Commercial Border Crossing and Wait Time Measurement at Laredo World Trade Bridge and the Colombia-Solidarity Bridge

Final Report

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List of Abbreviations

AAANLD	Asociación de Agentes Aduanales de Nuevo Laredo
ALFA	Association of Laredo Forwarding Agents
AWAM	Anonymous wireless address matching
BSIF	Border Safety Inspection Facility
CBP	Customs and Border Protection
CENSECOR	Central de Servicios de Carga de Nuevo Laredo
CENSOCAR	Central de Servicios de Carga de Nuevo Laredo
CODEFRONT	Corporación para el Desarrollo de la Zona Fronteriza de Nuevo León
ConOps	Concept of Operations
DPS	Department of Public Service
FAST	Free and Secure Trade
FHWA	Federal Highway Administration
GSA	General Service Administration
IAC	Interagency Cooperation Contract
IP	Internet Protocol
JWC	Joint Working Committee
NAFTA	North American Free Trade Agreement
POE	Port of Entry
POV	Privately Owned Vehicles
RFID	Radio Frequency Identification
TPP	Transportation Planning and Programming
TTI	Texas Transportation Institute
TxDOT	Texas Department of Transportation
UDP	User Datagram Protocol
US	United States
WIM	Weigh in Motion
WTB	World Trade Bridge

Chapter 1:
Background and Overview

This research is to establish a baseline and on-going measurement of border crossing times and delay by measuring travel times for commercial trucks crossing the port of entry (POE) from Mexico into Texas at the Laredo World Trade Bridge and the Colombia-Solidarity Bridge.

Delay time for commercial motor vehicles is a key indicator of transportation and international supply-chain performance, and the Texas Department of Transportation (TxDOT) is working with the Federal Highway Administration (FHWA) and other members of the U.S./Mexico Joint Working Committee (JWC) to implement automated border crossing and delay time measuring systems.

In 2006, the Texas Transportation Institute (TTI) analyzed various technologies that can be used to support automated measurement of border delay and crossing time at U.S./Mexico land ports of entry. This project was sponsored by the FHWA and radio frequency identification (RFID) was the selected technology for most of the U.S./Mexico land ports of entry.

FHWA, TxDOT, and other members of the JWC began working closely with U.S. Customs and Border Protection (CBP) to determine whether projects could be enhanced to measure border wait time in addition to total crossing time. Wait and crossing time are defined as:

- <u>Wait time</u>: "the time it takes, in minutes, for a vehicle to reach the CBP primary inspection booth after arriving at the end of the queue." This queue length is variable and depends on traffic volumes and processing times at each of the inspection facilities throughout the border crossing process.

- <u>Crossing time:</u> has the same beginning point in the flow as wait time, but its terminus is the departure point from the last compound that a vehicle transits in the border crossing process. As a metric, wait time is of greater significance than crossing time to CBP operations, whereas crossing time is of relatively greater interest to FHWA.

Following these definitions, in order to measure wait time, RFID readers need to be installed at the CBP primary inspection booths.

In July 2009, TxDOT contracted with TTI to install and operate the border crossing time measurement system at the World Trade Bridge and Colombia-Solidarity Bridge under an Interagency Cooperation Contract (IAC). The original contract was planned to end January 31, 2011. However, due to security constraints in the Nuevo Laredo region that prevented the installation of the RFID equipment at the Mexican side of the border, the contract was extended through the end of July 2011.

In January 2010, CBP internally sent forward a recommendation for approval of RFID installation at the primary inspection facility locations. This recommendation was made for the Pharr-Reynosa International Bridge and the Bridge of the Americas in El Paso.
Once CBP gave the authorization, TTI conducted an interference test in Pharr to check that there was no radio frequency interference between the equipment installed by CBP and the proposed

border crossing and wait time equipment. After the test was conducted successfully, the TTI team worked with TxDOT and FHWA to secure authorization from the General Service Administration (GSA) and CBP to install RFID devices at the primary inspection booths of the two crossings in the Laredo area.

During a December 2010 site visit by TxDOT and TTI staff, researchers noticed that traffic at the World Trade Bridge was queuing passed the location of the reader station in Mexico. Throughout 2010, U.S./Mexico truck traffic grew at double digits creating congestion at land border crossings. In order to read border crossing and wait times accurately, the reader in Mexico has to be located where the queue usually begins, therefore it was decided that the reader station had to be relocated farther south. In June 2011, the IAC was extended through March 31, 2012, in order to relocate the reader station and allow for more data collection period.

This report covers the work that TTI developed under the IAC with TxDOT, which includes the technology implementation, equipment procurement and installation and the data collection and analysis of information collected at the World Trade Bridge and the Colombia Solidarity Bridge.

ORGANIZATION OF THE REPORT

After this initial Chapter that describes the project background, Chapter 2 presents a description of the characteristics of the Laredo-Colombia land ports of entry. Chapter 3of the report describes the technology implementation process, including the technology evaluation and reader station locations processes.

Chapter 4 presents a description of the equipment procurement and installation. Chapter 5 describes the data collection and analysis process that was conducted with the information that was collected at both international bridges. Chapter 6 presents activities that are being considered for the future operation of the system and data dissemination.

The report includes four appendices with the list of stakeholder meeting participants and meeting agenda; the GSA permit support material; the equipment list; and the detailed report of the equipment installation at the CBP sites.

Chapter 2:
Laredo International Land Border Crossing Sites Description

INTERNATIONAL BRIDGES AT LAREDO

Laredo is located on the north bank of the Rio Grande River in South Texas. Laredo marked the third most populated city on the United States-Mexican border, after San Diego, California and El Paso, Texas. The city, along with Nuevo Laredo, Tamaulipas, Mexico, forms a Metropolitan Area with a population of 635,516 according to the 2010 census. Laredo is the U.S. major passage of the North American Free Trade Agreement (NAFTA) traffic with Mexico. About 43 percent (or $61.9 billion) of U.S. export and 39 percent (or $70.7 billion) of U.S. import to and from Mexico were through the Laredo port of entry in 2011.[1]

Laredo has four international bridges including two bridges for commercial vehicles and one railway bridge connecting two Mexican States of Tamaulipas and Nuevo León. Table 1 shows the current international bridges in operation.

