Measuring Border Delay and Crossing Times at the U.S./Mexico Border

Task 3 Report
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Federal Highway Administration
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Table of Contents

List of Exhibits

Measuring Border Delay and Crossing Times at the U.S./Mexico Border

Task 3. Implementation Plan

1. Introduction

1.1 Background

As part of the Federal Highway Administration (FHWA) Freight Performance Measurement (FPM) initiative, the Texas Transportation Institute (TTI) is analyzing technologies that can support automated measurement of border delay and crossing time for commercial vehicles at U.S./Mexico land ports of entry. TTI prepared a previous report documenting findings of the initial two tasks of this project:

- contact project stakeholders/gather baseline data, and
- identify technologies.

This second report presents a preliminary technology implementation plan (Task 3).

Results from Tasks 1 and 2 of this project identified three technologies that emerged as the most efficient ways of collecting border crossing time data. From the three technologies that had merit, one was discarded by FHWA (automatic license plate readers). The two remaining technologies with the most potential are: radio frequency identification (RFID) and global positioning system (GPS).

The objective of the overall project is to develop a system that is capable of collecting reliable and consistent border crossing time and delay information, that is permanent, that can easily share information, and that has potential to expand to areas outside border crossing regions. The two selected technologies meet these criteria. However, the definition of the final uses of the information has not been established, and that definition will affect the final choice of technology and procedures.

A clear definition of the final use of the information collected at the border is critical for development of the system and structure of a final implementation plan. A key element that needs to be defined is whether the information would be used on real-time basis and broadcasted or stored and analyzed on a daily, weekly, or monthly basis. In order to proceed with the project, the preliminary implementation plan presented in this report includes accommodation for data transmission from the field to a central location but does not include the development of the final information distribution system.

1.2 RFID and GPS Capabilities

The preliminary implementation plan illustrates potential installation of the two technologies at the El Paso/Ciudad Juarez border crossing international bridges (Bridge of the Americas and the Zaragoza Bridge). The two technologies under consideration collect information differently. While the GPS technology collects more detailed information, the RFID collects sufficient information to calculate border crossing time and delay. Exhibit 1 presents the data elements that each of the two technologies collect.

Data Element	GPS	RFID
Entry Date	X	X
Entry Time	X	X
Exit Date	X	X
Exit Time	X	X
Vehicle Route	X	
Vehicle Speed	X	
Stop Times*	X	
Idle Times*	X	

** Requires probe to be installed in the tractor*

Exhibit 1. Measured Data Elements by Technology

In Exhibit 1, Entry Date and Entry Time refer to the exact moment that a truck passes a predetermined point before entering the queue on the Mexican side of the border. Exit Date and Exit Time refer to the moment that same truck passes a predetermined point after exiting the state inspection facility on the U.S. side of the border. These four data elements are sufficient to calculate the total crossing time and could be recorded by both RFID and GPS.

GPS units will provide more detailed information than the entry and exit date and time. Because the exact longitudinal and latitudinal position of each truck is recorded every several seconds by the probe, a GPS unit will provide sufficient information to calculate the Vehicle Route and Vehicle Speed as it moves through the border crossing process. Also, GPS data will provide enough information to determine the Stop Times and Idle Times at any point during a border crossing trip.

RFID technology is currently in use at all major commercial border crossings under the U.S. Customs and Border Protection (CBP) “Free and Secure Trade” (FAST) program. CBP has provided truckers registered on the FAST program with RFID tags that are installed on a truck’s windshield and has installed RFID readers at each primary inspection booth in the U.S. Federal Inspection Compound. In Texas, the Department of Public Safety (DPS) is installing RFID readers at the state safety inspection facility at the Bridge of the Americas (BOTA) crossing in El Paso.

The proposed GPS arrangement has been used at the U.S./Canada border, and some motor carriers use the system to monitor driver performance, speed, fuel economy, and other elements in real time throughout the border crossing process.

The implementation plan for each of these two technologies is presented in the next section of this report. As mentioned previously, complete implementation requires the definition of the final uses of the information. Because the advantages of using RFID and GPS systems outweigh the disadvantages, and because the data collected through each method is sufficient to measure border delay and crossing times, implementation plans for both of these technologies will be designed and presented in the next section.

