Border-Wide Assessment of Intelligent Transportation System (ITS) Technology—Current and Future Concepts

Final Report

July 2012

Notice

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16. Abstract

The purpose of this effort was to conduct a border-wide assessment of the use of intelligent transportation systems (ITS) technologies and operational concepts at and near land border crossings between the U.S. and Mexico. The work focused on tolling, traffic management and operations, and safety. The specific objectives of this project were to research, assess and document how ITS technologies can be used in areas of:

- Toll collection and management in border regions, identifying technology used, system components, and any special data sharing arrangements between the two countries.
- Transportation operations and traffic management in US/MX border regions.
- Transportation safety policy and operations.
- Traffic management, traffic operation and traffic enforcement on tolled roads/tolled border-crossing roads.
- Archiving toll and traffic management data.

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LIST OF ABBREVIATIONS

AASHTO	American Association of State Highway Transportation Officials
ACE	Automated Cargo Environment
ACE/ITDS	Automated Commercial Environment/International Trade Data System
ACM	Automatic Coin Machine
ADOT	Arizona Department of Transportation
ADOT/MVD	Arizona Department of Transportation – Motor Vehicle Division
AET	All-Electronic Tolling
ALPR	Automatic License Plate Recognition
ASTM	American Society of Testing and Materials
ATA	American Trucking Associations
ATI	Alliance for Toll Interoperability
ATIS	Advanced Traveler Information Systems
AVC	Automatic Vehicle Classification
AVI	Automatic Vehicle Identification
BANOBRAS	Banco Nacional de Obras y Servicios Públicos
Battelle	(Company)
BCC	Border Crossing Card
BCIS	Border Crossing Information System
BCMoT	British Columbia Ministry of Transportation
BOTA	Bridge of the Americas
BSIF	Border Safety Inspection Facility
BTS	Bureau of Transportation Statistics
BWT	Border Wait Time
Caltrans	California Department of Transportation
CAPUFE	Caminos y Puentes Federales de Ingresos y Servicios Conexos
CBP	Customs and Border Protection
CBSA	Canada Border Services Agency
CCRMA	Cameron County Regional Mobility Authority
CCSP	Certified Cargo Screening Program
CCTV	Closed Circuit Television
CHP	California Highway Patrol
ConOps	Concept of Operations
CSC	Customer Service Center
C-TIP	Cross-Town Improvement Program
C-TPAT	Customs-Trade Partnership Against Terrorism
CTRMA	Central Texas Regional Mobility Authority

CVII	Commercial Vehicle Infrastructure Integration
CVISN	Commercial Vehicle Information Systems and Networks
DCL	Dedicated Commuter Lane
Delcan	(Company)
DHS	Department of Homeland Security
DMA	Dynamic Mobility Applications
DMV	Department of Motor Vehicles
DPS	Department of Public Safety
DSRC	Dedicated Short-Range Communications
EBTC	Eastern Border Transportation Coalition
EETS	European Electronic Toll Service
e-Manifest	Electronic Manifest
EMC	Emergency Management Center
EMS	Emergency Medical Services
EOC	Emergency Operations Center
EPA	Environmental Protection Agency
EPIC	Expedited Processing at International Crossings
EPS	Electronic Payment Services
EPSNIS	Electronic Payment Services National Interoperability Specification
e-Screening	Electronic Screening
ETC	Electronic Toll Collection
EU	European Union
FARAC	Fideicomiso de Apoyo al Rescate de Autopistas Concesionadas
FAST	Free and Secure Trade
FBCTRA	Fort Bend County Toll Road Authority
FCC	Federal Communications Commission
FDA	Food and Drug Administration
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
GIS	Geographic Information System
GPS	Global Positioning System
GSA	General Services Administration
GSM	Global System for Mobile Communications
GUTSA	Gutsa Construcciones, S.A. de C.V.
HAR	Highway Advisory Radio
HAZMAT	Hazardous Materials
HCTRA	Harris County Toll Road Authority

HGV	Heavy Goods Vehicle
HID	Hughes Identification Devices Global Inc.
HOT	High Occupancy Toll
HOV	High Occupancy Vehicle
IAVE	Identificación Automatica Vehicular
IBC e-Screening	International Border Crossing Electronic Screening
IBI	IBI Group (Company)
IBIS	Interagency Border Inspection System
IBWC	International Boundary and Water Commission
ICA	Ingenieros Civiles Asociados
IMIP	Instituto Municipal de Investigación y Planeación
IMTC	International Mobility and Trade Corridor
INDABIN	Instituto de Administración y Avalúos de Bienes Nacionales
INNP	Interoperability Network Pilot Program
INTEGRA	Integra Corporation of Mexico
Intermec	(Company)
ISM	Industrial, Scientific, and Medical
ISO	International Organization for Standardization
IAG	E-ZPass Interagency Group
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation System
IVAG	Imperial Valley Association of Governments
Kapsch	(Company)
LPI	License Plate Interoperability
MAC	Media Access Control
MAGs	Installed Digital Magnetometers
MARHNOS	Marhnos Engineering and Construction (Company)
MARK IV	(Company)
MCES	Motor Carrier Efficiency Study
MDOT	Michigan Department of Transportation
MDT	Montana Department of Transportation
MPO	Metropolitan Planning Organization
MTO	Ministry of Transportation of Ontario
MTQ	Ministère des Transports du Quebec
NAFTA	North American Free Trade Agreement
NB	Northbound
NEMA	National Electrical Manufacturers Association
NFBC	Niagara Falls Bridge Commission

NITTEC	Niagara International Transportation Technology Coalition
NMBA	New Mexico Border Authority
NMDOT	New Mexico Department of Transportation
NTCIP	National Transportation Communications for ITS Protocol
NTMI	New Technology Management, Inc. (Company)
NTTA	North Texas Tollway Authority
NYDOT	New York State Department of Transportation
NYSTA	New York State Thruway Authority
OBE	On-Board Equipment
OBU	On-Board Unit
OCACSA	Operación y Conservación de Autopistas Concesionadas
OCR	Optical Character Recognition
OME	Otay Mesa East
Omniair	(Consortium)
ORT	Open Road Tolling
OVC	Overview Camera
PDN-RMIS	Paso Del Norte Regional Mobility Information System
PeMS	Performance Monitoring System
POE	Port of Entry
PSE	Planned Special Event
QC	Query Central
QNA	QinetiQ North America (Company)
QWS	Queue Warning System
Raytheon	(Company)
REPUVE	Registro Público Vehicular
RF	Radio Frequency
RFID	Radio Frequency Identification
RFP	Request for Proposals
RSS	Real Simple Syndicate
RTMS	Remote Traffic Microwave Sensor
SAAQ	Société de l'assurance automobile du Québec
SANDAG	San Diego Association of Governments
SB	Southbound
SCT	Secretaría de Comunicaciones y Transportes
SDMS	Short Data Message Set
Sentrillion	(Company, formerly New Technology Management, Inc.)
SENTRI	Secure Electronic Network for Travelers Rapid Inspection
SIMEX	SIMEX Integracion de Sistemas, S.A.

Sirit	(Company)
SNS	Social Networking Site
SOA	Service Oriented Architecture
SOV	Single Occupancy Vehicle
SWIM	Slow Weigh-in-Motion
TC	Transport Canada
TDMA	Time Division Multiple Access
Technocom	(Company)
Tecsult	(Company)
TGT	Turnpike Global Technologies
THALES	Thales Group (Company)
TMC	Traffic Management Center
TMDD	Traffic Management Data Dictionary
TOC	Traffic Operation Center
TRMI	TRMI Systems Integration (Company)
TSA	Transportation Security Administration
TTA	Texas Turnpike Authority
TTI	Texas Transportation Institute
TxDOT	Texas Department of Transportation
U.S.	United States
USDOT	United States Department of Transportation
V2I	Vehicle-to-Infrastructure
V2R	Vehicle-to-Roadside
V2V	Vehicle-to-Vehicle
VES	Violation Enforcement System
VHF	Very High Frequency
VIP	Video Image Processing
VMS	Variable Message Sign
VWI	Vehicle Waveform Identification
WCOG	Whatcom Council of Governments
WebEOC	Web-Based Emergency Operations Center
WED	Western Economic Diversification Canada
WHTI	Western Hemisphere Travel Initiative
WIM	Weigh-In-Motion
WSDOT	Washington State Department of Transportation
XML	Extensible Markup Language

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EXECUTIVE SUMMARY

BACKGROUND

Cross-border transportation is an important element of the nation's transportation system. Adding transportation infrastructure at land border crossings is even more challenging than building transportation infrastructure elsewhere because of the international dimension and the different stakeholders that interact at an international border crossing. The use of Intelligent Transportation Systems (ITS) and other technologies is one way in which capacity at ports of entry (POEs) can be increased and enhance and improve the coordination between stakeholders on both sides of the border.

The purpose of this effort was to conduct a border-wide assessment of the use of intelligent transportation systems (ITS) technologies and operational concepts at and near land border crossings between the U.S. and Mexico. The work focused on tolling, traffic management and operations, and safety.

APPROACH

In order to reach the objective, the initial task was to conduct a scanning assessment of ITS technologies with a primary focus on the U.S.-Mexico border, substituting ITS experience on the U.S.-Canada border when experience with equivalent technology on the U.S.-Mexico border does not yet exist.

Two workshops were organized during the project. The objective of the workshops was to further document the state-of-the-practice, stakeholders' short- and long-term needs, and present and future technology solutions. In the initial workshop, the research team presented a summary and facilitated discussion of the ITS technologies that are being implemented at border regions.

During the second workshop, participants identified policy, legal, and institutional barriers to implementing ITS technologies along the United States' northern and southern borders. ITS solution providers and technology vendors presented their experiences in the implementation of innovative ITS projects at the borders.

SCAN ASSESSMENT KEY FINDINGS

The scan assessment was divided into several topics, and the key findings of each topic follow.

Border Operations

The border-crossing process for passenger and commercial vehicles at the U.S. northern and southern borders is complicated due to the number of stakeholders that participate in the process, involving two countries, private and public sectors, and all levels of government. The commercial vehicle crossing requires additional cargo inspection for trucks crossing into the United States, which adds a level of complexity.

There is a whole range of activities that take place at land border crossing, such as electronic filing of import and export declarations, agricultural inspections, drug interdiction, immigration check on the driver and passengers, vehicle safety checks, etc. All of these activities involve a certain level of technology and data systems; however, this study focuses only on the use of technology for traffic management.

The assessment shows that U.S. Customs and Border Protection (CBP) is the main stakeholder, at land border crossings, as it is required to perform security inspections on passenger and commercial vehicles. CBP has implemented several programs that use technology to aid in its mission. The trusted-traveler programs such as Free and Secure Trade (FAST) and Secure Electronic Network for Travelers Rapid Inspection (SENTRI) use RFID devices. FAST offers expedited clearance to carriers that have demonstrated supply chain security and that are enrolled in the Customs-Trade Partnership against Terrorism (C-TPAT). SENTRI provides expedited CBP processing for pre-approved, low-risk travelers at the U.S.-Mexico border (the U.S.-Canada version of SENTRI is called NEXUS).

The use of technology to improve international land border-crossing operations has increased in recent years. CBP and other federal and state agencies in the United States, Mexico and Canada as well as the private sector are implementing technologies to improve border-crossing operations. Coordination among these stakeholders is an important element in which ITS could play an important role.

Tolling at Land Border Crossings

Most of the tolls at the U.S. international ports of entry are collected at those crossings that have a bridge structure. At the U.S. southern border, 21 of the 46 border crossings collect tolls and are mostly located in the State of Texas. New crossings are being planned in all the border states, and due to funding restrictions, most likely these new facilities will be tolled. The majority of toll operations at land border crossings are using Automatic Vehicle Identification (AVI) technology such as radio frequency identification (RFID), proximity cards, and bar code technology. These systems are well established, reliable, and enforceable.

At existing international tolled crossings, the research did not find interoperability or enforcement agreements between U.S. and Mexican tolling agencies. These agreements are being discussed for planned land ports of entry to increase operational efficiency.

Toll rates at the U.S.-Canada crossing are coordinated bi-nationally; however, the scan indicated that there is no coordination of toll rates between U.S. and Mexican international bridge operators. Pricing schemes were not found along the U.S. northern and southern borders. The Texas Transportation Institute (TTI) conducted a study in 2007 about congestion pricing at international border crossings in El Paso and concluded that given the resource constraints of the agencies involved in managing the area's border crossings, it is likely that the most feasible option will be the implementation of a variable pricing regime.

Toll operators at U.S. roadways and the United States Department of Transportation (USDOT) Connected Vehicle program are exploring the use of the 5.9 GHz spectrum DSRC technology. However, the scan indicated that there are no concrete plans in the near future to implement 5.9 GHz DSRC technology at land ports of entry.

Traffic Management and Traveler Information

The scan revealed that sharing of real-time traffic management data and ITS usage between agencies from both sides of the U.S.-Mexico border has been limited, compared to U.S.-Canada counterparts. No bi-national Traffic Management Centers (TMCs) along the U.S.-Mexico border were identified, and communication between agencies is limited to methods such as radio and mobile phones. Traffic data-sharing information systems along the U.S.-Mexico border have not been developed due to funding constraints on the Mexican side of the border.

Regarding the sharing of ITS solutions, U.S.-Mexico border agencies have deployed those only to a very limited degree with the specific purpose of incident management around border crossings. Special events at and around border crossings (e.g., concerts, cultural and sporting events, major holydays) are planned ahead using ad-hoc meetings between bi-national agencies of all levels. Each agency lays out its subsequent roles according to its jurisdictions to assist traffic management during the event.

CBP and the Canada Border Services Agency (CBSA) are currently measuring border crossing and wait times at land POEs. This information is shared via the Internet. The FHWA and other state agencies are in the process of implementing several ITS technologies to measure border and crossing times for commercial vehicles along the U.S. southern border. FHWA will release several documents that would benefit other agencies to deploy similar systems in the near future.

As far as passenger vehicle border crossing times, Bluetooth seems to be a viable technology for measuring travel times. This technology is being implemented along the U.S.-Canada border and has been recently tested at a U.S.-Mexico POE.

The use of technologies such as smart phones, radar traffic sensors, and vehicle waveform identification has shown improvements in collection of wait and crossing times.

The scan revealed that television and radio are the most common methods of disseminating border-crossing times at land ports of entry. Internet and mobile devices are gaining market share in this arena.

Archived Data Management

A centralized repository of archived data would significantly reduce data redundancy, reduce data collection and storage cost, and increase efficiency of data retrieval.

There is a need for highly granular border crossing data by state and local agencies. In addition, local agencies need information such as queue lengths, wait times, and crossing times. This information is normally obtained during a relatively short period of data collection at the border.

A major problem in data storage management is the reluctance to purge data due to fear of losing aggregated data. Maintaining only aggregated data in the core database will undoubtedly result in improved performance.

Emerging Technologies

The USDOT Connected Vehicle Program has been considered as a key building block for Federal Motor Carrier Safety Administration's (FMCSA's) objective of significantly expanding the number of inspections that are conducted each year and the base of data on which to make performance-based enforcement decisions.

The Wireless Roadside Inspection (WRI) initiative involves emerging technologies used in the United States that have been tested with outstanding results for examining the condition of the vehicle and driver by assessing data collected by on-board systems.

The Connected Vehicle Program and the WRI have the potential to be implemented at international border crossings, as all commercial vehicles entering the United States need to be inspected, and drivers need to meet U.S. requirements.

Other emerging technologies that have implementation potential at the border crossings in the near future come from initiatives such as the Dynamic Mobility Applications (DMA) Program, Cross-Town Improvement Project (C-TIP), and the Commercial Vehicle Infrastructure Integration (CVII) initiative.

Inventory of ITS Projects on the U.S.-Mexico Border Regions

The scan analyzed several projects along the U.S.-Mexico border and identified the following:

Projects under Construction

- Border crossing and wait time at the Bridge of the Americas, El Paso, Texas
- Border crossing and wait time at the Pharr-Reynosa International Bridge, Pharr, Texas
- Border crossing and wait time at the Camino Colombia and World Trade Bridges, Laredo, Texas
- Border Waits Assessment Project at the Mariposa POE in Nogales, Arizona
- State Route 905/Otay Mesa POE, San Diego, California Region
- ITS Pre-Deployment Strategy for SR-11 and the Otay Mesa East POE

Projects under Consideration

- San Ysidro POE, San Diego Region
- State-of-the-Art ITS at Border Crossings in the El Paso Region

ITS Projects under Development in Mexico

- National Strategic Plan for Planning, Developing, and Implementing ITS in Mexico
- Development Plan for Updating Processes, Standards, and ITS Protocols
- Development of the Traveler Information System (INFOVIAJE)
- Strategic Plan for the Modernization and Improvement of the Electronic Toll Collection (ETC) System

WORKSHOP 1 FINDINGS

One of the findings from the first workshop was that a key element for the successful implementation of ITS technologies is to identify policy, legal, and institutional barriers to implementation. Given that Federal, State, and local agencies from two countries as well as private-sector stakeholders operate at the border, it is difficult and time-consuming to overcome these non-technical barriers.

Another key finding from the workshop was the realization that it is crucial to understand stakeholder needs prior to the implementation of any technology.

WORKSHOP 2 FINDINGS

The second workshop included participants from the public and private sectors. On the public sector side, state and local officials presented their implementation experiences. Private sector stakeholders presented their experiences with technology implementation that facilitate transportation across borders.

CONCLUSIONS

Various stakeholders that operate at the land border-crossing environment are implementing ITS technologies. However, every stakeholder is trying to tackle its own needs, and there is little if any coordination among stakeholders to develop standards that could lead to an integrated, interoperable system capable of sharing resources and perhaps information. One example of this is the use of RFID transponders (i.e., "tags"). Currently CBP is utilizing tags on commercial vehicles that are separate from FAST tags, to manage user fees. The same type of tags is being used for tolling purposes at some commercial crossings on both sides of the border. Various states are using the same technology to expedite vehicle inspection at the border. However, lack of coordination leads to having vehicles with multiple RFID tags that are similar or identical.

There are examples of a coordinated bi-national effort like the project currently underway at the proposed Otay Mesa East crossing in California. The San Diego Association of Governments (SANDAG) is developing a bi-national ITS pre-deployment plan that will incorporate the use of ITS technologies in the San Diego/Tijuana region.

With regard to future technologies, the information gathered during this research leads to the conclusion that the implementations of vehicle-to-infrastructure (V2I) technologies that have bi-directional communication capability between the vehicles and the border-crossing systems have potential to improve border operations in the future. Most likely, in the next 10-15 years tolling systems will be "tag-free" leaning heavily on 5.8 GHZ DSRC. This will depend on the level of adoption by toll operators and vehicle manufacturers as the connected vehicle program evolves.

CHAPTER 1. INTRODUCTION

BACKGROUND

Cross-border transportation is an important element of the nation's transportation system. In 2010, more than 90 million personal vehicles entered the United States – 28.8 million from Canada and 64 million from Mexico. Canada and Mexico are the first and third largest U.S. trading partners, respectively. In 2010, more than 10.2 million commercial vehicles crossed into the United States at both the northern and southern borders, handling trade valued at more than 556 billion dollars. U.S. merchandise trade with Canada and Mexico by all land modes rose by 37.4 percent in the 10 years between 2000 and 2010 (1), and it is expected that the growth rate will increase once the North American economies recover.

Increasing trends in cross-border traffic present challenges in infrastructure improvements at land ports of entry (POEs). Adding transportation infrastructure at land border crossings is even more challenging than building transportation infrastructure elsewhere because of the international dimension and the different stakeholders that interact at an international border crossing. Federal, State, and local agencies as well as private-sector stakeholders intervene in the process on both sides of the border. Dissimilar funding cycles, environmental regulations, and other rules in each country make the process of building additional capacity at international crossings lengthy and difficult.

Each international crossing is different in terms of traffic patterns, geography, configuration, and physical characteristics. This makes the planning process even more difficult as it requires accommodating stakeholders' needs and objectives at each POE.

There is a whole range of activities that take place at land border crossing, such as electronic filing of import and export declarations, agricultural inspections, drug interdiction, immigration check on the driver and passengers, vehicle safety checks, etc. All of these activities involve a certain level of technology and data systems; however, this study focuses only on the use of technology for traffic management.

The use of intelligent transportation systems (ITS) and other technologies is one way in which capacity at POEs could be increased and also enhance and improve the coordination among stakeholders on both sides of the border. However, one of the lessons learned from the 2001 *ITS at International Borders* study (2) is that "as with many domestic ITS/CVO [commercial vehicle operations] initiatives, institutional issues represent the most significant hurdle in deploying and using technology as a tool for improving processes at international borders."

OBJECTIVES OF THE STUDY

The purpose of this work effort was to conduct a border-wide assessment of the use of current and future ITS technologies and operational concepts at and near U.S. land border crossings. Researchers focused on tolling, traffic management, and operations and safety. The specific objectives of this project were to research, assess, and document how ITS technologies can be used in the following areas:

- Toll collection and management in border regions and identification of technology used, system components, and any special data-sharing arrangements between the two countries.
- Transportation operations and traffic management in the U.S.-Mexico border regions.
- Transportation safety policy and operations.
- Traffic management, traffic operation, and traffic enforcement on tolled roads and tolled border-crossing roads.
- Toll and traffic management data archival.

Other objectives included:

- Identifying the usage of ITS and other technologies by Federal, State, and local governments and other entities in border regions, as well as any coordination between agencies and cross-border.
- Documenting how updates to technology or its obsolescence can be handled.
- Documenting how appropriate agencies/entities operate and maintain operations on both sides of the border, and identifying potential funding sources and models.
- Researching, assessing, and documenting barriers to technology adoption in border regions.

Assessment Methodology

The initial task was to conduct a scanning assessment of ITS technologies with a primary focus on the U.S.-Mexico border, substituting ITS experience on the U.S.-Canada border when experience with equivalent technology on the U.S.-Mexico border does not yet exist.

Figure 1 illustrates the overall framework for conducting the border-wide assessment of technologies used. The approach to document the state-of-the-practice and future developments and concepts of ITSs at the border included two main components: a thorough literature review of documentation from the United States as well as other countries, and communication with key stakeholders that participate in the border-crossing process. Researchers analyzed findings from these two sources to prepare this document, which reports the state-of-the-practice and future ITS concepts that have potential to be implemented at the U.S.-Mexico border.

Two workshops were organized during the project. The objective of the workshops was to further document the state-of-the-practice, stakeholders' short- and long-term needs, and present and future technology solutions. In the initial workshop, the research team presented a summary and facilitated discussion of the ITS technologies that are being implemented at border regions. During the second workshop, participants identified policy, legal, and institutional barriers to implementing ITS technologies along the United States' northern and southern borders. ITS solution providers and technology vendors presented their experiences in the implementation of innovative ITS projects at the borders.

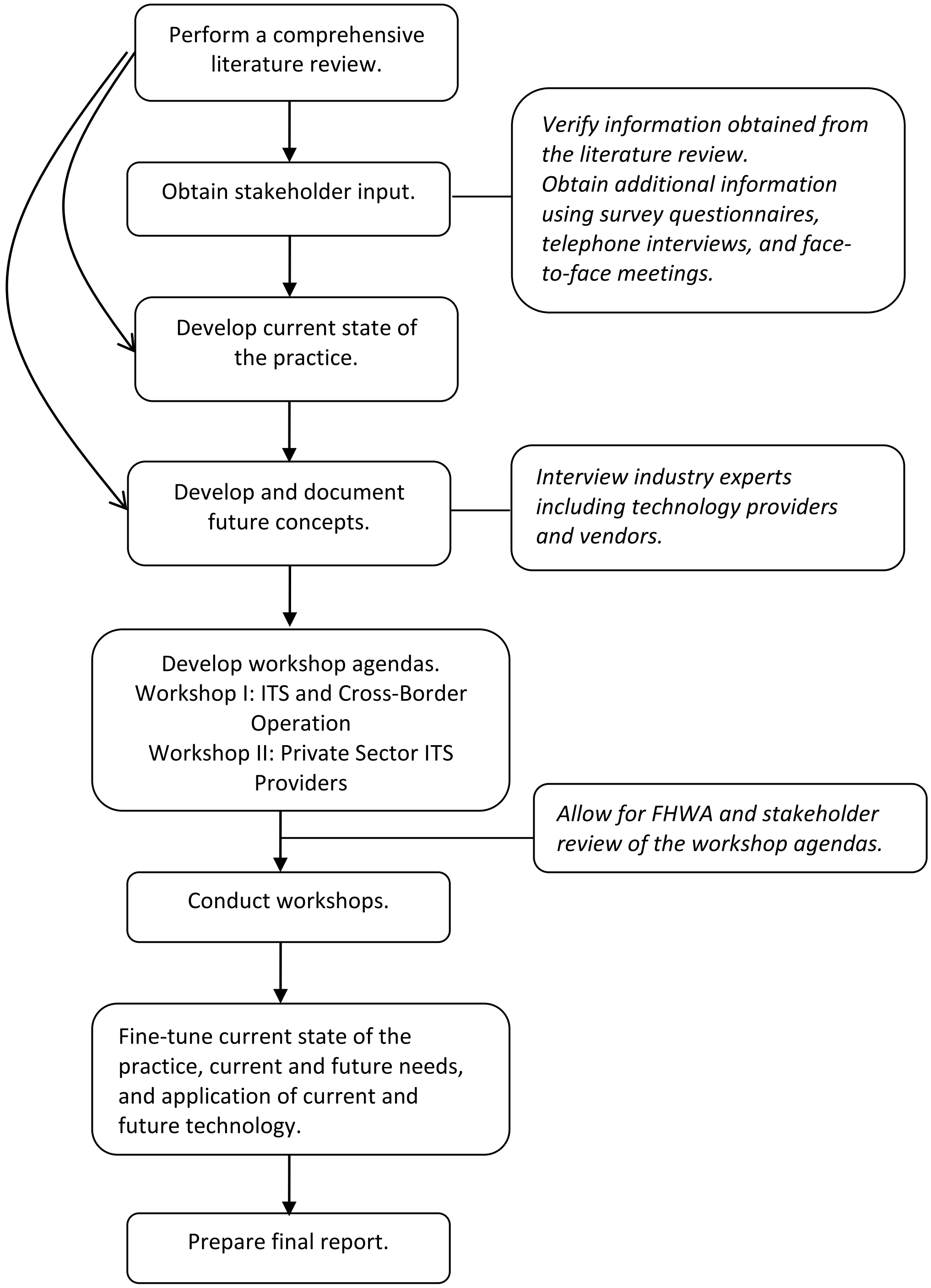

Figure 1. Flowchart describing overall framework for conducting the border-wide assessment.

The scan included the following topics pertaining to deployment of ITSs at border crossings on the U.S.-Mexico border:

- Planning and cross-border coordination.
- Tolling in border regions.
    - Transaction processing (e.g., interoperability, charging, collections).
    - Electronic tolling operations (e.g., account management, customer service).
    - Technology.
- Border transportation operations and traffic management and enforcement.
    - Operations.
    - Traffic management.
    - Commercial vehicle safety.
    - Enforcement.
- Traveler information.
- Archived data management.

The study identified and prepared case examples of ITS pre-deployment strategies and/or concepts of operations at border regions, identifying the geographic coverage as well as the operational scope that was covered in that particular example.

The study also assessed whether existing and planned systems were based on any existing ITS architecture and identified whether ITS deployments influenced one or more subsystems in the architecture. Any aspects of a regional ITS architecture need to be considered in project implementation and updated as user needs and services change. Understanding that the application of ITS architecture and standards is important to maximizing the benefits of ITS projects, the study also assessed the effect of the technology implementation on ITS architectures.

ORGANIZATION OF THE REPORT

Chapter 1 (this chapter) is the introduction. Chapters 2 through 6 present a discussion of the state-of-the-practice and future plans for each chapter's topic area.

Chapter 2 presents a brief description of the border-crossing process. The objective is to inform the reader of the various processes that take place at the border for private and commercial vehicles and introduce general concepts of ITS and other technologies being used.

Chapter 3 describes tolling and includes ITS transaction processing (e.g., interoperability, charging, and collections) and electronic tolling operations (e.g., account management and customer service). The final topic under tolling is ITS technologies being used and planned.

Chapter 4 describes transportation operations, traffic management and enforcement, operations, and traveler information at and around border crossings. These are divided into traffic management, commercial vehicle safety, and enforcement.

Chapter 5 includes a description of the state-of-the-practice of managing archived border crossing-related data.

Chapter 6 includes an inventory of ITS projects that are under either construction, procurement, or consideration in U.S.-Mexico border regions.

Chapter 7 includes key findings from the two workshops that were organized as part of the project.

Chapter 8 presents a series of conclusions for the overall project.

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CHAPTER 2. CROSS-BORDER COMMERCIAL AND PRIVATE VEHICLE PROCESSES

The objective of this chapter is to describe the overall commercial and private vehicle border-crossing process and the stakeholders that participate in the process. This description helps identify the use of ITS and other technologies by the various stakeholders; these technologies are described in the following chapters of the report.

BORDER-CROSSING PROCESS AT THE U.S.-MEXICO BORDER

The border-crossing process for passenger and commercial vehicles at the U.S.-Mexico border is complicated due to the number of stakeholders that participate in the process. The commercial vehicle crossing requires additional cargo inspection for trucks crossing from Mexico into the United States.