Table 1. International Bridges in Laredo, Texas.

Bridge	Connecting Mexican City	Commercial vehicles	Non-commercial vehicles	Pedestrians
Gateway to the Americas International Bridge (Bridge I)	Nuevo Laredo, Tamaulipas	No	Yes	Yes
Juarez-Lincoln International Bridge (Bridge II)	Nuevo Laredo, Tamaulipas	No	Yes	No
Laredo-Colombia Solidarity International Bridge (Bridge III)	Colombia, Nuevo Leon	**Yes**	Yes	Yes
World Trade International Bridge (Bridge IV)	Nuevo Laredo, Tamaulipas	**Yes**	No	No

World Trade International Bridge (WTB) is the busiest commercial POE in the State of Texas, and in the U.S. southern border. More than 1,300,000 trucks entered Laredo, Texas, through the WTB in 2011. The Laredo-Colombian Solidarity Bridge was the fourth busiest commercial POE in 2011 (Table 2).

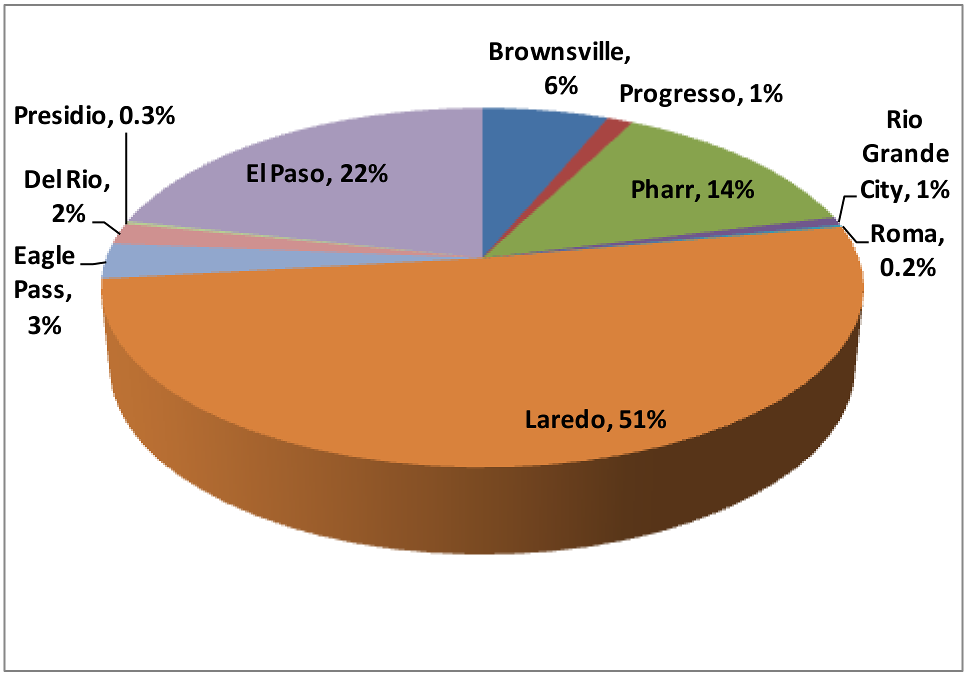
[1] Source: U.S. Department of Commerce Bureau of the Census, Foreign Trade Division, http://texascenter.tamiu.edu/texcen_services/trade_activity.asp.

Table 2. Northbound Truck Crossings in Texas (2011).

Bridge	Northbound Truck Crossings
World Trade Bridge	**1,327,479**
Pharr-Reynosa Intl. Bridge on the Rise	452,821
Ysleta-Zaragoza Bridge	379,508
Laredo-Colombia Solidarity Bridge	**374,781**
Bridge of the Americas	337,609
Veterans International Bridge	177,986
Camino Real International Bridge	106,423
Del Rio-Ciudad Acuña International Bridge	62,966
Progreso International Bridge	42,605
Free Trade Bridge	30,773
Rio Grande City-Camargo Bridge	24,398
Presidio Bridge	8,612
Roma-Ciudad Miguel Alemán Bridge	6,938

Source: U.S. Customs and Border Protection (CBP)

Laredo's economy is based on international trade with Mexico. Laredo's location at the southern end of I-35 close to the manufacturers in North Mexico promotes its vital role in trade between the United States and Mexico. Figure 1 shows the percentage of 2011 northbound truck crossings in Texas. Two commercial traffic bridges in Laredo handled more than half of the total trucks from Mexico to Texas in 2011. More specifically, 40% of all northbound trucks used the World Trade Bridge and 11% used the Laredo-Colombia Solidarity Bridge.



Source: U.S. Customs and Border Protection (CBP)

Figure 1. Texas-Mexico Northbound Truck Traffic Volume (2011).

