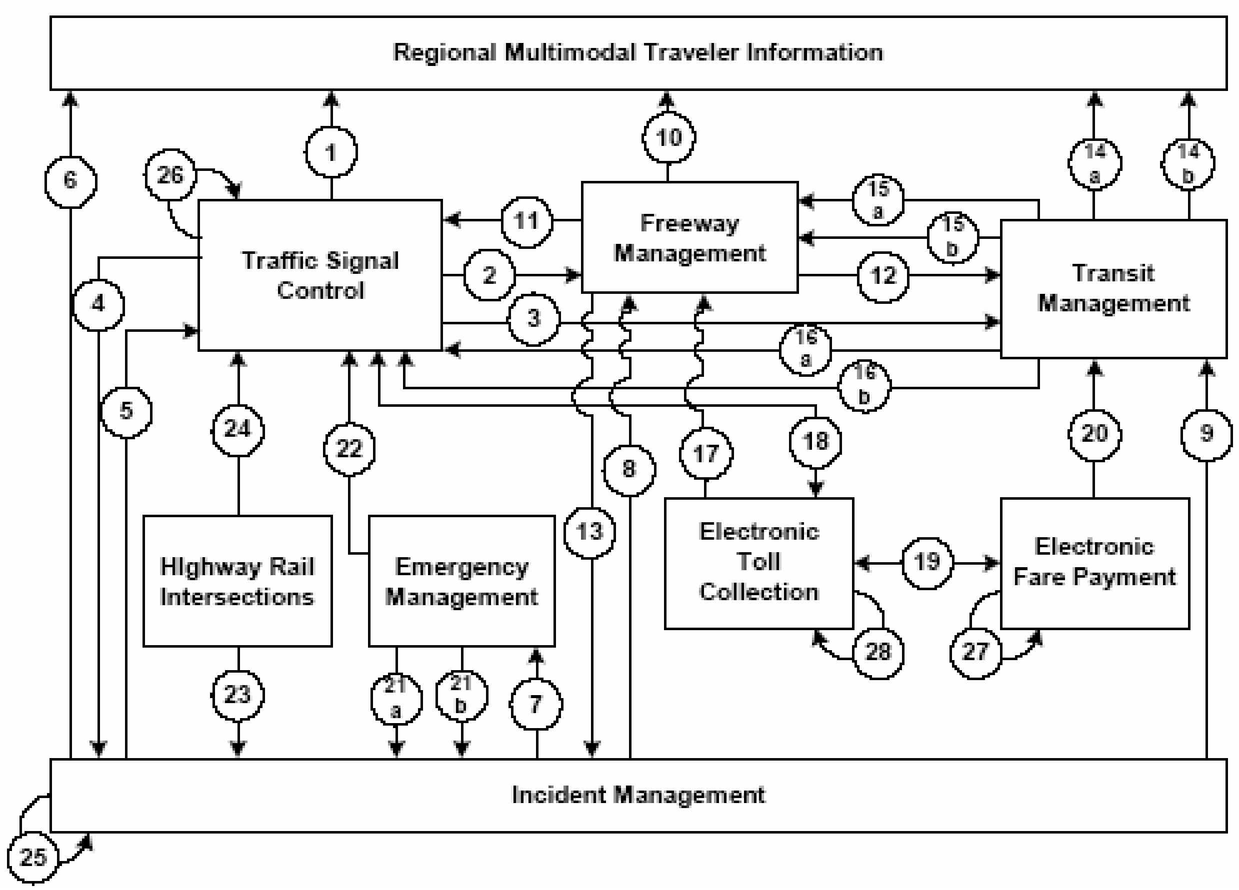

Figure 13. Summary of Integration Linkages under the Metropolitan ITS Infrastructure

For each of the links identified in Figure 13, a corresponding integration indictor was defined and reported in *Measuring ITS Deployment and Integration* (FHWA 1999). These integration indicators include a description of the link and calculation methods for both flow and control metrics (as appropriate). An example for Link ② is provided in Table 5.

Table 5. Integration Indicator Example for Link ②

2. Traffic Signal Control to Freeway Management	
Description:	Freeway Management Center monitors arterial travel times, speeds and conditions using data provided from Traffic Signal Control in order to adjust ramp meter timing, lane control or HAR in response to changes in real-time conditions on a parallel arterial.
Flow:	**Numerator:** Number of signalized plus CBD street miles covered by a transfer of information in real-time describing arterial travel times, speeds or conditions to an organization responsible for *Freeway Management*. **Denominator:** Total number of miles with real-time electronic traffic data collection capabilities located *within* the CBD plus the total number of miles with real-time electronic traffic data collection capabilities located *outside* the CBD
Control:	**Numerator:** Number of Freeway Management agencies that receive in real-time data on arterial travel times, speeds, or incidents from a *Traffic Signal System* operator. **Denominator:** Total number of agencies.

Before applying this general evaluation methodology to the *STRATIS* integration, the Laredo Region ITS components and linkages identified previously in Figure 4 through 12 and Table 4, were converted from the National ITS Architecture framework to the Metropolitan ITS Infrastructure framework. In general, the ITS components and their corresponding market packages were mapped to National ITS Architecture subsystems, which were then mapped to Metropolitan ITS Infrastructure elements. Table 6 summarizes this conversion process and Table 7 provides an updated summary of the existing STRATIS linkages under the dual framework.

Using the information provided in Table 7 and Figure 13, the applicable *STRATIS*-related ITS integration linkages were identified under the Metropolitan ITS Infrastructure. These linkages are depicted in Figure 14. With these linkages identified, researchers utilized the methods presented in *Measuring ITS Deployment and Integration* (FHWA 1999) to calculate respective integration indicators for both flow and control metrics (as appropriate). A summary of the general calculation methods for only the STRATIS-related ITS integration linkages is provided in Table 8.