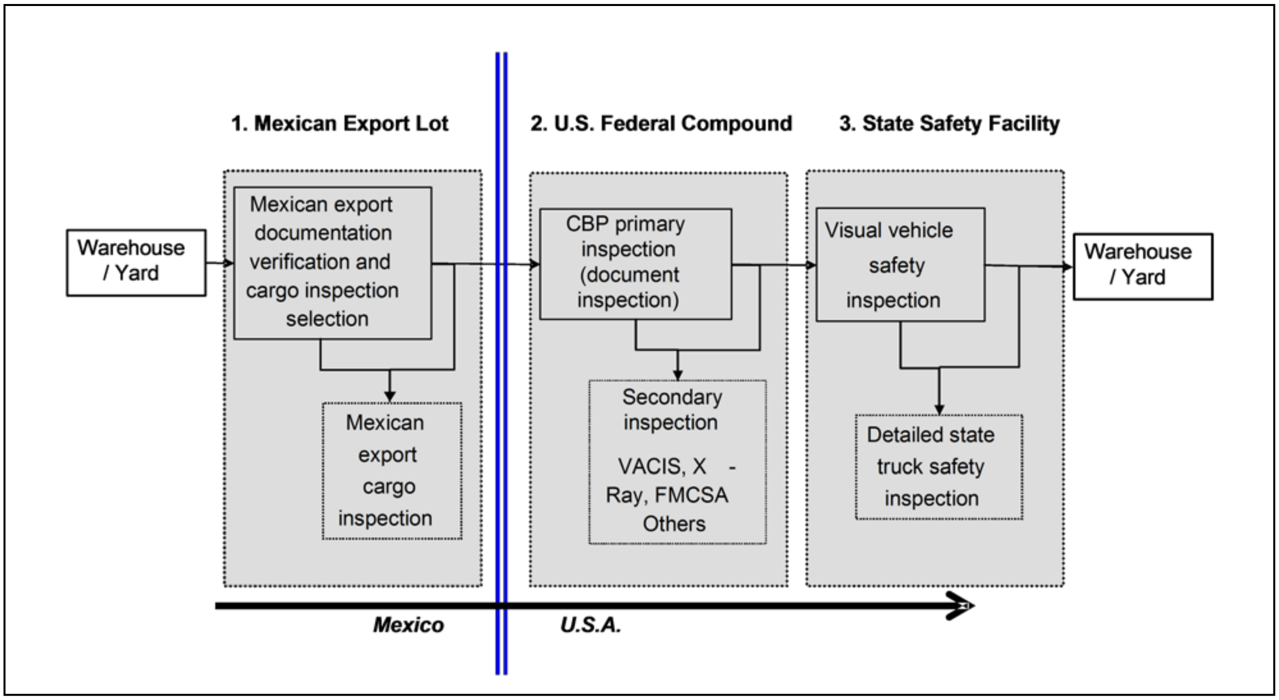
Northbound Commercial Vehicle Crossing Process

The original trucking provisions under the North American Free Trade Agreement (NAFTA) regarding opening the U.S. border to Mexican trucks were designed to improve transportation efficiency by enabling more seamless cross-border trucking operations. Currently, Mexican tractors are restricted to circulation in a narrow commercial zone extending out to 25 miles from the border (or up to 75 miles in Arizona). Therefore, Mexican truck shipments into the United States are required to use a drayage or transfer tractor that picks up a trailer on the Mexican side of the border and then hauls it into the United States, where it is dropped off so a U.S. long-haul tractor can carry the trailer further into U.S. territory.

The typical northbound border-crossing process requires a shipper in Mexico to file shipment data with both Mexican and U.S. Federal agencies, prepare both paper and electronic forms, and use a drayage or transfer tractor to move the goods from Mexico to the United States. Once the shipment is at the border with the drayage or transfer tractor and an authorized driver, the process flows through three main potential physical inspection areas:

- Mexican export lot,
- U.S. Federal compound and
- U.S. State safety inspection facility.

A description of the main activities that take place in the northbound border-crossing process is illustrated in Figure 2 and presented in the following sections.



Source: (3)

Figure 2. Flowchart depicting the commercial vehicle border-crossing process from Mexico to the United States.

The Mexican Export Lot

A drayage driver with the required documentation proceeds into the Mexican Customs (Aduanas) compound. For audit and interdiction purposes, Mexican Customs conducts inspections consisting of a physical review of the cargo of randomly selected outbound freight prior to its export. Shipments that are not selected proceed to the exit gate cross the border and continue on to the U.S. POE.

There are several international crossings along the U.S.-Mexico border that are tolled. Tolls are collected in Mexico for northbound traffic and in the United States for southbound traffic. Toll collection is manual (cash) and electronic. All of the crossings along the Texas-Mexico border are bridges that cross the Rio Grande River, and most of them are tolled. Before crossing into the United States, commercial vehicles pay tolls and proceed to the U.S. Federal Compound.

The U.S. Federal Compound

At the U.S. Customs and Border Protection (CBP) primary inspection booth, the driver of the truck presents identification and shipment documentation to the processing agent. The CBP inspector at the primary inspection booth uses a computer terminal to crosscheck the basic information about the driver, vehicle, and cargo with information sent previously by the carrier via the CBP's Automated Cargo Environment (ACE) electronic manifest (e-Manifest). The CBP inspector then makes a decision to refer the truck, driver, or cargo for a more detailed secondary inspection of any or all of these elements, or—alternatively—releases the truck to the exit gate.

Motor carriers or other eligible parties are currently required to file an electronic manifest (e-Manifest) with CBP's Automated Commercial Environment (ACE) system for most international truck shipments prior to a truck entering the United States through a land port. E-Manifests are filed at least 30 minutes prior to arrival of Free and Secure Trade (FAST)-enrolled trucks and 60 minutes prior to the arrival of non-FAST trucks. Among other information, the e-Manifest data identifies the port where the truck intends to cross. The e-Manifest enables CBP to prescreen the operator, conveyance, equipment, and shipment information before the truck arrives at the border. This allows CBP to focus its efforts and inspections on high-risk commerce and minimize unnecessary delays for low-risk commerce.

A secondary inspection includes any inspection that the driver, cargo, or conveyance undergoes between the primary inspection and the exit gate of the U.S. Federal Compound. Personnel from CBP usually conduct these inspections, which can be done by physically inspecting the conveyance and the cargo or by using non-intrusive inspection equipment (such as x-rays). Within the compound, other Federal agencies such as the Federal Motor Carrier Safety Administration (FMCSA) and Food and Drug Administration (FDA) have personnel and facilities to perform other inspections when required. A vehicle safety inspection could be conducted either at the Federal Compound (by FMCSA) or at the State Safety Inspection Facility depending on practice.

The State Vehicle Safety Inspection Facility

For the majority of POEs on the southern border, the State Safety Inspection Facility is located adjacent to the Federal Compound. State police inspect conveyances to determine whether they are in compliance with U.S. safety standards and regulations. If their initial visual inspection finds any violation, they direct the truck to proceed to a more detailed inspection at a special facility.

After leaving the State Safety Inspection Facility, the driver typically drives to the freight forwarder or customs broker yard to drop off the trailer for later pickup by a long-haul tractor bound for the final destination.

Commercial Border-Crossing Security Programs

CBP's FAST program is in operation at most of the major U.S. international land border crossings. Its objective is to offer expedited clearance to carriers that have demonstrated supply chain security and are enrolled in the Customs-Trade Partnership against Terrorism (C-TPAT). The FAST program allows U.S.-Canada and U.S.-Mexico partnering importers expedited release for qualifying commercial shipments.[1]

For a shipment to be considered a FAST shipment, it needs to comply with very specific regulations. The shipper in Mexico, the carrier that is transporting the cargo across the border and the driver all have to be C-TPAT certified.

[1] See U.S. Customs and Border Protection, FAST: Free and Secure Trade Program, at http://www.cbp.gov/xp/cgov/travel/trusted_traveler/fast/.

The time required for a typical Mexican export shipment to make the trip from the yard, distribution center or manufacturing plant in Mexico to the exit of the State Safety Inspection Facility for a particular POE depends on the number of secondary inspections required, the number of inspection booths in service, the traffic volume at that specific time of day, and for the shipment's eligibility to be expedited via FAST.

Southbound Commercial Vehicle Crossing

The southbound commercial vehicle crossing process has only one Mexican Customs inspection station. The process in Mexico is a red light/green light decision in which a loaded commercial vehicle is randomly selected for a secondary inspection if it gets a red light. Empty vehicles cross with no need to stop at a Mexican Customs' booth.

Recently, CBP has started to perform random manual inspections on the U.S. side of the border for commercial vehicles crossing into Mexico, aiming to identify illegal shipments of money and weapons. The U.S. POEs were not designed for southbound commercial vehicle inspection, and consequently this has created congestion.

Passenger Vehicle Crossing Process

On the Mexican side of the border, passenger vehicles are required to pay tolls at those crossings that have that requirement, usually POEs at international bridges. Drivers pay tolls either manually (i.e., in cash) or via Electronic Toll Collection (ETC) systems. Once passenger vehicles pay the toll, if one is required, they proceed to the U.S. Federal Compound.

At the U.S. Federal Compound, passenger vehicles have to go through primary and sometimes secondary inspections. At the primary inspection booths, CBP officers ask the individuals who want to enter the country to show proper documentation (i.e., proof of citizenship) and state the purpose of their visit to the United States. Additionally, during this stage of the process, a query on the Interagency Border Inspection System (IBIS) is executed to review the past records of violations that the traveler may have. If necessary, CBP officers direct the vehicle to secondary inspection.

At the primary inspection booth, Automatic License Plate Recognition (ALPR) scanners identify, and computers perform queries of, the vehicles against law enforcement databases that are continuously updated. A combination of electric gates, tire shredders, traffic control lights, fixed iron bollards, and pop-up pneumatic bollards ensure physical control of vehicles intending to cross.

At the secondary inspection station, a much more thorough investigation of the identity of those wanting to enter the United States as well as the purpose of their visit is performed. During this step, individuals may also have to pay duties upon their declared items. Upon completion, access to the United States is either granted or denied.

Passenger Vehicle Border-Crossing Security Programs

Similar to the FAST program for commercial vehicles, the Secure Electronic Network for Travelers Rapid Inspection (SENTRI) provides expedited CBP processing for pre-approved, low-risk travelers entering the United States at southern border POEs. Applicants must voluntarily undergo a thorough biographical background check against criminal, law enforcement, customs, immigration, and terrorist indices; a 10-fingerprint law enforcement check; and a personal interview with a CBP officer.

Once an applicant is approved for crossing the border under SENTRI, he or she is issued a document with radio frequency identification (RFID) that will identify his or her record and status in the CBP database upon arrival at the U.S. POE. A sticker decal is also issued to be affixed to the applicant's car, personal truck, or motorcycle. SENTRI users have access to specific, dedicated primary lanes into the United States. SENTRI dedicated commuter lanes exist at the Otay Mesa, El Paso, San Ysidro, Calexico, Nogales, Hidalgo, Brownsville, Anzalduas, Laredo, and San Luis POEs on the U.S.-Mexico border.

When an approved international traveler approaches the border in the SENTRI lane, the system automatically identifies the vehicle and the identity of its occupant(s) by reading the file number on the RFID card. The file number triggers the participant's data to be brought up on the CBP officer's screen. The data are verified by the CBP officer, and the traveler is released or referred for additional inspection.

Participants in the program wait for much shorter times than those in regular lanes waiting to enter the United States. Critical information required in the inspection process is provided to the CBP officer in advance of the passenger's arrival, therefore reducing the inspection time (4).

TECHNOLOGY AT LAND PORTS OF ENTRY

The use of technology to improve international land border-crossing operations has increased in recent years. As mentioned in this section, CBP is using technology to implement trusted-traveler programs such as FAST and SENTRI. FMCSA is currently identifying technologies to deploy a wireless roadside inspection program. State safety agencies are also implementing RFID-based technologies to streamline the inspection processes.

Coordination among stakeholders is an important element in which ITS could play an important role. The next sections of the report present a detailed assessment of current ITS applications at the border.

Technology for the SENTRI and NEXUS Programs

CBP's trusted-traveler programs provide expedited travel for pre-approved, low-risk travelers through dedicated lanes and kiosks. The NEXUS program is used at the U.S.-Canada border, and the SENTRI program is operational at the U.S.-Mexico border.

SENTRI

The SENTRI program is a U.S. initiative that allows for faster border-crossing times from Mexico to the U.S. A description of how this program operates from the user's standpoint is included in Chapter 2.

The cost for enrolling in the program is currently $122.25 and gives the member a 5-year membership to the SENTRI program (29). Tolls are paid separately. Not all SENTRI lanes are tolled and for those that are, tolls are paid by various forms as explained below. The technology used in the SENTRI program is very similar to the one used for tolling. It is based on a sticker transponder mounted on the left side of the windshield and read by an overhead antenna (Figure 3) and an RFID card that the driver waves in front of an antenna mounted on the side of the road (Figure 4. Each person in the vehicle needs to have a valid SENTRI RFID card. Transcore is the equipment manufacturer and system integrator for the SENTRI system.

Figure 3. Photograph showing overhead antenna used in the SENTRI program (4).

Figure 4. Photograph showing RFID card reader used in the SENTRI program (4).

Table 1 lists the border crossings with SENTRI systems. The table is divided into two groups: tolled and non-tolled border crossings. It is important to make a distinction because the non-tolled border crossings are relatively simple on the Mexican side, while the tolled border crossings require special handling by the Mexican operators and users.

When crossing from Mexico into the United States using tolled SENTRI lanes, users need to enroll in the Linea Express program. The Linea Express program was created to allow SENTRI users to use dedicated lanes as they enter the border crossing from the Mexican side and for toll payment. Enrollment in the Linea Express program can only be obtained after the user has been granted SENTRI status. In addition, at CAPUFE-operated bridges users have to pay an annual toll fee that allows them unlimited crossing privileges in the northbound direction. The annual fee varies by bridge crossing, but it is currently approximately USD$320 (30). Bridge crossings operated by others offer other forms of toll payments, such as tickets. Users still need to pay the regular toll to the U.S. bridge operator each time they cross in the southbound direction.

Table 1. SENTRI border crossings.

Border Crossing	U.S. City	U.S. State	Tolled
Veterans International Bridge	Brownsville	TX	Yes
McAllen-Hidalgo-Reynosa Bridge	Hidalgo	TX	Yes
Anzalduas International Bridge	Mission	TX	Yes
Juarez-Lincoln Bridge	Laredo	TX	Yes
Ysleta-Zaragoza Bridge	El Paso	TX	Yes
Good Neighbor Bridge *(SB only, NB DCL)* Stanton	ELP	TX	Yes
Paso del Norte Bridge *(Pedestrian only)*	ELP	TX	Yes
Nogales DeConcini	Nogales	AZ	No
San Luis	San Luis	AZ	No
Calexico East	Calexico	CA	No
Calexico West	Calexico	CA	No
Otay Mesa (Passenger)	Otay Mesa	CA	No
San Ysidro	San Diego	CA	No

In terms of technology, the Linea Express program's technology is very similar to the technology used for tolling. CAPUFE issues a transponder valid only on the border crossings that it operates to grant access to the dedicated Linea Express lanes. CAPUFE operates most of the border crossings with Linea Express lanes. Promofront, which is the concessionaire on the Ysleta-Zaragoza Bridge, has two payment options: prepaid tickets that allows users to pay the toll per use, and annual membership that provides unlimited border crossings for 1 year and includes a transponder (31). Neither of these transponders is compatible with the SENTRI-provided transponder. Unlike the SENTRI membership that can be used in any border crossing along the U.S.-Mexico border, the Linea Express program rules, membership, and fees vary by bridge/crossing operator. In some cases, the user needs to obtain separate memberships if he or she wishes to use the Linea Express; this is true in El Paso at the Good Neighbor Stanton Bridge and the Ysleta-Zaragoza Bridge, although these border crossings are only 13 miles apart. In this case, the user, assuming he or she selects the annual membership with transponder at the Ysleta-Zaragoza Bridge, may end up having three different transponders (32).

NEXUS

For the U.S.-Canada border, a similar trusted-traveler program was established in 2002 as part of the Shared Border Accord. NEXUS is a joint program with the Canada Border Services Agency

(CBSA) that allows prescreened, approved travelers to get faster processing. Users enrolling in this program receive a NEXUS card. NEXUS cards are Western Hemisphere Travel Initiative-(WHTI-) compliant documents for land and sea travel, as well as air travel when traveling to and from airports using the NEXUS program, and provide expedited travel via land, air, or sea to approved members between the U.S.-Canada border. A NEXUS card also fulfills the travel document requirements of the WHTI that require a passport or other secure travel documents by all U.S. and Canadian citizens (33) (34).

Sixteen U.S.-Canada border crossings currently offer dedicated passenger vehicle lanes for NEXUS members (35). The application processing fee for NEXUS membership is currently $50 per applicant. The membership is valid for 5 years.

The two main differences between the NEXUS and SENTRI programs are that (a) in the SENTRI program, the vehicle also needs to be enrolled; and (b) the NEXUS card is valid for entering Canada and the U.S., while the SENTRI membership provides benefits only when traveling from Mexico to the U.S.

The technology used in the NEXUS program is RFID-based. The NEXUS card is an RFID card similar to a credit card in size. Intermec is the equipment provider for the NEXUS program. Once in the lane, the user holds the card up to an RFID reader positioned well in front of the inspection booth. The reader flashes the participant’s photo and information onto a computer screen inside the booth. The inspector verifies that the photo on the screen matches the vehicle occupant and, if all checks out, authorizes the car to proceed (36).

Although the NEXUS card is not generally used for toll payment at the border crossings, at least one creative authority has found a way to tie the NEXUS card to its toll collection system. The Whirlpool Rapids bridge operated by the Niagara Falls Bridge Commission (NFBC) offers the NEXUS/Toll program that allows NEXUS users to open a prepaid toll account and tie their NEXUS card number to it. Then when the user presents his or her NEXUS card to the NEXUS reader located in front of the entrance gate at the Whirlpool Bridge, the card is checked for security clearance and a toll charge is deducted from the user’s account (37).

Ready Lane

Ready Lane is a dedicated primary vehicle lane for travelers entering the United States at land border crossings. Travelers who obtain and travel with a WHTI-compliant, RFID-enabled travel document receive the benefits of utilizing a Ready Lane to expedite the inspection process while crossing the border. The U.S. passport card, the SENTRI card, the NEXUS card, the FAST card, the new enhanced permanent resident “green card,” and the new border-crossing card are all RFID-enabled documents.

RFID technology allows information contained in a wireless “tag” to be read from a distance, enabling officers to more quickly, reliably, and accurately process travelers. The driver stops at the beginning of the lane and makes sure each passenger has his or her card out. Then when it is the driver’s turn, he or she drives slowly through the lane, holds all cards up on the driver’s side of the vehicle, and proceeds to stop at the officer’s booth (38) (39).

Ready Lanes are operational at the following selected POEs on the U.S.-Canada and U.S.-Mexico borders:

- Blaine, WA—Peace Arch.
- Del Rio, TX.
- Detroit, MI—Ambassador Bridge.
- El Paso, TX—Ysleta-Zaragoza Bridge.
- Nogales, AZ—DeConcini Crossing.
- Progresso, TX—Donna-Rio Bravo International Bridge.
- Otay Mesa, CA.

There are plans to open additional Ready Lanes in the near future.

Commercial Vehicle Inspection Technologies

FMCSA is currently investigating freight electronic screening (e-Screening) via wireless inspection that enables more efficient operations at border crossings under the Motor Carrier Efficiency Study (MCES) program. The International Border Crossing Electronic Screening (IBC e-Screening) System is a planned alert-based system. The IBC e-Screening intends to expedite the safe and legal flow of freight and passengers across northern and southern U.S. borders while targeting unsafe operations. It will accomplish this by wirelessly obtaining commercial vehicle information and verifying compliance with relevant requirements during the border-crossing process.

The IBC e-Screening concept leverages the FMCSA's investment in the FMCSA/CBP Query Central–Automated Commercial Environment/International Trade Data System (QC–ACE/ITDS) interface to provide an automated, data-driven approach to selection of vehicles for inspection at the northern and southern borders. This approach enables uniform and consistent application of policies and procedures related to safety and compliance assurance of cross-border commercial traffic.

The goal of the FMCSA project is to test technologies at selected international land border crossings to reduce the potential for large truck crashes by designing the IBC e-Screening system such that it will:

- Electronically identify the carrier, truck, trailer, and driver associated with commercial truck trips entering the United States at land POEs, using RFID transponders already on the vast majority of trucks entering the United States from Mexico and Canada.
- Electronically screen each component of that trip for factors of interest to State and FMCSA inspectors, providing for full safety and compliance verification of carriers, trucks, trailers, and drivers each time they enter the United States.
- Display the screening results to State and FMCSA enforcement officers and inspectors to assist them in making more informed inspection selection decisions in fixed and mobile operations and in mainline and ramp settings, significantly increasing the efficiency and effectiveness of their operations.

- Enable data monitoring/reporting by States and FMCSA to better position each organization to fulfill its mission

CHAPTER 3. TOLLING IN BORDER REGIONS

The use of tolls for roads and bridges is at least 2,700 years old, as tolls had to be paid by travelers using the Susa–Babylon highway under the regime of Ashurbanipal, who reigned in the seventh century B.C. (5). In the United States, the first toll roads or turnpikes started operation in the early 1800s. Toll collection technology has evolved very slowly, and it was not until the last two decades that tolling evolved from traditional manual collection to automatic coin machines, and later to ETC with the introduction of transponders and video tolling.

On this project, a detailed scan of the current and envisioned tolling technologies, operations, and transaction processing at the U.S.-Mexico and U.S.-Canada borders was conducted. With a 1,945-mile-long Mexican border and 3,987-mile-long Canadian border, it is understandable that each State, region, or facility has its own rules and systems for collecting, processing, and enforcing tolls. Integration was not paramount when these systems were initially deployed years or decades ago. The objective of this task was to provide a clear picture of what is being used or planned by agencies and facilities along the international borders and what are the benefits, challenges, and opportunities related to tolling. This section presents a comprehensive view of the current state-of-the-practice for toll collection in the border regions.

The first step consisted of performing a comprehensive literature review on the U.S.-Mexico and U.S.-Canada border crossings. The second step involved developing a questionnaire to fill the gaps from the literature review and contacting selected key personnel familiar with border tolling issues at select border crossings on the U.S.-Mexico border.

Published information related to tolling in border-crossing regions is limited. Part of the reason for this is the limited number of crossings that include tolling, the small size of these systems in comparison with other inland toll collection systems, and the lack of integration among border-crossing facilities. In 2009, approximately 105,850,000 passenger and commercial vehicles crossed the U.S.-Mexico and U.S.-Canada borders, including tolled and non-tolled border crossings. In comparison, a single major toll road, the New Jersey Turnpike, had approximately 634,000,000 toll transactions during the same period; thus, a single toll road had six times as many toll transactions as the entire cross-border traffic. This illustrates a major reason why research studies and reports are mostly focused on toll roads within the United States rather than at its borders.

As part of the literature review and interviews with key personnel, the following information related to transaction processing, operations, and tolling technology used or envisioned for border crossings was researched, assessed, and documented:

- Transaction processing (e.g., interoperability, charging, collections);
- Electronic tolling operations (e.g., account management, customer service); and
- Technology.

Transaction Processing (Interoperability, Charging, Collections)

As of 2010, a total of 46 border crossings were in operation at the U.S.-Mexico border. Table 2 lists these border crossings grouped by individual states. Currently, none of the land border crossings collects tolls; toll collection only occurs at selected bridge crossings over the Rio Grande River. (It should be noted that "land" in this narrow sense refers to a crossing without a bridge; "land" is used elsewhere in this report to refer more broadly to a port other than a marine or airport.) A total of 28 bridge crossings are currently under operation, and all of them are located in Texas. The number of bridges continues to grow to handle the cross-border traffic growth. In the next several years, at least five new bridges are planned to open at international border crossings on the southern border. In the near future, California and Arizona have plans to start collecting tolls at selected border crossings. New Mexico's current state law prohibits tolling statewide.

Table 2. General characteristics of U.S.-Mexico border crossings.

Border Crossing	U.S. City	U.S. State	Passenger Vehicle	Commercial Vehicle	Pedestrian	Type of Crossing	Mexican City	Mexican State
Veterans International Bridge	Brownsville	TX	Yes	Yes	Yes	Bridge	Matamoros	Tamaulipas
Gateway International Bridge	Brownsville	TX	Yes	No	Yes	Bridge	Matamoros	Tamaulipas
B&M Bridge	Brownsville	TX	Yes	No	Yes	Bridge	Matamoros	Tamaulipas
Free Trade Bridge	Los Indios	TX	Yes	Yes	Yes	Bridge	Lucio Blanco	Tamaulipas
Progresso International Bridge	Progresso	TX	Yes	Yes	Yes	Bridge	Nuevo Progresso	Tamaulipas
Donna International Bridge	Donna	TX	Yes	No	Yes	Bridge	Rio Bravo	Tamaulipas
Pharr-Reynosa Intl. Bridge on the Rise	Pharr	TX	Yes	Yes	NA	Bridge	Reynosa	Tamaulipas
McAllen-Hidalgo-Reynosa Bridge	Hidalgo	TX	Yes	No	Yes	Bridge	Reynosa	Tamaulipas
Anzalduas International Bridge	Mission	TX	Yes	No	Yes	Bridge	Reynosa	Tamaulipas
Los Ebanos Ferry	Los Ebanos	TX	Yes	No	NA	Ferry	Gustavo Diaz Ordaz	Tamaulipas
Rio Grande City-Camargo Bridge	Rio Grande	TX	Yes	Yes	NA	Bridge	Ciudad Camargo	Tamaulipas
Roma-Ciudad Miguel Aleman Bridge	Roma	TX	Yes	Yes	Yes	Bridge	Ciudad Miguel Aleman	Tamaulipas
Lake Falcon Dam	Falcon Heights	TX	Yes	NA	NA	Bridge	Ciudad Guerrero	Tamaulipas
Juarez-Lincoln Bridge	Laredo	TX	Yes	No	No	Bridge	Nuevo Laredo	Tamaulipas
Gateway to the Americas Bridge	Laredo	TX	Yes	No	Yes	Bridge	Nuevo Laredo	Tamaulipas
World Trade Bridge	Laredo	TX	No	Yes	No	Bridge	Nuevo Laredo	Tamaulipas
Laredo-Colombia Solidarity Bridge	Laredo	TX	Yes	Yes	No	Bridge	Columbia	Nuevo Leon
Camino Real International Bridge	Eagle Pass	TX	Yes	Yes	Yes	Bridge	Piedras Negras	Coahuila
Eagle Pass Bridge I	Eagle Pass	TX	Yes	No	Yes	Bridge	Piedras Negras	Coahuila
Del Rio-Ciudad Acuna International Bridge	Del Rio	TX	Yes	Yes	Yes	Bridge	Ciudad Acuña	Coahuila

Table 2. General characteristics of U.S.-Mexico border crossings. (Continued)

Border Crossing	U.S. City	U.S. State	Passenger Vehicle	Commercial Vehicle	Pedestrian	Type of Crossing	Mexican City	Mexican State
Lake Amistad Dam	Del Rio	TX	Yes	No	NA	Bridge	Ciudad Acuña	Coahuila
Presidio Bridge	Presidio	TX	Yes	Yes	NA	Bridge	Ojinaga	Chihuahua
Fort Hancock-El Porvenir Bridge	Fort Hancock	TX	Yes	No	NA	Bridge	El Porvenir	Chihuahua
Fabens-Caseta Bridge	Fabens	TX	Yes	No	Yes	Bridge	Práxedis Guerrero	Chihuahua
Ysleta-Zaragoza Bridge	El Paso	TX	Yes	Yes	Yes	Bridge	Ciudad Juarez	Chihuahua
Bridge of the Americas (BOTA)	El Paso	TX	Yes	Yes	Yes	Bridge	Ciudad Juarez	Chihuahua
Good Neighbor (Stanton) Bridge	El Paso	TX	Yes	No	Yes	Bridge	Ciudad Juarez	Chihuahua
Paso del Norte Bridge	El Paso	TX	Yes	No	Yes	Bridge	Ciudad Juarez	Chihuahua
Santa Teresa	Santa Teresa	NM	Yes	Yes	Yes	Land	San Jeronimo	Chihuahua
Antelope Wells	Antelope Wells	NM	Yes	No	Yes	Land	El Berrendo	Chihuahua
Columbus	Columbus	NM	Yes	Yes	Yes	Land	Puerto Palomas	Chihuahua
Douglas	Douglas	AZ	Yes	Yes	Yes	Land	Agua Prieta	Sonora
Naco	Naco	AZ	Yes	Yes	Yes	Land	Naco	Sonora
Nogales DeConcini	Nogales	AZ	Yes	No	Yes	Land	Heroica Nogales	Sonora
Nogales Mariposa	Nogales	AZ	Yes	Yes	Yes	Land	Heroica Nogales	Sonora
Sasabe	Sasabe	AZ				Land	Sasabe	Sonora
Lukeville	Lukeville	AZ	Yes	Yes	Yes	Land	Sonoyta	Sonora
San Luis	San Luis	AZ	Yes	Yes	Yes	Land	Rio Colorado	Sonora
San Luis II	San Luis	AZ	No	Yes	No	Land	Rio Colorado	Sonora
Andrade	Andrade	CA	Yes	Yes	Yes	Land	Los Algodones	Baja Calif.
Calexico East	Calexico	CA	Yes	Yes	Yes	Land	Mexicali	Baja Calif.

Table 2. General characteristics of U.S.-Mexico border crossings. (Continued)

Border Crossing	U.S. City	U.S. State	Passenger Vehicle	Commercial Vehicle	Pedestrian	Type of Crossing	Mexican City	Mexican State
Calexico West	Calexico	CA	Yes	No	Yes	Land	Mexicali	Baja Calif.
Tecate	Tecate	CA	Yes	Yes	Yes	Land	Tecate	Baja Calif.
Otay Mesa (Commercial)	Otay Mesa	CA	No	Yes	No	Land	Tijuana	Baja Calif.
Otay Mesa (Passenger)	Otay Mesa	CA	Yes	No	Yes	Land	Tijuana	Baja Calif.
San Ysidro	San Diego	CA	Yes	No	Yes	Land	Tijuana	Baja Calif.