DESCRIPTIONS OF THE INTERNATIONAL BRIDGES FOR COMMERCIAL VEHICLES AT LAREDO

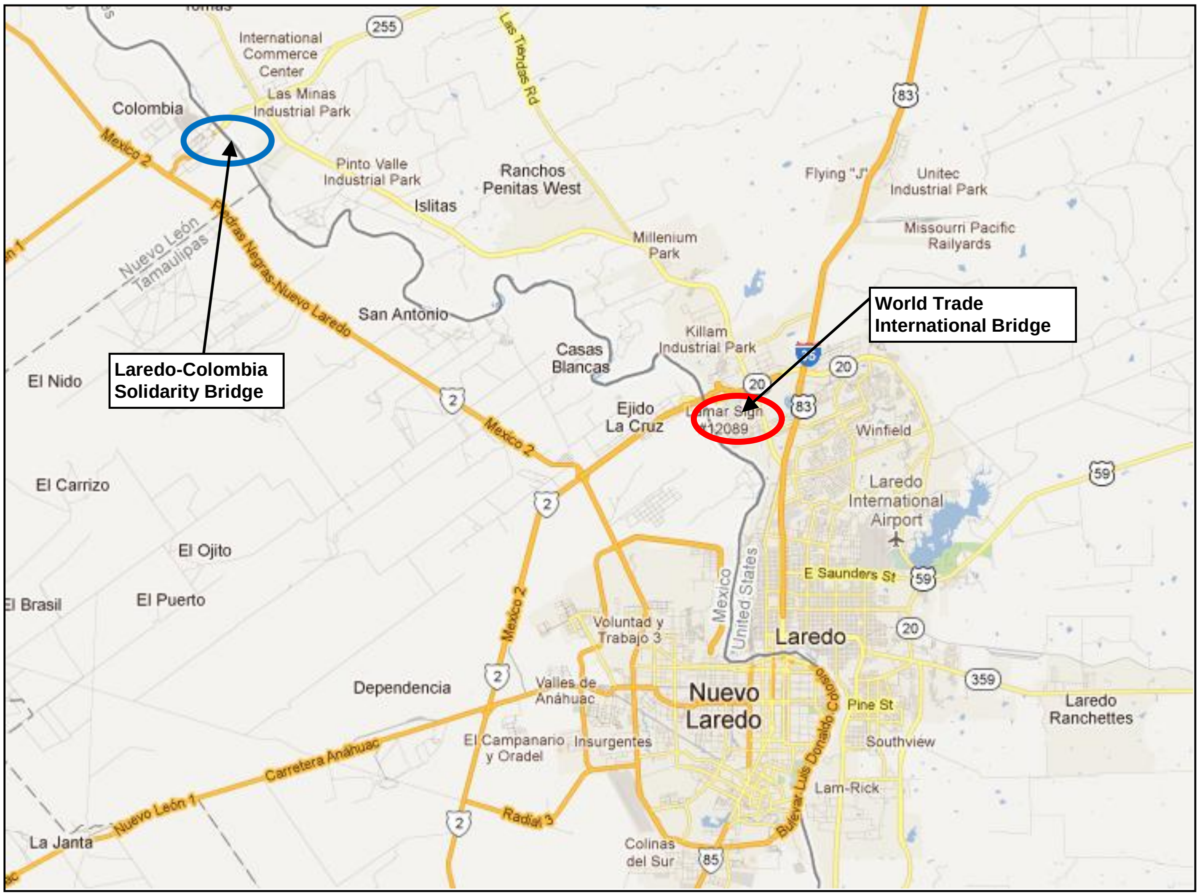
World Trade Bridge

The World Trade Bridge is located at the northern side of Laredo-Nuevo Laredo Metropolitan Area. It is owned and operated by City of Laredo and by the State of Tamaulipas (Fideicomiso del Puente III) on the Mexican side of the border. It was constructed to relieve traffic congestion in Interstate 35 south through Laredo, Texas, since most commercial traffic crossed the border through the Juarez-Lincoln International Bridge at downtown Laredo or the Laredo-Colombia Solidarity International Bridge, located farther north of the metro area. The bridge connects to Interstate 35 through the northern part of Loop 20 at Laredo, Texas, and also connects to Mexico's highway 2 and to highway 85D at Nuevo Laredo, Tamaulipas. The WTB is 977 ft long with eight lanes. The bridge is also known as Laredo Bridge 4, Puente Internacional Nuevo Laredo III and Puente del Comercio Mundial Nuevo Laredo III.

Laredo-Colombia International Bridge

The Laredo-Colombia International Bridge is located at the most northern part of City of Laredo's boundary. Among the Texas-Mexico border crossings, this is the only that one connects the State of Texas with the Mexican State of Nuevo León. This eight-lane bridge is 1,216 ft long with two sidewalks for pedestrians. The Colombia international bridge serves all traffic, including pedestrians. The bridge connects to Interstate 35 via State Highway 255 (Camino Colombia Toll Road) and has access to North of Laredo, Texas, via FM 1472 (Mines Road), Texas. On the Mexican side it is located at the northern terminus of Nuevo León State Highway Spur 1 in Colombia, Anáhuac Municipality. On the Mexican side of the border, the bridge is owned and operated by the Corporación para el Desarrollo de la Zona Fronteriza de Nuevo León (CODEFRONT). The bridge is also known as Laredo International Bridge 3, Colombia Bridge, Puente Solidaridad, Puente Colombia and Puente Internacional Solidaridad Colombia.

Figure 2 shows the locations of WTB and Laredo-Colombia Solidarity International Bridge with major highway connections around Laredo-Nuevo Laredo Metropolitan Area.



Source: TTI using Google Maps

Figure 2. World Trade Bridge and Laredo-Colombia Solidarity International Bridge Location.