2. Implementation Plans

2.1 RFID

Procedure for Implementation

Step 1: Prepare Site
Before any data collection can begin, the site must be inspected to ensure it can meet all operational requirements of the proposed system. This inspection involves several activities. The first activity is to identify any permit requirements for placing the readers both in Mexico and the U.S. TTI will work with city, state, and/or federal officials to meet all requirements for installing equipment on their properties.

The second activity is to identify all potential structures where RFID readers and antennas could be mounted. Overhead traffic signs are typically the best structures to hold these types of devices. Because most RFID tags are located in the upper left portion of a truck's windshield, placing antennas directly above the trucks is the best way to ensure accurate readings as trucks pass underneath them. If no overhead signs are present where a reader and antenna must be installed, TTI will gain permission from city, state, and/or federal officials before building and installing an overhead structure for both the RFID reader and antennas.

The third and final activity of site preparation is to define how information collected from each reader will be transmitted. This transmission can be done by wireless or land-line communication devices. Because each port of entry (POE) is different, TTI will determine which type of information transmission is best suited for that specific POE.

Step 2: Install Readers
One reader will be installed at each POE to identify incoming vehicles at a predetermined point prior to entering the Mexican export lot. One antenna will be set up for each lane of traffic passing under the measuring location. This predetermined point will be located before a vehicle reaches the queue at the

border. Measuring locations at the end of the crossing will be set up at the exit of the state inspection facility. These before-and-after measuring locations will provide enough information to calculate total border crossing times.

If additional detail is required, other measuring locations can be set up at points where trips could be segmented, such as entrance or exit points of the federal inspection facility. These additional measurements would provide a clearer picture of how long trucks spend in each inspection facility on both sides of the border. Data could be compared between trucks that are using FAST lanes and those that are not. Aerial maps of both POEs at El Paso have been provided below to illustrate where potential measuring locations could be installed at both bridges. Exhibits 2 and 3 illustrate possible measuring locations at BOTA and the Zaragoza Bridge, respectively.