Sources: (6), (7), (8), (9), (10) and (11).

As part of the literature review, researchers selected the busiest Canadian border crossings to assess tolling issues at the U.S.-Canada border. Table 3 shows the 10 busiest border crossings with Canada. These 10 border crossings represent more than 55 percent of the total traffic volume at the northern border (12).

Table 3. Top 10 busiest border crossings on the U.S.-Canada border.

Border Crossing	U.S. City	U.S. State	Passenger Vehicle Traffic	Comm. Vehicle Traffic	Pedestrian Traffic	Type of Crossing	Canadian City	Canadian Province
Blue Water Bridge	Port Huron	MI	Yes	Yes	NA	Bridge	Point Edward	Ontario
St-Bernard-de LaColle	Champlain	NY	Yes	Yes	NA	Land	LaColle	Quebec
Lewiston-Queenston	Lewiston	NY	Yes	Yes	No	Bridge	Queenston	Ontario
Whirlpool Rapids	Niagara Falls	NY	Yes	No	NA	Bridge	Niagara Falls	Ontario
Rainbow Bridge	Niagara Falls	NY	Yes	No	Yes	Bridge	Niagara Falls	Ontario
Peace Bridge	Buffalo	NY	Yes	Yes	Yes	Bridge	Fort Erie	Ontario
Ambassador	Detroit	MI	Yes	Yes	No	Bridge	Windsor	Ontario
Detroit-Windsor	Detroit	MI	Yes	Yes	No	Tunnel	Windsor	Ontario
Pacific Highway	Blaine	WA	Yes	Yes	NA	Land	Surrey	BC
Peace Arch (Douglas)	Blaine	WA	Yes	No	NA	Land	Surrey	BC

Sources: (6), (12), (13), (14), (15), (16), (17), (18), and (19).

U.S.-Mexico and U.S.-Canada Bi-National Tolling Implementation Approaches

For a new southern border crossing to open there must be a great deal of bi-national cooperation between the United States and Mexico. Both countries need to coordinate the complexities that a new crossing involves, from a presidential permit (for bridges built after 1972) and Coast Guard approval on the U.S. side and approvals from the Mexican state and federal government on the Mexican side, to accessibility and traffic and environmental impact studies (11).

There are various bi-national groups that participate in the definition of new international border crossings or expansions to existing crossings. The International Boundary and Water Commission (IBWC) meets regularly to define border crossings.

Tolling at international crossings is agreed to between the two neighboring countries, and tolls are collected in the originating country. At the U.S.-Mexico border, Caminos y Puentes Federales de Ingresos y Servicios Conexos (CAPUFE) or a State agency, depending on the crossing ownership, usually collects tolls in Mexico. For example, the World Trade Bridge in

Laredo is owned by the state of Tamaulipas, and a state agency manages and collects tolls for trucks crossing from Mexico into the United States. The Colombia Solidarity Bridge crossing has a similar scheme in which the state of Nuevo Leon also operates and collects tolls. For southbound traffic, the City of Laredo collects tolls at the World Trade Bridge.

Currently, there is no interoperability between U.S. and Mexican tolling agencies. Even though most of the technologies that are currently being used are similar, there are no interoperability or enforcement agreements. In the case of El Paso, some preliminary discussions about future interoperability between Promofront, the Mexican operator of the Ysleta-Zaragoza Bridge, and the City of El Paso border crossings have taken place.

In some instances on the U.S. side, when the same agency operates multiple border-crossing facilities, these facilities are interoperable at the local level, such as in the Laredo and El Paso areas.

Tolling Overview in Texas beyond the Border

Currently, all tolled border crossings on the U.S.-Mexico border are in Texas. This section will describe the tolling state-of-the-practice in Texas beyond its border with Mexico and the level of interoperability with the tolled border crossings. There are six agencies that operate toll roads in Texas, excluding the operators of tolled border crossings. Table 4 lists these agencies and their primary transponder programs. The TxTag, TollTag, and EZ TAG programs are interoperable. This means that with the exception of the border crossings and the Dallas-Fort Worth and Dallas Love Field airports, all tolled ETC facilities within Texas are interoperable.

Table 4. Toll agencies with active toll roads in Texas (excluding border crossings).

Toll Operator or Agency	Region	Primary Transponder Program
Texas Turnpike Authority (TTA)	Statewide	TxTag
North Texas Tollway Authority (NTTA)	Dallas-Fort Worth	TollTag
Harris County Toll Road Authority (HCTRA)[1]	Houston Metro	EZ TAG
Central Texas Regional Mobility Authority (CTRMA)	Austin	TxTag
Cameron County Regional Mobility Authority (CCRMA)[2]	Brownsville	TxTag
Fort Bend County Toll Road Authority (FBCTRA)[1]	Houston Suburbs	TxTag

[1] HCTRA and FBCTRA entered into an agreement giving HCTRA rights to operate and maintain the Fort Bend County toll roads (20).

[2] Tolling will start in May 2011.

TTA operates the Camino Colombia (SH 255) toll road that begins near the Colombia Solidarity International Bridge and stretches 22 miles east to I-35 north of Laredo. This is the closest toll road in Texas to a border crossing (21). This road is an all-electronic tolling (AET) facility. The primary method of payment is via a transponder. Vehicles without a transponder are video-tolled (1-dollar surcharge), and if no payment is received, a violation occurs. Since the toll road is so close to the U.S.-Mexico border, a high percentage of its users are from Mexico.

CCRMA opened the first phase of the new SH 550 Toll Road to drivers on March 10, 2011. SH 550 is an AET facility located east of Brownsville near the U.S.-Mexico border. SH 550 will be toll-free for the first 2 months; on May 2011, tolling will start. TTA is providing the toll collection system (22).

TTA offers a Day Pass option to prepay tolls. TTA does not currently have an interoperability agreement with any tolled border-crossing facilities, other U.S. states, or any Mexican agencies. On the other hand, there is some level of cooperation with at least one of the largest border-crossing operators in Laredo. A customer with the Laredo Trade Tag program is allowed to open a separate account with the TxTag program and enroll his or her Laredo Trade transponder. The user benefits by installing only one transponder instead of two and still being able to use all the toll facilities in both programs. TTA is also having preliminary interoperability talks with some border-crossing facilities and tolling agencies in Oklahoma and Kansas.

TTA offers the eGo Plus sticker transponders from Transcore based on the American Trucking Associations (ATA) protocol. TTA is assessing the use of 5.9 GHz technology but does not currently have concrete plans for that frequency.

Most of the toll roads in Texas have fixed tolls. Currently, only Houston has managed lane facilities with variable pricing. In the Dallas-Fort Worth region, several new managed lane projects with variable pricing are in the pipeline and scheduled to open in the next 3 to 5 years.

NTTA and CTRMA are members of the Alliance for Toll Interoperability (ATI) group. TTA has applied for ATI membership. ATI was formed to promote and implement interstate interoperability. In March 2011, the ATI issued a Request for Proposals (RFP) for an Interoperability Network Pilot Program (INPP) in the United States. The INPP consists of the development and implementation of a Pilot License Plate Interoperability (LPI) Hub for the exchange of account holder license plate information and account holder identification. Three hubs are proposed to operate a maximum of 6 months during the pilot. The ATI INPP transaction-processing concept provides a method to process license-plate-based transactions that cannot be identified by the toll operator as belonging to an existing toll account or a known violator at an Away Agency. This program is envisioned to be an interim solution for the toll industry to establish national interoperability until the toll industry adopts open-source RFID equipment or compatible multiprotocol RFID devices (23).

The need for interoperability among border crossings and toll roads within the United States will continue to increase as more toll roads near the border are built, such as the Loop 375 César Chávez managed lanes in El Paso, Texas. Furthermore, in the near future, California is planning to add tolled border crossings such as the Otay Mesa East POE. The Otay Mesa East border crossing will most likely be interoperable with existing (SR-125) and future (SR-11) toll roads in the San Diego area (24). On the Mexican side, there are four toll facilities that operate near the border:

- Carretera Federal 2 in Reynosa—this highway runs parallel to the border between Matamoros and Reynosa.
- Corridor Fiscal (Carretera Federal 15) in Arizona—this highway leads to the Nogales Mariposa border crossing.
- Carretera Federal 2 in Baja California—this highway runs parallel to the border with California.
- Puente Cucapá near San Luis Colorado—this bridge crosses Carretera 2 leading to the San Luis II border crossing.

There are no corresponding tolling facilities on the U.S. side. The first three facilities are part of the Identificación Automática Vehicular (IAVE) program (described in the section below) and are therefore interoperable. The Puente Cucapá opened in 2010 and is not part of the IAVE program. This bridge is operated by CAPUFE on behalf of the concessionaire (25).

Methods of Toll Collection

Normally, tolling agencies or operators select the methods for collecting tolls based on the technology available at the time of implementation, the budget, the market, and, to some degree, what nearby toll facilities have implemented. The most typical methods for collecting tolls are manual collection, electronic toll collection, and automatic toll collection via automatic coin machines.

In manual toll collection, which is the simplest toll collection, a collector operating from a booth collects the toll. Automatic coin machines (ACMs) allow collection of several methods of payments such as coins, tokens, smart cards, and credit cards without the need for a collector. ETC is the most complex and latest method for collecting tolls. Although it has been in use for more than 20 years, ETC continues to evolve.

ETC is comprised of four subsystems: AVI, automatic vehicle classification (AVC), violation enforcement system (VES), and transaction processing, which includes a back office and customer service center (CSC). AVI is the most visible part of the system and probably the only one the user is aware of. AVI allows the proper identification of the vehicle so a toll can be charged to a particular customer. In terms of equipment, ETC can be accomplished through various technologies: a bar-coded label affixed to the vehicle and read by an optical device, a proximity card that is waved at a card reader, an RFID transponder mounted in the vehicle and a roadside unit to read it, and automatic license plate recognition (ALPR), in which an image of the vehicle’s license plate is captured and then matched to an account or the vehicle’s owner.

Of the 46 U.S.-Mexico border crossings, only 21 collect tolls (excluding the Los Ebanos Ferry crossing). Table 5 shows the U.S.-Mexico tolled border crossings. On the U.S.-Mexico border, Texas is the only State with tolled border crossings. The San Luis II POE has a connecting bridge on the Mexican side where tolls are collected in both directions by the Mexican operator. Because no toll is collected on the U.S. side, this bridge is considered – for the purpose of this study – a tolled facility near the border instead of a typical tolled border crossing.

Table 5. Method of toll collection at U.S.-Mexico tolled border crossings.

Border Crossing	U.S. City	ETC Technology on the U.S. side	ETC Technology on the Mexican side
Veterans International Bridge	Brownsville	Barcode AVI (installed in 1999)	Transponder (IAVE)
Gateway International Bridge	Brownsville	Barcode AVI (installed in 1999)	Transponder (IAVE)
B&M Bridge	Brownsville	HID Proximity Card (Xpress Card Plus)	None
Free Trade Bridge	Los Indios	Barcode AVI (installed in 1999)	None
Progresso International Bridge	Progresso	None	Transponder (IAVE)
Donna International Bridge	Donna	None	None
Pharr-Reynosa Intl. Bridge on the Rise	Pharr	Transponder (eGo Tag)	Transponder (IAVE)
McAllen-Hidalgo-Reynosa Bridge	Hidalgo	HID Prox, Card (EZCrossBridge TollTag)	Transponder (IAVE)
Anzalduas International Bridge	Mission	HID Prox, Card (EZCrossBridge TollTag)	None
Rio Grande City-Camargo Bridge	Rio Grande	Barcode AVI	Transponder (IAVE)
Roma-Ciudad Miguel Aleman Bridge	Roma	None	Transponder (IAVE)
Juarez-Lincoln Bridge	Laredo	Transponder (Laredo Trade Tag, eGo)	Transponder (IAVE)
Gateway to the Americas Bridge	Laredo	Transponder (Laredo Trade Tag, eGo)	Transponder (IAVE)
World Trade Bridge	Laredo	Transponder (Laredo Trade Tag, eGo)	None
Laredo-Colombia Solidarity Bridge	Laredo	Transponder (Laredo Trade Tag, eGo)	None
Camino Real International Bridge	Eagle Pass	HID Proximity Card Reader	None
Eagle Pass Bridge I	Eagle Pass	HID Proximity Card Reader	Transponder (IAVE)
Del Rio-Ciudad Acuna Intl. Bridge	Del Rio	Barcode AVI	Transponder (IAVE)
Ysleta-Zaragoza Bridge	El Paso	Barcode AVI	Transponder
Good Neighbor Bridge	El Paso	Barcode AVI	Transponder (IAVE)
Paso del Norte Bridge	El Paso	Barcode AVI	Transponder (IAVE)

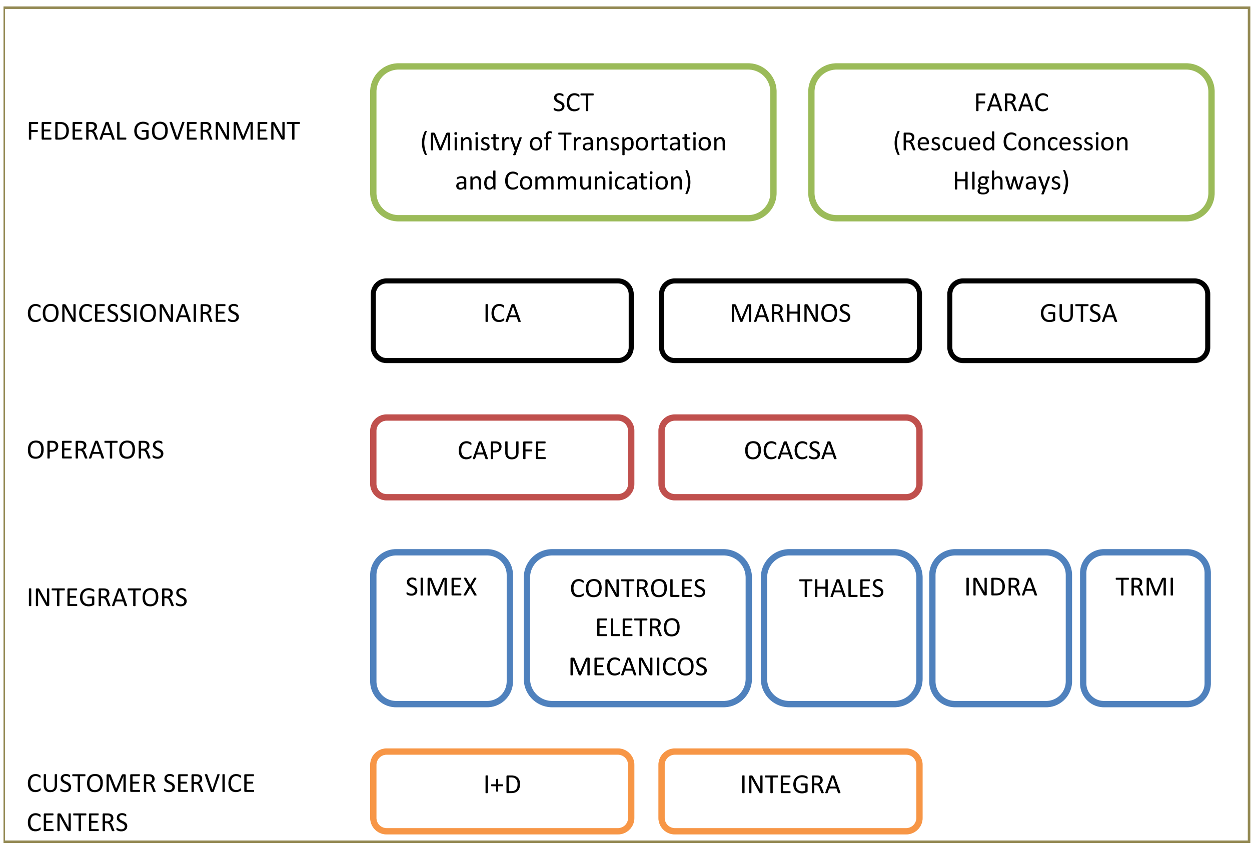
Note: HID = Hughes Identification Devices Global Inc.

Sources: (6), (8), (9), (10), (11), and (26).

Of the 21 tolled border crossings, 18 currently have AVI technology already in place and 3 have not implemented AVI yet. The sites with AVI have various types of AVI technology. Five sites use transponder-based AVI technology, five sites use proximity cards that are electronically read by card readers with the tolls automatically debited from the customers' accounts, and eight sites use barcode technology. On the Mexican side, the situation is different; the number of border crossings equipped with ETC technology does not match the U.S. sites so equipped. On the Mexican side, 14 border crossings have AVI, and all of them use transponder-based technology.

In Mexico, the agency in charge of operating most of the toll highways and border crossings nationwide is CAPUFE. Private concessionaires such as Ingenieros Civiles Asociados (ICA), also operate toll highways, but to a lesser extent after the Mexican government had to bail out most of the private concessions after the Mexican economic crisis of 1994. CAPUFE is a toll corporation owned by the Mexican federal government, which currently operates more than 700 toll lanes (27). CAPUFE ETC transponder-based technology uses the Transcore ATA protocol, although it is upgrading to multiprotocol readers capable of reading multiple protocols such as the International Organization for Standardization (ISO) 18000-6B eGo tag.

CAPUFE's ETC program is called IAVE and currently has 385 lanes equipped with AVI equipment. While CAPUFE has standardized ETC on its IAVE system, the other concessions have not standardized it. IAVE is currently accepted at 13 U.S.-Mexico border crossings. Of all the Mexican crossings with transponder-based AVI, only the Ysleta-Zaragoza Bridge is not part of IAVE. The obvious advantage of having a single agency operating most of the toll facilities is the use of the same transponder/reader protocol, consolidated CSC operations, and no interoperability issues. Figure 5 presents an overview of the toll road operations, management, and funding in Mexico.



Source: (28)

Figure 5. Diagram describing Mexican toll road concessionaires, operators, integrators and customer service centers.

The Mexican government agency that owns most of the toll roads in Mexico is called Banco Nacional de Obras y Servicios Público (BANOBRAS). CAPUFE operates BANOBRA's toll roads on its behalf. Another example of agencies working together is the Fideicomiso de Apoyo al Rescate de Autopistas Concesionadas (FARAC) which "rescues" highways that had been under a concession, and these are operated by the Operación y Conservación de Autopistas Concesionadas (OCACSA). Currently, BANOBRAS is involved in a study to make all the tolling facilities in Mexico interoperable. As part of this study, BANOBRAS is evaluating how to leverage the plans of the Mexican Department of Motor Vehicles to install a transponder in all vehicles for registration. In 2008, the Mexican Department of Motor Vehicles selected Neology to provide 30 million ISO 18000-6C sticker transponders for this purpose. Technically, these transponders could be used for tolling as well.

Table 6 shows toll collection methods utilized at U.S.-Canada tolled border crossings. Seven out of the 10 selected border crossings are tolled, and unlike on the southern border, these tolled crossings are located in different states. All of the tolled border-crossing operations on the northern border use ETC technology for toll collection with the exception of the Blue Water Bridge, where the only method of payment available is cash and tokens. For those border crossings using ETC technology, six use transponder-based technology and one uses proximity cards.

Table 6. Method of toll collection at U.S.-Canada tolled border crossings.

Border Crossing	U.S. City	U.S. State	ETC Technology
Blue Water Bridge	Port Huron	MI	None, tokens/cash
Lewiston-Queenston	Lewiston	NY	Transponder, ExpressPass program (Transcore eGo tag)
Whirlpool Rapids	Niagara Falls	NY	Transponder, NEXUS card used for tolls (IBM tag identical to eGo)
Rainbow Bridge	Niagara Falls	NY	Transponder, ExpressPass program (Transcore eGo tag)
Peace Bridge	Buffalo	NY	Transponder, E-ZPass
Ambassador	Detroit	MI	Transponder (Mark IV)
Detroit-Windsor	Detroit	MI	Proximity cards for tolls (NEXPRESS), tokens

Sources: (6), (12), (13), (14), (15), (16), (17), (18), and (19).

Toll Rate Determination Based on Time of Day and Congestion Levels

All of the tolled border crossings on the U.S.-Mexico border and the selected tolled border crossings on the U.S.-Canada border currently have fixed toll rates. Currently, there is no pricing in place to adjust tolls based on congestion levels or toll rate schedules based on the time of the day and day of the week. The fixed toll rates are generally based on the type of vehicle, number of axles, and weight. The future Otay Mesa East POE will include a pricing component that is based on wait/crossing time, congestion management, and emissions reduction.

Coordination of Toll Rates between Operators on Opposite Sides of Borders and Supporting Agreements

On the U.S.-Canada border, there is coordination of toll rates on opposite sides of the border. In most cases, this is due to the way the agency was set up. Table 7 lists U.S.-Canada border crossings and direction of tolling. Four of the border crossings are tolled in only one direction. The other three border crossings—Blue Water Bridge, Ambassador Bridge, and Detroit-Windsor tunnel—are tolled in both directions, and tolls are the same in both directions for passenger vehicles. The same agency operates the Ambassador Bridge and the Detroit-Windsor Tunnel, so toll rate coordination is inherent. The Blue Water Bridge is operated jointly by the Michigan Department of Transportation (DOT) and Blue Water Bridge Canada; tolls are the same in both directions for all vehicle classes.

Table 7. Direction of tolling at U.S.-Canada border crossings.

Border Crossing	U.S. City	U.S. State	Direction of Tolling
Blue Water Bridge	Port Huron	MI	Both ways
Lewiston-Queenston	Lewiston	NY	One way
Whirlpool Rapids	Niagara Falls	NY	One way
Rainbow Bridge	Niagara Falls	NY	One way
Peace Bridge	Buffalo	NY	One way
Ambassador	Detroit	MI	Both ways
Detroit-Windsor	Detroit	MI	Both ways

Sources: (6), (13), (14), (15), (16), (17), (18), and (19).

For the U.S.-Mexico border, there is no published information about the level of coordination for setting tolls. Unlike U.S.-Canada border crossings, most of the bridges on the Mexican side are owned/operated by the Mexican government. The only exceptions are the B&B Bridge operated by the Brownsville & Matamoros Bridge Company, the Ebanos Ferry operated by private citizens, the World Trade Bridge (Puente III) operated by the state of Tamaulipas, and the Colombia Bridge operated by the State of Nuevo Leon. Interviews with selected border crossings indicate that there is no coordination of toll rates between U.S. operators and CAPUFE; each party sets tolls independently. In addition, there is no coordination in the setting of toll rates among U.S. operators along the U.S.-Mexico border. Tolls are set by each operator depending on its operations, budgetary and maintenance needs, and local conditions. However, operators tend to check the rates of the other operators when updating their tolls. This explains why the tolls are similar along the border. For example, the toll for a passenger vehicle currently ranges from $2.25 to $3.00.

In-Lane and Post-Event Enforcement Strategies for Drivers Avoiding Tolls

In manual lanes where a toll collector is present, usually the toll evasion rate is rather small. The use of toll barriers or gates is another method for deterring toll evaders. Toll barriers can be used in manual, automatic, or ETC lanes. Tolled border crossings in El Paso, Texas, have toll barriers. The downside is that vehicle throughput is reduced significantly even with high-speed gates with opening and closing times of less than 1 second. Regardless of the lane type, a VES is used to reduce the number of violators by acting as a deterrent. There are several types of VESs.

Police presence at the collection point or downstream of it is a very effective deterrent, but the cost associated with this makes it very costly if used on a regular basis. A more cost-effective solution is the use of cameras taking images of license plates; the cameras then perform optical character recognition (OCR) scans of the image to get the owners' information. Most of the current VESs perform the OCR automatically, thus reducing the cost for manual processing. Only those images in which the OCR does not meet a certain confidence level are reviewed by a person. Most of the toll roads where ETC is used have a VES component.

Published information about border-crossing enforcement is limited. Interviews with key personnel at select border crossings confirmed the use of gates to reduce toll evasion as their primary deterrent. In the case of El Paso, cameras are present at each lane to take an image of the license plate, but there is no integration with the Department of Motor Vehicles to try to locate the vehicle owner. This is not considered a true VES system. The number of violations in toll roads near the borders, such as the Camino Colombia near Laredo, by vehicles with Mexican license plates is rather low. However, this might change as more AET toll roads are built near the border.

Accepted Currency for Manual Payment Facilities

At the U.S.-Canada border, all of the selected tolled bridge crossings accept U.S. and Canadian currency. At the U.S.-Mexico border, all the Mexican and the largest U.S. border-crossing operators accept U.S. and Mexican currency for toll payment. The exchange rate varies by crossing and is set by the operating agency.

TECHNOLOGY

Cross-Border Scan of Tolling Technologies and Tolling Standards Used by Regional Partners

As mentioned earlier, there is no interoperability at the U.S.-Mexico border on tolling operations. In the European Union (EU), there are several tolling systems that are currently being used. The most common time-based fee is the Eurovignette, which is a vignette or sticker-based system used in an agreement between several EU Member States that gives access to the road network on each other's territory—hence the term "Eurovignette." The EU is harmonizing tolling systems as well as rates using various technologies such as stickers (vignettes), global positioning systems (GPS), and RFID. The European Electronic Toll Service (EETS) is being developed with the anticipation that it will eventually enable road users to easily pay tolls using one system throughout the whole EU.

Enforcement Technologies Being Applied for Toll Payment Capture

A VES system is considered a subsystem of the toll collection system. A description of the various VES systems available is presented earlier in the document. This section will discuss mainly a camera-based VES. Its original use was solely for capturing license plate images of toll evaders. However, in the last few years, as newer cameras and illumination systems have become available in conjunction with greatly improved ALPR technology and OCR engines, VES systems have also started to be used for video tolling. The main purpose of the VES is to capture images of the vehicle license plates. Depending on the toll authority and business rules, the VES system captures the rear and/or front images. The VES equipment consists of a camera (or array of cameras), an illumination system, and a controller card or computer that interfaces with the lane controller and/or the back office.

In an open road toll (ORT) environment, the cameras and illumination system are usually mounted on an overhead canopy. The number of cameras and layout depends on the lane configuration (single lane vs. multilane), lane width, shoulder width, need for capturing front and/or rear license plates, and type of camera used. In a traditional lane with booth configuration, the VES cameras are usually located in the island or mounted on the booth's roof. VES systems have been widely used since the 1990s; however, reading of the license plate was traditionally done manually at the back office. In recent years, OCR and ALPR technology accuracy has evolved to the extent that now license plate reading is left mostly to the ALPR engine, leaving manual review for only those images that are too complex for the ALRP engine. The significant cost reduction for processing images and the high degree of accuracy of ALPR technology have allowed toll operators to offer video tolling as an alternate payment method without the need of a transponder.

Despite the recent progress made in OCR and ALPR, video tolling and VES systems still have several shortcomings (40):

- Poor image resolution, usually because the plate is out of focus.
- Blurry images, particularly motion blur, most likely at higher vehicle speeds.
- Poor lighting and low contrast due to overexposure, reflection, shadows, or plate background color or style.
- Difficulty in extracting the number plate due to:
  a. An object obscuring (part of) the plate, often a tow bar or dirt on the plate.
  b. A different font, as in out-of-state plates and vanity plates.
  c. Different plate styles, as in Federal vehicles.
  d. Circumvention techniques (such as reflective plates).

There are other types of VES systems than camera-based. As mentioned in an earlier section, police enforcement and toll gates are the simplest types of enforcement but are not necessarily cost effective or efficient. Some toll roads have been using mobile readers to identify violators on-site. An example of this is the mobile transponder readers used by police on the Minneapolis I-394 high occupancy toll (HOT) lanes. Enforcement vehicles contain portable transponder readers, enabling enforcement officers to validate operational transponders while driving alongside of or immediately behind a target vehicle (41). Toll roads near the border, such as SR-125 near San Diego, California and SH-255 near Laredo, Texas use ALPR as their primary enforcement technology. Tolled border crossings, on the other hand, rely more on toll barriers (gates) and in some cases – such as the El Paso region – on a basic camera-based VES without ALRP or the means to send violation notices.

Dedicated Short Range Communication Technology Use at the Border

The 915 MHz Dedicated Short Range Communications (DSRC) has been the de-facto ETC technology in the United States. In October 1999, the U.S. Federal Communications Commission (FCC) allocated in the United States 75 MHz of spectrum in the 5.9 GHz band for DSRC to be used by ITS (42). Its main advantages are low latency, range, and security. One of the many applications for 5.9 GHz DRSC is in the tolling industry. The 5.9 GHz DSRC technology is interoperable and open source. This means that equipment replacements, upgrades, and spares can be bought from multiple manufacturers and operate seamlessly.

In a tolling environment, the roadside equipment will communicate with the vehicle's on-board equipment (OBE). The OBE might take several forms and shapes as it transitions from its earlier implementation phase to the ultimate goal of having the OBE embedded in the vehicle as it comes from the assembly plant. Due to the years it will take for vehicle manufacturers to start producing vehicles with integrated OBE and reach significant market penetration, the tolling industry is developing interim OBE that are portable and self-powered and will resemble the 915 MHz toll transponders currently in use.

The literature review did not indicate that the 5.9 GHz DSRC technology is planned in the near future for toll facilities in the U.S. Interviews with selected border-crossing operators indicated that they are following 5.9 GHz developments closely but know of no concrete plans in the near future. In the medium- to long-term range, the San Diego Association of Governments (SANDAG), as part of its regional transportation plan, has identified future plans for Connected Vehicle vehicle-to-infrastructure (V2I)/Smart Roads platform concepts, which specify 5.9 GHz.