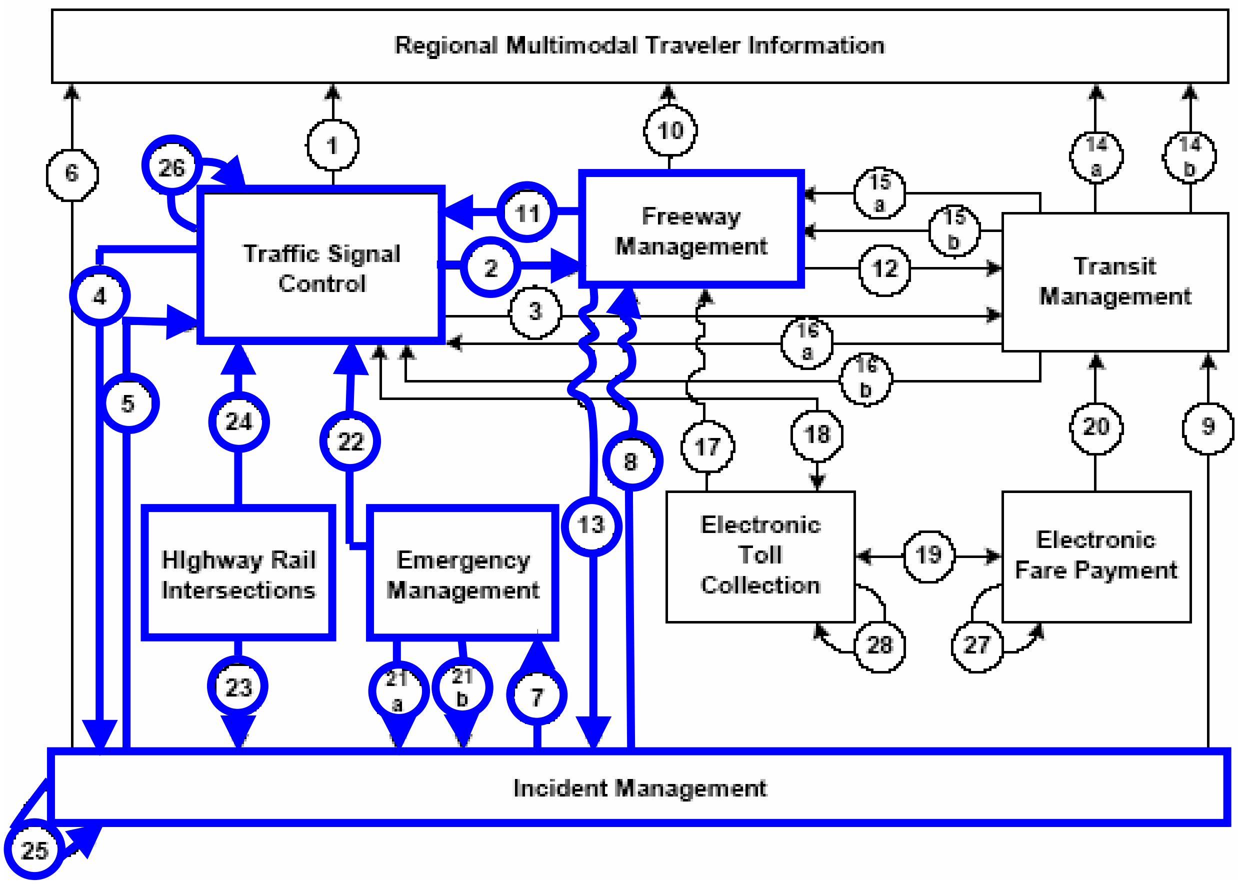

Figure 14. Summary of STRATIS-related Integration Linkages under the Metropolitan ITS Infrastructure

Table 6. National ITS Architecture to Metropolitan ITS Infrastructure Conversion Process

STRATIS-RELATED ITS COMPONENTS	NATIONAL ITS ARCHITECTURE SUPPORTED MARKET PACKAGES	NATIONAL ITS ARCHITECTURE SUBSYSTEM	METROPOLITAN ITS INFRASTRUCTURE ELEMENT
National Weather Service	ATMS08: Incident Management		Incident Management (IM)
TAMIU Archive	AD01: ITS Data Mart	Archived Data Management	(No applicable element defined)
TxDOT Laredo CCTV	ATMS01: Network Surveillance	Roadway/Traffic Management	Freeway Management (FM)
	ATMS03: Surface Street Control	Roadway/Traffic Management	Traffic Signal Control (TSC)
	ATMS04: Freeway Control	Roadway/Traffic Management	Freeway Management (FM)
	ATMS08: Incident Management	Traffic Management	Incident Management (IM)
TxDOT Laredo DMS	ATMS06: Traffic Information Dissemination	Roadway/Traffic Management	Freeway Management (FM)
	MC08: Work Zone Management	Roadway/Traffic Management	Freeway Management (FM)
TxDOT Laredo Field Sensors	ATMS01: Network Surveillance	Roadway/Traffic Management	Freeway Management (FM)
	ATMS03: Surface Street Control	Roadway/Traffic Management	Traffic Signal Control (TSC)
	ATMS04: Freeway Control	Roadway/Traffic Management	Freeway Management (FM)
	ATMS08: Incident Management	Roadway/Traffic Management	Incident Management (IM)
TxDOT Laredo HAR	ATMS06: Traffic Information Dissemination	Roadway/Traffic Management	Freeway Management (FM)
	MC08: Work Zone Management	Roadway/Traffic Management	Freeway Management (FM)
TxDOT Laredo Traffic Signals	ATMS03: Surface Street Control	Roadway/Traffic Management	Traffic Signal Control (TSC)
	ATMS13/15: Standard Railroad Grade Crossing/Railroad Operations Coordination	Roadway/Traffic Management	Highway-rail Intersections (HRI)
	EM02: Emergency Routing	Emergency Management	Emergency Management (EM)

Table 7. Existing STRATIS Linkages under the Dual ITS Framework

COMPONENTS	Information **from** STRATIS	NATIONAL ITS ARCHITECTURE Supported Market Packages									Information **to** STRATIS	NATIONAL ITS ARCHITECTURE Supported Market Packages								
		ATMS01: Network Surveillance	ATMS04: Freeway Control	ATMS06: Traffic Information Dissemination	MC08: Work Zone Management	ATMS08: Incident Management System	ATMS03: Surface Street Control	EM02: Emergency Routing	ATMS13/15:Standard Railroad Grade Crossing/ Railroad Operations Control	AD01: ITS Data Mart		ATMS01: Network Surveillance	ATMS04: Freeway Control	ATMS06: Traffic Information Dissemination	MC08: Work Zone Management	ATMS08: Incident Management System	ATMS03: Surface Street Control	EM02: Emergency Routing	ATMS13/15:Standard Railroad Grade Crossing/ Railroad Operations Control	AD01: ITS Data Mart
METROPOLITAN ITS INFRASTRUCTURE[1]		**FM**				**IM**	**TSC**	**EM**	**HRI**	**-**		**FM**				**IM**	**TSC**	**EM**	**HRI**	**-**
National Weather Service											Weather information					✓				
TAMIU Archive	Traffic archive data									✓										
TxDOT Laredo CCTV	Traffic video surveillance control	✓	✓	✓		✓					Traffic images	✓	✓	✓		✓				
TxDOT Laredo DMS	Roadway information system data				✓				✓		Roadway information system status				✓				✓	
TxDOT Laredo Field Sensors	Traffic sensor control	✓	✓	✓		✓					Traffic flow	✓	✓	✓		✓				
TxDOT Laredo HAR	Roadway information system data				✓				✓		Roadway information system status				✓				✓	
TxDOT Laredo Traffic Signals	Signal control data		✓					✓			Signal control status		✓							
	HRI request HRI control data						✓				HRI status						✓			

[1] FM=Freeway Management, IM=Incident Management, TSC=Traffic Signal Control, EM=Emergency Management, HRI=Highway-rail Intersections