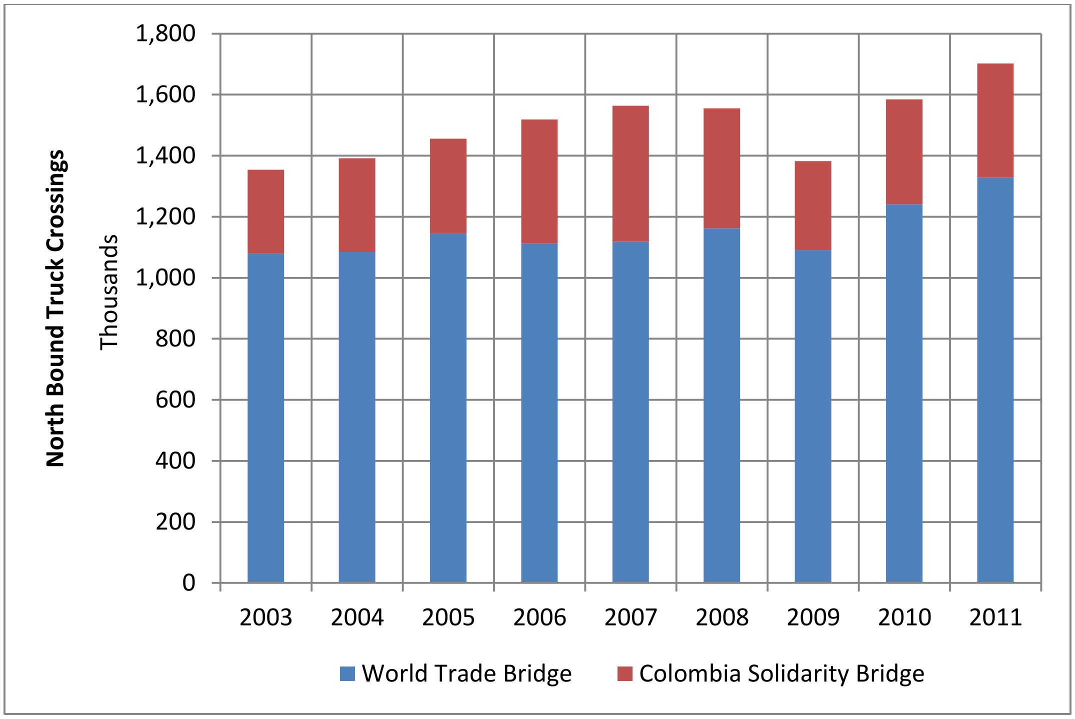
Operational Characteristics of the Laredo International Bridges

According to the U.S. Customs and Border Protection (CBP),[2] both bridges operate for commercial vehicles from 8:00 a.m. to midnight, Monday through Friday and from 8:00 a.m. to 4:00 p.m. on Saturdays. On Sunday, World Trade International Bridge operates from 10:00 a.m. to 2:00 p.m., while Laredo-Colombia Solidarity Bridge operates from noon to 4:00 p.m. Both facilities are tolled with Free and Secure Trade (FAST) designated lanes. For privately owned

[2] US Customs and Border Protection, Locate a Port of Entry, http://www.cbp.gov/xp/cgov/toolbox/contacts/ports/tx/2304.xml.

vehicles (POVs), Laredo-Colombia Solidarity Bridge is open from 8:00 a.m. to midnight every day, Monday through Sunday.

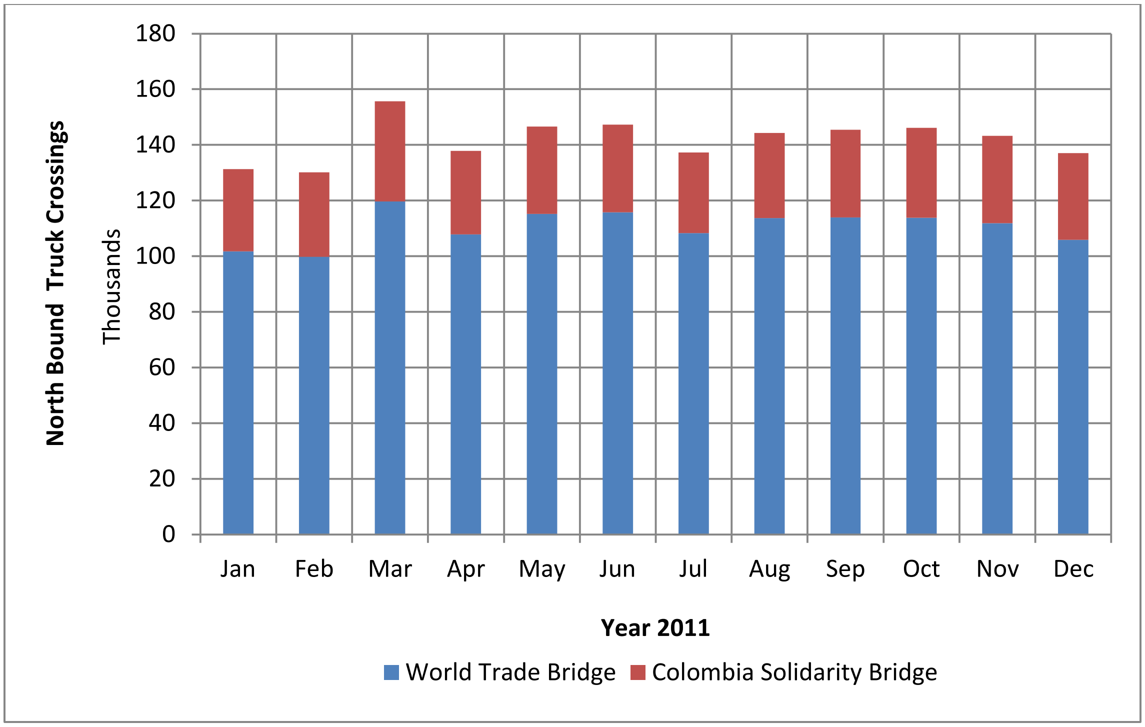
In the last decade the total number of truck crossings at Laredo was increasing. The total number of northbound traffic through the two commercial bridges in Laredo reached the highest point of 1.7 million trucks in 2011 even though there was a significant drop in 2009 due to the economy downturn. The World Trade Bridge has a share of close to 80% of the total crossings in the region. That is, the World Trade Bridge handled about 1,300,000 trucks and the Laredo-Colombia Solidarity Bridge handled about 370,000 trucks in 2011 (Figure 3).



Source: U.S. Customs and Border Protection (CBP)

Figure 3. Yearly Northbound Truck Movements through Laredo International Bridges.

Figure 4 shows the monthly northbound truck crossings in 2011. On average about 111,000 trucks per month entered Texas via the World Trade Bridge and about 32,000 trucks per month via the Laredo-Colombia Solidarity Bridge. Both bridges reached the peak monthly volumes of 120,000 trucks and 36,000 trucks in March, while the World Trade Bridge has the lowest monthly traffic in February and the Laredo-Colombia Solidarity Bridge in July.



Source: U.S. CBP

Figure 4. Monthly Northbound Truck Crossings at Laredo International Bridges (2011).