Current Deployments

The 5.9 GHz technology is still in the demonstration and trial phases. Its use in tolling applications is moving forward at a slow pace. Although there has been interest in advancing this technology, no toll road operator or authority has issued an RFP specifying 5.9 GHz DRSC as the sole AVI requirement. A few recent RFPs, such as the Triangle Expressway in North Carolina and SR-520 in Washington State, do mention 5.9 GHz as a requirement, but only to the extent of asking proposers for an AVI solution that will allow them to migrate from 915 MHz to 5.9 GHz in the future. The Georgia State Road and Tollway Authority I-85 HOT lanes RFP gives the option to propose either 915 MHz or 5.9 GHz technology. As of today, 5.9 GHz has been deployed only as a test bed or in demonstration projects. Some of these demonstration projects related to tolling applications are listed below.

V2V/V2I Proof-of-Concept Test: Researchers conducted this test in Detroit, Michigan, in 2008. It tested the ability of DSRC to enable interoperable vehicle-to-vehicle (V2V) and V2I transactions for a suite of safety and mobility applications.

Denver 5.9 GHz Toll Test Bed: This project consisted of testing an ETC system for ORT at one of the mainline barrier plazas on the E-470 highway near Denver for a two-week period in August and September 2008. As part of the test, 5.9 GHz DSRC equipment from Kapsch was used. Kapsch equipment included readers, antennas, and transponders. According to the test results, a 100 percent read success rate was achieved (43).

ITS World Congress DSRC Live Demonstration: As part of the 15th ITS World Congress, Kapsch demonstrated its first fully live, functional 5.9 GHz DSRC interoperable technologies and integrated safety systems network in Manhattan and on the Long Island Expressway. More than 40 roadside equipment units were deployed as part of this demonstration (44).

EPS (Electronic Payment Services): This project entails developing a vehicle-to-roadside (V2R) electronic payment services national interoperability specification (EPSNIS) and confirming that the specification and use thereof supports a legacy environment (clearing transactions from toll roads and merchants through a toll authority) (45). The test phase of this project includes collocating 5.9 GHz equipment next to the 915 MHz AVI equipment at one bridge of the Port Authority of New York and New Jersey. This project is in progress.

5.9 GHz Test at Port of Hood Toll Bridge: The Oregon-Washington Bridge Company is conducting this test. The equipment was installed in the fall of 2010. One lane was equipped with a Kapsch 5.9 GHz reader along with the existing 915 MHz Transcore reader. This test allows for live testing in parallel with the Transcore eGo sticker transponders. Two hundred transponders are part of the test, which is expected to last 6 months (46).

5.9 GHz DSRC Wireless Roadside Inspection System for New York State Energy Research and Development Authority: Kapsch will develop, demonstrate, and commercialize a system to allow State enforcement agencies to conduct virtual truck inspections evaluating the real-time safety of the commercial vehicle at highway speeds. The key components are in-vehicle applications on a Kapsch 5.9 GHz DSRC aftermarket device. The first of its kind, this virtual inspection system will be deployed at the Schodack integrated electronic screening site on I-90 near Albany, New York, and is expected to be operational in 2011. The system will validate driver's licenses; the status of registration; credentials; weight; and on-board safety systems including brakes, lights, and tires of participating trucks. This project supports broader efforts that are part of the FMCSA Wireless Roadside Inspection (WRI) Program as well as many of the USDOT's Connected Vehicle Program goals (47).

Assessment of Equipment Manufacturers for Tolling Applications

This section will explore the progress made by the industry in terms of having a commercially available 5.9 GHz solution specifically for tolling applications. A scan of the major vendors was conducted for this report, and the results are presented below. The information was obtained from several sources and not always directly from the manufacturer due to confidentiality issues.

Kapsch: Kapsch has offered a 5.8 GHz solution for several years. It recently acquired a unit of TechnoCom's mobility solutions business based in California, which is deeply involved in V2I technologies. In 2010, Kapsch announced its 5.9 GHz solution and showcased it in the ITS World Congress and Denver trials. In January 2011, Kapsch acquired Mark IV industries, which is the sole source transponder and reader supplier for the E-ZPass® group.

Transcore: Transcore is a member of the Omniair consortium and is involved in V2I. As part of V2I, Transcore is one of the four AVI equipment manufacturers responsible for prototyping a 5.9 GHz solution. The prototype tasks include development of standards, hardware, software, and testing. The other three members are Mark IV, Sirit, and Raytheon. Transcore has proprietary 915 MHz solutions such as the eGo sticker tags and Encompass® reader. On September 14, 2009, Transcore announced that its Encompass 6 reader has been engineered to accommodate the future upgrade to 5.9 GHz technology.

Mark IV: Mark IV is a member of the Omniair consortium, is involved in V2I, and has been very active in developing and testing 5.9 GHz technology. As part of the V2I/V2V proof-of-concept testing in Detroit, Michigan, Mark IV tested its 5.9 GHz equipment in 2008. At some point, Mark IV offered its 5.9 GHz OTTO on Board^{SM} product, which consists of an OBE and roadside unit. However, this product was oriented toward the ultimate V2I goal of having the OBE integrated to the vehicle infrastructure. With Kapsch's recent acquisition of Mark IV, the future of the OTTO on Board^{SM} product is not clear.

Sirit: Sirit is a member of the Omniair consortium and is involved in V2I. Its involvement in the 5.9 GHz arena appears to be more of a supporting role in developing and proving radio frequency test tools. As part of the V2V/V2I proof-of-concept testing in Detroit, Sirit provided a sniffer test tool to independently verify transmitted DSRC data and protocols.

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CHAPTER 4. TRANSPORTATION OPERATIONS AND TRAFFIC MANAGEMENT AND ENFORCEMENT

TRANSPORTATION OPERATIONS

Several regions along the U.S.-Mexico border need to maximize the efficiency of transportation operations at their international border crossings using traditional as well as advanced technology, including ITS. The objective of this chapter is to research, assess, and document the current state of use of ITS technologies and operational concepts by agencies on the U.S.-Mexico and U.S.-Canada borders to improve traffic management and transportation management around the border crossings.

This chapter describes bi-national coordination and identifies where there are possibilities for coordination between agencies across the border in support of traffic management and operation around the border crossings. As an example, a list of technologies deployed at various border crossings along the U.S.-Mexico and U.S.-Canada borders was compiled on a separate project. The information obtained from the literature review was updated through interviews with the stakeholder agencies.

Level of Data Sharing and Integration with Mexican Partners

Review of regional U.S. ITS architectures provides significant insight into how individual regions prioritize information sharing with Mexican agencies. Based on a brief overview of regional ITS architectures from the U.S. side, it is clear that stakeholders from individual regions have placed different priorities on interfacing with Mexican counterpart agencies. For example, Laredo's ITS architecture does not include stakeholders from Mexico, while Pharr's ITS architecture includes Mexican emergency management agencies (EMAs) as a stakeholder group and interfaces with TMCs operated in the Pharr region—even though none exist at present. New Mexico's statewide architecture mentions interfaces with New Mexico Department of Transportation (NMDOT) District 1 (Las Cruces region) with a Mexican regional TMC. Analysis of inconsistencies between regional ITS architectures regarding information sharing with Mexican agencies should be investigated.

The literature review and interviews with officials on both sides of the border revealed that sharing of real-time traffic management data between agencies from both sides of the U.S.-Mexico border has been limited. Compared to Canadian agencies on the U.S.-Canada border, Mexican counterparts on the U.S.-Mexico border have only to a very limited degree deployed ITS with the specific purpose of incident management around border crossings. In addition, none of the cities on the Mexican side of the border has deployed TMCs to manage and operate transportation systems including border crossings. TMCs are a crucial platform for sharing information between regions. However, conversations with officials mentioned that there has been little or no progress in U.S. agencies sharing their TMC data with agencies in Mexico.

This may change in the future. Secretaría de Comunicaciones y Transportes (SCT) is planning to deploy several TMCs in the border region. SCT is going ahead with construction of regional TMCs in the cities of Monterrey and Chihuahua. The TMCs will monitor Mexican federal roadways and toll roads, many of which terminate at international border crossings. These

TMCs will be able to operate ITS field devices deployed on roadways close to border crossings and provide ATI, which will include traffic conditions on roadways as well as border crossings (48). In addition, the ITS system envisioned by SCT includes TMCs to be operated by toll concessionaires that will share real-time data with TMCs on the U.S. side of the border (49).

Interviews with officials revealed that agencies from both sides of the border make requests for assistance while responding to disasters. In the absence of TMCs, communication among agencies on both sides of the border is limited to methods such as radio and mobile phones. It is important to keep in mind that requests for information/assistance between the two countries happen at the city level and not county or State level (50). Thus, data sharing among cross-border agencies should happen at the local level because of the immediate need to respond to incidents and emergencies and the fact that local enforcement agencies are the first ones to respond.

Regions in the United States have adopted a consistent set of standards for information exchange. A recommended list of standards can be found in a report prepared by the National ITS Architecture Team for the recent Border Wait-Time Project on the U.S.-Canada border. The standards come from the National ITS Architectures of both the United States and Canada. Table 8 displays a list of candidate ITS standards for the Border Wait-Time Project, including Lead Standards Developing Organization (SDOs).

Table 8. Candidate ITS standards for the Border Wait-Time Project on the U.S.-Canada border.

Lead SDO	Standard Name
AASHTO/ITE	Traffic Management Data Dictionary (TMDD) and Message Sets for External TMC Communications
AASHTO/ITE/NEMA	National Transportation Communications for ITS Protocol (NTCIP) Center-to-Center Standards Group
AASHTO/ITE/NEMA	NTCIP Center-to-Field Standards Group
AASHTO/ITE/NEMA	Global Object Definitions
AASHTO/ITE/NEMA	Object Definitions for Closed Circuit Television Camera (CCTV) Control
AASHTO/ITE/NEMA	Object Definitions for Data Collection and Monitoring Devices
AASHTO/ITE/NEMA	Object Definitions for Closed Circuit Television Switching
AASHTO/ITE/NEMA	Data Element Definitions for Transportation Sensor Systems
ASTM	Standard Practice for Metadata to Support Archived Data Management Systems

Note: ITE: Institute for Transportation Engineers, AASHTO: American Association of State Highway Transportation Officials, NEMA: National Electrical Manufacturers Association, ASTM: American Society for Testing and Materials

Source: (51).

An efficient bi-national data exchange can only take place if agencies on both sides of the border follow common standards whether the exchange takes place between centers or field devices. The SCT recently finalized the National ITS Strategic Plan, which includes planning, development, and implementation strategies for ITS at the national, regional, and local levels. Other studies include developing and updating ITS processes, standards, and protocols. The objective of the study was to use this result to promote ITS system implementation and interoperable applications at the local and regional levels. The project will ensure software and hardware consistency, interconnectivity, and compatibility. It will define the institutional structure needed to supervise the implementation of the Mexican National ITS Strategic Plan.

Different levels of adoption of current ITS standards by both countries (and regions across the border) will most likely hinder exchange of real-time traffic data. It remains to be seen how ongoing and future projects (discussed in chapter 6) plan and implement real-time data exchange between agencies (rather than TMCs) in both countries.

Technology Used for Inspecting, Weighing, and Screening to Increase Efficiency

Several Border States are implementing technologies to increase efficiency at border crossings. The Arizona Department of Transportation (ADOT implemented a project called Expedited Processing at International Crossings (EPIC), which combined proven ITS technologies to expedite processing, compliance monitoring, and traffic management, at the Nogales POE in 1998. EPIC's features included the slow weigh-in-motion (SWIM) system, CCTV monitoring, AVI, VMSs, digital imaging equipment, future installation of thermal imaging for safety-related issues, and USDOT number readers sending data to the database system for storage and integration of information from all of the technologies, communications systems, and ancillary equipment. EPIC also provided a means to access and update information from motor carrier service records. Currently, ADOT is coordinating the implementation of EPIC III with their commercial vehicle border crossing time and wait-time measurement projects.

The Department of Public Safety (DPS) in Texas and the California Highway Patrol (CHP) in California operate border vehicle safety inspection facilities (BSIFs). The Texas DPS, working with the Texas Department of Transportation (TxDOT), is implementing an RFID-based system to monitor inspection times inside the BSIF and also to identify carriers that should not bypass the inspection process based on their safety records. The system is similar to the FAST system but is based on information from the carrier's safety records. This system is being implemented at the Bridge of the Americas in El Paso and is not fully deployed yet.

The BSIFs in Texas and California have weigh-in-motion (WIM) systems that identify overweight vehicles as they enter the vehicle safety inspection stations. Commercial vehicle weight regulations in Mexico and Canada are different from those the U.S. Rules and regulations for the two U.S. NAFTA trading partners allow for heavier trucks; therefore, it is important to verify that trucks coming into the United States comply with local standards. WIM border data are currently not being shared or archived.

Technology Being Deployed or Proposed to Improve Border-Crossing Time by CBP

CBP's dual mission is to secure the nation's borders while facilitating legitimate trade and travel. CBP enforces a number of trade laws and protects domestic industry by applying quota and visa restrictions. These different security and economic aspects that CBP needs to enforce can be divided into three types of inspections at land POEs:

- Immigration inspections: These inspections enforce immigration laws and focus on keeping aliens who violate any of the laws from entering the country.
- Customs inspections: These inspections have the purpose of controlling the import and export flows of the United States, collecting the necessary revenues, and preventing the smuggling of illicit goods.
- Agriculture inspections: These inspections are meant to ensure a safe and affordable food supply.

CBP has implemented a variety of technologies at land POEs, and the most recent implementation is part of the WHTI. Other technologies for scanning were implemented as part of the trusted-traveler programs for commercial and passenger vehicles (FAST and SENTRI). Table 9 and Figure 6 present technologies that currently are in operation at the federal compounds at land POEs. Table 9 includes information on the stages of the process and the programs under which these technologies operate.

Table 9. Land POE technologies and their use in traffic screening and border crossing programs.

Land POE Technology	Ped. Pre-screening	POV pre-screening	CV pre-screening	Ped. Primary	POV Primary	CV Primary	Ped. Secondary	POV Secondary	CV Secondary	FAST program	NEXUS program	SENTRI program	US-VISIT program	RPM program
Closed-circuit television (CCTV)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No
Data mining	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No
Explosive Detection Systems	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No
Fingerprint Recognition	No	No	No	No	No	No	No	No	No	No	No	No	Yes	No
K-9 Unit	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	No	No	No	No	No
License Plate Reader (LPR)	No	Yes	Yes	No	No	No	No	No	No	No	No	No	No	No
Passport Readers	No	No	No	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	No	No
Proximity Cards	No	No	No	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	No	No
Fixed Gamma-ray imaging	No	No	No	Yes	No	No	No	No	No	No	No	No	No	No
Mobile Gamma-ray imaging	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Vehicle Tags Radio-frequency Identification (RFID)	No	Yes	Yes	No	No	No	No	No	No	Yes	Yes	Yes	No	No
ID Cards RFID	No	No	No	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	No	No
Fixed Radiation Portal Monitor (RPM)	Yes	Yes	Yes	No	No	No	No	Yes	Yes	No	No	No	No	Yes
Portable RPM	Yes	Yes	Yes	No	No	No	No	Yes	Yes	No	No	No	No	Yes
Fixed X-ray Imaging	No	No	No	Yes	No	No	No	Yes	Yes	No	No	No	No	No
Mobile X-ray Imaging	No	No	No	No	No	No	No	No	Yes	No	No	No	No	No
Advanced Backscatter X-ray Imaging	No	No	No	No	No	No	No	Yes	Yes	No	No	No	No	No

*Advanced backscatter x-ray imaging is an emerging technology that is being implemented on a limited basis at certain land POEs

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Legend

1. Closed-circuit Television
2. Fingerprint Recognition
3. K-9 Unit
4. License Plate Reader
5. Passport Readers
6. Proximity Cards
7. Gamma ray Imaging
8. Radio-frequency Identification
9. Radiation Portal Monitor
10. X-ray Imaging

Source: (52)

Figure 6. Photograph depicting technologies implemented at the CBP compound in the Bridge of the Americas.

Planned Special Events at and around Border Crossings

Federal, State, and local agencies play a significant role in planning and responding to planned special events (PSEs) that impact operation of border crossings and the surrounding areas. PSEs include visits to the border by high-profile individuals, major cultural and sporting events, major holidays (e.g., Easter and Christmas) that draw huge cross-border shopping trips, large cross-border cattle movements, and introduction of new identification requirements to cross the border. While none of these events requires closing the POE, one may severely increase the wait times of passenger vehicles entering the United States.

Based on the interviews conducted with the stakeholder agencies of the border regions, such events are planned ahead using ad-hoc meetings among agencies of all levels (53). Table 10 lists agencies and their roles, methods of communication, and ITS use at different border regions. Each agency then lays out its subsequent roles according to its jurisdictions to assist traffic management during the event. In most cities, even if the roadways are State maintained, they may be operated by the cities. In such cases, local law enforcement agencies respond to incidents around border crossings. One major difference between the U.S.-Canada and U.S.-Mexico borders is that most major border crossings on the U.S.-Mexico border are situated in the middle of urban centers (often downtowns and central business districts) on both sides of the border. Hence, local law enforcement agencies are expected to be significantly involved while planning and managing special events around border crossings.

While responding to the event, agencies with access to ITS field devices use such devices to monitor the progression of traffic around border crossings. However, none of the border regions has developed a centralized information system through which communication and data sharing could occur between the agencies to monitor the progression of traffic during the event. Communication among agencies on both sides of the border is limited to methods such as radio communication and mobile phones.

Table 10. Method of communication and use of ITS to inform motorists for planned special events.

Border Region	Agencies and Their Roles in Managing Planned Special Events	Method of Communication	Use of ITS to Inform Motorists
Laredo – Nuevo Laredo	Webb and Hidalgo County Metropolitan Planning Organization (MPO), Nuevo Laredo, City of Laredo, police and fire departments, TxDOT, Mayor's Office from both cities across the border, CBP, EPA, and DPS. City of Laredo/Hidalgo County MPO coordinates the meetings to plan for a special event and brings rest of the agencies together. Each agency then lays out its subsequent role(s) according to its jurisdiction to assist traffic management during the event.	While responding to an event, agencies on the U.S. side use ITS field devices but do not have centralized information systems in place through which communication and data sharing could occur among the agencies to monitor the progression of traffic during the event.	Mostly limited to display of information via fixed VMSs on the U.S. side only, and press releases carried through local media.
El Paso – Ciudad Juarez	El Paso MPO, Ciudad Juarez, City of El Paso, police and fire departments, TxDOT, IMIP, Mayor's Office from both cities across the border, CBP, EPA, and DPS. El Paso MPO coordinates the meetings to plan for a special event and brings rest of the agencies together. Each agency then lays out its subsequent role(s) according to its jurisdiction to assist traffic management during the event.	While responding to an event, agencies use ITS field devices on the U.S. side but do not have centralized information systems in place through which communication and data sharing could occur among the agencies to monitor the progression of traffic during the event.	Mostly limited to display of information via fixed VMSs on the U.S. side, and press releases carried through local media.
Santa Teresa – Ciudad Juarez	New Mexico Border Authority (NMBA), City of Sunland Park, City of Las Cruces, Ciudad Juarez, police and fire departments, NMDOT, Mayor's Office from both cities across the border, CBP, EPA, DPS. NMBA coordinates the meetings to plan for a special event and brings rest of the agencies together. Each agency then lays out its subsequent role(s) according to its jurisdictions to assist traffic management during the event.	Mostly limited to face-to-face meetings and telephone calls.	Press releases carried through local media.

Note: EPA = Environmental Protection Agency, IMIP = Metropolitan Planning Agency of Ciudad Juarez, NMBA = New Mexico Border Authority.

Real-Time Incident Management at and around Border Crossings

State and local agencies play a significant role in responding to incidents around border crossings. Individual roles of these agencies depend on the presence of State and/or local roadways that lead to and from the border crossings and their current jurisdictions for traffic operation on these roadways. In most cities, even if the roadways are State-maintained, they may be operated by the cities. In such cases, local law enforcement agencies respond to incidents around border crossings. One major difference between the U.S.-Canada and U.S.-Mexico borders is that most major border crossings on the U.S.-Mexico border are situated in the middle of urban centers (often downtowns and central business districts) on both sides of the border. Hence, local law enforcement agencies are much more involved during incident management on the U.S.-Mexico border, while State and county agencies play a much bigger role on the U.S.-Canada border.

While local police and fire departments respond to all incidents, local fire departments have a much bigger role in responding to hazardous materials (HAZMAT)-related incidents. Local fire departments are trained to contain HAZMAT spills. Given the circumstances of the spill and nature of the HAZMAT, the EPA and regional emergency management may be called upon to contain the incident.

All the border State DOTs at the U.S.-Mexico border operate TMCs with significant investments in ITS for incident management. Compared to agencies on the U.S.-Canada border, their counterparts on the U.S.-Mexico border have deployed ITS only to a very limited degree with the specific purpose of incident management around border crossings. Table 11 describes roles and responsibilities of local, State, and Federal agencies on both sides of the border for real-time incident management.

Table 11. Roles and responsibilities of various local, State, and Federal agencies for real-time incident management.

Agency	Description of Roles and Responsibilities	Access to ITS
U.S. and Mexican County or Municipal Public Safety Agencies	These agencies are responsible for law enforcement and first response and include city or county police departments, fire, and ambulance services; sheriff's departments; and State police. Fire departments are de-facto response agencies for HAZMAT-related incidents at and around border crossings.	Cities on the U.S. side of the border have agreements with State DOTs to access ITS field devices.
U.S. State Department of Public Safety/Highway Patrol	State Department of Public Safety (in TX, NM, and AZ) and the Highway Patrol (in CA) manage incidents on State highways in the United States.	State DPS and Highway Patrol have agreements with State DOTs to access ITS field devices.
U.S. State DOTs	State DOTs are responsible for managing, operating, and/or maintaining State-owned transportation infrastructure around border crossings. Services provided include advanced traffic management, traveler information, and other services.	State DOTs own and operate a wide range of ITS field devices for incident management.
Mexican Army	The Mexican Army inspects trucks entering the U.S. for narcotics and illegal goods.	None
U.S. and Mexican Federal Law Enforcement	Federal law enforcement agencies respond to major incidents at and around border crossings.	None
U.S. and Mexican Toll Authorities	These agencies include Government agencies (and could include public-private arrangements) responsible for the administration, operation, and maintenance of bridges, tunnels, turnpikes, and other fee-based roadways. They help local police and fire departments.	Agencies are equipped with CCTVs and VMSs on their facilities and use them to monitor toll violators; if needed, field devices can be used for traffic management.
U.S. EMAs	These include county and State agencies that coordinate overall response to large-scale incidents or major disasters. These agencies have mandates to set up emergency operations centers to respond to and recover from natural, manmade, and war-caused emergencies, and for assisting local governments in their emergency preparedness, response, and recovery efforts.	EMAs coordinate with State DOTs to access ITS field devices during incident response.
Mexican EMAs	These EMAs are in charge of dispatching police, medical, and firefighter units in Ciudad Juarez, Mexico. Anyone can call this number to report all kinds of incidents including HAZMAT incidents.	The agency uses the same technology as the one used by the 9-1-1 system in the United States. The only difference is that the agency can identify the location of nearest field unit using GPS devices.
U.S. EPA	EPA call center will assist with basic containment and call an EPA contractor that is specially trained to respond and contain specific HAZMAT problems. Local law enforcement will assist with the HAZMAT containment along with local fire department.	State DOTs and/or city police and fire departments assist the EPA with traffic management activities during HAZMAT incidents, but EPA does not have access to ITS field devices.

Source: (54) and (55).

Table 12 describes how various border regions manage incidents and how motorists are provided with incident-related information.

Table 12. Method of communication and use of ITS to inform motorists for incident management.

Border Region	Agencies and Their Roles in Managing Incidents	Method of Communication	Use of ITS to Inform Motorists
Laredo-Nuevo Laredo	City of Laredo, Nuevo Laredo, police departments, fire departments, TxDOT, CBP, and EPA. Because all the border crossings are within the city limits, police and fire departments have jurisdictions to respond to incidents around the border crossings. CBP responds to all incidents within its compound and occasionally requests assistance from the local fire department and EPA to respond to HAZMAT-related incidents within the CBP compound.	During the event, there are no information systems in place through which communication and data sharing could occur between agencies on both sides of the border to monitor the progression of traffic during the incident. U.S. agencies such as TxDOT, police departments, and fire departments do, however, exchange information via very high frequency (VHF) radio and have access to CCTV cameras installed by TxDOT on State roadways.	Mostly limited to relay of information via fixed DMSs, and local media in the United States.
El Paso-Ciudad Juarez	City of El Paso, Ciudad Juarez, City of Sunland Park, police departments, fire departments, TxDOT, CBP, EPA. Because all the border crossings are within the city limits, police and fire departments have jurisdictions to respond to incidents around the border crossings. While CBP responds to all incidents within its compound, it occasionally requests assistance from the fire departments and EPA to respond to HAZMAT-related incidents within the CBP compound.	During the event, there are no information systems in place through which communication and data sharing could occur between agencies on both sides of the border to monitor the progression of traffic during the incident. U.S. agencies such as TxDOT, police departments, and fire departments do, however, exchange information via VHF radio and have access to CCTV cameras installed by TxDOT on State roadways.	Mostly limited to relay of information via fixed dynamic message signs, and local media in the United States.
Santa Teresa-Ciudad Juarez	Highway Patrol is the major agency responsible for managing incidents around border crossings, since none of them is within city limits, except for City of Columbus.	During the event, there are no information systems in place through which communication and data sharing could occur between agencies on both sides of the border to monitor the progression of traffic during the incident. U.S. agencies such as the Highway Patrol and fire departments do, however, exchange information via VHF radio. There are no CCTV cameras deployed close to border crossings.	There are no VMS signs close to border crossings. Hence, incidents are relayed through the 5-1-1 system in the U.S.

Along the U.S.-Mexico border areas, many cities have signed sister city agreements. Many of these agreements were inspired by the U.S. and Mexico Border 2012 Program. The cities of Laredo and Nuevo Laredo developed a cross-border contingency plan in 1998 as part of a sister city agreement to allow either city to utilize resources and manpower essential to respond to emergencies and disasters within the two Federal boundaries (56). A similar bi-national emergency plan (focused on HAZMAT) was signed in 2007 among the City of El Paso, Ciudad Juarez, and the City of Sunland Park under the 14th border sister city agreement (57). The plan calls for police, fire, paramedics, and other emergency response personnel from both sides of the border to respond quickly to large fires, dangerous chemical spills, or other emergencies. In 2000, the border cities of Nogales, Arizona and Sonora also signed a bi-national prevention and emergency response plan to improve their ability to prevent and respond to fire, chemical, and/or HAZMAT emergencies (58).

However, due to liability issues associated with the risk of responding to a HAZMAT incident on the other side of the border, fire departments on the U.S. side are not allowed to cross into Mexico and directly respond to HAZMAT incidents (54). For example, one of the most important liability issues is disability insurance. Insurance companies in the U.S. will neither recognize nor pay disability to U.S. fire station personnel if they are injured when responding to an incident in Mexico.

This dilemma might be changing soon because authorities are trying to mandate disability coverage regardless of where an accident or disability occurs. However, no authority will risk predicting the outcome. In spite of these hurdles, the cities of El Paso and Sunland Park on the U.S. side maintain a close relationship with colleagues from Ciudad Juarez and provide frequent training in HAZMAT response. There are existing information-sharing agreements, some of which are formalized and some of which are informal. For example, the El Paso Fire Department has close ties with counterparts in Ciudad Juarez and communicates with fire stations from the other side of the border via telephone calls in case of a HAZMAT incident.

Disaster Preparedness, Response, and Recovery

About 5,000 tons of HAZMAT worth over $4 billion dollars was exported to Mexico in 2002. The U.S.-Mexico border region experiences a concentrated flow of HAZMAT. On the Mexican side, 2,600 manufacturing plants use and/or produce an enormous amount of HAZMAT; the material is then processed at factories in Mexico, the products are shipped around the world, and the remaining HAZMAT is brought back to the United States. Under NAFTA requirements, all HAZMAT that is shipped into Mexico or generated during the manufacturing process must be shipped back to its point of origin, typically the United States. The U.S. side has concentrated areas of storage and disposal facilities. Thus, the delivery and return of HAZMAT has created a HAZMAT transportation corridor.

Fifty percent of the trade that crosses through Laredo involves HAZMAT. Laredo has an enormous potential for a disaster involving HAZMAT due to the volume of HAZMAT cargo and commerce alongside the tourism present on both sides of the border (59). Additionally, Laredo has over 60 million square feet of warehouse space, and at least a quarter of that space contains HAZMAT and is highly vulnerable to terrorism including biochemical terrorism.

The literature review and interviews with officials from border regions revealed that disasters due to HAZMAT are the biggest concern—even bigger than natural disasters.

Border cities along with the counties have formed emergency management offices/centers, which work closely with State and Federal emergency agencies such as the Federal Emergency Management Agency (FEMA) and the U.S. EPA. The purpose of the emergency operations centers (EOCs) is to provide a location where multiple levels of Government, agencies, and organizations can coordinate decisions, resources, and public information on a strategic level.

Emergency management centers (EMCs) are also responsible for the development and implementation of emergency plans, training, public outreach—and most importantly—coordination of local, State, and Federal officials while responding to major disasters.

For example, the El Paso County Office of Emergency Management is responsible for developing and implementing plans for the protection of the community and for minimizing the effects of a natural or manmade disaster. The agency is further responsible for designing and directing local emergency exercises, coordinating the activities of local agencies and resources during disaster, coordinating requests for assistance, and providing information to State and Federal agencies during disaster operations. The agency also coordinates with other city and county departments regarding responsibilities during a disaster, compiling, and submitting all reports required by the State and Federal agencies. This agency is also responsible for responding to HAZMAT incidents. The agency has defined disasters as incidents that require mass emergency evacuations, natural and manmade disasters, HAZMAT incidents, and border violence incidents.