Table 8. Summary of STRATIS-related ITS Integration Indicators

2. Traffic Signal Control to Freeway Management	
Description:	Freeway Management Center monitors arterial travel times, speeds and conditions using data provided from Traffic Signal Control in order to adjust ramp meter timing, lane control or HAR in response to changes in real-time conditions on a parallel arterial.
Flow:	**Numerator:** Number of signalized plus CBD street miles covered by a transfer of information in real-time describing arterial travel times, speeds or conditions to an organization responsible for *Freeway Management*. **Denominator:** Total number of miles with real-time electronic traffic data collection capabilities located *within* the CBD plus the total number of miles with real-time electronic traffic data collection capabilities located *outside* the CBD
Control:	**Numerator:** Number of Freeway Management agencies that receive in real-time data on arterial travel times, speeds, or incidents from a *Traffic Signal System* operator. **Denominator:** Total number of agencies.
4. Traffic Signal Control to Incident Management	
Description:	Incident Management monitors real-time arterial travel times, speeds and conditions using data provided from Traffic Signal Control to detect arterial incidents and manage incident response activities.
Flow:	**Numerator:** Number of signalized plus CBD street miles covered by a transfer of information in real-time describing arterial travel times, speeds or conditions to an organization responsible for *Freeway or Arterial Incident Management*. **Denominator:** Total number of miles with real-time electronic traffic data collection capabilities located *within* the CBD plus the total number of miles with real-time electronic traffic data collection capabilities located *outside* the CBD.
Control:	**Numerator:** Number of Incident Management agencies that receive in real-time data on arterial travel times, speeds, or incidents from a *Traffic Signal System* operator and use this data to detect incidents. **Denominator:** Total number of agencies.
5. Incident Management to Traffic Signal Control	
Description:	Traffic Signal Control monitors incident severity, location, and type information collected by Incident Management to adjust traffic signal timing or information provided to travelers in response to incident management activities.
Flow:	**Numerator:** Total number of freeway plus arterial miles covered in the electronic transfer, in real-time, of information on incident severity, location, and type to an organization responsible for *Traffic Signal Control* on arterial and CBD streets. **Denominator:** Total number of freeway plus arterial miles covered by a formal procedure for managing incidents.
Control:	**Numerator:** Number of agencies that receive in real-time data on freeway and arterial incident severity, location and type from an organization operating a freeway or arterial incident management program **and** use this information to adjust signal timing **times** the total number of signalized intersections located within and outside CBD **Denominator:** Total number of signalized intersections located within and outside CBD
7. Incident Management to Emergency Management	
Description:	Incident severity, location, type data collected as part of Incident Management used to notify Emergency Management for incident response.
Flow:	**Numerator:** Total number of freeway plus arterial miles covered in the electronic transfer, in real-time, of information on incident severity, location, and type to an organization responsible for *Emergency Management Services.* **Denominator:** Total number of freeway plus arterial miles covered by a formal procedure for managing incidents.
8. Incident Management to Freeway Management	
Description:	Incident severity, location, and type data collected by Incident Management are monitored by Freeway Management for the purpose of adjusting ramp meter timing, lane control or HAR messages in response to freeway or arterial incidents.

Table 8. Summary of STRATIS-related ITS Integration Indicators (Continued)

8. Incident Management to Freeway Management (Continued)	
Flow:	**Numerator:** Total number of freeway plus arterial miles covered in the electronic transfer, in real-time of information on incident severity, location, and type to an organization responsible for *Freeway Management*. **Denominator:** Total number of freeway plus arterial miles covered by a formal procedure for managing incidents.
Control:	**Numerator:** Number of Freeway Management agencies that receive, in real-time, data on freeway incident severity, location and type from an organization operating a *Freeway Incident Management Program* **and** use this information to adjust ramp meter timing or lane control devices in real-time or to convey information to travelers via roadside infrastructure such as VMS or HAR **Denominator:** Total number of agencies
11. Freeway Management to Traffic Signal Control	
Description:	Freeway travel time, speeds, and conditions data collected by Freeway Management are used by Traffic Signal Control to adjust arterial traffic signal timing or arterial VMS messages in response to changing freeway conditions
Flow:	**Numerator:** Number of freeway miles covered by an electronic transfer of information describing freeway travel times, speeds, or conditions from a Freeway Management agency to a agency responsible for *Traffic Signal Control* on arterial and CBD streets,. **Denominator:** Number of miles under surveillance by Loop Detectors **plus** number of miles under surveillance by Other Technologies **plus** number of freeway segments monitored by probe reader stations **times** the average length of the segment **less** the miles covered by the probe readers that are also covered by other electronic traffic data collection equipment.
Control:	**Numerator:** Number of agencies that receive in real-time data on freeway travel times, speeds, or conditions from a freeway management organization **and** use this information to adjust signal timing **times** the total number of signalized intersections located within and outside CBD **Denominator:** Total number of signalized intersections located within and outside CBD
13. Freeway Management to Incident Management	
Description:	Incident Management monitors freeway travel time, speed and condition data collected by Freeway Management to detect incidents or manage incident response.
Flow:	**Numerator:** Number of freeway miles covered by an electronic transfer of information describing freeway travel times, speeds, or conditions from a Freeway Management agency to an agency responsible for *Incident Management.* **Denominator:** Number of miles under surveillance by Loop Detectors **plus** number of miles under surveillance by Other Technologies **plus** number of freeway segments monitored by probe reader stations **times** the average length of the segment **less** the miles covered by the probe readers that are also covered by other electronic traffic data collection equipment.
Control:	**Numerator:** Number of Incident Management agencies that receive information describing freeway travel times, speeds, and conditions automatically in real-time **and** use this information to detect incidents or manage incident response in real-time. **Denominator:** Number of agencies.
21a. Emergency Management Services to Incident Management (incident severity)	
Description:	Incident Management is notified of incident location, severity and type by Emergency Management for the purpose of identifying incidents on freeways or arterials
Flow:	**Numerator:** Number of Incident Management agencies that receive, in real-time, *incident severity, location and type* data from an emergency service agency **times** the average of the percent of Police, Fire and Emergency Medical services that participate in a formal working agreement or incident management team. **Denominator:** Number of agencies

Table 8. Summary of STRATIS-related ITS Integration Indicators (Continued)

21b. Emergency Management Services to Incident Management (incident clearance activities)	
Description:	Incident Management is notified of incident clearance activities by Emergency Management for the purpose of managing incident response on freeways or arterials.
Flow:	**Numerator:** Number of Incident Management agencies that receive, in real-time, *incident clearance activities* data from an emergency service agency **times** the average of the percent of Police, Fire and Emergency Medical services that participate in a formal working agreement or incident management team. **Denominator:** Number of agencies
22. Emergency Management Services to Traffic Signal Control	
Description:	Emergency Management vehicles are equipped with traffic signal priority capability.
Flow:	**Numerator:** Number of ER vehicles with traffic signal system communications. **Denominator:** Total number of Emergency Response vehicles operated
Control:	**Numerator:** Total number of signalized intersections located within and outside CBD that allow signal preemption or priority to emergency vehicle. **Denominator:** Total number of signalized intersection located within and outside CBD
23. Highway Rail Intersections to Incident Management	
Description:	Incident Management is notified of crossing blockages by Highway-rail intersection for the purpose of managing incident response.
Flow:	**Numerator:** Number of highway rail intersections covered by a transfer of information on train or vehicle blockage on highway intersection in real-time, from an agency responsible for maintaining rail intersection. **Denominator:** Total number of highway-rail intersections
24. Highway Rail Intersections to Traffic Signal Control	
Description:	Highway-rail intersection and Traffic Signal Control are interconnected for the purpose of adjusting traffic signal timing in response to train crossing.
Flow:	**Numerator:** Number of traffic signals equipped with capability to adjust signal timing in response to train crossing **Denominator:** Total number of traffic signals maintained by the agency that area within 200 feet of a highway-rail intersection
25. Incident Management intra component integration	
Description:	Agencies participating in formal working agreements or incident management plans coordinate incident detection, verification, and response.
Flow:	**Numerator:** Percent of local state and state police + fire agencies + emergency medical vehicles participating in a formal working Incident Management agreement or Incident Management Team **Denominator:** 3
26. Traffic Signal Control intra component integration	
Description:	Agencies operating traffic signals along common corridors sharing information and possibly control of traffic signals to maintain progression on arterial routes.
Flow:	**Numerator:** Number of agencies that *share information describing fixed timing plans* with other agencies in order to maintain progression on an arterial route that includes signals maintained by both agencies **or** number of agencies that *coordinate changes to fixed plans* with other agencies in order to maintain progression on an arterial route that includes signals maintained by both agencies **Denominator:** Number of agencies