The border crossing process for commercial vehicles entering the U.S. requires several steps in which the vehicles need to stop. The time it takes a truck to cross would depend on the time spent at each of these points of inspection, toll collection, and the time it takes to move from one station to the next, which is a function of traffic volume and number of available booths.

The northbound commercial border crossing process begins at the Mexican Export Lot on the Mexican side of the border. After clearing export customs on the Mexican side, a truck proceeds to a toll booth operated by the Mexican operator of the bridge.

Once a truck pays tolls through an electronic toll-collection system or manually, then it crosses the bridge. Immediately upon entering the United States, the truck continues to the U.S. Federal Compound. Entrance to the Federal Inspection Compound is accessed through the primary inspection booths. At these primary inspection booths, a CBP agent determines whether the truck requires any secondary inspection and directs the driver to it, or otherwise instructs the driver to simply proceed to the exit. Final clearance to exit the Federal Inspection Compound is given at booths at the exit of the premises.

After leaving the Federal premises, the truck usually proceeds to the State Border Safety Inspection Facility (BSIF), where the Texas State Department of Public Safety (DPS) staff performs vehicle safety inspections. The WTB does not have a BSIF, and the DPS vehicle safety inspectors operate within the Federal Compound. The Colombia Bridge has a temporary BSIF with a permanent one under construction, expected to be operational the second half of 2012.

Aerial views of the World Trade Bridge and Laredo-Colombia Solidarity Bridge are presented in Figures 5 and 6.

Source: Bing® Maps

Figure 5. Aerial View of the World Trade Bridge.

Source: Bing® Maps

Figure 6. Aerial View of the Colombia-Solidarity International Bridge.

Chapter 3:
Border Crossing and Wait Time Technology Implementation

TECHNOLOGY SELECTION

In order to define the best technology to use to measure commercial vehicle border crossing and wait times at the two international border crossings in the Laredo region, two technologies were tested: Bluetooth and RFID.

Bluetooth Technology Test

The initial task of the project was to examine the potential for the utilization of Anonymous Wireless Address Matching (AWAM) with Bluetooth technology as an alternative for travel time measurements at the two commercial border crossings in Laredo.

In order to evaluate the potential of capturing Bluetooth addresses, between August 11 and 13, 2009, the TTI personnel deployed temporary devices at the northbound entrance to the World Trade Bridge crossing on the Mexican side and at the northbound exit onto Loop 20. To determine the viability of a corridor for AWAM a reasonable number of Bluetooth devices must be detected along the route. Past research has suggested approximately 5% of vehicles have some type of readable Bluetooth device onboard.[3]

A preliminary AWAM test was conducted at the DPS inspection station on the U.S. side of the Colombia-Solidarity crossing. The test entailed counting the number of trucks that passed by a single point (the exit of the DPS station) and to capture Bluetooth addresses at the same time. The result gives an indication of the penetration of Bluetooth into the commercial vehicles using the Colombia-Solidarity border crossing (Table 3).

[3] http://www.catt.umd.edu/documents/UMD-BT-Brochure_REV3.pdf.

Table 3. Colombia Bridge Bluetooth Devices during Test.

Start	End	Trucks	Bluetooth	Percentage with Bluetooth
11:00:00	11:15:00	14	3	21.4%
11:15:00	11:30:00	13	5	38.5%
11:30:00	11:45:00	19	2	10.5%
11:45:00	12:00:00	12	1	8.3%
12:00:00	12:15:00	19	2	10.5%
12:15:00	12:30:00	19	0	0.0%
12:30:00	12:45:00	26	2	7.7%
12:45:00	13:00:00	21	1	4.8%
13:00:00	13:15:00	16	1	6.3%
13:15:00	13:30:00	17	1	5.9%
13:30:00	13:45:00	27	2	7.4%
13:45:00	14:00:00	16	2	12.5%
	Totals	219	22	10.0%

The test was conducted between the hours of 11 a.m. and 2 p.m. and showed an average of 18 to 19 trucks per 15 minute interval. The Bluetooth address data returns an average (over the entire test period) of 10% of the vehicles having a readable device onboard. Given the data, the best performance an address matching system would be able to reach would be about 1 to 2 matches per 15 minutes or 4 to 8 matches per hour. Researchers are not confident this sample volume is sufficient to accurately measure the crossing time at this border crossing. In practice the match rate will be less and the number cited above since there is no guarantee that a vehicle read at one station will be read at another.

The Bluetooth address data taken at Colombia-Solidarity Bridge do not support furthering the concept at this port of entry. Vehicle volumes are simply too low to generate enough address matches to accurately measure an average crossing time. Single trucks that experience an unusually long crossing time will significantly skew the data sample.

An earlier observation noted that the volume of commercial vehicles at the Colombia Bridge were of such a small number that a deployment at the World Trade Bridge would be more reflective of the potential for capture in a more effective manner.

The temporary deployment of AWAM equipment consisted of a notebook computer, Bluetooth adapter (to capture the addresses of the potential vehicle devices, if so equipped) and cellular modem. The cellular modem transmitted the captured addresses back to the system server located in the TTI Houston office, where real-time calculations of travel time were computed. Figure 7 shows an illustration of the equipment deployment.

Figure 7. AWAM Portable Equipment Deployment at Mexican Entrance to World Trade.

The two collection sites at the WTB are shown in Figures 8 and 9.

Figure 8. AWAM Data Collection Site at Mexican Entrance to World Trade.

Figure 9. AWAM Data Collection Site at U.S. Exit from World Trade.

Results of AWAM observation

The temporary AWAM equipment was deployed as described for about four hours on the morning of Thursday, August 13, during a reasonably heavy period of traffic at the crossing. A count of exiting vehicles found that approximately 170 vehicles per hour passed through the crossing.

Table 4. World Trade Bridge Bluetooth Devices during Test.