The agency also provides an emergency notification service that contacts individuals and provides vital information/instructions during a city-wide emergency or disaster. The agency maintains an emergency alert system called EPEMERGENCYALERT.COM and can send alerts to the county residents only. It uses geographic information system (GIS) technology to send alerts to only those target areas.

Similar EMAs exist in all U.S. cities along the U.S.-Mexico border region, as Table 13 shows. All of these agencies, except Mexican agencies and the agencies in Nogales have capabilities to alert their residents about impending situations.

The cities of Laredo and Nuevo Laredo developed a cross-border contingency plan in 1998 as part of the sister city agreement to allow either city to utilize resources and manpower essential to respond to emergencies and disasters within the two Federal boundaries (56). A similar bi-national emergency plan (focused on HAZMAT) was signed in 2007 between the City of El Paso, Ciudad Juarez, and the City of Sunland Park under the 14th border sister city agreement (58). The plan calls for police, fire, paramedics, and other emergency response personnel from both sides of the border to respond quickly to large fires, dangerous chemical spills, or other emergencies. In 2000, the border cities of Nogales and Arizona-Sonora also signed a bi-national prevention and emergency response plan to improve their ability to prevent and respond to fire, chemical, and/or HAZMAT emergencies (58).

It is obvious from the literature review and interview with officials that despite the need to share information in real time between agencies in Mexico and the United States, none of the agencies has developed such a system. Interviews with officials revealed that agencies from both sides of the border do make requests for assistance in times of disaster. Most of the requests for assistance and coordination still happen through a traditional method of communication—telephones. Even though sister city agreements allow agencies on both sides of the border to utilize communication to share information while planning, responding, and managing HAZMAT incidents in real time, such systems have not been developed due to lack of funds.

Table 13. Use of ITS by border agencies for disaster preparedness, response, and recovery.

Border Region	Disaster Response Plan	Agencies Involved in Responding	Use of ITS
Laredo-Nuevo Laredo	Yes	City of Laredo, County of Webb, TxDOT	Not available
El Paso-Ciudad Juarez	Yes	City of El Paso, El Paso County, TxDOT	El Paso Emergency Alert System run by the City/County of El Paso delivers messages by telephone, text, email, etc. to its residents. The system provides radio operators with all forms of communications as well as provides supplemental communications to the Sheriff's Office. City/County also uses the Web-based Emergency Operations Center (WebEOC) as a crisis information management system and provides secure real-time information sharing among partner agencies. TxDOT relays information to motorists on fixed VMSs about the hazardous conditions.
		Ciudad Juarez under the direction of Civil Protection	There is no centralized alert system such as El Paso and San Diego have.
Santa Teresa-Ciudad Juarez	Yes	Dona Ana County	EOC is operated by Luna and Dona Ana Counties. The center communicates with the first responders, but there is no centralized alert system like the ones El Paso and San Diego have.
		Ciudad Juarez under the direction of Civil Protection	There is no centralized alert system like the ones El Paso and San Diego have.
Nogales-Nogales	Yes	Pima County, City of Nogales	A system is available for residents of the county to receive alerts via text messages and email (60). Service does not extend to residents across the border.
Otay Mesa-Tijuana	Yes	San Diego County and 18 other incorporated cities within the county	San Diego County and other incorporated cities use WebEOC (61).

Source: (61)

Traffic Management

Technology and State-of-Practice Scan to Measure and Share Border Wait Times and Delay

The CBP and the CBSA are two agencies that measure border wait times and share the information in the public domain. The CBP measures wait times of vehicles inbound to the United States using one of five methods depending on the POE: unaided visual observation, cameras, driver surveys, time-stamped cards, and ALPRs. The CBSA uses similar techniques (62). CAPUFE, the Mexican federal agency that operates the border crossings, does not relay border wait times. Mexican motorists rely on the information relayed by the CBP for such information.

Understanding the shortcomings of the data relayed by the border agencies, the FHWA and TxDOT have deployed several ITS projects. These deployments use RFID technology to measure and relay highly accurate and reliable wait times and crossing times of commercial vehicles. These RFID technology-based systems have already been deployed at the Bridge of the Americas in El Paso, Texas, and the Pharr-Reynosa International Bridge in Pharr, Texas. TxDOT is further deploying similar systems in Laredo and McAllen, Texas. The Arizona Department of Transportation is implementing a similar RFID-based system to measure wait times of trucks at the Mariposa POE in Nogales.

A border wait-time (BWT) work group comprised of the CBP, FHWA, CBSA, and Transport Canada (TC) has been working together to foster the use of technologies for automating the measurement and dissemination of U.S.-Canada land border crossing wait time data (51).

The working group is undertaking the Border Wait Time Project, which has the purpose of (a) identifying and evaluating automated, technology-based solutions for measuring border wait times, and (b) deploying an automated, technology-based solution for measuring border wait times at two border-crossing locations along the U.S.-Canada border.

The initial phase of the project will involve testing of a range of approaches to border wait time determination (e.g., queue length measurement systems, fixed-point vehicle re-identification systems, and dynamic vehicle tracking systems) at two international border crossings:

- Peace Bridge—Buffalo/Niagara Region.
- Pacific Highway—British Columbia/Washington Region.

Later phases of the project will identify solutions that meet functional needs and agency budget limitations and facilitate deployment at all U.S.-Canada international border crossings.

Toll collection agencies and concessionaires on the U.S.-Mexico border continue to use ALPR technology for toll collection and enforcement. However, toll collection agencies mainly deploy ALPR at entrances and exits of bridges or tunnels and may not have incentives to deploy ALPR farther upstream or downstream to measure wait or crossing times. However, use of ALPR to measure and relay wait times or crossing times is nonexistent at POEs on the U.S.-Mexico border.

Some private concessionaires on the U.S.-Canada border use Bluetooth technology to measure crossing times of passenger vehicles, which are then relayed to motorists via Internet and VMSs. However, there are concerns that private concessionaires might be reluctant to accurately report longer wait times if there are competing concessionaires operating in the same region.

Deployment of vehicle detection technology for the purposes of measuring traffic volume and queue length at border crossings is limited. Very few agencies on the U.S.-Canada border have deployed vehicle detectors at border crossings. The Ontario Ministry's Advanced Traffic Management Section led an initiative to implement an intelligent Queue Warning System (QWS) on Hwy 402 to automatically detect queues and warn motorists in advance of the queue via variable message signs. The system leveraged the experience gained from a similar system previously implemented by ATMS on the Hwy 405 and Queen Elizabeth Way Niagara U.S. border crossing. The system consists of inductive loop detectors to detect vehicle queue, CCTV cameras for queue verification, and flashing beacons and VMSs to warn approaching motorists. Instead of physically connecting camera sites to a TMC, the system uses a long-haul wireless Ethernet system utilizing existing communications towers as repeater sites using 5.8 GHz spread spectrum radio (63).

Volume of vehicles that cross the border is also collected by both CBSA and CBP and is distributed to State DOTs and other agencies in highly aggregated temporal granularity. In addition, agencies operating at the border are also interested in deploying vehicle detectors to count volume of approaching vehicles with hopes of using that information to estimate queue lengths and delay time. Both the Washington State DOT (WSDOT) and British Columbia Ministry of Transportation (BCMoT) have installed inductive loop detectors on roadways approach the Cascade Gateway border crossing. A system maintained by the Whatcom Council of Governments (WCOG) archives the vehicle detector data and provides historical wait time, volume, queue length, and service rate data to regional organizations, agencies, and the public (64).

However, past studies have shown conflicting results in terms of these algorithms being able to accurately estimate queue lengths and wait times. A fundamental problem is that the reliability and accuracy of counting vehicles and speed reduces significantly with increasing density and slow-moving traffic, which is typical at major border crossings.

Table 14 includes a list of border crossings and agencies deploying various ITS technologies to collect data such as volume of approaching vehicles, crossing times, wait times, and queue length.

Vehicle detection technologies are divided into two broad categories—intrusive and non-intrusive. Intrusive detection technologies include inductive loops, which are widely used for a variety of transportation applications. Non-intrusive detection technologies include microwave radar, active radar or laser, and video image processing. Table 15 describes the basic operations theory of an elected few intrusive and non-intrusive vehicle detection technologies, which were chosen in this study due to their widespread use compared to other technologies. Non-intrusive detection technologies have an advantage over intrusive detectors because they do not disrupt traffic flow during installation and maintenance and are highly reliable and flexible. These benefits have encouraged some transportation professionals to replace inductive loop detectors with non-intrusive detectors. Table 16 includes a brief description of strengths and weaknesses of inductive loop, microwave radar, laser, and video image processing-based vehicle detection technologies.

Table 14. List of technology implementations to measure volume, wait times, and crossing times at various border crossings.

Location	Proponents	Technology	Direction	Vehicles	Factors Measured	Status
Blaine-Pacific Highway and Douglas (Peace Arch) crossings at the US-Canada border	BCMoT, WSDOT, IBI Group, WCOG, TC, WED	Loop detectors + license plate reader	U.S.-bound and Canada-bound	Cars only, extending to trucks at Northbound Blaine crossing	Volume of vehicles, toll collection	Operational since 2003
Sarnia, Ontario-Port Huron, Michigan	MTO, Delcan, TC	loop detectors	U.S.-bound only	Separate measures for cars and trucks	Volume of vehicles	End of 2008
LaColle, Quebec-Champlain, New York	Tecsult, MTQ, SAAQ, TC	Radar detectors	U.S.-bound only	Mixed traffic	Volume of vehicles	Spring 2008
Buffalo, New York-Niagara Falls, Ontario (three locations)	NYSDOT, NYSTA, MTO, NITTEC	RFID	U.S.-bound and Canada-bound	Mixed traffic, but planning to separate cars and trucks	Crossing times	October 2008
Lynden and Sumas, Washington	WSDOT	License plate readers	Canada-bound only	Cars only	Volume of vehicles, toll collection	Summer 2008
Bluetooth Functionality Test	TC (Ontario), TGT	Bluetooth readers	U.S.-bound and Canada-bound	Cars only	Crossing times	Data collected since late 2006
GPS project at seven locations in Ontario and Quebec	TC (Ontario), TGT, EBTC	GPS logs	U.S.-bound and Canada-bound	Trucks only	Crossing times	Pilot ongoing since Spring 2006
El Paso, Texas-Mexico Bridge of the Americas	FHWA, TTI/ Battelle	RFID	U.S.-bound only	Trucks only	Crossing times and wait times	Operational since 2009
Pharr-Reynosa International Bridge	TxDOT, TTI, City of Pharr	RFID	U.S.-bound only	Trucks only	Crossing times and wait times	Operational since 2009
Mariposa-Nogales POE	ADOT, TTI/ Battelle	RFID	U.S.-bound only	Trucks only	Crossing times and wait times	2011
San Ysidro, California	Premier Wireless	Video image processing	U.S.-bound only	Cars only	Volume of vehicles, toll collection	Discontinued in 2005
Douglas, Arizona-Mexico	Sentrillion (formally New Technology Management, Inc. or NTMI)	Video image processing	U.S.-bound only	Cars only	Volume of vehicles, toll collection	No longer in operation
World Trade and Camino Colombia International Bridges	TTI, TxDOT	RFID	U.S.-bound only	Trucks only	Crossing times	End of 2010
Otay Mesa, California-Mexico	FHWA, Delcan	GPS	U.S.-bound only	Trucks only	Crossing times	Spring/Summer 2008

Adapted from: (62)

Note: MTO: Ministry of Transportation of Ontario, MTQ: Ministère des Transports du Quebec, SAAQ: Société de l'assurance automobile du Québec, NYSDOT: New York State Department of Transportation, NYSTA: New York State Thruway Authority, NIITEC: Niagara International Transportation Technology Coalition, TGT: Turnpike Global Technologies, EBTC: Eastern Border Transportation Coalition, NTMI: New Technology Management Inc., WED: Western Economic Diversification Canada

Table 15. Basic operations theory of various vehicle detection technologies.

Technology	Basic Operation Theory
Inductive Loops	An inductive loop detector senses the presence of a conductive metal object by inducing electrical currents in the object. The induced current decreases the loop inductance, which is sensed by the inductive loop electronics unit. The electronics unit interprets the decreased inductance as vehicle detection and sends an appropriate call to the controller.
Microwave Radar	A microwave radar detectors transmits low-energy microwave radiation at the detection zone, and based on the frequency shift that results from relative motion between a frequency source and a listener, detects passing vehicles. The microwave radar detector measures this shift to determine vehicle passage and speed.
Video Image Processing	A video image processing (VIP) detectors measure changes between successive video image frames. Passing vehicles cause variations in the gray levels of the black-and-white pixel groups. VIP systems analyze these variations to determine vehicle passage.
Laser	A laser radar is an active sensor in that it transmits energy in the near infrared spectrum. This detector uses multiple laser diode sources to emit a number of fixed beams that cover the desired lane width. A laser radar provides vehicle presence at traffic signals, volume, speed, length assessment, queue measurement, and classification.

Source: (65).

Table 16. Strengths and weaknesses of commercially available vehicle detection technologies.

Technology	Strength	Weakness
Inductive Loops	• Has flexible design to satisfy large variety of applications. • Offers mature, well-understood technology. • Has large experience base. • Provides basic traffic parameters (e.g., volume, presence, occupancy, speed, headway, and gap). • Is insensitive to inclement weather such as rain, fog, and snow. • Provides best accuracy for count data as compared with other commonly used techniques.	• Installation requires pavement cut. • Improper installation decreases pavement life. • Installation and maintenance require lane closure.
Microwave Radar	• Is typically insensitive to inclement weather at the relatively short ranges encountered in traffic management applications. • Allows for direct measurement of speed. • Has multiple lane operation available.	• Method cannot detect stopped vehicles.
Video Image Processing	• Monitors multiple lanes and multiple detection zones/lane. • Is easy to add and modify detection zones. • Has rich array of data available. • Provides wide-area detection when information gathered at one camera location can be linked to another.	• Performance is affected by inclement weather such as fog, rain, and snow; vehicle shadows; vehicle projection into adjacent lanes; occlusion; day-to-night transition; vehicle/road contrast; and water, salt grime, icicles, and cobwebs on camera lens. • Reliable nighttime signal actuation requires street lighting.
Laser	• Transmits multiple beams for accurate measurement of vehicle position, speed, and class. • Has multiple lane operation available.	• Operation may be affected by fog when visibility is less than ≈20 ft (6 m) or blowing snow is present. • Installation and maintenance, including periodic lens cleaning, require lane closure.

Source: (65).

Non-intrusive vehicle detectors such as microwave, laser, and VIP are slowly replacing inductive loop detection technology. These detectors have gained a lot of market over the last 5 years, especially for freeway traffic operations and management. Many State agencies are replacing older inductive loop detectors with microwave radar detectors. Because microwave detectors stay on the side of the road and are non-intrusive, their maintenance cost is much lower than inductive loop detectors, which require lane closures and pavement removals during replacement and maintenance (66). Laser technology is relatively new compared to radar and is slowly gaining market for toll collection applications.

Non-intrusive vehicle detection technology has improved significantly over the last few years as a result of increased demand for such technology. For example, in a report published by the University of Utah in 2003, the non-intrusive technologies rated lower, with the average level of satisfaction ranging from 2.8 to 3.4 out of 5, compared to inductive loops. This was mainly due to factors such as immature technology, lack of experience and familiarity with new technologies, complexity of the installation process, maintenance requirements, and expense (66). If a similar survey were to be undertaken now, the level of satisfaction for non-intrusive detectors may well rank higher than inductive loop detectors.

Direct hardware and software purchase costs are not the only costs associated with a sensor. Installation, maintenance, and repair should also be factored into the sensor selection decision. Installation costs include fully burdened costs for technicians to prepare the road surface or subsurface (for inductive loops or other surface or subsurface sensors), install the sensor and mounting structure (if one is required for over-roadway sensors), purchase and install conduit, close traffic lanes, divert traffic, provide safety measures where required, and verify proper functioning of the device after installation is complete. Table 17 includes data output, communication bandwidth, and the cost of commercially available vehicle detectors.

Table 17. Traffic output data (typical), communications bandwidth, and cost of commercially available vehicle detectors.

Sensor Technology	Count	Presence	Speed	Output Data	Classification	Multiple Lane, Multiple Detection Zone Data	Communication Bandwidth	Sensor Purchase Cost[a] (each in 1999 U.S. $)
Inductive loop	Yes	Yes	Yes [b]	Yes	Yes [c]	No	Low to moderate	Low [i] ($500–$800)
Microwave radar	Yes	Yes [e]	Yes	Yes [e]	Yes [e]	Yes [e]	Moderate	Low to moderate ($700–$2,000)
Active infrared	Yes	Yes	Yes [f]	Yes	Yes	Yes	Low to moderate	Moderate to high ($6,500–$3,300)
Passive infrared	Yes	Yes	Yes [f]	Yes	No	No	Low to moderate	Low to moderate ($700–$1,200)
Video image processor	Yes	Yes	Yes	Yes	Yes	Yes	Low to high [h]	Moderate to high ($5,000–$26,000)

Source: (65).

Notes:

a) Installation, maintenance, and repair costs must also be included to arrive at the true cost of a sensor solution, as discussed in the text.

b) Speed can be measured by using two sensors a known distance apart or estimated from one sensor, the effective detection zone, and vehicle lengths.

c) With specialized electronics unit containing embedded firmware that classifies vehicles.

d) With special sensor layouts and signal processing software.

e) With microwave radar sensors that transmit the proper waveform and have appropriate signal processing.

f) With multidetection zone passive or active mode infrared sensors.

g) With models that contain appropriate beam-forming and signal processing.

h) Depends on whether higher-bandwidth raw data, lower-bandwidth processed data, or video imagery is transmitted to the TMC.

i) Includes underground sensor and local detector or receiver electronics. Electronics options are available to receive multiple sensors, multiple lane data.

Table 18 compares the annualized per-lane cost for inductive loop detectors, VIPs, multiple detection zone presence-detecting microwave radar, and acoustic array sensors for a six-lane freeway sensor station. Motorist delay and excess fuel consumption incurred during installation further add to the annualized cost of the inductive loops (65).

Table 18. Annualized per-lane sensor cost comparison to instrument a six-lane freeway sensor station.

Vehicle Detection Technology	Number Required for 6 Lanes	Expected Life	Annualized Cost
Inductive Loops	12	10	$746
Video Image Processor	2 cameras, 1 processor	10	$580
Microwave Radar	1	7	$314

Source: (65).

On the other hand, non-intrusive vehicle detection technologies have not been proven to provide better accuracy in the context of border crossings. It is believed that both technologies have significantly low operation and long-term maintenance benefits (67).

The cost of vehicle detectors mainly includes three components: sensor cost, which is the direct cost for purchasing the sensors from vendors; installation cost; and maintenance costs. However, a satisfactory cost comparison between various sensor technologies can only be made when the specific application is known (68). For example, a microwave presence radar mounted in a side-looking configuration may perform other applications, such as simple monitoring of multilane freeway traffic flow or surface street vehicle presence and speed. In this case, the microwave sensors replace a greater number of loops that would otherwise need to be installed in the travel lanes. Furthermore, the microwave sensor potentially provides direct measurement of speed at a greater accuracy than that provided by the loops.

One of the most widely used methods of relaying wait times to users is through agency Web sites, which are then further relayed by local media outlets such as radio and television stations. Some of these agencies also have a separate Web page with the same information for mobile users. A few agencies in California and Washington have integrated the wait-time information into their regional 5-1-1 systems and relay digitally prerecorded message with wait times. Agencies have also started to use Real Simple Syndicate (RSS) to "push" wait-time information. Through RSS, outside agencies can easily "pull" wait-time or any other information using open standards more efficiently. Because many agencies re-relay CBP-published wait-time information, the frequency of relay is the same as the one used by the CBP, which is hourly. Researchers found only two agencies that use social networking Web sites such as Twitter to relay wait-time information.

A user's response to current wait times is at best subjective and anecdotal. There do not appear to be studies that have documented users' responses to wait times in the short term. Were there to be, questions might include:

- Do users set a preference for border crossings?
- If they do, then what are the factors and threshold values of these factors that influence decisions to choose one border crossing over the other?

For many users, the best strategy is to allocate “extra” time to cross the border based on past experience and historical occurrences of delay. This extra time is in fact what transportation engineers describe as the buffer time, which has a direct correlation with reliability of the wait-time information received by the users. Longer buffer times by users indicate perceived unreliability of the information they are receiving (or have received) and lesser confidence that the wait time will improve prior to crossing the border. Scientific, reliable techniques to measure crossing and wait times will significantly decrease this lack of confidence, but it will take time to educate the users about the reliability of these techniques.

How users react to en-route wait-time information relayed by field ITS devices such as VMSs and local media is still unknown. In freeway operation and management, researchers have used focus group studies, interviews, and visual simulations to understand motorist behaviors in real-time traffic conditions. Similar studies might be helpful to understand users’ behavior to real-time information at border crossings.

In addition, it is unclear which pre-trip and en-route information sources are comparatively more effective: CCTV snapshots compared to wait time for pre-trip information? Local media versus VMS messages for en-route information? Also, what would happen if a significant portion of users are sent the same information about current delay at one of the border crossings? Will all or a major portion of the users shift to another border crossing and in doing so increase the delay at the other one? Intuition and studies have shown that this is a likely scenario. So the question is how to provide targeted information to users and at the same time receive feedback on how the users are reacting to the information that is being provided to them.

Level of Integration between Traffic Operations and Management Systems on Opposite Sides of the Border

Sharing of real-time data between agencies on both sides of the U.S.-Mexico border has been nonexistent so far. None of the cities on the Mexican side of the border has deployed TMCs to manage and operate transportation systems including border crossings. However, SCT is planning to deploy several TMCs in the border region. Table 19 includes a list of border regions on both sides of the U.S.-Mexico border that have existing and planned TMCs.

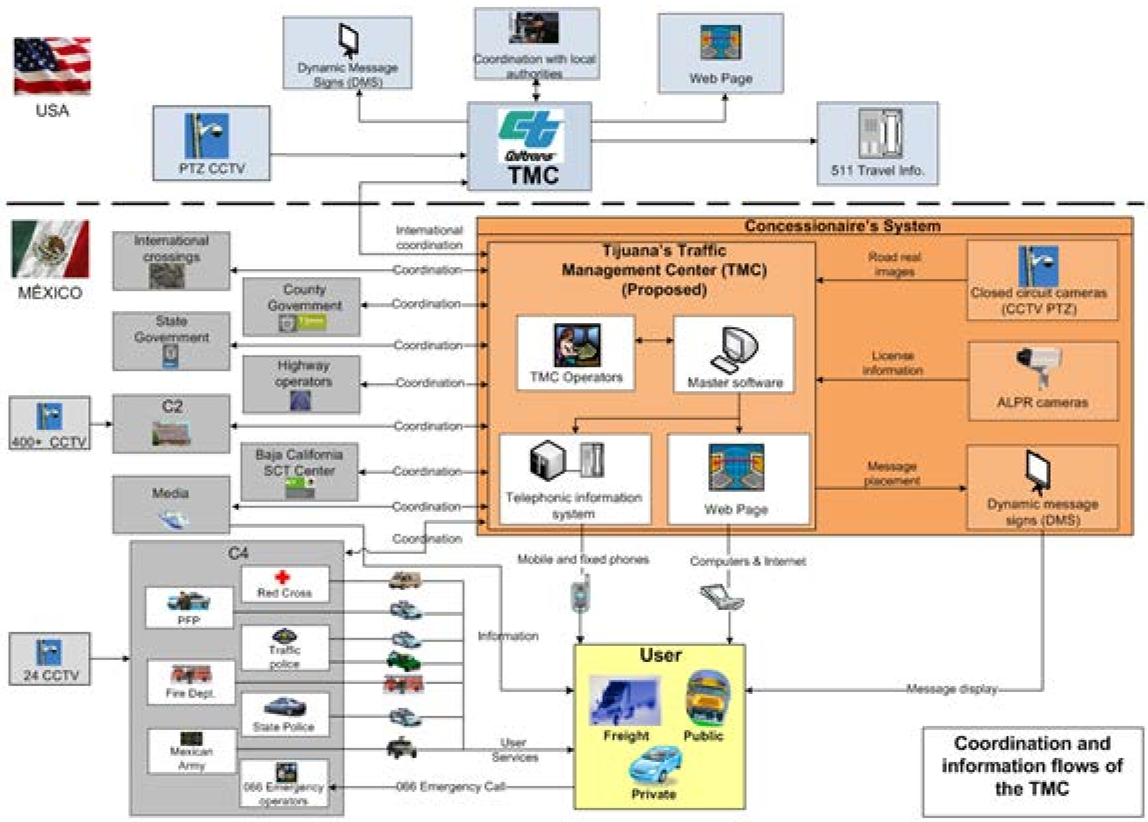
Table 19. Existing and planned deployment of traffic management centers in cities around various border crossings.

Border Crossing	Country	TMC Location	Agency	Status
San Ysidro and Otay Mesa	U.S.	San Diego	SANDAG	Existing
San Ysidro and Otay Mesa	Mexico	Tijuana	SCT	Planned
Calexico East and West	U.S.	Calexico	Imperial Valley Association of Governments (IVAG*)	Planned
Mariposa-Nogales	U.S.	Tucson	ADOT	Existing
Santa Teresa	U.S.	Las Cruces	NMDOT	Planned
El Paso (Bridge of the Americas, Ysleta, Paso Del Norte)	U.S.	El Paso	TxDOT	Existing
El Paso (BOTA, Ysleta, Paso Del Norte)	Mexico	Chihuahua City	SCT	Planned
Laredo (World Trade, Camino Colombia)	U.S.	Laredo	TxDOT	Existing

* Has plans to use SANDAG's existing 5-1-1 system to relay border wait times.

SCT is going ahead with construction of regional TMCs in the cities of Monterrey and Chihuahua. The TMCs will monitor Mexican federal roadways and toll roads, many of which terminate at international border crossings. These TMCs will be able to operate ITS field devices deployed on roadways close to border crossings and provide ATIS information that will include traffic conditions on roadways as well as border crossings (48). In addition, the ITS system envisioned by SCT includes TMCs to be operated by toll concessionaires that will share real-time data with TMCs on the U.S. side of the border (49). Figure 7 shows a sample ITS design for sharing border-crossing-related data between U.S. and Mexican agencies in the Tijuana region.

On the other hand, major cities on the U.S. side have one or more TMCs operated by the cities and/or States. City-operated TMCs mostly focus on local arterials, and the State-operated TMCs manage traffic on State-maintained highways and freeways. However, conversations with officials revealed that there has been little or no progress in sharing the TMC data with agencies in Mexico.



Source: (49)

Figure 7. Flowchart describing proposed ITS operations at the Tijuana border region.

ITS architectures developed for border regions provide roadmaps to integrate transportation systems among agencies within the region and countries. ITS architectures typically identify stakeholder agencies and define roles and responsibilities that each agency plays in the region. In addition, the architecture identifies functions, market packages, equipment packages, and how agencies interface for specific purposes. It also includes current interfaces among agencies and ones that the region plans to implement in the future. Table 20 lists existing and planned interfaces between agencies on both sides of the border, as reflected in their corresponding regional ITS architectures. The list also demonstrates that stakeholders from individual regions have placed different priorities on interfacing with Mexican counterpart agencies.

Mexico's National ITS Architecture was first drafted in 2005. The architecture coordinates the management and operation of various transportation facilities throughout Mexico and support personal and goods movements. The effort of development of the architecture was led by the SCT. The architecture provides a great deal of emphasis on standardization and harmonization of information exchange among Mexican and U.S. agencies at all levels.

Table 20. Existing and future interface between agencies in the U.S. and Mexico in the ITS architecture for individual regions.

U.S. Border Region, State	Interface Between Agencies on Both Sides of the Border	Status
El Paso, Texas (69)	Includes Juarez IMIP as the only stakeholder from Mexico to exchange archived data with the El Paso MPO.	Existing
Laredo, Texas (69)	The Regional ITS Architecture does not include stakeholders from Mexico.	Not Applicable
Pharr, Texas (69)	Includes Mexican EMAs as a stakeholder group and interfaces with TMCs operated by the cities of Brownsville, Harlingen, McAllen, Pharr, and TxDOT Pharr for emergency management.	Future
Las Cruces, New Mexico (70)	The Regional ITS Architecture does not include stakeholders from Mexico.	Not Applicable
New Mexico Statewide (71)	Includes Mexican Customs and Border Patrol, which represents the border patrol agency in Chihuahua, Mexico. Interfaces with NMDOT District 1 TOC and regional EOC for traffic incident management and disaster response and recovery, respectively.	Future
	Includes Mexico Public Safety, which represents public safety providers (police, fire, and Emergency Medical Services, or EMS) in Chihuahua, Mexico, and the surrounding Mexican States. Interfaces with New Mexico Statewide EOC and regional EOCs for disaster response and recovery. Interfaces with NM DPS Dispatch Center and NMDOT District 1 TOC for emergency call taking and dispatch and traffic incident management, respectively.	Future
	Includes Mexico Regional TMC that represents the regional TMC located in Chihuahua, Mexico, that would coordinate traffic information or operations with New Mexico. Interfaces with the NMDOT District 1 TOC to regional traffic control.	Future
Imperial County, California (72)	The Regional ITS Architecture does not include stakeholders from Mexico.	Not Applicable
Entire Mexico (49)	ITS design includes real-time information sharing between concessionaire's TMC and State-operated ones in the U.S. along the border regions.	Future

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CHAPTER 5. TRAVELER INFORMATION AND ARCHIVED DATA MANAGEMENT

TRAVELER INFORMATION

Traveler information allows travelers to choose the most efficient mode and route to their final destinations. Advanced Traveler Information Systems (ATIS) use ITS to provide timely and detailed information about traffic incidents, weather, construction, and special events to improve travel time predictability, allow drivers to make better choices, and reduce congestion. Traveler information applications use a variety of technologies, including Internet Web sites, telephone hotlines, and television and radio to allow users to make more informed decisions regarding trip departures, routes, and mode of travel (73). It is generally believed that traveler information systems are among the most cost-effective investments that a transportation agency can make (74). From a systems perspective, traveler information has the potential to reduce travel times, delay, fuel consumption, and emissions. From a motorist's perspective, traveler information can increase efficiency of travel, relieve stress, and increase trip reliability.