Integration Outcomes

To determine the integration outcomes (i.e., improvements in safety, traffic congestion and delay, etc.), methods recommended in the *TEA-21 ITS Evaluation Guidelines* (FHWA 1999g) were used. A six-step process for ITS project evaluation is recommended:

Step 1: Form the Evaluation Team

Step 2: Develop the Evaluation Strategy

Step 3: Develop the Evaluation Plan

Step 4: Develop One or More Test Plans

Step 5: Collect and Analyze Data and Information

Step 6: Prepare the Final Report

Each of these steps is described in more detail below.

Evaluation Team

Laredo Region stakeholders participating in the *STRATIS* integration were listed previously in Table 2. The Evaluation Team comprised at least one member from each of the stakeholder agencies and organizations.

The evaluation was conducted by the Texas Transportation Institute, Texas A&M University System (as Independent Evaluator). Key roles of the evaluator requiring early involvement in the project were:

- identifying key stakeholders;
- eliciting a meaningful set of goals and objectives for the project and their relative priorities from the stakeholders;
- obtaining insight and consensus regarding which measures will indicate the degree to which project success has been achieved; and
- communicating changes in goals, objectives, and measures as the project progresses.

In the interests of conducting an effective evaluation, the Evaluation Team convened for quarterly meetings facilitated by the Texas Transportation Institute.

Evaluation Strategy

The Evaluation Strategy relates the purpose of the project to the overall ITS goal areas, such as:

- traveler safety,
- traveler mobility,

- transportation system efficiency,
- productivity of transportation providers,
- conservation of energy and protection of the environment, or
- others as appropriate to address unique features of a project (FHWA 1999g).

Each of these goal areas can be associated with outcomes of deployment that lend themselves to measurement (FHWA 1999g):

Goal Area	Measure of Effectiveness (MOE)
Safety	• reduction in the overall rate of crashes • reduction in the rate of crashes resulting in fatalities • reduction in the rate of crashes resulting in injuries
Mobility	• reduction in delay • reduction in transit time variability • improvement in customer satisfaction
Efficiency	• increases in freeway and arterial throughput or effective capacity
Productivity	• cost savings
Energy/Environment	• decrease in emissions levels • decrease in energy consumption

A major purpose of the Evaluation Strategy development process is to focus the stakeholders' attention on identifying which of the above goal areas have priority in their project (FHWA 1999g). For the Laredo Region *STRATIS* Integration Project, each Evaluation Team member was asked to distribute 10 total points across six goal areas including customer satisfaction, energy/environment, productivity, system efficiency, mobility, and safety. Goal areas with higher importance were assigned a greater number of points. From these ratings made by individual stakeholders, a set of ratings for the collective group was determined. Using the collective group ratings, the goals areas were ranked according to importance and project evaluation resources were assigned consistently with the evaluation priorities of the group.

The priority goal areas resulting from this exercise, in order of importance, are listed in Table 9, along with corresponding measures of effectiveness. Goal areas related to customer satisfaction, energy and environment and agency productivity were low-ranking and hence, were not considered further in this evaluation.

Table 9. STRATIS Integration Evaluation Strategy, Evaluation Plan, and Test Plan Outcomes

EVALUATION STRATEGY			EVALUATION PLAN	TEST PLANS	
GOAL AREA	**GOALS**	**MOES**	**HYPOTHESES**	**METHODS**	**DATA NEEDS**
Traveler Safety	Improve safety • crash rates • incident impacts • traveler information	Reduction in: • overall crash rate • fatality crash rate • injury crash rate • secondary crash rate • incident durations • approach speeds • erratic maneuvers	ITS integration reduces: • primary/ secondary crash rates • incident durations • approach speeds • erratic maneuvers ITS integration improves: • traveler information	• before/after analysis • modeling/simulation • surveys/interviews	• historical crash data • dispatch logs • detector/video data • personnel interviews • DMS/HAR system logs
Traveler Mobility	Improve mobility • travel time • reliability • traveler information	Reduction in: • travel time delay • queue lengths • travel time variability	ITS integration reduces: • travel time delay • queue lengths • travel time variability ITS integration improves: • traveler information	• before/after analysis • modeling/simulation • surveys/interviews	• detector/video data • probe vehicle data • personnel interviews • HRI system logs • DMS/HAR system logs
Transportation System Efficiency	Improve system efficiency • vehicle throughput • network LOS	Increase in: • vehicle throughput • vehicle speed	ITS integration increases: • vehicle throughput • network LOS ITS integration improves: • traveler information	• before/after analysis • modeling/simulation • surveys/interviews	• detector/video data • probe vehicle data • personnel interviews • HRI system logs • DMS/HAR system logs

Evaluation Plan

After the goals are identified and evaluation priorities are set by the stakeholders in the Evaluation Strategy, the Evaluation Plan refines the evaluation approach by formulating hypotheses. Hypotheses are "if-then" statements that reflect the expected outcomes of the ITS project (FHWA 1999g). Table 9 lists appropriate hypotheses corresponding to the ranked goal areas and measures of effectiveness.

Test Plans

The development of test plans includes both an identification of appropriate evaluation methods and an identification of supporting data needs (see Table 9).

Methods. Appropriate evaluation methods were considered for each of the hypothesis related to traveler safety, traveler mobility, and transportation system efficiency. Each of these general methods is challenged in its ability to distinguish the impacts of the fundamental technology from the impacts of the *integration* of technologies. Additional methodological challenges are described below.

- *Traveler Safety.* To investigate the effects of ITS and ITS integration on traveler safety, a comparison can be made between crash rate (or fatality rate, or injury rate) in the period before and the period following implementation. The length of the study period and the collection of data in both time periods should be sufficiently large. Even with an adequate sampling period, the random nature of crash occurrences may preclude statistical confirmation of a significant difference between the number of crashes in the "before" and "after" periods. For these reasons, surrogate measures may provide a better (or at least equally desirable) indicator of the safety gains of ITS. For example, the use of DMS may reduce speeds during inclement weather, which in turn, is expected to reduce the risk of a crash occurring (FHWA 1999g). However, the surrogate measures may not be as readily available as crash data.