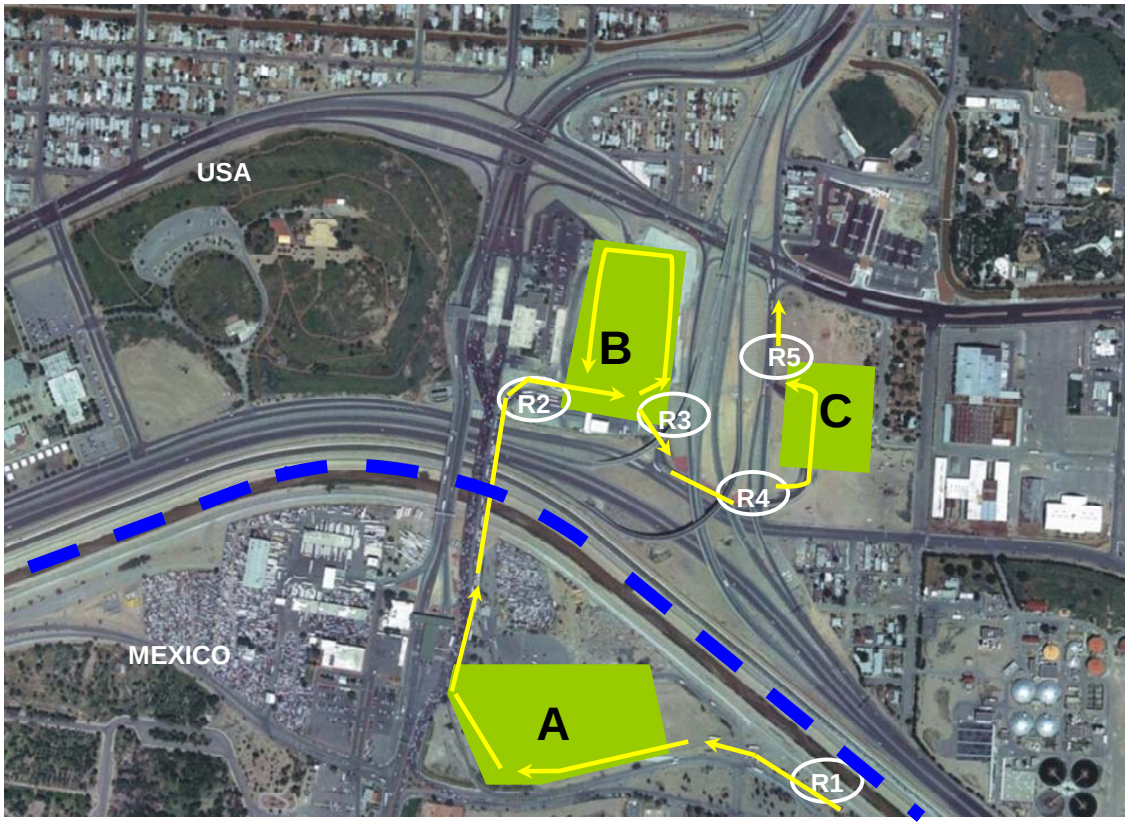
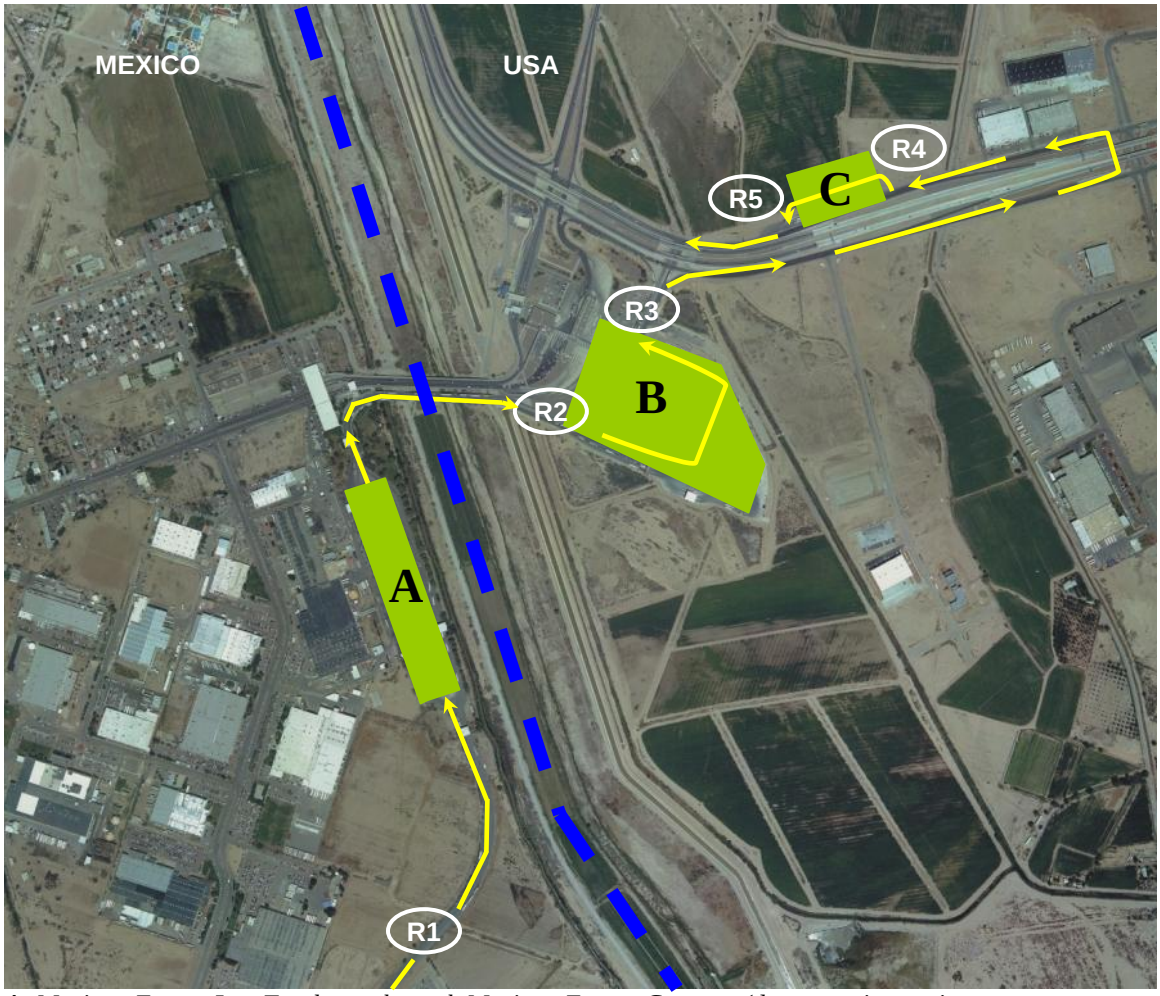