Traveler information is divided into two categories: pre-trip and en-route. Pre-trip traveler information provided via Internet Web sites, other wireless devices, 5-1-1 telephone numbers, other telephone services, television, radio, or kiosks allows users to make a more informed decisions for trip departures, routes, and modes of travel. En-route traveler information provided via wireless devices, 5-1-1 telephone numbers, other telephone services, radio, and in-vehicle signing allows users to make informed decisions regarding alternate routes and expected arrival times.

Every State in the United States incorporates some form of traveler information on freeways, State highways, and arterials. Across the country, cities collect information with varying levels of sophistication, from simple Highway Patrol reports to complex systems of camera surveillance and electronic traffic sensors. Likewise, the means of disseminating the information varies. The most common methods of information dissemination are highway advisory radio (HAR), VMSs, and telephone information services. A growing number of cities also provide Web/Internet sites and personal data assistant-type in-vehicle devices for traveler information (74).

With the growing number of systems being deployed at border crossings to measure crossing times and wait times, more and more State and regional agencies relay the information to motorists and commercial vehicle operators. The information typically includes wait times, crossing times, traffic conditions, and visual queue conditions around border crossings. These systems are able to relay information to traveling motorists and commercial vehicle operators as pre-trip and en-route information.

Use of Variable Message Signs at and around Border Crossings

A quick review of agency Web sites and the literature review revealed that almost none of the agencies on the U.S.-Mexico border currently provide border-related information displayed on VMSs. Several agencies on the U.S.-Canada border provide queue warning and wait-time information through VMSs deployed at approaches leading to border crossings. Table 21 includes a list of agencies on both the U.S.-Canada and U.S.-Mexico borders that have deployed either fixed or portable VMSs for the purposes of relaying information about border crossings.

Table 21. Deployment of VMSs by agencies for the purpose of relaying information about border crossings.

Agency	Fixed Signs	Portable Signs
Texas Department of Transportation (75), (76)	Yes	No
New Mexico Border Authority (77)	No	No
New Mexico Department of Transportation (78)	No	No
Arizona Department of Transportation (79)	No	No
SANDAG and California Department of Transportation (Caltrans) (80)	No	No
Washington State Department of Transportation (81)	Yes	No
BCMoT (82)	Yes	No
New York State Department of Transportation (83)	No	No
Buffalo and Fort Erie Public Bridge Authority (Peace Bridge) (84)	Yes	No
Niagara Falls Bridge Commission (85)	No	No
Blue Water Bridge Canada (86)	No	No
Michigan Department of Transportation (87)	No	No
Montana Department of Transportation (88)	No	No
SCT (49)	Planned	No

However, SANDAG is planning to relay border-crossing information on SR-905, which provides an essential connection between the Otay Mesa border crossing with Mexico and the regional freeway system in California. This project will construct a six-lane freeway from I-805 to the Otay Mesa POE, the busiest commercial border crossing on the California-Mexico border. This project, along with the future Otay Mesa East POE and SR-11, will provide for efficient transportation of goods and services in the Otay Mesa border region. The first half of the six-lane freeway began construction in April 2008, and the remaining half began in June 2009.

This includes a 5-1-1 travel information system, fiber-optic communication traffic monitor systems, ramp meter systems, signals with video detection, CCTV systems, and VMSs all connecting to a base communication hub. A corridor management plan for the proposed SR-905 project is intended to provide a unified, multimodal system management concept for managing and preserving freight mobility in the corridor (89).

Agencies planning to deploy VMSs for border crossings need to be aware that the efficiency of such deployment depends upon whether travelers understand the information correctly, how they value the usefulness of information, and whether they follow the suggested alternates. Studies have shown that the preferences on route switching increase with the information contents provided by the VMSs. When only qualitative information is provided through the VMS, the rates of switching routes are low. On the contrary, when a VMS provides guidance information, most travelers tend to switch because it is implied that the alternative routes are the best routes

(90). Whether a similar conclusion can be drawn for border crossings is a topic of future research—mainly because motorists do not have many choices when it comes to border crossings.

In addition, an analysis of diversions for different incident messages showed that the number of diversions varied considerably according to incident circumstances. It is apparent that it is not only the severity of the problem reported that influences the level of diversions but also other factors such as the specific location mentioned and the availability of viable alternative routes to avoid the problem location. The results for route guidance information showed that substantial diversions occur when the route advice differs from normal.

Use of Social Networking Sites, Web Sites, and Mobile Devices

Almost all State DOTs, CBP, and CBSA relay border-crossing-related information using agency Web sites over the Internet. CBP and CBSA relay border wait times using RSS as well. State DOTs such as Washington and California relay border wait-time information using existing 5-1-1 systems. On the U.S.-Mexico border, the only source of border wait times is the CBP since none of the border crossings is instrumented to measure wait times or crossing times, except the Bridge of the Americas and Pharr-Reynosa International Bridge. On the U.S.-Canada border, even though the primary source of border wait times is CBSA, several privately operated bridges relay wait-time and crossing time information using technologies that are primarily used for toll collection.

Table 22 lists agency use of social networking sites (SNSs), e-mail, and mobile devices by agencies to relay border crossing and wait times. Table 23 lists agencies that relay border crossing and wait times to motorists via Twitter. “Followers” mean individuals who have signed on to follow the tweets (messages) released by the agency. Without following the agency, individuals cannot receive or read tweets from the agency. “Listed” means the number of other Web sites that list the agency’s Twitter messages on their own Web site. The small number of current followers clearly indicates under-utilization or limited use of social media sites to receive traffic-related information.

CBP publishes wait times at all U.S.-Canada-Mexico border crossings. The information is updated every hour and includes the number of lanes open for FAST, non-FAST, SENTRI, and non-SENTRI; the maximum number of available lanes; and the name of the border crossing (35).

Table 22. Use of social networking sites, e-mail, and mobile devices by agencies to relay border crossing and wait times.

Agency	Facebook	Twitter	Email	RSS	5-1-1 System	Web Site	Mobile Apps
CBP (91)	No	No	No	Yes	No	Yes	Yes
CBSA (92)	No	Yes	No	No	No	Yes	Yes
SCT (49)	No	No	No	No	Yes***	Yes***	Yes***
TxDOT (75), (76)	No	No	No	No	No	Yes*	No
NMBA (77)	No	No	No	No	No	Yes*	No
NMDOT (78)	No	No	No	No	No	No	No
ADOT (79)	No	No	No	No	Yes	Yes	Yes
SANDAG and Caltrans (80)	No	No	No	No	Yes	Yes*	No
WSDOT (81)	No	Yes	Yes	Yes	No	Yes	No
BCMoT (82)	No	No	No	No	No	Yes**	No
NTDOT (83)	No	No	No	No	No	No	No
Buffalo and Fort Erie Public Bridge Authority (Peace Bridge) (84)	No	No	No	No	No	Yes	Yes
Niagara Falls Bridge Commission (85)	No	Yes	No	No	No	Yes	No
Blue Water Bridge Canada (86)	No	No	No	No	No	Yes	No
Michigan Department of Transportation (MDOT) (87)	No	No	No	No	No	No	No
Montana Department of Transportation (MDT) (88)	No	No	No	No	No	No	No

* Same as CBP wait times; ** Same as CBSA wait times; *** Planned.

Table 23. Use of social networking site Twitter by agencies to relay border crossing and wait times.

Agency	Followers	Listed
CBSA (92)	332	39
Niagara Falls Bridge Commission	822	36

Source: (85)

SNSs are Web-based services that allow individuals to (a) construct a public or semi-public profile within a bounded system, (b) articulate a list of other users with whom they share a connection, and (c) view and traverse their list of connections and those made by others within the system (93). Examples of these sites include Facebook, Twitter, LinkedIn, and Foursquare. These Web sites are popular among the younger population who favor the Internet over traditional forms of media such as television, radio, and newspapers for news and information. However, they are becoming increasingly popular among all users of the Internet. Government agencies, including several other State transportation departments, are using new media such as social networking sites to enhance their efforts to provide information to the public.

These sites function differently than standard Web pages and feature the consolidation of different information sources onto one page, often with information "pushed" to them. The sites generally require individuals to register and select sources they wish to "follow" with updates flowing to their social networking pages automatically.

Social networking sites have dramatically altered how people interact and share information. Moreover, with the amount of time most drivers spend behind the wheel increasing along with traffic congestion, social networking will inevitably find its way into cars. It has already, when one considers the fact that some motorists feel compelled to update their status on a phone when they should be looking at the road (94).

Some companies are already developing interfaces that will allow motorists to receive audible tweets and Facebook status updates, as well as record their own by using voice control and steering wheel buttons. Similarly, location-aware applications could easily allow car owners to note their location and find where friends are via social networking sites like Foursquare. The car itself could even send tweets and "check in" at locations (94).

Many State agencies including State DOTs publish real-time traffic information on these social networking sites, assuming that these sites allow wider dissemination of traffic information to motorists. There seems to be significant (latent) demand for personalized information services that would allow users to retrieve information when needed, to the point where a significant number of San Francisco Bay-area travelers stated they would be willing to pay either on a per-call basis or a monthly subscription fee for a customizable service. However, the new information must be superior to the information that can be obtained for free through radio or television or other Internet outlets and services (95).

Being able to send messages regarding traffic conditions to mobile devices has come with mixed feelings. Safety experts and policymakers are wondering whether they are giving a mixed message to motorists regarding using mobile devices while driving. At least 22 States that ban texting while driving also offer motorist information services via Twitter. Those information services provide locations of road emergencies, traffic congestion reports, and more (96). Some supporters of text-messaging bans say that states that provide traffic information via Twitter are undermining these laws.

Agencies also use Internet Web sites, mobile devices, and SNSs to relay information regarding traffic conditions around border crossings. Compared to the U.S.-Mexico border, agencies on the U.S.-Canada border have deployed more ITS devices to relay such information to motorists. Table 24 lists agency use of Internet Web sites to relay traffic-related information around border crossings. The most prevalent information includes CCTV snapshots of queue conditions, color-coded speed information, and location of recent incidents. These agencies also relay similar information through SNSs, RSS, email, and Web sites. Only a few State DOTs on the U.S. side of the Canadian border have integrated these systems with their statewide 5-1-1 system. On the U.S.-Mexico border, only SANDAG provides border-crossing-related information through its regional 511 system.

Table 25 lists use of social networking sites, email, the 5-1-1 system, and mobile devices by agencies to relay traffic conditions around border crossings. Figure 8 shows a snapshot of SANDAG's 5-1-1 system Web site. Figure 9 illustrates a proposed countrywide 5-1-1-type system being developed by the SCT.

Table 24. Use of Web sites by agencies to relay traffic conditions around border crossings.

Agency	CCTV Snapshots	Color-Coded Speed Information	Textual Speed Information	Incident Location
CBP	Not Applicable	Not Applicable	Not Applicable	Not Applicable
CBSA	Not Applicable	Not Applicable	Not Applicable	Not Applicable
SCT (49)	Yes*	Yes*	Yes*	Yes*
TxDOT (75), (76)	Yes	Yes	Yes	Yes
NMBA (77)	No	No	No	No
NMDOT (77)	No	No	No	Yes
ADOT (79)	No	No	No	Yes
SANDAG and Caltrans (80)	No	Yes	Yes	Yes
WSDOT (81)	Yes	Yes	Yes	Yes
BCMoT (82)	Yes	Yes	Yes	No
NYDOT (83)	Yes	Yes	Yes	Yes
Buffalo and Fort Erie Public Bridge Authority (Peace Bridge) (84)	Yes	No	No	No
Niagara Falls Bridge Commission (85)	Yes	No	No	No
Blue Water Bridge Canada (86)	Yes	No	No	No
MDOT (87)	Yes	Yes	Yes	Yes
MDT (88)	No	No	No	Yes

Note: * Planned

Table 25. Use of social networking sites, email, and mobile devices by agencies to relay traffic conditions around border crossings.

Agency	Facebook	Twitter	Email	RSS	5-1-1 System	Web Site
TxDOT (75), (76)	No	Yes	Yes	No	No	Yes
NMBA (77)	No	No	No	No	No	No
NMDOT (77)	No	No	No	No	Yes	Yes
ADOT (79)	No	No	No	No	Yes	Yes
SANDAG and Caltrans (80)	No	No	No	No	Yes	Yes
WSDOT (81)	No	No	Yes	No	Yes	Yes
BCMoT (82)	No	No	No	No	Yes	No
NYDOT (83)	No	No	No	No	Yes	Yes
Buffalo and Fort Erie Public Bridge Authority (Peace Bridge) (84)	No	No	No	No	No	Yes
Niagara Falls Bridge Commission (85)	No	No	No	No	No	Yes
Blue Water Bridge Canada (86)	No	No	No	No	No	Yes
MDOT (87)	No	No	No	No	No	Yes
MDT (88)	No	Yes	No	Yes	Yes	Yes
SCT (49)	No	No	No	No	Yes*	Yes*

* Planned only on toll roads leading to and from international border crossings at the U.S.-Mexico border.

Source: (97)

Figure 8. Screen Snapshots of the San Diego-area 5-1-1 system.

Source: (49)

Figure 9. Screen snapshots of the planned nationwide 5-1-1 traveler information system in Mexico.

Effectiveness of Traveler Information at Border Crossings

The literature review revealed that effectiveness of traveler information at and around border crossings has not been studied. Past studies have focused on its effectiveness on urban freeways and arterials only. However, conclusions similar to the ones drawn for urban freeways can be applied to border crossings. From these past studies, a general consensus is that motorists use traveler information to the extent that they perceive it to deliver reliable, resourceful, and relevant information (98).

In a study performed among Seattle-area travelers, researchers found that the use of advanced traveler information is fairly uncommon, with travelers seeking information on only 10 percent of their trips and making a change in response to information on less than 1 percent of their trips. Information sources included radio, television, Web sites, and VMSs (99). As to why travelers often do not seek any information in the first place, this seems most closely tied to trip characteristics. Simulation models of traveler information usage suggest that the overall user benefit to consulting traveler information is quite modest, but that information can be of great value for certain types of trips, particularly those of high traffic variability and time sensitivity. When an attempt is made to consult information, no information may be available for the trip in question, or it may not be detailed or accurate enough to be useful in making decisions. Even when learning of delays, travelers may have (or feel that they have) no real alternatives for changing their trip or route.

A similar study comparing responses from motorists in Seattle and Los Angeles to online traffic information also revealed that location matters, as motorists in Los Angeles experience significantly longer commutes and greater congestion and volatility in traffic conditions. While motorists in both regions gave positive assessments of the traffic Web sites, Seattle respondents were more enthusiastic. On several dimensions, Seattle respondents expressed more intense support for their site. Moreover, Seattle motorists were more likely to benefit from the service, with greater numbers agreeing that online traffic information saved them time and reduced the stress of traveling. An analysis of the data indicates that underlying traffic conditions in the two regions bear greatly on customers' responses to the service. The greater congestion and volatility in Los Angeles increase motorists' demand for up-to-the-minute information and undermine customers' expectation that any information service can provide much relief (100).

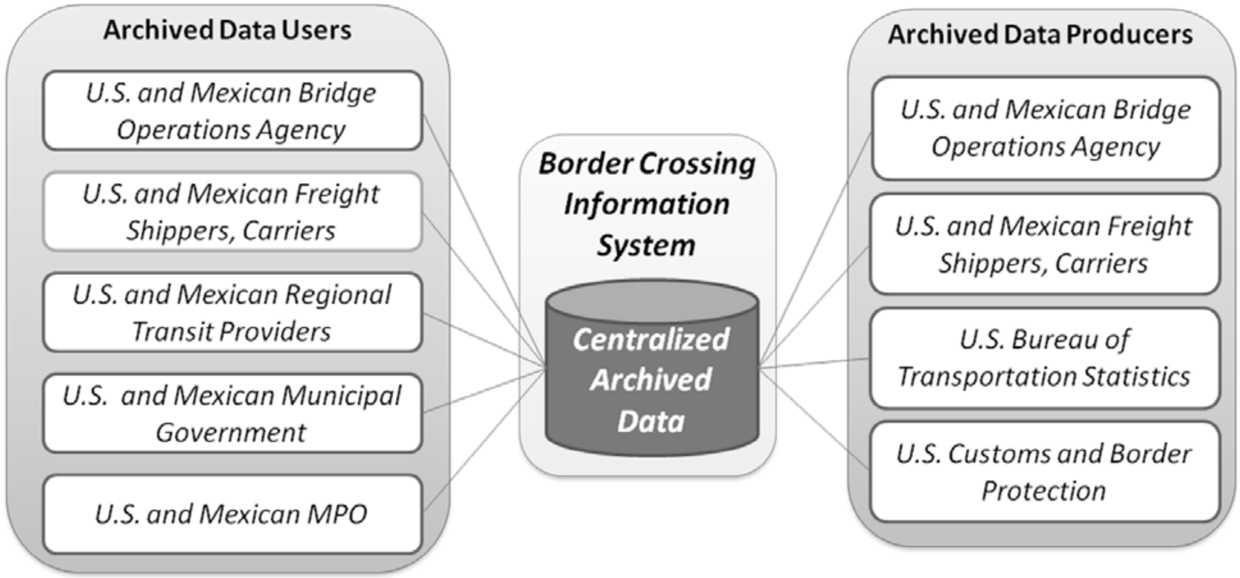
One of the interesting findings from both studies is that television and radio remain the predominant sources of traffic information—even though Internet and mobile devices have become so ubiquitous and pervasive.

In a survey performed among Seattle-area travelers, researchers found that less than half of the respondents were aware of the fact that traffic information was available through Internet Web sites and only 22 percent had used the service, while more than 95 percent of the respondents were aware of similar traffic information being provided by television and radio, and more than 60 percent used one or both information sources (99). Hence, it would be safe to say that the majority of travelers at present probably use radio and television to obtain information about border crossings rather than Internet or mobile devices. Quantification of effectiveness of providing advanced traveler information about border crossings, both pre-trip and en-route, is still elusive even though its benefit is not doubtful.

ARCHIVED DATA MANAGEMENT

One of the features of an ITS is the large amount of data it produces. Archived ITS data have a tremendous value in planning infrastructure, measuring performance, and evaluating strategies and management decisions. However, archived ITS data are greatly underutilized by agencies, mostly due to complex data transformation (hence, the cost and labor) required to convert the data into usable information. It is important to note that the archived data should not be limited to the data collected by ITS at the border but should also include data collected using non-ITS methods such as intercept surveys and manual data collection.

A centralized repository of archived data would significantly reduce data redundancy, reduce data collection and storage cost, and increase efficiency of data retrieval. A centralized repository would also be responsible for maintaining and updating the data on behalf of all participating stakeholders. As Figure 10 illustrates, a proposed border-crossing information system should provide a centralized repository of archived data and enhance the data by aggregating in different spatial and temporal granularity (55). In addition, users can obtain archived data from a single repository instead of multiple agencies, thereby reducing overall cost and increasing efficiency of data retrieval.



Source: (55)

Figure 10. Diagram depicting the proposed centralized repository of archived border-crossing data.

Use of Archived ITS Data for Border Infrastructure Planning and Operation

It is well-known that archived border-crossing data are used by private and public agencies with responsibilities to plan, operate, and manage border-crossing infrastructure. However, limited studies have been performed to document how agencies archive and use archived ITS data for planning and operational purposes. Archived data are then used by agencies, such as metropolitan planning organizations, city agencies, CBP, and the General Services Administration (GSA), to plan future infrastructure improvements and manage resources to operate border crossings efficiently. Private travelers, freight shippers, and carriers may use the archived data in limited scope.

Local and regional agencies such as metropolitan planning agencies use archived border-crossing data, especially volume, to develop near- and long-term regional travel demand models. In these models, border crossings are treated as external zones. Table 26 lists agency use of archived border-crossing data.

Interviews with several MPO personnel revealed that MPOs' need for highly granular border-crossing data is unmatched by other types of State and local agencies. MPOs' use of archived data for demand modeling ranges from hourly volume to annual volume trends. They also use hourly volumes for model calibration, which is crucial for simulation of traffic around border crossings. MPOs, however, do not have access to continuously accessible finely granular data and have to rely on short project studies to obtain such data. In addition to volume of vehicles in both directions, MPOs also need information such as queue lengths, wait times, and crossing times. This information is normally obtained by a short period of data collection at the border.

In addition, none of the agencies listed in Table 26 has developed specifications and requirements for archived border-crossing data in terms of accuracy, reliability, scope, and usability.

Table 26. Use of archived border-crossing data by agencies.

Agency	Current Application	Data Types Archived	Data Types Required for Archival	Future Applications
TxDOT (50)	Project-driven studies, project planning, funding requests	Monthly volume of northbound vehicles	Smaller temporal granularity volume, wait times, crossing times	Project-driven studies
El Paso MPO (53)	Project-driven studies, saturation counts for travel demand modeling	Monthly volume of northbound vehicles	Smaller temporal granularity volume, wait times, crossing times	Identification of peak periods for calibration of travel demand models
IMIP	Not available	Not available	Not available	Not available
NMBA (101)	Project-driven studies, project planning, funding requests	Daily, weekly, monthly volume of northbound vehicles	Wait times, crossing times	Project-driven studies
Las Cruces MPO (101)	Project-driven studies, saturation counts for travel demand modeling	Monthly volume of northbound vehicles	Wait times, crossing times	Project-driven studies
NMDOT (101)	Project-driven studies	Monthly volume of northbound vehicles	Wait times, crossing times	Project-driven studies
ADOT	Not available	Not available	Not available	Not available
SANDAG	Not available	Not available	Not available	Not available
Caltrans	Not available	Not available	Not available	Not available
SCAG	Not available	Not available	Not available	Not available

Note: SCAG: Southern California Association of Governments

The deployment of ITS at border crossings has increased the possibility of collecting border-crossing-related data to support a set of performance measures and ultimately a performance management process for evaluating and improving international border crossings for freight as well as passenger movement. Such performance measures apply to:

- Compare border-crossing performance nationally.
- Take into account local operation of crossings.
- Derive from a system to provide travel time information to travelers and shippers.
- Apply archived travel time data and travel time reliability information.
- Consider causal data that explain the differences in travel time.

- Reflect changes in operating practices and infrastructure at individual crossings.

The unique elements of the border-crossing system mean that the performance measure must satisfy the typical measurement requirements as well as several factors, as described earlier. Given the wide range and diversity of available measures, it is important to have a clear basis for assessing and comparing border-crossing performance measures. However, collection and estimation of border-crossing performance measurement indices should consider the following:

- Performance measures should be calculated from operational and policy data that are collected as part of daily operations.
- Performance measures should be consistent with the procedures used by all three countries at the international borders.
- The levels of performance are perceived differently by shippers, manufacturers, crossing operators, and inspection agencies. Thus, statistics should be relevant for the variety of audiences. This will require that the measurement base lines or comparison standards be evident or easily communicated.
- Changes in designs, demand, and operating procedures at individual border crossings should be reflected in the performance measure.
- Estimation of performance measures should be independent of the data collection technology used to collect travel-time-related parameters.

One of the major parameters to measure performance at border crossings should be related to travel time for both freight and passenger movement, which would be a basis for establishing common indices to compare performances of border crossings throughout the U.S.-Mexico and U.S.-Canada borders, irrespective of characteristics of individual crossings.

However, the literature review and the subsequent interviews with officials from various agencies revealed that none of the transportation agencies in border regions has adopted performance measures at border crossings. Most agencies use annual volume trend as a de facto performance measure. These agencies did express interest in adopting travel-time-based performance measures of border crossings if such data were available.

Existing and Planned Sources of Archived Border ITS Data

The Bureau of Transportation Statistics (BTS) maintains a centralized repository of border-crossing-related data, which can be accessed through a public-domain Web site. Tables 27 through 29 lists type and scope of border-crossing-related data for commercial vehicles, passenger vehicles, and transit and pedestrians respectively, provided by the BTS. However, data available from the BTS are highly aggregated (monthly and annually) by port group instead of by individual border crossing. For example, border wait times at POEs (collected by the CBP) available from the BTS are averaged monthly for a particular port group. In a port group, there may be some crossings that are rarely congested and some that are almost always congested. Also, from an operational standpoint, monthly averages of border wait times are not useful and lack information such as hourly fluctuations. In addition, agencies such as MPOs that analyze the impact of border-crossing trends to plan for short- and long-term infrastructure improvements require highly disaggregated border-crossing data in terms of type of transportation modes and vehicle entry programs. Highly aggregated data are not adequate for these agencies to understand hourly and daily trends at individual border crossings.

Table 27. Type and scope of commercial vehicle border-crossing-related data available from the Bureau of Transportation Statistics.

Type of Data	Data Scope
Volume	Only northbound monthly and yearly total data for each POE starting in 1994
HAZMAT	Only northbound monthly and yearly total data for each POE starting in 1994
Travel Time of Segments Entering and Exiting POE	Not available
Number of Trips and Average Travel Time of Trips within the Region	Not available
Distribution of Ultimate Origin-Destinations of Trucks	Not available
Export and Import Value by Origin Port and Destination State	Monthly and yearly total data for each POE starting in 1994
Export and Import Volume by Origin Port and Destination State	Monthly and yearly total data for each POE starting in 1994
Import and Export Value by Commodity and Mode	Monthly and yearly total data for each POE starting in 1994

Table 28. Type and scope of passenger vehicle border-crossing-related data available from the Bureau of Transportation Statistics.

Type of Data	Data Scope
Volume	Only northbound monthly and yearly total data for each POE starting in 1994
Travel Time of Segments Entering and Exiting POE	Not available
Vehicle Occupancy	Not available
POE Preference	Not available
Length of Stay	Not available
Frequency of Trips	Not available

Table 29. Type and scope of transit and pedestrian border-crossing-related data available from the Bureau of Transportation Statistics.

Type of Data	Data Scope
Volume	Only northbound monthly and yearly total data for each POE starting in 1994
Trip Purpose	Not available
Frequency of Trips	Not available
North and Southbound Volume	Only northbound monthly and yearly total data for each POE starting in 1994
North and Southbound Bus Passengers	Only northbound monthly and yearly total data for each POE starting in 1994

In 2003, both the BCMoT and WSDOT installed Advanced Traveler Information Systems (ATISs) for passenger cars at the Blaine-Pacific Highway and Douglas (Peace Arch) border crossings. The systems use loop detectors to estimate the wait times for cars crossing the border in both directions. The collected data are archived and available online at http://www.cascadegatewaydata.com/. Measures of delay, queue length, number of vehicles in the queue, traffic volume, and number of vehicles departing the queue per five minutes can be viewed online or downloaded for further analysis (64). The archived data are aggregated into different temporal granularities such as hourly, daily, and monthly.

Technical Issues Related to Border ITS Data Archiving

Agency Deployment of Border-Crossing Data Archive

Archived data in ITSs refers to the systematic retention and re-use of transportation data generated for various purposes (102). Data archiving is also referred to as data warehousing or operations data archiving. Sensors and detectors used in ITS deployments produce a huge amount of data, which have to be converted into information for effective use of the data. To achieve this, the raw data have to be archived, filtered, and aggregated into useful information. Only then can archived data be used in managing existing and planning future infrastructure.

The widespread deployment of vehicle detectors and sensors by State and local DOTs has created a massive amount of raw data. Agencies mostly use the aggregated data, such as daily and annual volume of vehicles, for project design, studies, and other planning purposes. However, archived data have many other benefits, such as real-time operation of transportation infrastructure, real-time decision making, performance evaluation monitoring, environmental analysis, and theoretical research. Even though these benefits are obvious to the agencies, very few of them have implemented a well-structured data archiving program. While deploying ITS, many agencies do not prioritize archived data and mostly focus on operational benefits of real-time data. There are several reasons why agencies do so:

- Agencies are mostly focused on day-to-day operations and do not see the utility of archiving the raw data (102).
- Planning/decision-making bodies of agencies are not familiar with ITS deployments and their products and thus may not know the full extent of the benefits of archived data or the capabilities they offer.
- There are limited resources to operate and maintain archived data.
- Most importantly, agency personnel are not fully aware of strengths and benefits of archived ITS data.

Development and maintenance of a border-crossing data warehouse, whether small or large, requires highly skilled resources, continuous funding, and – most of all – support from the stakeholders.

Existing and Planned Border-Crossing Data Warehouses

One of the earliest deployments of archived border-crossing data was implemented by the Whatcom Council of Governments (WCOG) in 2002. The system is referred to as the Cascade Gateway Border Data Warehouse and was designed to archive real-time traffic data from the Cascade Gateway system of border crossings on the U.S.-Canada border (64). The archived data in the data warehouse is managed by the WCOG. ITS data are supplied to the data warehouse by the BCMoT on the Canadian side and WSDOT on the U.S. side. Both agencies operate independent systems, which include a series of inductive loop detectors. The data from them are used to calculate traffic volumes and arrival rates and estimate wait times of passenger vehicles. One of the challenges facing the Cascade Gateway Data Warehouse has been retaining highly skilled database administration and software developers to maintain the warehouse.