- *Traveler Mobility.* The effect of ITS or ITS integration on traveler mobility is most often described in terms of travel time delay and variability. Delay is typically measured in seconds per vehicle or minutes per vehicle of delay. Delay can be measured in many different ways depending on the type of transportation improvement being evaluated. Some methods include “floating car", observed stops, or expected vs. observed travel times before and installation of a system. The calculation of travel time variability involves an analysis of the spread (or distribution) of travel time around the mean (or average) travel time. Travel time variability can be calculated under different time horizons, such as within day and day-to-day variability of a given trip or goods movement from an origin to a destination. Several types of statistics can be computed on a travel time data set which is indicative of the variability (e.g., standard deviation or variance around the mean, range of travel times (low to high), etc.) (FHWA 1999g).

- *Transportation System Efficiency*. Measuring the effect of ITS or ITS integration on transportation system efficiency relies on two general concepts: effective capacity and vehicle throughput. Effective capacity is the maximum potential rate at which persons or vehicles may traverse a link, node, or network under a representative composite of roadway conditions. Capacity, as defined by the Highway Capacity Manual (HCM) (Transportation Research Board 2000), is: "maximum hourly rate at which persons or vehicles can reasonably be expected to traverse a given point or uniform section of a lane or roadway during a given time period under prevailing roadway, traffic and control conditions." The major difference between effective capacity and capacity is that capacity is assumed to be measured under good weather and pavement conditions and without incidents, whereas effective capacity can vary depending on these conditions and the use of management and operations strategies such as ITS. Capacity (and effective capacity) is calculated given the design and operation of the network segment and does not change unless the physical construction or operation of that network segment are changed (FHWA 1999g). Throughput is defined as the number of persons, vehicles, or units of freight *actually* traversing a roadway section or network per unit time. Increases in throughput are sometimes realizations of increases in effective capacity. Care must be given to interpreting results, however, because throughput changes may be due to factors beside effective capacity changes (e.g., changes in demand). Thus, not all throughput changes are indicative of improvements in the efficiency of a transportation system. Throughput can be measured by taking volume counts of the number of persons or vehicles traversing a roadway section or network per unit time.

Data Needs. With these methods in mind, researchers identified supporting data needs and explored data availability. In each case, with historical crash data providing a single exception, data were available only for the period following *STRATIS* integration; no comparative data were available for the period preceding *STRATIS* integration. This lack of “before” data precluded any quantitative determination of changes in traveler mobility and transportation system efficiency attributable to *STRATIS* integration.

With a focus on traveler safety, researchers explored the availability of historical crash data in more detail. At a minimum, crashes occurring in 2001 and 2002 should be considered as the “before” period, with crashes occurring in 2004 and 2005 comprising the “after” period. The Crash Records Information System (CRIS), maintained by the Texas Department of Public Safety (DPS), is the primary source of historical crash data in the State. Unfortunately, the most recent available electronic records available through this system are from 2001. Crash data from 2002, 2004, and 2005 is only obtainable through a manual search conducted by DPS personnel with a nominal per day fee. According to DPS personnel, the current backlog for manual searches is 14 to 16 weeks, not including the time required to perform the search. In addition, this manual search would produce only a crash frequency for the roadway segments of interest; no details would be included that would allow investigation into a reduction in crash severity or secondary crash occurrence.

Given: (1) the lack of available “before” data to support any quantitative determination of changes in traveler mobility and transportation system efficiency attributable to *STRATIS* integration, (2) the lack of accessible “before” and “after” data to support any quantitative determination of changes in traveler safety attributable to *STRATIS* integration, and (3) the difficulty in distinguishing the impacts of the fundamental technology from the impacts of the *integration* of technologies, further pursuit of integration outcomes was discontinued in this investigation.

Qualitative Assessments

In addition to measuring *STRATIS* integration levels and outcomes, affected stakeholders were asked to provide qualitative information regarding the integration process and perceived benefits. A series of questions were developed and structured around the previously-described five dimensions of integration defined by Cluett, et al (2006) to characterize the extent of integration for traffic management centers: (1) Physical Integration, (2) Technical Integration, (3) Procedural Integration, (4) Institutional Integration, and (5) Operational Integration. These questions are summarized in Table 10.

Table 10. Qualitative Assessment Questions

Physical Integration	• How is *STRATIS* physically linked (e.g., fiber optic, wireless network, etc.) with each of the following components? In other words, how is data or information exchanged between *STRATIS* and each of the following components? • TxDOT Laredo CCTV • TxDOT Laredo DMS • TxDOT Laredo Field Sensors • TxDOT Laredo HAR • TxDOT Laredo Traffic Signals • TAMUI Archive • National Weather Service • Have any problems been encountered with respect to these physical linkages (i.e., speed of data transmission, reliability, maintenance, etc.)? Please describe.
Technical Integration	• What technical issues were encountered when integrating these components through *STRATIS*? Please describe. • How did these technical issues affect the: • cost of the integration effort? • timeline of the integration effort? • expected outcomes or capabilities of the integration effort?
Procedural Integration	• Have any policies, plans, or procedures been developed to support integrated operations? • If yes, are these policies, plans and procedures: • written down? • accessible to staff? • reinforced with training and exercises?
Institutional Integration	• What institutional issues were encountered when integrating these components through *STRATIS*? Please describe. • organizational issues? • human resource issues? • public acceptance issues? • regulatory/legal issues? • financial issues? • other issues? • How were these issues overcome?
Operational Integration	• What operational benefits or detriments have resulted from the integration of these components through *STRATIS*. Please describe. • Are any new procedures performed as a result of this integration? In other words, has integration provided additional capabilities that are being exploited? Please describe. • Have any new working relationships developed, within or outside TxDOT (e.g., DPS, City of Laredo, etc.), as a result of this integration? In other words, have other TxDOT or non-TxDOT personnel realized value in what *STRATIS* can offer? Please describe.

CHAPTER 4
EVALUATION RESULTS

When evaluating the experiences of TxDOT's *STRATIS* TMC in integrating existing field equipment including closed circuit television (CCTV) cameras, loop detectors/video identification vehicle detection systems (VIVDS), dynamic message signs (DMS), highway advisory radio (HAR), and train monitoring systems, two general aspects of integration were considered:

1. the level or degree of integration (i.e., integration indicators) achieved by *STRATIS*, and

2. the integration outcomes (i.e., improvements in safety, traffic congestion and delay, etc.) achieved by STRATIS.

In addition to each of these considerations, stakeholder surveys solicited more qualitative information regarding the integration process and perceived benefits.

The determination of integration outcomes achieved by *STRATIS* was limited by a lack of available "before" data to support determination of traveler mobility and transportation system efficiency measures and a lack of accessible "before" and "after" data to support determination of traveler safety measures. Hence, the evaluation results focus only on the level or degree of integration achieved by *STRATIS* and any qualitative assessments.

Integration Indicators

When considering the level or degree of integration achieved by *STRATIS* approximately three years after implementation, integration indicators suggest several opportunities for enhanced integration. Of the 14 applicable linkages defined in *Measuring ITS Deployment and Integration* (FHWA 1999) using the Metropolitan ITS infrastructure, only 5 of *STRATIS'* linkages have any measurable degree of integration (see Table 11):

2. Traffic Signal Control to Freeway Management

4. Traffic Signal Control to Incident Management

7. Incident Management to Emergency Management

8. Incident Management to Freeway Management

13. Freeway Management to Incident Management.

TxDOT Laredo Traffic Signals provides arterial travel times, speeds, and conditions on approximately 10 miles of a total 22 miles under *STRATIS* surveillance. This incoming information is used to adjust freeway operational or control strategies (i.e., lane control, HAR, DMS, etc.) but is not used to adjust traffic signal timings or traveler information along the arterials. This information is used, however, to detect arterial incidents and support incident response activities.