Exhibit 2. Aerial photo hybrid map. Bridge of the Americas at El Paso, Texas.
A: Mexican Export Lot. Trucks go through Mexican Export Customs (document inspection, cargo inspection selection).
B: U.S. Federal Compound. Trucks go through U.S. Customs Primary Inspection (document inspection). If secondary inspection is required, truck(s) are sent to the U.S. Secondary Inspection (VACIS, X-Ray, INS, USCS, USDA, FDA, EPA, US DOT, K-9, others).
C: State Safety Inspection Facility. Checks that trucks comply with all safety requirements.

Exhibit 2. Aerial Photo Hybrid Map. Bridge of the Americas at El Paso, Texas

For BOTA, readers and antennas must be installed at R1 and R5. If greater detail is required, additional readers and antennas can be set up at R2 and R3. Currently, the Texas Department of Public Safety has plans to install a reader at the entrance to the state inspection facility at R4 as well as within the state compound. If the DPS is willing to share data collected from its RFID reader, no reader would have to be installed between the federal and state compounds. Also, if DPS does install a reader at R4 and share data, no reader would be required at R3.



A: Mexican Export Lot. Trucks go through Mexican Export Customs (document inspection, cargo inspection selection).
B: U.S. Federal Compound. Trucks go through U.S. Customs Primary Inspection (document inspection). If secondary inspection is required, truck(s) are sent to the U.S. Secondary Inspection (VACIS, X-Ray, INS, USCS, USDA, FDA, EPA, US DOT, K-9, others).
C: State Safety Inspection Facility. Checks that trucks comply with all safety requirements.

Exhibit 3. Aerial Photo Hybrid Map. Zaragoza Bridge at El Paso, Texas

The layout of the Zaragoza Bridge is similar to the layout at BOTA. In order to get total crossing times, measuring locations must be installed at R1 and R5. If additional detail on border crossing times is required, measuring locations can be set up at R2, R3, and/or R4. No beneficial information would be gathered by having a reader at both R3 and R4, therefore if one measuring location is installed at either of these sites, it would not be necessary to install a second measuring location at the other.

Step 3: Test System
Once all RFID readers are in place, the project team can begin to collect border crossing times. When a truck equipped with an RFID tag passes under an antenna, it will send the time and date to the reader installed at each site. The data recorded on the reader in Mexico will be transmitted to a computer connected to the U.S. readers. The information can then be collected and sent to the central processing computer, which will sort and analyze the data in order to calculate the total crossing time for each sample truck. The RFID data will be collected from the onsite computer periodically. Any problems with the data collection will be noted and addressed during this step.

Step 4: Deploy System
Before the RFID system is deployed, an information dissemination plan must be formulated. This dissemination plan will define who will receive access to the information collected and how that information will be used. After a dissemination plan is created and the system is determined to be operating correctly, data can continue to be collected in order to monitor crossing times for each truck with an RFID tag that passes through the system.

Timeline

Exhibit 4 displays an estimated timeline for the implementation of an RFID border wait time measuring system.