The Center for International Intelligent Transportation Research at TTI developed the Paso Del Norte Regional Mobility Information System (PDN-RMIS), which has been in operation since 2007 (103). The system not only provides real-time traffic conditions and border-crossing information to motorists in the El Paso region but also provides archived data from various ITS devices deployed in the region. The system archives border-wait-time-related data relayed by the CBP. The data include delay and number of lanes open for commercial and passenger vehicles. The system also archives external information such as weather, daily exchange rate, messages relayed by VMSs, and incident locations.

TTI, with funding from the FHWA, is developing a separate archived data warehouse that will include crossing and wait-time data from various ITS deployments on the U.S.-Mexico border. The information system is named the Border Crossing Information System (BCIS).

Table 30 includes types of data, spatial and temporal granularity, and data storage-related information from the above-mentioned data warehouses.

Table 30. Type and scope of border-crossing-related data currently archived.

Agency	Data Type	Spatial Granularity	Temporal Granularity	Level of Data Filtering and Aggregation	Data Storage Medium	Frequency of Data Retrieval	Archived in Database or Flat Files	Frequency of Data Purging
PDN-RMIS (103)	Wait times relayed by CBP, exchange rate, weather	Crossing, lane type, vehicle type	Hour	Not filtered, aggregated	Hard drive inside servers	Every 15 minutes	Database	No established policy, raw data have never been purged
WCOG (64)	Departure rate, volume, queue length, delay, wait time for personal vehicle and commercial vehicle	Crossing, detector, lane, route, direction	Minutes, hour, day, month, year	Aggregation includes summation, average, minimum, maximum, standard development	Hard drive inside servers	Five-minute increment data sent by BCMoT and WSDOT	Database	No established policy

Temporal and Spatial Granularity

Granularity refers to the level of detail of the data archived. High granularity refers to data that are at or near the transaction level or raw data. Low granularity refers to data that are summarized or aggregated. Granularity of archived data is directly proportional to the size of the data warehouse and thus the cost of maintaining the system. The higher the granularity, the more storage space required to archive the data. In addition, the higher the granularity, the more rows (records) that constitute tables, results in additional storage requirements with impact on performance.

Data warehouses mentioned above store data in various temporal granularities—mostly in minutes, hours, days, months, and years. However, there are no guidelines and standard procedures regarding granularities of the archived data. In most cases, the decision to create and maintain certain levels of temporal granularity of data depends on aggregated data needs. For example, for many traffic studies, vehicle volume is required at 15- and 60-minute periods. Raw data from vehicle sensors often come in less than 1-minute packets (i.e., aggregated in less than 1 minute), which is used to create 15-minute and 60-minute data. Thus, the data warehouse includes multiple levels of temporal granularities because there is computing overload if 1- or 15-minute data are used every time users query for 60-minute data.

The raw data as they are archived represent the highest granularity in terms of space (i.e., spatial granularity). For example, data from one or more detectors from a single location represent the highest granularity data. Data from more than one location can be aggregated to obtain information about longer roadway segments. In terms of border crossings, the smallest spatial granularity should be an individual border crossing, and the highest should be individual lane type (e.g., SENTRI or FAST). The Cascade Gateway Data Warehouse archives vehicle detector data by individual detector, lane, route, and direction and wait times by individual lane type, direction, and border crossing.

Size and Scope of ITS Data

Archived data should be most preferably implemented in a data warehouse architecture. This allows systematic retention, processing, and management of a large amount of ITS data. This will also allow multiple types of border-related data to be stored in a relational database structure. For example, wait times and crossing times of vehicles can be related to volume of vehicles and external factors such as fuel prices and exchange rates. A data warehouse architecture is suitable to archive voluminous data and is not suitable to store transactional data that need to be accessed by hundreds of users at the same time for their daily work. The Cascade Gateway Data Warehouse and Paso Del Norte Regional Mobility Information System (PDN-RMIS) have grown significantly in size.

All of the above-mentioned data warehouses do not have policies to limit the scope of ITS data to be archived. Depending on availability of resources to manage the data warehouse and the ability to acquire storage space size and scope of ITSs, the amount of data is not of great concern. However, the data should be the ones that can be used to measure operational performance of border crossings.

Latest generation database servers allow storage of geospatial data and allow users to perform spatial query. GPS data from vehicles can be easily archived and processed to obtain border-related information and related with data from other ITS devices.

Data Filtering and Aggregation

Data filtering is crucial to impose appropriate quality control over the data. Data filtering needs to occur at different levels of aggregation and should include removal and reporting of erroneous data, imputation or removal of missing data, and removal of inaccurate data. Causes of erroneous/missing/inaccurate data occur very frequently and are mostly due to such things as equipment failures, telecommunication failures, and equipment calibration errors.

Many ITS devices can sense equipment errors and have capabilities to flag such errors along with the data that are transferred. These errors are easy to identify and remove prior to further aggregating. Correcting missing data due to equipment and telecommunication failure can be easy or extremely complex and depends on the span for which the data are lost. It is preferable to define algorithms to impute missing data and have them implemented in the data warehouse. Identifying systematically produced inaccurate data due to equipment calibration errors is difficult early on because the data may have very subtle differences from the true data. In such cases, it will be difficult to flag the raw data as erroneous. Business intelligence tools are used to identify subtle differences in raw and aggregated data.

On the other hand, quick notification of an erroneous data stream to the system administrator will help identify hardware- and software-related problems. Thus, mechanisms should be put in place to notify the system administrator if erroneous data are coming from field devices or if failure of hardware/software occurs. One should bear in mind that sizable resources are required to establish robust filtering algorithms in the data warehouse.

In the end, all archived data user services should have mechanisms to report quality of data that are relayed to the end users.

Data aggregation depends on the need for different levels of spatial and temporal granularity. Typically, algorithms should be included in the data warehouse to periodically aggregate the data (at pre-defined time intervals), or algorithms should be triggered when new data enter the data warehouse. Both techniques have advantages and disadvantages and trade-offs in the form of performance and computing overhead.

Data aggregation at predefined times should be performed when the system is not being used heavily, such as nighttime or off-peak periods. If the aggregation requires processing a huge number of records, this technique is also efficient. Publishing daily, weekly, or monthly data can be done with some time lag, and the algorithm does not need to run every time new data enter the database. On the other hand, publishing real-time information such as current crossing time or predicted crossing time for next hour aggregation and processing of data should take place as soon as new data become available.

Data Storage Management

One of the greater concerns of archived data is to determine the length of time data need to be archived and the threshold for physical size archive. The length of time data are stored is obviously dependent on the temporal granularity of data, which has an impact on the record size and storage space. Smaller granularity data require less storage space compared to raw data. However, a database with raw data that have grown substantially over the years poses performance-related problems. Thus, two things need to happen: development of policies to purge raw data after a certain time has elapsed and/or movement of the raw data to a separate and independent physical storage medium (e.g., DVD or magnetic tapes). However, there is reluctance in purging raw data due to fear of losing aggregated data. Maintaining only aggregated data in the core database will undoubtedly result in improved performance, especially when end users query the data.

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CHAPTER 6. INVENTORY OF ITS PROJECTS ON THE U.S.-MEXICO BORDER REGIONS

The objective of this chapter is to develop an inventory of ITS projects on the U.S.-Mexico border. These projects include ITS studies and deployments. The ITS projects also include deployment projects that are part of larger highway construction projects. It is intended that the inventory will assist readers of this report to gain an understanding of ITS projects being developed at regions other than their own and will assist them in planning, procuring, and constructing ITS projects. The inventory, however, does not include ITS-related research being performed by academics. ITS projects are divided into the three following categories:

- Projects under construction: This includes ITS deployments that have already been let or contracted and are under construction.
- Projects being procured: This includes ITS deployments that are being procured.
- Projects under consideration: This includes ITS deployments that are being planned or conceptualized by border regions.
- Projects being studied: This includes studies being performed by Government agencies at all levels to plan and deploy ITSs. These studies include feasibility studies, design studies, and technology development, standards, and protocol studies.

PROJECTS UNDER CONSTRUCTION

Various Border Wait-Time Measurement Projects in Texas

Bridge of the Americas, El Paso

In 2006, FHWA initiated Part I of Measuring Border Delay and Crossing Times at the U.S.-Mexico Border. This project was among the first steps in the current process to automate measurement of crossing times. Technology candidates were screened for their applicability to automate the crossing time measurement process. In order to measure travel time and the associated delay, the chosen technology needed to be flexible enough to cover the complete trip and be applicable at all POEs. The technology considered most appropriate for the intended purpose was AVI using passive RFID.

In 2007, FHWA began Part II of Measuring Border Delay and Crossing Times at the U.S.-Mexico Border. For this part of the research, FHWA initiated two projects, one of which became the deployment of RFID at the Bridge of the Americas land border crossing between El Paso and Ciudad Juarez. This project initially implemented two RFID reader stations with an algorithm designed to only measure crossing time. The automated crossing time measurement system became operational in July 2009.

In January 2010, FHWA internally sent forward a recommendation for CBP and GSA approval of a permit for RFID installation at the primary inspection facility locations at two Texas land border crossings—BOTA and Pharr-Reynosa—where crossing time data were already being automatically measured using RFID. That recommendation was accepted by GSA. FHWA subsequently proceeded to have RFID equipment that would enable the measurement of border wait time installed at both the BOTA and Pharr-Reynosa CBP primary inspection facilities.

In addition to incorporating more RFID reader stations at Pharr and BOTA, the modification included (among other tasking) development of (a) a guidebook for analysis and dissemination of border-crossing time and wait-time data, (b) step-by-step guidelines for implementing RFID to measure border wait and crossing times, and (c) a prototype Web tool with design documentation and specifications and supporting user guidance and demonstration.

Pharr-Reynosa International Bridge, Pharr

The objective of the deployment was to install and implement RFID technology to measure border-crossing time and travel delay for commercial trucks crossing from Mexico into Texas at the Pharr-Reynosa border crossing. Based on feedback from the stakeholder meeting and the definition of the number and location of RFID reading stations, the concept of operations (ConOps) that was previously developed under the FHWA BOTA project was modified to meet the Pharr-Reynosa border-crossing time measurement requirements. The deployment of the RFID readers and other communication equipment was completed in October 2009. Since then, the system has been collecting tag identification data from northbound trucks entering the United States and sending them to a central server in El Paso.

Camino Colombia and World Trade Bridge, Laredo

The objective of the deployment was to install and implement RFID technology to measure border-crossing time and travel delay for commercial trucks crossing from Mexico into Texas at the Camino Columbia and World Trade Bridge border crossings. The design of the RFID systems is similar to the ones developed for the Pharr-Reynosa and BOTA border crossings. The deployment of the RFID readers and other communication equipment will commence in 2011.

Border Waits Analysis Project in Nogales, Arizona

The overall goal of this project is to install a system that automatically and accurately measures border wait times (i.e., “border waits analysis”) for northbound commercial freight vehicles crossing the U.S.-Mexico border at the Mariposa POE in Nogales, Arizona-Sonora. The Technical Advisory Committee (TAC) has identified two main objectives in order to meet the overall goal of this project. The first involves selecting one or more appropriate technology(ies) for the proposed border waits analysis system, and RFID has been chosen as the technology to be used. The second consists of implementing the system itself. It has been determined that data shared from ADOT’s EPIC system at the Mariposa POE will enable processing of crossing time data as well. Once the selected technology system has been implemented for the Mariposa POE, both border crossing and wait-time data will be collected and disseminated to all stakeholders involved in the border-crossing process at the Mariposa POE. Coordination with the regional stakeholders has taken place to help develop the appropriate design and implementation plans.

State Route 905/Otay Mesa POE, San Diego Region

SR-905 provides essential connection between the Otay Mesa POE with Mexico and the regional freeway system in California. This project will construct a six-lane freeway from I-805 to the busiest commercial border crossing on the California-Mexico border (89). This project, along with the future Otay Mesa East POE and State Route 11, will provide for efficient transportation of goods and services in the Otay Mesa border region.

The project includes a 5-1-1 travel information system, fiber-optic communication traffic monitor systems, ramp meter systems, video detection signals, CCTV systems, and VMSs, all connecting to a base communication hub.

A corridor management plan for the SR-905 project is intended to provide a unified, multimodal system management concept for managing and preserving freight mobility in the corridor. When fully implemented, the project will incorporate ITS technologies to help manage demand and efficiency of the corridor. ITS improvements will provide a safer and more reliable route, helping to minimize accidents that can cause non-recurrent congestion and delays.

Caltrans and SANDAG have also implemented the Freeway Performance Monitoring System (PeMS) in the San Diego region. PeMS provides a robust source of data that enables monitoring of the performance of individual transportation corridors as well as the overall system. Emphasis is placed on assessing and identifying portions of the corridor/system that are not performing optimally. With the inclusion of SR-905 data in PeMS, ongoing operations of the corridor can be monitored so that problems can be addressed early on in order to preserve long-term corridor mobility.

Projects Being Procured

ITS Pre-Deployment Strategy for SR-11 and the Otay Mesa East POE

SANDAG and Caltrans, in cooperation with the GSA and other project stakeholders, are proposing to develop the new cross-border facility and the associated transportation facility, SR-11, as a state-of-the-art border-crossing facility. The new facility will be located approximately 2 miles east of the existing Otay Mesa POE and will create a third border crossing along the San Diego region’s border with Tijuana. Mexican government agencies are advancing Mesa de Otay II, the Mexican side of the cross-border facility, and associated transportation routes.

SANDAG and Caltrans are pursuing multiple objectives with the new POE, including:

- Building additional physical capacity at the border; maximizing the efficiency of the new facility by using state-of-the-art ITSs and innovative operating concepts.
- Introducing a toll-pricing model at the border that is based on wait/crossing time and focused on congestion management and emissions reduction at the border.
- Developing the project as a national model of public/public partnering.
- Designing a project that exemplifies both environmental and economic stewardship.

SANDAG was awarded ITS funding to create a comprehensive ITS pre-deployment strategy, which will evaluate ITS technologies to facilitate a bi-national ITS concept of operations that includes technology options to enable variable toll rates, advanced traveler information, state-of the-art toll collection technologies, enhanced border operations, and new institutional relationships to accelerate and optimize deployment.

SANDAG has retained a bi-national consulting group to develop ITS pre-deployment strategies and subsequent oversight activities for implementation phases for the proposed new Otay Mesa East POE and the connecting SR-11.

PROJECTS UNDER CONSIDERATION

San Ysidro POE, San Diego Region

This project first proposes a people-moving system to replace the existing pedestrian bridge over Interstate 5 that will be removed as part of the GSA reconfiguration project (104). This people-moving system should integrate state-of-the-art traveler information, border-crossing information, and commercial advertising space.

In addition to a 5-1-1 system, the project also envisions an integrated smart parking approach. Parking at the border must first promote use of mass transit, but smart parking strategies can also capture revenues from those driving to the POE. A smart parking option will be evaluated, and if included, would provide those drivers with state-of-the-art parking slot information and peak/off-peak parking pricing.

Traveler information kiosks located in the reconfigured commercial spaces would enhance the travel experience and provide pedestrian amenities geared to the cross-border traveler. The so-called pedestrian deck can be designed as an inviting traveler esplanade with attractive retail outlets and food stations.

A coordinated, pedestrian-friendly, multimodal system that includes local and long-haul buses, jitneys, airport connector buses, trolleys, taxis, and pick-up and drop-off opportunities for transit riders and pedestrians is planned. An integrated multimodal center that is based upon making mass transit options more accessible and more viable must be developed. Without such an integrated multimodal traveler center, 25,000 pedestrians per day are subject to an inefficient crossing experience that encourages Single Occupancy Vehicle (SOV) travel and is congested, carbon emission intensive, and increasingly expensive. The enhanced multimodal center will be supported by a complete traveler information system. That traveler information system will provide information about all on-carriage options; bus, trolley, and airline schedules; and real-time border delay notifications.

State-of-the-Art ITS at Border Crossings in the El Paso Region

Stakeholders in the El Paso-Ciudad Juarez region are seeking to develop a comprehensive state-of-the-art ITS at all three border crossings in the El Paso region. Objectives of the ITS deployment are to measure, relay, and archive volume, crossing times, and wait times and to queue length of passenger vehicles and commercial vehicles both in northbound and southbound directions. The ITS deployment will be in coordination with a system already deployed at one of the bridges to measure crossing and wait times of northbound commercial vehicles.

ITS PROJECTS UNDER DEVELOPMENT IN MEXICO

National Strategic Plan for Planning, Developing, and Implementing ITSs in Mexico

The objective of the National Strategic Plan is defining programs and strategies to develop and implement ITS service applications in Mexico that support a better operation and use of the multimodal transportation network in Mexico. This strategy will help maintain Mexico's competitive position internally at the international level, considering the nation's social and environmental objectives defined by relevant stakeholders. The plan will define the sector's policy for implementing ITS services in Mexico at the national and urban levels. It will define strategic plans and programs to implement the ITS Strategic Plan in Mexico, as well as resources and the schedule for completing these activities. It will also define the institutional arrangement required to manage the implementation of Mexico's ITS Strategic Plan (49).

Development Plan for Updating Processes, Standards, and ITS Protocols

The objective of this project is to establish a development plan for updating processes, standards, and ITS protocols to promote the implementation of ITS systems. These protocols and standards include the interoperability and the implementation of transportation systems at the local and regional levels. The project will assure that hardware and software interconnections and interfaces are consistent and compatible within an advanced transportation system (49).

Development of the Traveler Information System (INFOVIAJE)

The project will define the general characteristics of the INFOVIAJE system from the technological, financial, commercial, and legal perspectives. During this project, the INFOVIAJE CONOPS will be developed. The CONOPS will include the definition of the system's performance, identification and coordination with key stakeholders, definition of processes and specific procedures for the adequate operation of the system, conceptual and initial design of road data input into the system and coordination with fixed-line telephone and cellular service suppliers. The project will define the technical, functional, operative, financial, and infrastructure requirements of the INFOVIAJE global system; the GIS portal and maps; the INFOVIAJE software functions; the database structure; the report structure; the (general) telephone system; the voice recognition system (VRS); the public, stakeholder, and SCT Web pages; the backup system; and the telecommunications requirements (49).

Strategic Plan for the Modernization and Improvement of the Electronic Toll Collection System

The project will create a strategic plan for ETC in Mexico that includes the operational, regulatory, and legal aspects. The plan will include the definition of technologies and the commercial and legal structure required to migrate gradually from the current operation to the desired model. It will identify stakeholder needs and define equipment configurations and key procedures that will facilitate the interaction between stakeholders. The project will propose technological improvements that can be implemented to increase the use and efficiency of ETC systems so that payment time at booths can be reduced to optimize existing infrastructure. The plan will establish the legal framework required to regulate the provision of ETC services, identifying required changes in the laws and regulations (49).

CHAPTER 7. WORKSHOP ORGANIZATION AND FINDINGS

As part of this project, the research team organized two workshops to further document the state-of-the-practice, stakeholders' short- and long-term needs, and present and future technology solutions.

The first workshop took place in Austin, Texas on April 5, 2011, with 28 participants in the conference room and more than 10 participating via Webinar. The workshop objective was to describe and discuss ITS technologies that are being implemented at border regions. Appendix A has the detailed agenda and workshop participant list. The audience for the first workshop was mainly State and Federal officials from the U.S., Mexico, and Canada, and the workshop evaluated integration opportunities in the border region, evaluated State and locally owned toll road operations at border crossings, and showcased experience measuring wait times, non-intrusive toll systems, and variable pricing technologies.

The second workshop took place at Caltrans District 11 offices in San Diego, California, on June 29, 2011. More than 45 people from public and private sectors participated in person at the workshop, and more than 10 participated via Webinar. Based on the results and feedback from that initial workshop, the meeting in San Diego focused on three aspects:

- Policy, legal, and institutional aspects of border ITS implementations.
- Implementation experiences from solution providers and technology vendors.
- Future solutions/products for cross-border ITSs and technologies.

In particular, the first objective was to identify policy, legal, and institutional barriers to implementing ITS technologies along the United States' northern and southern borders. The second objective was to learn directly from ITS solution providers and technology vendors concerning their experiences in the implementation of innovative ITS projects at the borders. The third objective was to explore technologies that are perceived to have promise for facilitating transportation across the borders, in both directions and for both commercial and passenger vehicles. The final agenda and participant list is presented in Appendix B.

KEY OUTCOMES FROM THE WORKSHOPS

During the first workshop, the research team presented a summary of the technology scan findings and facilitated discussion of the ITS technologies that are being implemented at border regions. As mentioned earlier, during the first workshop the audience consisted mainly of State DOTs and Federal agencies. The discussion led to the following points for each of the topics that were presented in the scan report.

Tolling in Border Regions

- Ready Lanes are being deployed along the U.S.-Mexico border. These lanes allow for a faster crossing using a WHTI-compliant document. They do not pre-clear to the same security level as SENTRI or NEXUS lanes. The number of Ready Lanes is expected to grow in the near future.

- San Luis II POE is the newest POE in Arizona where tolls are collected, marking the first time that a POE collects tolls west of Texas. Another example will be the future Otay Mesa East POE in California, which also involves a tolled access road. In the future, more POEs in California and Arizona will be developed with a tolling component as the financing mechanism as GSA and other Federal budgets are cut. New Mexico law currently prohibits tolling.
- Texas law is very restrictive of automated visual identification of vehicles but allows the use of ALPR for tolling purposes. The only other legal way to identify vehicles is using red light cameras.
- Mexico's Department of Motor Vehicles (DMV) is in the process of equipping every vehicle with an RFID transponder (30 million). This may be leveraged for tolling or other ITS applications
- Video enforcement in Mexico is nonexistent; as a result, gate barriers at border crossings are used to control access.
- Currently, Mexican violators cannot be pursued in the U.S. However, tolling violations by Mexican drivers appear not to be a concern to toll operators in the U.S. due to the low violation rates. As more all-electronic toll roads are built near the border, this might become an issue. There is a need to educate and inform Mexican drivers about alternatives for paying for tolls, such as the Day Pass offered by TTA.
- Tolling interoperability between the U.S. and Mexico and between U.S. tolled border crossings is very limited and currently not a top priority for the agencies involved.

Border Transportation Operations

- Real-time data sharing at the border is limited or non-existent. There are plans to create an integrated bi-national system at new POEs, such as the Otay Mesa East in California.
- The lack of protocols for sharing data is one of the reasons that there is little or no data sharing among stakeholders. BIFA is a response to how to share info. It is based on U.S. and Canadian national architectures and their components, with added Customs components. It involves Transport Canada/FHWA/CBP/CBSA. A key benefit is that it gets stakeholders involved in talking about the process.

Traffic Management

- Concessionaire toll roads leading to the border do not have an incentive to inform the public about delays and best routes since doing so can diminish their revenue.
- Reliable border wait-time information for contiguous border crossings is needed. Officials should provide drivers with traveler information in advance so they can make route selection far away from the border. In addition to border wait times, information for how to get to the border crossing is needed (travel planning).
- New Mexico cannot sell TMC data or spend money providing it to third parties. Texas cannot sell its TMC data either. An alternative is for Texas to do *quid pro quo* with a third party, in which the third party provides something nonmonetary in exchange.

- British Columbia and Washington State have had BWT measurement since 2003, using inductive loops at two crossings. It is for both northbound and southbound traffic and mostly for passenger vehicles. At Windsor, Ontario there is border wait time measurement using loops and overhead lasers.

Enforcement

- CBP continues to expand the use of RFID technologies for trusted traveler programs on commercial and private vehicles.
- State vehicle inspection agencies are also implementing RFID-based systems to expedite the screening of commercial vehicles that cross from Mexico into the United States.

Traveler Information

- Currently the main source of traffic information still remains television and radio in border regions. Radio stations regularly report traffic conditions based on cameras or visual counts at border regions. Sometimes the information is not accurate because it is not provided constantly and could be lagging in time.
- The border wait time projects currently under development will provide information in close to real-time basis, as well as archived data.

Archived Data Management

- Transportation agencies are mostly focused on day-to-day operation, and therefore the archived data management activities are not a priority. Very few agencies have well-structured plans for archiving and using the data.
- Maintenance and operating cost past research shows that adoption and sustainability are not easy. Understanding needs prior to implementing technology is a key element to secure the successful long-term operation of ITS projects at border crossings.

A conclusion from the first workshop was that a key element for the successful implementation of ITS technologies is to identify policy, legal, and institutional barriers to implementing. Given that Federal, State, and local agencies from two countries as well as private-sector stakeholders operate at the border; it is difficult and time-consuming to overcome these non-technical barriers. Another key finding from the workshop was the realization that it is crucial to understand stakeholder needs prior to the implementation of any technology.

The second workshop included participants from public- and private-sector. On the public sector side, state and local officials presented their implementation experiences. Private-sector stakeholders presented technology implementation experiences that facilitate transportation across borders. The specific objectives of the second workshop were:

1. Identify policy, legal, and institutional barriers to implementing ITS technologies along the United States' northern and southern borders.
2. Learn directly from ITS solution providers and technology vendors concerning their experiences in the implementation of innovative ITS projects at the borders.

3. Explore technologies that are perceived to have promise for facilitating transportation across the borders, in both directions and for both commercial and passenger vehicles.

The federal agencies that presented their perspective included FHWA, FMCSA and SCT. State DOTs included presentations from California, Arizona, New Mexico and Texas.

ITS solution providers and technology vendors presented their experiences in the implementation of innovative ITS projects at the borders in the following subjects:

- Tolling in Border Regions
- Border Transportation Operations, Traffic Management and Enforcement
- Traveler Information
- Archived Data Management

The various companies that made presentations during the workshop were:

- FreeAhead, Roy Sumner, *Border Wait Time*
- G4 Apps, Bob Borrows, *Intelligent Connected Vehicle and Smart Phone Solutions in Smart Border ITS*
- Inrix, Ryan Glancy, *A Non-Infrastructure Based Traffic Data Solution*
- Intelligent Imaging Solutions, Brian Heath, *Smart Roadside Inspection Systems*
- IRD, Tom Der, *Border Transportation Operations*
- Kapsch, Bob Frank, *Tolling and border crossing solutions for the 21st century*
- R.C. Ice and Associates, US National ITS Architecture Team, Ron C. Ice, *Regional ITS Architectures at Land Border*
- Telvent, Jorgen Pedersen, *Turning Vision into Action*
- Transcore, Hal Pittman, *RFID Interoperability*

Key conclusions from the second workshop are:

- Utilizing the advanced V2I capability of 5.9 GHz DSRC to allow bi-directional communication capability between the vehicle and the border-crossing systems is a technology that has potential for border crossing operations. The information that his technology is capable of collecting includes vehicle's weight, dimensions, last inspection, cargo content, and travel history.

- In the next 10-15 years, tolling will likely be "tag free" and lean heavily on 5.8 GHZ DSRC. A transponder will merge with other electronics (smart phones, navigation devices, or a vehicle's OBU) for customer convenience. These devices will be interoperable, open standard, and capable of performing multiple tasks. This will depend on the level of adoption by toll operators and vehicle manufacturers as the connected vehicle program evolves.

CHAPTER 8. CONCLUSIONS

The Conclusions section is divided into two main areas. The first one presents conclusions from the scan, organized in five areas that were analyzed. The second section includes the conclusions from the two workshops that were conducted as part of this research.

SCAN CONCLUSIONS

Border Operations

The border-crossing process for passenger and commercial vehicles at the U.S. northern and southern borders is complicated due to the number of stakeholders that participate in the process, involving two countries, private and public sectors, and all levels of government.

Various stakeholders that operate at the land border environment are implementing ITS technologies. However, there is little or no coordination among stakeholders to develop standards that could lead to an integrated, interoperable system, capable of sharing resources and perhaps information. One example of this is the use of the RFID tags, where CBP is using the tag on commercial vehicles to control user fees. The same type of tag is being used for tolling purposes at some commercial crossings, on both sides of the border. Various states are using the same technology to expedite vehicle inspection at the border. This lack of coordination leads to having vehicles with multiple, similar or identical RFID tags.

There are examples of a coordinated bi-national effort like the project currently underway at the proposed Otay Mesa East crossing in California. SANDAG is developing a bi-national ITS pre-deployment strategy that will incorporate the use of ITS technologies in the San Diego/Tijuana region.

Tolling at Land Border Crossings

Toll interoperability at the U.S. – Mexico border is limited to the local level between nearby U.S. border crossings, and no interoperability exists between U.S. and Mexican tolling agencies. Although a few operators are having preliminary discussions aimed at becoming interoperable, this study generally did not find a concerted effort towards interoperability. The primary reason for this is the complexity of dealing with foreign customers and agencies.

In terms of tolling technology, most of the U.S. – Mexico border crossings do have some form of AVI even though is not always RFID-based AVI. However, several U.S. border crossings are planning to upgrade to RFID AVI in the near future. It is also expected that new border crossings will select RFID as their AVI technology solution. Interviews with selected border-crossing operators indicated that they are following 5.9 GHz DSRC developments closely but know of no concrete plans in the near future.

Traffic Management and Traveler Information

The scan revealed that sharing of real-time traffic management data and ITS usage between agencies from both sides of the U.S.-Mexico border has been limited, compared to U.S.-Canada sharing. No bi-national TMCs along the U.S.-Mexico border were identified, and what communication there is between agencies is limited to methods such as radio and mobile phones. Data and information sharing in real-time between border agencies have not been developed due to funding and institutional constraints.

U.S.-Mexico border agencies have deployed ITS solutions only to a very limited degree with the specific purpose of incident management around border crossings. Special events at and around border crossings (e.g., concerts, cultural and sporting events, major holydays) are planned ahead using ad-hoc meetings between bi-national agencies of all levels. Each agency lays out its subsequent roles according to its jurisdictions to assist traffic management during the event.