Start	End	Trucks	Bluetooth	Percentage with Bluetooth
10:00:00	10:15:00	48	6	12.5%
10:15:00	10:30:00	66	3	4.5%
10:30:00	10:45:00	102	9	8.8%
10:45:00	11:00:00	92	4	4.3%
11:00:00	11:15:00	100	6	6.0%
11:15:00	11:30:00	74	9	12.2%
11:30:00	11:45:00	127	8	6.3%
11:45:00	12:00:00	67	7	10.4%
12:00:00	12:15:00	56	1	1.8%
12:15:00	12:30:00	73	11	15.1%
12:30:00	12:45:00	69	6	8.7%
12:45:00	13:00:00	55	2	3.6%
13:00:00	13:15:00	61	4	6.6%
13:15:00	13:30:00	117	4	3.4%
	Totals	1107	80	7.2%

Review of the captured addresses showed that approximately 7% of the vehicles (over the entire data collection period) carried Bluetooth equipped devices (Table 4).

To get a crossing time measurement a Bluetooth address must be detected by two stations. The addresses are matched and a crossing time is recovered by calculating the time interval between detection. This process was conducted at the World Trade Bridge and resulted in 31 unique address matches and thus crossing time data samples. The samples are spread out between 9:38 a.m. and 12:45 p.m. with this time representing when the truck exited the World Trade Bridge compound on the U.S. side.

It is assumed that the very short crossing times are for tractors or tractors with empty trailers. There are a variety of longer crossing times but not really enough to ascertain a reliable average time for this group. Because of the low sample size, a single match reflecting a truck that underwent an uncharacteristic delay will skew an average and will also be difficult to pick out as an outlier.

Table 5. Address Matches at World Trade Bridge during Test.

US Exit Time	Crossing Time
8/13/2009 9:38	0:15:40
8/13/2009 9:43	0:11:01
8/13/2009 9:45	0:15:31
8/13/2009 9:53	0:13:43
8/13/2009 9:58	0:20:22
8/13/2009 9:59	0:13:17
8/13/2009 10:01	0:26:52
8/13/2009 10:04	0:12:38
8/13/2009 10:25	0:28:41
8/13/2009 10:27	0:28:39
8/13/2009 10:32	0:34:17
8/13/2009 10:34	0:24:23
8/13/2009 10:39	0:42:30
8/13/2009 10:43	1:32:06
8/13/2009 10:59	1:53:48
8/13/2009 11:00	1:54:46
8/13/2009 11:02	0:13:09
8/13/2009 11:11	2:03:46
8/13/2009 11:11	2:03:55
8/13/2009 11:18	0:12:04
8/13/2009 11:18	0:15:20
8/13/2009 11:22	0:26:06
8/13/2009 11:25	1:36:50
8/13/2009 11:34	0:22:46
8/13/2009 11:42	0:15:05
8/13/2009 11:48	1:12:25
8/13/2009 11:59	0:51:53
8/13/2009 12:16	1:40:52
8/13/2009 12:18	3:12:07
8/13/2009 12:21	1:35:42
8/13/2009 12:45	2:00:53

Conclusion from Bluetooth Technology Test

While the few matched addresses did reasonably represent travel time (Table 5), it was felt by the TTI personnel that the numbers were not sufficient for an adequate sample for the project.

RFID Technology Test

While initial observation indicated a significant number of what appeared to be RFID tags on the windshields of the trucks, it turned out after further investigation that there are four tag systems in use in the region:

1. The Mexican operator of the World Trade Bridge (Fideicomiso del Puente III) uses a tag that has a different frequency than the FAST ego Tag.
2. The Mexican operator of the Colombia Bridge (CODEFRONT) has recently launched a program with a tag similar to the FAST tag.
3. The City of Laredo has deployed an Electronic Toll Collection system “Laredo Trade Tag” for commercial and non-commercial vehicles that is being used at the international bridges in the region. The technology used by the Laredo Trade Tag system is similar to the FAST tags.
4. U.S. Customs and Border protection has implemented the Free and Secure Trade (FAST) program in the region and is operational at both the World Trade Bridge and the Colombia Bridge. Interviews with the DPS personnel and Mexican toll representatives indicated that FAST tags were not in high use on either of these crossings.

Examples of the observed tags are shown in Figure 10.