Table 11. STRATIS Integration Indicator Results

INDICATOR		RESULTS
2. Traffic Signal Control to Freeway Management		
Description:	Freeway Management Center monitors arterial travel times, speeds and conditions using data provided from Traffic Signal Control in order to adjust ramp meter timing, lane control or HAR in response to changes in real-time conditions on a parallel arterial.	
Flow:	**Numerator:** Number of signalized plus CBD street miles covered by a transfer of information in real-time describing arterial travel times, speeds or conditions to an organization responsible for *Freeway Management*. **Denominator:** Total number of miles with real-time electronic traffic data collection capabilities located *within* the CBD plus the total number of miles with real-time electronic traffic data collection capabilities located *outside* the CBD	10/22 miles
Control:	**Numerator:** Number of Freeway Management agencies that receive in real-time data on arterial travel times, speeds, or incidents from a *Traffic Signal System* operator. **Denominator:** Total number of agencies.	TxDOT is solely responsible for Freeway Management
4. Traffic Signal Control to Incident Management		
Description:	Incident Management monitors real-time arterial travel times, speeds and conditions using data provided from Traffic Signal Control to detect arterial incidents and manage incident response activities.	
Flow:	**Numerator:** Number of signalized plus CBD street miles covered by a transfer of information in real-time describing arterial travel times, speeds or conditions to an organization responsible for *Freeway or Arterial Incident Management*. **Denominator:** Total number of miles with real-time electronic traffic data collection capabilities located *within* the CBD plus the total number of miles with real-time electronic traffic data collection capabilities located *outside* the CBD.	10/22 miles
Control:	**Numerator:** Number of Incident Management agencies that receive in real-time data on arterial travel times, speeds, or incidents from a *Traffic Signal System* operator and use this data to detect incidents. **Denominator:** Total number of agencies.	1/6 potential Incident Management agencies with arterial jurisdiction
5. Incident Management to Traffic Signal Control		
Description:	Traffic Signal Control monitors incident severity, location, and type information collected by Incident Management to adjust traffic signal timing or information provided to travelers in response to incident management activities.	
Flow:	**Numerator:** Total number of freeway plus arterial miles covered in the electronic transfer, in real-time, of information on incident severity, location, and type to an organization responsible for *Traffic Signal Control* on arterial and CBD streets. **Denominator:** Total number of freeway plus arterial miles covered by a formal procedure for managing incidents.	No measurable integration
Control:	**Numerator:** Number of agencies that receive in real-time data on freeway and arterial incident severity, location and type from an organization operating a freeway or arterial incident management program **and** use this information to adjust signal timing **times** the total number of signalized intersections located within and outside CBD **Denominator:** Total number of signalized intersections located within and outside CBD	No measurable integration

Table 11. STRATIS Integration Indicator Results (Continued)

<table>
<tr><td colspan="2">INDICATOR</td><td>RESULTS</td></tr>
<tr><td colspan="3">7. Incident Management to Emergency Management</td></tr>
<tr><td>Description:</td><td colspan="2">Incident severity, location, type data collected as part of Incident Management used to notify Emergency Management for incident response.</td></tr>
<tr><td>Flow:</td><td>Numerator: Total number of freeway plus arterial miles covered in the electronic transfer, in real-time, of information on incident severity, location, and type to an organization responsible for Emergency Management Services.
Denominator: Total number of freeway plus arterial miles covered by a formal procedure for managing incidents.</td><td>22/22 miles
Each agency has formal procedures for managing incidents; these procedures are not integrated between agencies.</td></tr>
<tr><td colspan="3">8. Incident Management to Freeway Management</td></tr>
<tr><td>Description:</td><td colspan="2">Incident severity, location, and type data collected by Incident Management are monitored by Freeway Management for the purpose of adjusting ramp meter timing, lane control or HAR messages in response to freeway or arterial incidents.</td></tr>
<tr><td>Flow:</td><td>Numerator: Total number of freeway plus arterial miles covered in the electronic transfer, in real-time of information on incident severity, location, and type to an organization responsible for Freeway Management.
Denominator: Total number of freeway plus arterial miles covered by a formal procedure for managing incidents.</td><td>22/22 miles
Each agency has formal procedures for managing incidents; these procedures are not integrated between agencies.</td></tr>
<tr><td>Control:</td><td>Numerator: Number of Freeway Management agencies that receive, in real-time, data on freeway incident severity, location and type from an organization operating a Freeway Incident Management Program and use this information to adjust ramp meter timing or lane control devices in real-time or to convey information to travelers via roadside infrastructure such as VMS or HAR
Denominator: Total number of agencies</td><td>TxDOT is solely responsible for Freeway Management</td></tr>
<tr><td colspan="3">11. Freeway Management to Traffic Signal Control</td></tr>
<tr><td>Description:</td><td colspan="2">Freeway travel time, speeds, and conditions data collected by Freeway Management are used by Traffic Signal Control to adjust arterial traffic signal timing or arterial VMS messages in response to changing freeway conditions</td></tr>
<tr><td>Flow:</td><td>Numerator: Number of freeway miles covered by an electronic transfer of information describing freeway travel times, speeds, or conditions from a Freeway Management agency to a agency responsible for Traffic Signal Control on arterial and CBD streets,.
Denominator: Number of miles under surveillance by Loop Detectors plus number of miles under surveillance by Other Technologies plus number of freeway segments monitored by probe reader stations times the average length of the segment less the miles covered by the probe readers that are also covered by other electronic traffic data collection equipment.</td><td>No measurable integration</td></tr>
<tr><td>Control:</td><td>Numerator: Number of agencies that receive in real-time data on freeway travel times, speeds, or conditions from a freeway management organization and use this information to adjust signal timing times the total number of signalized intersections located within and outside CBD
Denominator: Total number of signalized intersections located within and outside CBD</td><td>No measurable integration</td></tr>
</table>

Table 11. STRATIS Integration Indicator Results (Continued)