	Weeks																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	→
Step 1: Prepare Site																					
Step 2: Install Readers																					
Step 3: Test System																					
Step 4: Deploy System																					

Exhibit 4. Estimated Timeline for RFID System Implementation

Approximate Costs

Exhibit 5 shows the preliminary cost estimates for each RFID measuring location at a given POE for two lanes of traffic. The minimum number of measuring

locations must be two (one at beginning and one at end of border crossing process) in order to measure the total travel time. However, up to four recording sites can be installed at each POE to gather more detailed information on a given truck's trip across the border.

Component	Cost
Tag/Transponder Reader Equipment*	$6,000
Mounting Structure and Installation**	$12,000
Communications Device(s)***	$2,000
Electronic Equipment (Solar Kit and Central Computer)	$6,000
Electronic Equipment Installation	$5,000
Total	**$31,000**

** Assumes that one Encompass 2 Reader and two 915 MHz antennas will be installed at each measuring location.*
*** Assumes that no overhead signs are present to hold readers and antennas. If TTI is permitted to install equipment on existing structures, this cost would decrease significantly.*
**** Assumes cellular (wireless) technology will be used to transmit data from reader to onsite computer.*

Exhibit 5. Approximate Costs of RFID System Measuring Location Setup and Installation

Detailed cost estimates of the Tag/Transponder Reader Equipment, Communication Devices, and Electronic Equipment are provided in the appendix of this report. This cost estimate does not include any information dissemination or processing fees. These costs will be defined when the final use of the information is defined.

2.2 GPS

Procedure for Implementation

Step 1: Prepare Site
Unlike RFID, only one reader is required to obtain GPS data from each probe during the border crossing process. This reader does not have to be installed directly above traffic in order to gather accurate information from each probe. Because of this, the process for installing a GPS reader is much easier than installing an RFID measuring location. However, since GPS does require equipment to be installed, TTI will meet with local, state, and/or federal officials in order to acquire any necessary permits and meet all requirements for installing equipment on their properties. TTI will also conduct interviews with both public and private stakeholders in order to assess GPS's usability at each POE before going any further in the implementation process.

Step 2: Define Sample Size and Identify Interested Carriers
In order to define an adequate sample size for this program, TTI will analyze freight traffic patterns and volumes at each POE. A sample size will be determined in order to ensure that the information collected will provide sufficient data for calculating morning, afternoon, and evening crossing times. This will provide a clearer picture of where delay in the border crossing process is taking place throughout the day. Carriers interested in participating in this study will be identified in this step.

Step 3: Solicit Carrier Participation
Because GPS relies on a probe being installed in a truck to monitor that specific truck's location throughout the border crossing process, private carriers must be solicited to partake in this study. Data recorded throughout the study can be shared with participating carriers in order to encourage their involvement. Agreements with participating carriers will be reached in order to ensure accurate information sharing. Agreements will also be made to guarantee that after a probe is installed in a selected tractor, that tractor will be used for border crossings throughout the entire length of the agreement.

Step 4: Install GPS Readers and Distribute Probes
Only one reader is required to collect border crossing data at each site. This reader can be installed at the end of the northbound border crossing process, which is after the state inspection facility (R5 in Exhibit 2 and Exhibit 3). During this step, the project team will begin installing the GPS probes in each truck selected to take part in this study. Detailed data such as time of day, physical location, and bearing is stored in each GPS probe as the truck moves throughout its trip, and will be extracted when the unit passes the reader at the end of each northbound crossing.

Step 5: Test System
The data collected for each trip will be extracted from the recorder and transmitted to a central computer, where it will be analyzed to calculate the total crossing time. Because of the large amounts of data each probe stores, only information from certain predetermined coordinates will be used to document border crossing time. By setting coordinates between each inspection facility, the exact time a truck spends inside each location can be calculated. Problems with the data collection will be noted and addressed during this step.

Step 6: Deploy System
Before the GPS system is deployed, an information dissemination plan must be formulated. This dissemination plan will define who will receive access to the information collected, and how that information will be used. After a dissemination plan is created and the system is determined to be operating correctly, data can continue to be collected in order to monitor crossing times for each truck with a GPS probe that passes through the system.