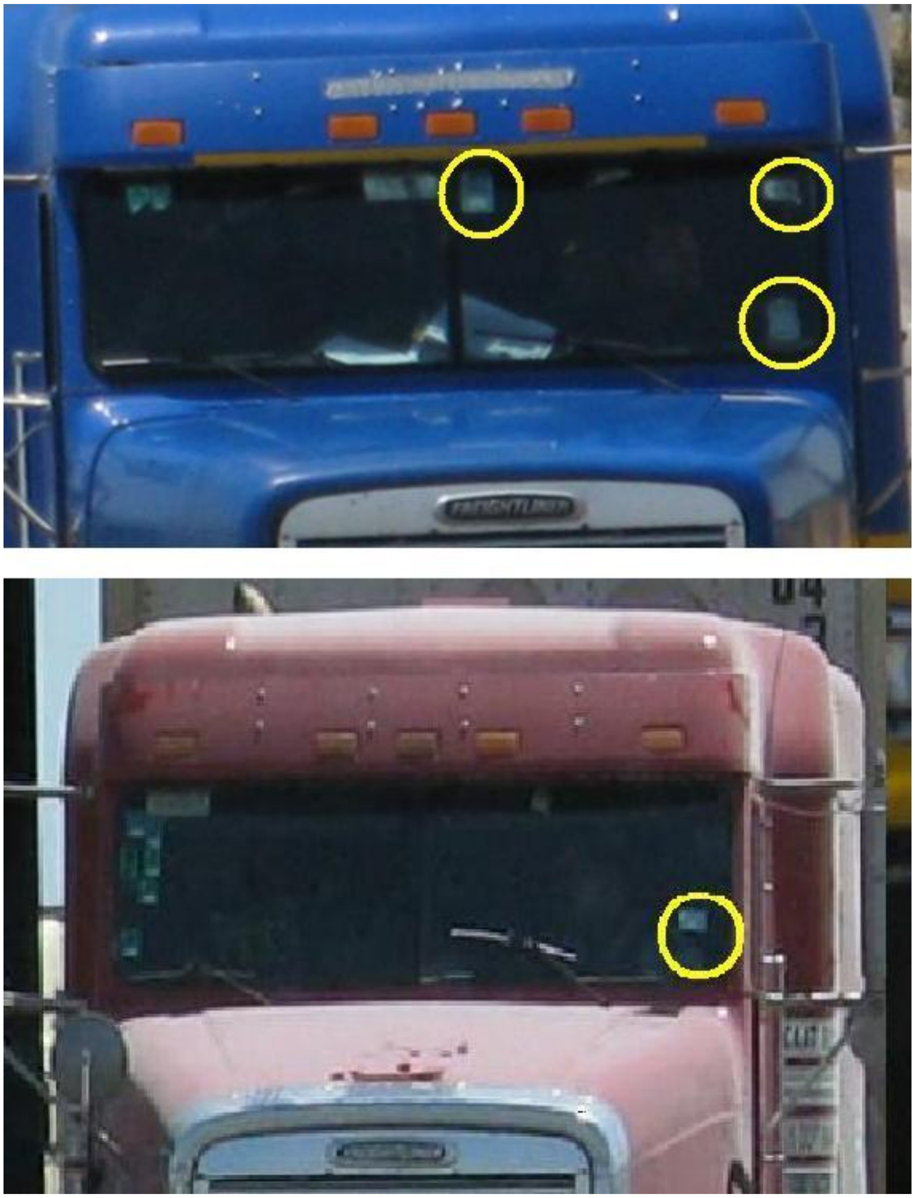


Figure 10. Toll Tags Displayed on Sample Vehicles at Laredo Crossings.

On November 4 and 5, 2009, the TTI team collected RFID tag data from the exit area of the two international bridges open to commercial vehicles. The purpose of the data collection was to determine the concentration of readable RFID tags in the commercial vehicle fleet using both bridges. RFID technology will be used for a project to measure border crossing times and the team needed to determine the quantity of tags currently in use. A low number of tags in circulation would hamper an RFID approach and likely require an effort to get vehicle owners to install tags.

World Trade Bridge

The TTI team deployed portable RFID reading equipment at a location outside the Customs and Border Protection (CBP) compound on a single lane ramp to Loop 20. All commercial vehicles exit CBP and proceed up this ramp. TXDOT's Transportation Planning and Programming (TPP)

Division has a weigh-in-motion sensor on the ramp and thus has channeled all commercial vehicles into one lane to pass over it. This situation is ideal for the portable reading equipment since it is unable to accurately read beyond an adjacent lane. Figure 11 shows the data collection location with respect to the World Trade Bridge CBP facility exit.

Figure 11. World Trade Bridge Data Collection Location.

The test plan was to setup a portable RFID reader near the travel lane and capture tags from passing vehicles. The vehicles must be in an adjacent lane for the reading equipment to reliably capture the tag's identification data. The tag data were logged using a laptop computer with files being created every 30 minutes producing 30 minute sample intervals. In addition to the tag reader, the team deployed a video camera that recorded the passage of the vehicles. An audible beeper was wired to the reader in a manner such that the beeper would indicate when a tag was read. The beeper was placed near the video camera microphone and provided a method of signaling when a tag was read superimposed on the video. The combination of video and beeper audio would allow the team to review the audio/visual data and determine exactly which vehicles had readable tags. Figure 12 shows the data collection setup on the Loop 20 ramp outside of the World Trade Bridge CBP facility.

Figure 12. Data Collection Equipment Setup at World Trade Bridge.

Data were collected at the World Trade Bridge from 10:00 a.m. to 5:00 p.m. on Nov. 4, 2009. The tag reader recorded tags on all vehicles while a member of the team visually counted the passing vehicles. The results of the data collection effort are given in Figure 13.

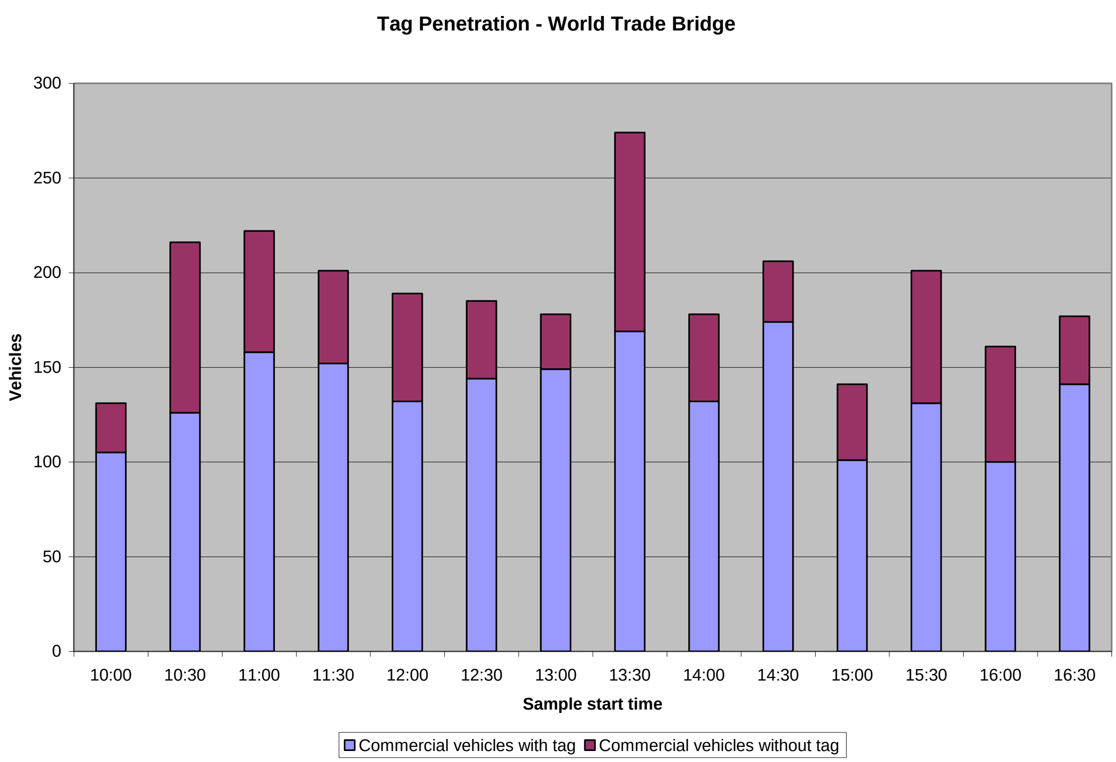


Figure 13. RFID Tag Penetration at World Trade Bridge.