INDICATOR		RESULTS
13. Freeway Management to Incident Management		
Description:	Incident Management monitors freeway travel time, speed and condition data collected by Freeway Management to detect incidents or manage incident response.	
Flow:	**Numerator:** Number of freeway miles covered by an electronic transfer of information describing freeway travel times, speeds, or conditions from a Freeway Management agency to an agency responsible for *Incident Management.* **Denominator:** Number of miles under surveillance by Loop Detectors **plus** number of miles under surveillance by Other Technologies **plus** number of freeway segments monitored by probe reader stations **times** the average length of the segment **less** the miles covered by the probe readers that are also covered by other electronic traffic data collection equipment.	12/12 miles
Control:	**Numerator:** Number of Incident Management agencies that receive information describing freeway travel times, speeds, and conditions automatically in real-time **and** use this information to detect incidents or manage incident response in real-time. **Denominator:** Number of agencies.	1/3 potential Incident Management agencies with freeway jurisdiction
21a. Emergency Management Services to Incident Management (incident severity)		
Description:	Incident Management is notified of incident location, severity and type by Emergency Management for the purpose of identifying incidents on freeways or arterials	
Flow:	**Numerator:** Number of Incident Management agencies that receive, in real-time, *incident severity, location and type* data from an emergency service agency **times** the average of the percent of Police, Fire and Emergency Medical services that participate in a formal working agreement or incident management team. **Denominator:** Number of agencies	No measurable integration
21b. Emergency Management Services to Incident Management (incident clearance activities)		
Description:	Incident Management is notified of incident clearance activities by Emergency Management for the purpose of managing incident response on freeways or arterials.	
Flow:	**Numerator:** Number of Incident Management agencies that receive, in real-time, *incident clearance activities* data from an emergency service agency **times** the average of the percent of Police, Fire and Emergency Medical services that participate in a formal working agreement or incident management team. **Denominator:** Number of agencies	No measurable integration
22. Emergency Management Services to Traffic Signal Control		
Description:	Emergency Management vehicles are equipped with traffic signal priority capability.	
Flow:	**Numerator:** Number of ER vehicles with traffic signal system communications. **Denominator:** Total number of Emergency Response vehicles operated	No measurable integration
Control:	**Numerator:** Total number of signalized intersections located within and outside CBD that allow signal preemption or priority to emergency vehicle. **Denominator:** Total number of signalized intersection located within and outside CBD	No measurable integration

Table 11. STRATIS Integration Indicator Results (Continued)

<table>
<tr><th colspan="2">INDICATOR</th><th>RESULTS</th></tr>
<tr><td colspan="3">23. Highway Rail Intersections to Incident Management</td></tr>
<tr><td>Description:</td><td>Incident Management is notified of crossing blockages by Highway-rail intersection for the purpose of managing incident response.</td><td>No measurable integration</td></tr>
<tr><td>Flow:</td><td>Numerator: Number of highway rail intersections covered by a transfer of information on train or vehicle blockage on highway intersection in real-time, from an agency responsible for maintaining rail intersection.
Denominator: Total number of highway-rail intersections</td><td>No measurable integration</td></tr>
<tr><td colspan="3">24. Highway Rail Intersections to Traffic Signal Control</td></tr>
<tr><td>Description:</td><td colspan="2">Highway-rail intersection and Traffic Signal Control are interconnected for the purpose of adjusting traffic signal timing in response to train crossing.</td></tr>
<tr><td>Flow:</td><td>Numerator: Number of traffic signals equipped with capability to adjust signal timing in response to train crossing
Denominator: Total number of traffic signals maintained by the agency that area within 200 feet of a highway-rail intersection</td><td>No measurable integration</td></tr>
<tr><td colspan="3">25. Incident Management intra component integration</td></tr>
<tr><td>Description:</td><td colspan="2">Agencies participating in formal working agreements or incident management plans coordinate incident detection, verification, and response.</td></tr>
<tr><td>Flow:</td><td>Numerator: Percent of local state and state police + fire agencies + emergency medical vehicles participating in a formal working Incident Management agreement or Incident Management Team
Denominator: 3</td><td>No measurable integration</td></tr>
<tr><td colspan="3">26. Traffic Signal Control intra component integration</td></tr>
<tr><td>Description:</td><td colspan="2">Agencies operating traffic signals along common corridors sharing information and possibly control of traffic signals to maintain progression on arterial routes.</td></tr>
<tr><td>Flow:</td><td>Numerator: Number of agencies that share information describing fixed timing plans with other agencies in order to maintain progression on an arterial route that includes signals maintained by both agencies or number of agencies that coordinate changes to fixed plans with other agencies in order to maintain progression on an arterial route that includes signals maintained by both agencies
Denominator: Number of agencies</td><td>No measurable integration</td></tr>
</table>

Similarly, information regarding freeway incidents, including incident severity, location, and type, is used to notify emergency responders for incident response and to adjust freeway operational or control strategies. While *STRATIS* provides outgoing information to emergency responders regarding incidents, emergency responders do not, in turn, provide information to *STRATIS* regarding incident severity, location, or type or incident clearance activities. It is speculated that a formal procedure for managing incidents is consistently applied within the total 22 miles under *STRATIS* surveillance although these procedures are likely agency-specific and are not well-integrated across different incident management agencies.

Specific opportunities for enhanced integration include:

- 5. Incident Management to Traffic Signal Control
- 11. Freeway Management to Traffic Signal Control
- 21a. Emergency Management Services to Incident Management (Severity)
- 21b. Emergency Management Services to Incident Management (Clearance)
- 22. Emergency Management Services to Traffic Signal Control
- 23. Highway-rail Intersections to Incident Management
- 24. Highway-rail Intersections to Traffic Signal Control
- 25. Incident Management Intra-component Integration
- 26. Traffic Signal Control Intra-component Integration

As mentioned previously, *STRATIS* is not currently using freeway or arterial travel time, speeds, and conditions to adjust traffic signal timing or traveler information along arterials. TxDOT does not currently share or coordinate traffic signal timing plans with other agencies also managing Traffic Signal Control systems. In addition, *STRATIS* is not currently using information about highway-rail intersection blockages to adjust traffic signal timing. The TxDOT Laredo traffic signal systems do not currently allow signal pre-emption or priority to emergency vehicles.

Qualitative Assessments

In addition to measuring *STRATIS* integration levels and outcomes, affected stakeholders were asked to provide qualitative information regarding the integration process and perceived benefits. A series of questions were developed and structured around the previously-described five dimensions of integration defined by Cluett, et al (2006) to characterize the extent of integration for traffic management centers: (1) physical integration, (2) technical integration, (3) procedural integration, (4) institutional integration, and (5) operational integration.

- *Physical Integration.* STRATIS is physically linked with TxDOT Laredo's CCTV, DMS, field sensors, and traffic signals through fiber optic connections and with TxDOT Laredo's HAR through a paging system. Both proven communication mediums, stakeholders reported no problems related to these physical linkages related to speed of transmission, reliability, maintenance, etc.

- *Technical Integration.* Stakeholders similarly reported no technical issues related to these physical linkages; STRATIS integration efforts proceeded on-time, on-budget, and with resultant outcomes and capabilities adequately achieved.

- *Procedural Integration.* Policies, plans or procedures to support integrated operations under STRATIS were not yet developed at the time of this investigation, although TxDOT indicated plans for such development.

- *Institutional Integration.* Possibly benefiting from previous efforts to identify and overcome institutional challenges related to ITS implementation, stakeholders reported no organizational, human resource, public acceptance, regulatory/legal, financial or other issues associated with STRATIS integration. STRATIS integration may have been further simplified since much of the integration effort occurred through a single agency – TxDOT.

- *Operational Integration.* While no new formalized procedures have reportedly developed as a result of this integration, stakeholders cited several resulting benefits:

  - The City of Laredo Traffic Division, utilizing a link to TxDOT Laredo's field sensors and CCTV, has experienced improved traffic monitoring and incident verification along I-35.