Timeline

An estimated timeline for the implementation of a GPS border wait time measuring system is shown in Exhibit 6.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	→
Step 1: Prepare Site																					
Step 2: Define Sample Size																					
Step 3: Solicit Carrier Participation																					
Step 4: Install Reader and Distribute GPS Probes																					
Step 5: Test System																					
Step 6: Deploy System																					

Exhibit 6. Estimated Timeline for Implementation of a GPS System

Approximate Costs

Exhibit 7 shows the preliminary cost estimates for implementing a GPS system in order to measure border crossing times.

Component	Cost
GPS Reader	$1,500
GPS Probes*	$3,500
Electronic Equipment	$2500
Probe Installation	$6,000
Total	**$13,500**

**Assumes probes are leased for 1 month. Each probe costs $35/month to lease, and $650 to buy. This cost assumes 100 probes will be leased for the study.*

Exhibit 7. Approximate Costs of GPS System Setup and Installation at Each POE.

Detailed cost estimates for GPS Equipment are provided in the appendix of this report. This cost estimate does not include any information dissemination or processing fees. These costs will be defined when the final use of the information is defined.

Appendix

Exhibits 8 and 9 show the costs of RFID and GPS equipment from various vendors (as of July 2007). These costs do not include any installation, software, or information dissemination or processing fees.

RFID Equipment Costs

Parts Number	**EVR RFID Read Devices and Supporting Equipment**	Price per Unit	Number of Units	**Cost**	Retailer/Manufacturer
10-2210-200	Encompass 2 – 2210 Readers	$3,920	1	$3,920	Transcore
12-3153-001	AA-3153 Beacon 915 MHz Antenna	$750	2	$1,500	
58-1620-006	Cable, 35 foot, with connector	$266	2	$532	
76-1620-005	110VAC-18VAC Transformer	$27	2	$54	
			Sub Total EVR RFID Read Devices and Supporting Equipment =	**$6,006**	

Parts Number	**Verizon Cell Modem Package**	Price per Unit	Number of Units	**Cost**	Retailer/Manufacturer
CP-WAN-B311-A-S	ConnectPort WAN 3G Router with embedded Verizon EVDO RevA module and VPN with antenna	$835	1	$835	USAT
Antenna SMA	Dual band cellular/PCS low profile antennas	$52	2	$104	
Service	USAT Device Provisioning Service	$40	1	$40	
			Sub Total Verizon Cell Modem Package =	**$979**	

Parts Number	**Solar Panel Kit**	Price per Unit	Number of Units	**Cost**	Retailer/Manufacturer
BP350U	BP Solar module, 50 watt 12Vdc	$289	2	$578	Southwest Photovoltaic
400211	side of pole mount kit for modules	$149	1	$149	
SS10	Morningstar controller 10amp 12vdc	$43	1	$43	
BP2/6	Aluminum cabinet 44x10.25x16.5 with banding brackets	$609	1	$609	
MK8G31	Gel battery 96AH 12Vdc	$149	2	$298	
kit	System cable, intermodal cable, output cable and battery cables	$49	1	$49	
			Sub Total Solar Panel Kit =	**$1,726**	

Parts Number	**Misc. Electronic Equipment**	Price per Unit	Number of Units	**Cost**	Retailer/Manufacturer
N/A	Central Processing Computer	$2,500	1	$2,500	To Be Determined
			Sub Total Misc. Electronic Equipment =	**$2,500**	

Cost Component	Price per Unit	Number of Units	**Cost**
RFID Read Devices and Supporting Equip.	$6,006	1	$6,006
Cell Modem Package	$979	2	$1,958
Solar Panel Kit	$1,726	2	$3,452
Central Processing Computer	$2,500	1	$2,500
		Grand Total =	**$13,916**

Exhibit 8. Approximate Cost of RFID Equipment

GPS Equipment Costs

Part Description	Price per Unit (1 – 14 units)	Number of Units	Cost	Retailer/Manufacturer
Bluetooth GPS Probe Reader	$1,500	1	$1,500	Turnpike Global Technologies
GPS Probe	$35	100	$3,500	
Central Processing Computer	$2,500	1	$2,500	To Be Determined
	Total Cost =		**$7,500**	

Exhibit 9. Approximate Cost of GPS Equipment