The FHWA and other state agencies are in the process of implementing several ITS technologies to measure border and crossing times for commercial vehicles along the U.S. southern border.

The use of technologies such as RFID, smart phones, wireless networks, radar traffic sensors, and vehicle waveform identification has shown improvements and has shown tremendous potentials for collection of wait and crossing times at the border.

Archived Data Management

A centralized repository of archived data would significantly reduce data redundancy, reduce data collection and storage cost, and increase efficiency of data retrieval.

There is a need for highly granular border crossing data by state and local agencies. In addition, local agencies need information such as queue lengths, wait times, and crossing times. This information is normally obtained during a relatively short period of data collection at the border.

Emerging Technologies

The USDOT Connected Vehicle Program is a key building block for FMCSA's objective of significantly expanding the number of inspections that are conducted each year and the base of data on which to make performance-based enforcement decisions.

The WRI initiative involves emerging technologies used in the United States that have been tested with outstanding results for examining the condition of the vehicle and driver by assessing data collected by on-board systems.

Other emerging technologies that have implementation potential at border crossings in the near future come from initiatives that include the DMA Program, C-TIP, and CVII.

CONCLUSIONS FROM WORKSHOPS

A conclusion from the first workshop was that a key element for the successful implementation of ITS technologies is to identify policy, legal, and institutional barriers to implementation. Given that Federal, State, and local agencies from two countries as well as private-sector stakeholders operate at the border, it is difficult and time-consuming to overcome these non-technical barriers. Another conclusion from the workshop was the realization that it is crucial to understand stakeholder needs prior to the implementation of any technology.

The main conclusions from the second workshop, in which vendors and other stakeholders presented their experiences, were:

- Utilizing the advanced V2I capability of 5.9 GHz DSRC to allow bi-directional communication capability between the vehicle and the border-crossing systems is a technology that has potential for border crossing operations.

- The future of tolling will likely be "tag free" but lean heavily on DSRC. A transponder will merge with other electronics (smartphones, navigation devices, or a vehicle's OBU) for customer convenience. These devices will be interoperable, open standard, and capable of performing multiple tasks.

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REFERENCES

1. *North American Transportation Statistics Database.* [Online] November 2009. [Cited: 01 25, 2011.] http://nats.sct.gob.mx/nats.
2. **Federal Highway Administration.** *Intelligent Transportation Systems at International Border - A Cross Cutting Study.* 2001.
3. *Status of the US-Mexico Commercial Border Crossing Process: Analysis of Recent Studies and Research.* **Villa, J C.** Washington, D.C. : Transportation Research Record: Journal of the Transportation Research Board, 2006, Vol. 1966.
4. **U.S. Customs and Border Protection.** SENTRI Program Description. [Online] [Cited: January 28, 2011.] http://www.cbp.gov/xp/cgov/travel/trusted_traveler/sentri/sentri.xml.
5. **Gilliet, Henri.** *Toll roads-the French experience.* Saint-Quentin-en-Yvelines : Transrouts International, 1990.
6. **U.S. Department of Transportation.** Toll Facilities in the United States Bridges-Roads-Tunnels-Ferries. [Online] August 2009. [Cited: January 20, 2011.] http://www.fhwa.dot.gov/policyinformation/tollpage/
7. **New Mexico Border Authority.** New Mexico Ports of Entry. [Online] [Cited: January 21, 2011.] http://www.nmborder.com/index.html.
8. **City of McAllen.** International Bridge. *City of McAllen, TX.* [Online] [Cited: January 23, 2011.]
9. **HNTB.** El Paso Border Operations Plan. *El Paso Border Operations Plan.* [Online] [Cited: January 20, 2011 .] http://www.elpasoborderplan.org/index.php?b=st.
10. **City Of Eagle Pass.** Eagle Pass International Bridge System. *Eagle Pass.* [Online] [Cited: February 2, 2011.] http://www.eaglepasstx.us/default.aspx?name=Bridge_Tolls_Services.
11. **Tranportation, Texas Department of.** *2010 Texas-Mexico International Bridges and Border Crossings Existing and Proposed.* 2010.
12. **U.S. Department of Transportation.** Border Crossing/Entry Data. [Online] [Cited: 2 3, 2011.] http://www.bts.gov/programs/international/transborder/TBDR_BC/TBDR_BC_Index.html
13. **Transportation Border Working Group.** Border Map. *TBWG.* [Online] [Cited: January 14, 2011.] http://www.thetbwg.org/map-michigan_e.htm.
14. **DOT, Michigan.** Michigan's publicly-owned bridges. *MDOT.* [Online] [Cited: February 1, 2011.] http://www.michigan.gov/mdot/0,1607,7-151-9618---,00.html.
15. **Niagara Falls Bridge Commission.** Express Pass Toll Program. *Niagara Falls Bridge Commission.* [Online] [Cited: January 10, 2011.] http://www.niagarafallsbridges.com/ExpressPass.php3.
16. *Sticker tags infiltrate heart of E-ZPass - Niagara bridges NY-Ont.* **Samuel, Peter.** 3202, Frederick : Tollroadsnews, 2007.

17. **Buffalo and Fort Erie Public Bridge Authority.** Current Toll Rates. *The Peace Bridge.* [Online] 2010. [Cited: January 8, 2011.] http://www.peacebridge.com/index.php?option=com_content&view=article&id=19&Itemid=638.

18. **Ambassador Bridge.** Auto Reward Card. *Ambassador Bridge.* [Online] [Cited: January 10, 2011.] http://www.ambassadorbridge.com/Fuel/AutoRewardCard.aspx?Auto=Y.

19. **Blue Water Bridge.** Toll Rates. *Blue Water Breidge Canada.* [Online] [Cited: January 10, 2011.] http://www.bwba.org/toll_e.html.

20. **Harris County Toll Road Authority.** Frequently Asked Questions – Interoperability. [Online] [Cited: 03 10, 2011.] https://www.hctra.org/about_faq/interoperability/.

21. **Texas Department of Transportation.** http://caminocolombia.org/. [Online] [Cited: 03 05, 2011.] http://caminocolombia.org/.

22. **Cameron County Regional Mobility Authority.** *FirstSection of SH 550 Toll to Open March 10.* [News Advisory] Brownsville : s.n., 2011.

23. **Alliance for Toll Interoperability.** Interoperability Hub Request for Proposal. Raleight : ATI, 2011.

24. **Bureau, SANDAG Service.** *California-Baja California Border Master Plan - Executive Summary.* San Diego : SANDAG, 2008.

25. **Secretaria de Comunicaciones y Transportes.** Sala de Prensa. *SCT.* [Online] 09 29, 2010. [Cited: 05 2011, 2011.] http://www.sct.gob.mx/despliega-noticias/article/comunicado-154-operara-sct-puente-cucapa-del-cruce-internacional-san-luis-rio-colorado-ii-en-son/.

26. Laredo Trade Tag. *Laredo Trade Tag.* [Online] [Cited: December 20, 2010.] http://laredotradetag.com/.

27. *TransCore's eGo sticker tag challenged by Neology in Mexico contract.* **Samuel, Peter.** Frederick : Tollroadsnews, May 4, 2010, Vol. 4731.

28. **TRMI Systems Integration.** *Mexico: Toll Industry Overview.* Mexico City : s.n., 2009.

29. **U.S. Customs and Border Protection.** SENTRI Eligibility and Fees. [Online] [Cited: 03 2011, 03.] http://www.cbp.gov/xp/cgov/travel/trusted_traveler/sentri/sentri_eligibility.xml.

30. **Caminos y Puentes Federales.** Linea Express de CApufe (LINEXP). [Online] [Cited: 03 07, 2011.] 4) http://www.capufe.gob.mx/portal/site/wwwCapufe/menuitem.b890cedd73bc7f015a034bd7316d8a0c/ .

31. **PROMOFRONT.** Puente Internacional Zaragoza-Ysleta. [Online] [Cited: 03 07, 2011.] http://www.puenteinternacionalzaragozaysleta.com/index.html .

32. **Foreign Trade Association.** Dedicated Commuter Lane/Linea Express II Zaragosa/Ysleta/ Port of Entry. [Online] [Cited: 03 08, 2011.] http://www.epfta.org/news_detail.sstg?id=13.

33. **U.S. Custom and Border Protection.** NEXUS Program. [Online] [Cited: 03 08, 2011.] http://www.cbp.gov/xp/cgov/travel/trusted_traveler/nexus_prog/ .

34. **Protection, U.S. Custom and Border.** *Nexus Fact Sheet.* s.l. : DHS, 2010.

35. **U.S. Customs and Border Protection.** CBP Border Wait Times. [Online] 2010. [Cited: October 18, 2010.] http://apps.cbp.gov/bwt/.

36. **Intermex.** NEXUS Supports Life in the Fast Lane with RFID Border Crossing Program. [Online] [Cited: 03 07, 2011.] http://www.intermec.com/learning/content_library/case_studies/cs981.aspx.

37. **Niagara Falls Bridge Commission.** Nexus Toll Program. [Online] [Cited: 03 07, 2011.] http://www.niagarafallsbridges.com/nexus_toll_program.php3 .

38. **U.S. Customes and Border Protection.** Ready Lane - WHTI compliant Radio Frequency Identification . [Online] 04 28, 2011. [Cited: 05 02, 2011.] https://help.cbp.gov/app/answers/detail/a_id/1210/~/ready-lane---whti-compliant-radio-frequency-identification-%28rfid%29.

39. **U.S. Customs and Border Protection.** Ready Lane. *Western Hemisphere Travel Initiative.* [Online] [Cited: 05 02, 2011.] http://www.getyouhome.gov/html/rfid/RFID_FAQ.html.

40. Persad, **Dr. Khali, et. al.** *Toll Collection Technology and Best Practices.* Austin : Center for Transportation Research, 2007.

41. **HNTB.** *Considerations for High Occupancy Vehicle (HOV) Lane to High Occupancy Toll (HOT) Lane Conversions Guidebook.* s.l. : FHWA, 2007.

42. **Commission, Federal Communications.** FCC ALLOCATES SPECTRUM IN 5.9 GHz RANGE FOR INTELLIGENT. Washington : FCC, 1999.

43. **Kapsch.** Big Success with the Performance Evaluation of the new 5.9 GHz tolling technology from Kapsch TrafficCom at the Trial Facility in Denver, Colorado. [Press Release]. s.l. : Press Release, 2008.

44. ITS America Call for Best New Innovative Practice. s.l. : Kapsch, 2009.

45. **Muriello, Mark.** *Development and Testing of Electronic Payment Services National Interoperability Specification for Next Generation ETC Services, I-95 Corridor Coalition.* New York : Port Authority of New York and New Jersey.

46. **Samuels, Peter.** *5.9GHz ET test at Hood River OR-White Salmon WA toll bridge over Columbia River.* Frederick : Tollroad News, 2010. 4897.

47. **PRWEB.** Kapsch TrafficCom to Deploy Real-time, 5.9 GHz DSRC Wireless Roadside Inspection System for New York State Energy Research and Development Authority. Carlsbad : Kapsch, 2011. Press Release.

48. Cuan, **Manuel.** *Secretariat Communicacion de Transporte.* July 2009.

49. *National ITS Studies in Mexico.* **Erazo, Juan Jose and Cuan, Manuel.** San Diego : Presented to Joint Working Committee, 2010.

50. **Fino, Edgar.** *Traffic Engineer.* Februrary 3, 2010.

51. **National ITS Architecture.** *Border Wait Time Project ITS Architecture.* 2010.

52. **Villa, J. C.** *Screening, Scanning, and Inspection Processes (SSIP).* s.l. : DHS National Center for Border and Immigration Security, 2009.

53. **Medina, Michael.** Assistant Director, El Paso Metropolitan Planning Organization. *Personal Interview.* January 24, 2011.

54. **Rajbhandari, Rajat, et al.** *Pilot Information System for Cross-Border HAZMAT Transportation.* College Station : Southwest Region University Transportation Center, Texas A&M University, 2009.

55. **Rajbhandari, Rajat, Villa, Juan Carlos and Aldrete, Rafael.** *Expansion of the Border Crossing Information System.* College Station : University Transportation Center for Mobility, Texas A&M University, 2009.

56. *Cross Border Contingency Plan, U.S.-Mexico Sister Cities Laredo/Nuevo Laredo.* 1998.

57. New Mexico-Texas-Chihuahua Regional Workshop. *U.S. Environmental Protection Agency.* [Online] September 14, 2010. [Cited: January 28, 2011.] http://www.epa.gov/Border2012/regional/chi-sister.html.

58. EPA Announces Nogales Sister City Response Plan. *Business News America.* [Online] March 20, 2000. [Cited: January 28, 2011.] http://www.bnamericas.com/news/waterandwaste/EPA_Announces_Nogales_Sister_City_Response_Plan.

59. **City of Laredo.** Emergency Operations Center. *Homeland Security.* [Online] [Cited: January 27, 2011.] http://www.ci.laredo.tx.us/CASS/Pres_Fed/content/homeland_security/emergency_operations_center.html.

60. **Pima County.** Pima County Health Department. *Local Emergency Planning Committee.* [Online] [Cited: February 02, 2011.] http://www.pima.gov/lepc/pdf/Pima-Revised-HazMat-Plan-FINAL-DRAFT.pdf

61. **County of San Diego.** Office of Emergency Services. *WebEOC.* [Online] [Cited: February 02, 2011.] http://www.co.san-diego.ca.us/oes/emergency_management/oes_jl_EM.html.

62. **Sabean, J., Jones, C.** *Inventory of Current Programs for Measuring Wait Times at Land Border Crossings: Report for Customs and Border Protection, Department of Homeland Security and Canada Border Services Agency*. 2008.

63. *Highway 402 Queue Warning System (Wireless Long Haul Application).* **Browne, Roger and Byrne, Alan.** Toronto, Canada : Presented at the 2008 Annual Conference of the Transportation Association of Canada, 2008.

64. **Whatcom Council of Governments.** Border Data Warehouse: User Guide. *Cascade Gateway Data.* [Online] April 2007. [Cited: November 5, 2010.] http://cascadegatewaydata.com/docs/Userguide.pdf.

65. **Klein, L A, Mills, M K and Gibson, D R.** *Traffic Detector Handbook, Third Edition - Volume I.* McLean, Virginia : Federal Highway Administration, Turner Fairbank Research Center, 2006.

66. **Martin, P T, Fend, Y and Wang, X.** *Detector Technology Evaluation.* Utah : University of Utah, Department of Civil and Environmental Engineering, 2003.

67. **Middleton, D and Parker, R.** *Initial Evaluation of Selected Detectors to Replace Inductive Loops on Freeways.* College Station, Texas : Texas Transportation Institute, 2000.

68. **Mimbela, L. and Klein, L.** *A Summary of Vehicle Detection and Surveillance Technologies Used in Intelligent Transportation System.* Las Cruces, New Mexico : The New Mexico State University, 2000.

69. **Texas Department of Transportation.** *Texas Regional ITS Architecture Home Page.* [Online] 2007. [Cited: November 2, 2010.] http://www.consystec.com/texas/default.htm.

70. **Las Cruces Metropolitan Planning Organization.** *Las Crucel Regional ITS Architecture.* [Online] 2007. [Cited: November 2, 2010.] http://www.consystec.com/lascruces/web/_regionhome.htm.

71. **New Mexico Department of Transportation.** *Final New Mexico Statewide ITS Architecture.* [Online] 2007. [Cited: November 2, 2010.] http://www.consystec.com/nm/web/_regionhome.htm.

72. **Southern California Association of Governments.** *Southern California Regional ITS Architecture, Phase 2.1-Imperial County Regional ITS Architecture, Version 4.0.* Los Angeles, California : Southern California Association of Governments, 2005.

73. **U.S. Department of Transportation.** Applications Overview. *Rsearch and Innovative Technology Administration.* [Online] [Cited: November 1, 2010.] http://www.itsoverview.its.dot.gov

74. **Kristof, Taryn, Lowry, Mike and Rutherford, Scott.** *Assessing the Benefits of Traveler and Transportation Information Systems.* Seattle : Washington State Transportation Center, University of Washington, 2005.

75. **Texas Department of Transportation.** TransVista Traffic Information. *El Paso District News and Information.* [Online] [Cited: October 19, 2010.] http://elpits.dot.state.tx.us/its-trafficinfo/.

76. Traveler Information Map. ***STRATIS.*** [Online] [Cited: October 19, 2010.] http://its.txdot.gov/LRD/lrd.htm.

77. **New Mexico Border Authority.** [Online] [Cited: October 19, 2010.] http://www.nmborder.com/.

78. **New Mexico Department of Transportation.** New Mexico Road Conditions. [Online] [Cited: February 03, 2011.] http://nmroads.com/.

79. **Arizona Department of Transportation.** Arizona 511. [Online] [Cited: February 03, 2011.] http://www.az511.gov/adot/files/traffic/.

80. *Recent 511 Deployer Updates/Issues, California 511 Workshop.* **San Diego Association of Governments.** San Diego : s.n., 2008.

81. **Washingington Department of Transportation.** Canadia Border Traffic. -. [Online] 2010. [Cited: October 18, 2010.] http://www.wsdot.wa.gov/traffic/border/.

82. **British Columbia Ministry of Transportation and Infrastructure.** Wait Times for Peace Arch Crossing. [Online] 2010. [Cited: October 18, 2010.] http://www.th.gov.bc.ca/ATIS/index.htm.

83. **New York State Department of Transportation.** Traffic Conditions. *511 Traffic, Travel And Transit Info.* [Online] [Cited: October 18, 2010.] http://www.511ny.org/traffic.aspx.

84. **Buffalo and Fort Erie Public Bridge Authority.** The Peace Bridge. [Online] [Cited: October 19, 2010.] http://www.peacebridge.com/webcam.php.

85. **Niagara Falls Bridge Commission.** Traffic Conditions. [Online] [Cited: October 19, 2010.] http://www.niagarafallsbridges.com/traffic_conditions.php3.

86. **Government of Canada.** Blue Water Bridge Canada. [Online] [Cited: October 19, 2010.] http://www.bwba.org/main_e.html.

87. **Michigan Department of Transportation.** Michigan's Publicly Owned Bridges. [Online] [Cited: October 19, 2010.] http://www.michigan.gov/mdot/0,1607,7-151-9618---,00.html.

88. **Montana Department of Transportation.** Traveler Information Map. [Online] [Cited: October 19, 2010.] http://roadreport.mdt.mt.gov/map/.

89. **California Department of Transportation.** *State Route 905/125 Interchange at Otay Mesa Port of Entry, Transportation Border Congestion Relief Program Application.* 2008.

90. *Real-Time Traffic Information and Its Impact on Route Switching Behavior of Expressway Drivers.* **Jou, R., et al.** 2, pp. 187-223, s.l. : Journal of Advanced Transportation, Vol. 38.

91. **U.S. Customs and Border Protection.** -. *CBP Border Wait Times.* [Online] [Cited: October 18, 2010.] http://apps.cbp.gov/bwt/.

92. **Canada Border Services Agency.** Border Wait Times. [Online] 2010. [Cited: October 18, 2010.] http://www.cbsa-asfc.gc.ca/general/times/menu-e.html.

93. *Social Network Sites: Definition, History, and Scholarship.* **Boyd, D. M. and Ellison, N. B.** s.l. : Journal of Computer-Mediated Communication, 2007, Vol. 13(1).

94. **Edmunds Daily.** Telematics Detroit 2010: Smartphones and Apps Change Everything. [Online] [Cited: October 22, 2010.] http://www.telematics.info/news/6620/Smartphones-and-Apps-Change-Everything.html.

95. *Traveller Response to New Dynamic Information Sources: Analyzing Corridor and Area-Wide Behavioural Surveys.* **Yim, Y. and Khattak, K.** Washington D.C. : Presented at the 81st Annual Meeting of the Transportation Research Board, 2002.

96. **MSNBC.** States give mixed signals on texting and driving. [Online] September 18, 2009. [Cited: October 22, 2010.] http://www.msnbc.msn.com/id/32919375/ns/technology_and_science-tech_and_gadgets/.

97. **SANDAG.** San Diego Traffic, Transit, and Commute Info. *San Diego 511.* [Online] [Cited: December 22, 2010.] http://www.511sd.com/.

98. *Use and Effects of Advanced Traveller Information.* **Chorus, C G, Molin, E J and Wee, B V.** 2, s.l. : Transport Reviews, March 2006, Vol. 26.

99. **Pierce, S. and Lappin, J.** Why don't more people use advanced traveler information? Evidence from the Seattle area. *Paper Presented at the 83rd Annual Meeting of the Transportation Research Board.* Washington D.C. : s.n., 2004.

100. **Petrella, M. and Lappin, J.** Los Angeles and Seattle: A Comparative Analysis of Customer Response to Online Traffic Information. *Presented at the 83rd Annual Meeting of the Transportation Research Board.* Washington D.C. : s.n., 2004.

101. **Creek, James.** *Project Manager, New Mexico Border Authority.* March 7, 2011.

102. **Turner, S.** *Guidelines for Developing ITS Data Archiving Systems, Report 2127-3.* College Station, Texas : Texas Transportation Institute, Texas A&M University, 2001.

103. *Paso Del Norte Regional Mobility Information System - Creating Archived Transportation Data User Services and Advanced Traveler Information System.* **Rajat Rajbhandari, Rafael Aldrete.** pp 110-120, Washington D.C. : Transportation Research Record: Journal of the Transportation Research Board, 2009, Vol. 2121.

104. **California Department of Transportation.** *San Ysidro Port of Entry Border Investment Strategey, Transportation Border Congestion Relief Program Application.* 2008.

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APPENDIX A:

FIRST BORDER-WIDE ITS WORKSHOP

LIST OF PARTICIPANTS OF THE FIRST BORDER-WIDE ITS WORKSHOP

Name	Organization	Name	Organization
Marisa Walker	ADOT	Alesia Gamboa	TxDOT Traffic ITS
Bill Tate	Battelle	Charlie Farnham	TxDOT Traffic ITS
Crystal Jones	FHWA	Scott E. Nodes	ADOT
Sylvia Grijalva	FHWA	Doug Woodall	TxDOT Turnpike Authority
Travis Black	FHWA	Matt Schiemer	
Chris Flanigan	FMCSA	Jesse Glazer	FHWA California
Charles Remkes	New Mexico	Frank Cechini	FHWA California
Michael Smelker	New Mexico	Steve Pyburn	FHWA California
Kate Hartman	RITA	Vivien Hoang	FHWA New Mexico
Samuel Johnson	SANDAG	Andrea Hoffman	SANDAG
Tina Casgar	SANDAG	Christopher Burke	SANDAG
Juan José Erazo	SCT	Jonathan Sabean	Transport Canada
Manuel Cuan Chu	SCT	Edgar Fino	TxDOT- El Paso
Tammy Duncan	Southwest Research Institute	Danny Magee	TxDOT- Laredo
Harry Grothues	Southwest Research Institute	Melissa Montemayor	TxDOT- Laredo
Juan Carlos Villa	TTI	Linda Sexton	TxDOT Turnpike Authority
Rajat Rajbhandari	TTI	Reza Karimvand	ADOT
Roberto Macias	TTI	Mario Orzo	Caltrans
Eduardo Hagert	TxDOT - GPA-IRO	Jennifer Brown	FHWA Arizona
Agustin de la Rosa	TxDOT - IRO	Manuel Sanchez	FHWA California
Esther Hitzfelder	TxDOT - IRO	Mark Olson	FHWA Texas
Manuela Ortiz	TxDOT - IRO	Gabriela Contreras-Apodaca	New Mexico
Charles Koonce	TxDOT - TRF-ITS	Jesse Medina	Pharr
Jesus Leal	TxDOT- Pharr		

Agenda of the First Border-Wide ITS Workshop

Item Description	Schedule	Speaker
Introduction, Welcoming Remarks, Ground Rules	08:30-08:45	Crystal Jones
US DOT ITS Program Overview	08:45:9:15	Kate Hartman
Goals and Objectives of the Project	09:15-09:20	Bill Tate
Scan Methodology and Approach	09:20-09:30	Juan C. Villa
Planning and Cross-Border Coordination	09:30-09:40	Juan C. Villa
Tolling Issues in Border Regions – Transaction Processing	09:40-09:55	Roberto Macias
Tolling Issues in Border Regions – Electronic Tolling Operations	09:55-10:10	Roberto Macias
Tolling Issues in Border Regions – Technology	10:10-10:30	Roberto Macias
Break	**10:30-10:45**	
Border Transportation Operations	10:45-11:00	Rajat Rajbhandari
Enforcement	11:00-11:15	Juan C. Villa
Traffic Management	11:15-11:30	Rajat Rajbhandari
Traveler Information	11:30-11:45	Rajat Rajbhandari
Archived data management	11:45-12:00	Rajat Rajbhandari
Lunch Break	**12:00-13:15**	
ITS Commercial Vehicle Safety IBC E-Screening initiative	13:15-13:35	Chris Flanigan
Border ITS Canadian Perspective	13:35-13:55	Jonathan Sabean
Border ITS Mexican Perspective	13:55-14:15	Juan J. Erazo
Open Discussion on Current and Future ITS Needs of the Stakeholders at the Border	14:15-15:00	Floor
Break	**15:00-15:15**	
Operational and Technological Challenges to Meet the Needs of the Stakeholders	15:15-16:00	Floor
Feedback from the Participants about Technology Solutions to be Demonstrated and Discussed. Define specific implementation case studies that could be requested to industry	16:00-16:45	Juan C. Villa
Closing Remarks and Adjourn	16:45-17:00	Crystal Jones

APPENDIX B:

SECOND BORDER-WIDE ITS WORKSHOP

LIST OF PARTICIPANTS OF THE SECOND BORDER-WIDE ITS WORKSHOP

Name	Organization	Name	Organization
Marisa Walker	ADOT	Francisco Calvario	SCT
Angelica Echegaray	Aduanas	Harry Grothues	Southwest Research Institute
Carlos Morales	Aduanas	Jorgen Pedersen	Telvent
Bill Tate	Battelle	Harold Pittman	TransCore
Mario Orso	Caltrans	Juan Villa	TTI
Sergio Pallares	Caltrans	Rajat Rajbhandari	TTI
Carlos Cortez	Caltrans	Roberto Macias	TTI
Jacqueline Appleton	Caltrans	Salvador Perez	TxDOT
Nicola Bernard	Caltrans	Esther Hitzfelder	TxDOT - IRO
Jose Ornelas	Caltrans Border Liaison	Charles Koonce	TxDOT - TRF-ITS
Mark Jensen	Cambridge Systematics	Eran Aichler	Delcan Corporation
Chris Flanigan	DOT.FMCSA	Jesse Glazer	FHWA California
Crystal Jones	FHWA	Vivien Hoang	FHWA New Mexico
Sylvia Grijalva	FHWA	David Franklin	FHWA U.S. - Canadian Border Coordinator
Travis Black	FHWA	Matthew Schiemer	Gannett Fleming
Manuel Sanchez	FHWA California	Moojan Khazra	IBI Group
Roy Sumner	FreeAhead Inc	Simon Smith	IBI Group
Bob Burrows	G4 Apps Inc.	Rob Hedley	IBM
Ramon Riesgo	GSA	David Salgado	ICTC
Alvaro Alamilla	IBI Group	Brian Mofford	Intelligent Imaging Systems
Chris Kimbrell	IBI Group	Charles Remkes	New Mexico DOT
Don Murphy	IBI Group	Kate Hartman	RITA
Ryan Glancy	INRIX	John Karabias	RTR Technologies LLC.
Tom Der	IRD (International Road Dynamics Inc.)	Christopher Burke	SANDAG
Bob Frank	Kapsch	Samuel Johnson	SANDAG
Michael Smelker	New Mexico DOT	Tina Casgar	SANDAG
Ron Ice	R. C. Ice and Associates	Greg Pieper	SmarTek Systems, Inc.
Andrea Hoff	SANDAG	Tammy Duncan	Southwest Research Institute
Anna Borrell-Rovira	SANDAG	Shel Leader	Telvent
Cheryl Mason	SANDAG	Scott Brosi	TransCore
Chris Burke	SANDAG	Jonathan Sabean	Transport Canada
Stacy Corona	SANDAG	Manuela Ortiz	TxDOT - IRO
Hector Vanegas	SANDAG	Jesus Leal	TxDOT- Pharr
Juan José Erazo	SCT	Alesia Gamboa	TxDOT Traffic ITS

AGENDA OF THE SECOND BORDER-WIDE ITS WORKSHOP

Topic	Start	End	Presenter
Welcoming Remarks	08:30	08:40	Caltrans
Introductions, Workshop Objectives and Organization	08:40	09:00	FHWA
Federal Perspective	09:00	09:15	FHWA
	09:15	09:30	SCT
	09:30	09:45	GSA
Discussion on Federal Perspective	09:45	10:20	All
Break	10:20	10:30	
State and Local Perspective	10:30	10:45	SANDAG/Caltrans
	10:45	11:00	ADOT
	11:00	11:15	TxDOT
	11:15	11:30	NMDOT
Discussion on State/Local Perspective	11:30	12:15	All
Lunch	12:15	01:30	
Tolling in Border Regions	01:30	01:45	Transcore
	01:45	02:00	Kapsch
Border Transportation Operations, Traffic Management and Enforcement	02:00	02:15	IRD
	02:15	02:30	Intelligent Imaging Solutions
	02:30	02:45	R.C. Ice and Associates
Break	02:45	03:00	
Traveler Information	03:00	03:15	Telvent
	03:15	03:30	Inrix
Archived Data Management	03:30	03:45	IBM
Guided Discussion on Future Concepts	03:45	04:30	RTR Technologies, G4 Apps, and FreeAhead
Discussion on Implementation Experiences	04:30	05:15	All
Closing Remarks and Adjourn	05:15	05:30	FHWA

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