  - The City of Laredo Police Department, utilizing a link to TxDOT Laredo's field sensors and CCTV, has experienced improved incident verification along I-35.

  - The Texas Department of Public Safety, utilizing a link to TxDOT Laredo's field sensors and CCTV, has experienced improved incident verification along I-35.

  - Communication between TxDOT and the City of Laredo Traffic Division, the City of Laredo Police Department, and the Texas Department of Public Safety has improved, resulting in enhanced incident management efforts.

Given the lack of physical, technical, and institutional challenges encountered and the resulting reported benefits related to improved traffic monitoring, incident management, and communication capabilities, the *STRATIS* integration appears to be a qualitative success.

CHAPTER 5
CONCLUSIONS

The TxDOT, Laredo District, began deployment of ITS in 1996 and completed the *South Texas Regional Advanced Transportation Information System (STRATIS)* traffic management center in 2003. *STRATIS* was developed to integrate existing field equipment including CCTV cameras, loop detectors/VIVDS, DMS, HAR, and train monitoring systems in the greater Laredo Region.

Concurrently with the development of *STRATIS,* and in response to FHWA's final rule to implement Section 5206(e) of the TEA-21, TxDOT initiated the development of the *Regional ITS Architecture* (Kimley-Horn and Associates, Inc. and ConSysTech Corp. 2002) and the *Regional ITS Deployment Plan* (Kimley-Horn and Associates, Inc. 2003).

One of the primary purposes in developing an ITS Architecture for the Laredo Region was to ensure that while various agencies are deploying ITS components, some commonalties exist between them that allow and facilitate the exchange of data seamlessly and automatically. A key aspect of Laredo's ITS vision is to integrate systems both on an intra-regional and an inter-regional basis. Intra-regional integration can provide opportunities for enhanced information sharing that would, in turn, speed implementation of reactive and proactive operational plans, ensure provision of consistent traveler information, improve transit system operational performance and schedule adherence, and reduce congestion and improve safety during planned or unplanned roadway or border crossing closures. Similarly through enhanced information sharing, inter-regional integration can support larger-scale operations related to border crossing and homeland security activities or emergency evacuation.

The purpose of this investigation was to evaluate the experiences of the TxDOT's *STRATIS* in integrating existing field equipment. This investigation considered three general aspects of integration:

1. the level or degree of integration (i.e., integration indicators) achieved by *STRATIS*,
2. the integration outcomes (i.e., improvements in safety, etc.) achieved by *STRATIS*, and
3. qualitative information regarding the integration process and perceived benefits.

Integration Indicators

When considering the level or degree of integration achieved by *STRATIS* approximately three years after implementation, integration indicators suggest several opportunities for enhanced integration. Of the 14 applicable linkages defined in *Measuring ITS Deployment and Integration* (FHWA 1999) using the Metropolitan ITS infrastructure, only 5 have any measurable degree of integration:

2. Traffic Signal Control to Freeway Management

4. Traffic Signal Control to Incident Management

7. Incident Management to Emergency Management

8. Incident Management to Freeway Management

13. Freeway Management to Incident Management.

TxDOT Laredo Traffic Signals provides arterial travel times, speeds, and conditions on approximately 10 miles of a total 22 miles under *STRATIS* surveillance. This incoming information is used to adjust freeway operational or control strategies (i.e., lane control, HAR, DMS, etc.) but is not used to adjust traffic signal timings or traveler information along the arterials. This information is used, however, to detect arterial incidents and support incident response activities.

Similarly, information regarding freeway incidents, including incident severity, location, and type, is used to notify emergency responders for incident response and to adjust freeway operational or control strategies. While *STRATIS* provides outgoing information to emergency responders regarding incidents, emergency responders do not, in turn, provide information to *STRATIS* regarding incident severity, location, or type or incident clearance activities. It is speculated that a formal procedure for managing incidents is consistently applied within the total 22 miles under *STRATIS* surveillance although these procedures are likely agency-specific and are not well-integrated across different incident management agencies.

As mentioned previously, *STRATIS* is not currently using freeway or arterial travel time, speeds, and conditions to adjust traffic signal timing or traveler information along arterials. TxDOT does not currently share or coordinate traffic signal timing plans with other agencies also managing Traffic Signal Control systems. In addition, *STRATIS* is not currently using information about highway-rail intersection blockages to adjust traffic signal timing. The TxDOT Laredo traffic signal systems do not currently allow signal pre-emption or priority to emergency vehicles.

Integration Outcomes

The determination of integration outcomes achieved by *STRATIS* was limited by a lack of available "before" data to support determination of traveler mobility and transportation system efficiency measures and a lack of accessible "before" and "after" data to support determination of traveler safety measures.

Qualitative Assessments

In addition to measuring *STRATIS* integration levels and outcomes, affected stakeholders were asked to provide qualitative information regarding the integration process and perceived benefits. A series of questions were developed and structured around the previously-described five dimensions of integration defined by Cluett, et al (2006) to characterize the extent of integration for traffic management centers: physical integration, technical integration, procedural integration, institutional integration, and operational integration.

STRATIS is physically linked with TxDOT Laredo's CCTV, DMS, field sensors, and traffic signals through fiber optic connections and with TxDOT Laredo's HAR through a paging system. Both proven communication mediums, stakeholders reported no problems related to these physical linkages related to speed of transmission, reliability, maintenance, etc. Stakeholders similarly reported no technical issues related to these physical linkages; *STRATIS* integration efforts proceeded on-time, on-budget, and with resultant outcomes and capabilities adequately achieved.

Possibly benefiting from previous efforts to identify and overcome institutional challenges related to ITS implementation, stakeholders reported no organizational, human resource, public acceptance, regulatory/legal, financial or other issues associated with *STRATIS* integration. *STRATIS* integration may have been further simplified since much of the integration effort occurred through a single agency – TxDOT.

Policies, plans or procedures to support integrated operations under *STRATIS* were not yet developed at the time of this investigation, although TxDOT indicated plans for such development. While no new formalized procedures have reportedly developed as a result of this integration, stakeholders cited several resulting benefits including enhanced traffic monitoring and incident verification capabilities by the City of Laredo Traffic Division, enhanced incident verification by the City of Laredo Police Department and the Texas Department of Public Safety, and improved communications among these agencies and TxDOT, better supporting incident management efforts.

Given the lack of physical, technical, and institutional challenges encountered and the resulting reported benefits related to improved traffic monitoring, incident management, and communication capabilities, the *STRATIS* integration appears to be a qualitative success.

Recommendations

Continued improvements to the *STRATIS* integration effort should focus on increasing the level or degree of integration achieved. In particular, efforts should focus on

- improving linkages that currently have no measurable integration (i.e., 9 of the 14 possible linkages identified in Table 11);
- encouraging bidirectional rather than unidirectional exchange (e.g., regularly receiving information *from* law enforcement agencies regarding incident management status);
- managing major parallel roadways within a traffic corridor instead of a single roadway (i.e., actively controlling arterial signals to improve traffic management); and
- broadening the geographic scope of information exchange to enhance inter-regional integration.

The level of integration achieved thus far has been well-supported by stakeholders and free from common physical, technical, and institutional challenges; implementation of these recommended improvements is expected to experience similar levels of support and success.

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