Tag and vehicle count data are organized into 30 minute blocks or bins. During each 30 minute period the total number or tags recorded is shown and compared to the total number of passing commercial vehicles. It is quite evident from the chart that a significant number of vehicles using the World Trade Bridge are outfitted with an RFID tag of some kind. Taking an overall look at the data, the number of vehicles with a readable tag is in excess of 70% of all passing vehicles.

The 70% number should be considered a maximum percentage with a true percentage likely being a little lower. It is quite possible that some of the passing vehicles, especially tractor trailer combinations, have more than one readable tag. The tag recording mechanism did not include a timestamp and thus multiple tags on one vehicle could not be filtered out. The multiple tag effect would skew the above conclusions higher than true numbers. A brief review of the video tape indicted that indeed a few trucks had more than one readable tag but there were not enough of these multi-tag trucks to significantly skew the results.

Colombia – Solidarity Bridge

A data collection setup very similar to the one at the World Trade Bridge was planned for November 5. TPP has a weight-in-motion station between the Colombia-Solidarity International Bridge and the CBP complex and the Texas Department of Public Service (DPS) vehicle safety inspection station. The road narrows to a single lane at the weigh-in-motion site, which was ideal for installing the RFID tag reader. This site does differ in an important aspect to that of the World Trade Bridge site. All vehicles moving through the border crossing pass this site, commercial and passenger vehicles. Figure 14 shows the site selected for the data collection.

Figure 14. Colombia-Solidarity International Bridge Data Collection Site.

The team deployed the portable tag reading equipment and the video camera in a manner similar to the World Trade Bridge session as shown in Figure 15. Early in the data collection process, a reasonable number of passenger vehicles had RFID tags and were being collected. It became obvious that the number of passenger vehicles with tags were significant. A simple raw tag read number per sample period would not produce an accurate picture of commercial vehicles with tags.

Figure 15. Colombia-Solidarity International Bridge Data Collection Setup.

The team decided to utilize the video with the embedded beep to manually count the number of commercial vehicles. The video camera creates a new video file on approximate 52 minute intervals. These files were chosen for manual counts and the 52 minute sample interval was used over the 30 minute interval for the World Trade Bridge data. Four video files were chosen spanning the time period of 10:45 a.m. to 2:14 p.m. Since passenger and commercial vehicles were present on the roadway, the manual video count centered strictly on tractor trailer combinations. Pickup and flat bed trucks were not counted because it could not be determined if they had passed through the commercial vehicle or passenger vehicle portion of the Colombia-Solidarity complex. Tractor trailer combinations would have passed through the commercial side. The results are given in Figure 16.

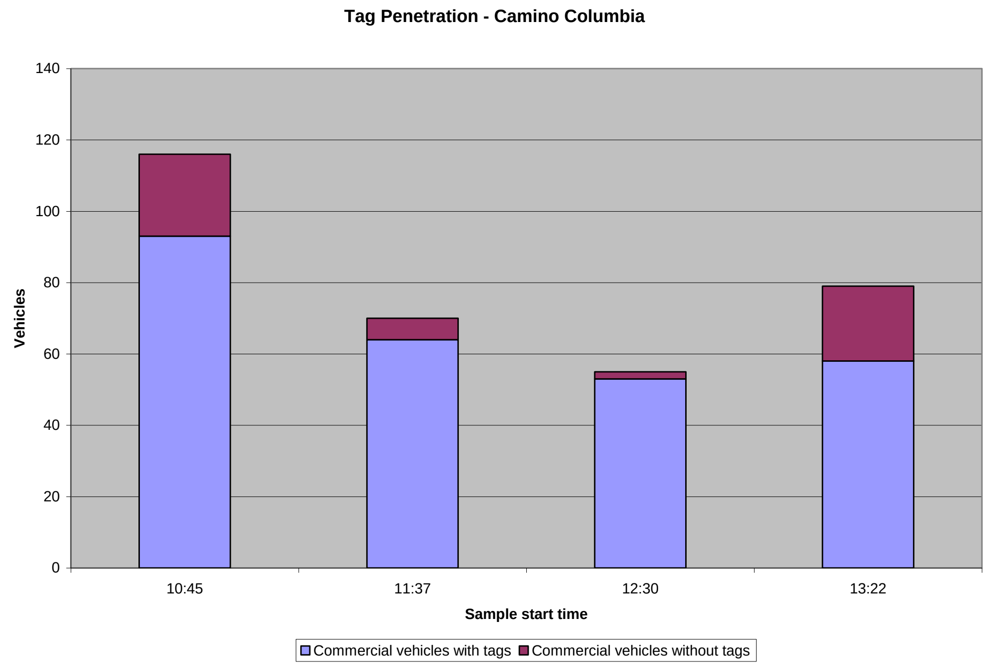


Figure 16. Tag Penetration at Colombia-Solidarity International Bridge.

Very high percentages of tractor trailer combinations carry an RFID tag at Colombia-Solidarity International Bridge. The biggest standout that did not have tags was vehicles pulling new semi-tractors. Nearly all other tractor trailer combination had a tag.

Conclusion from RFID Technology Test

Sample RFID tag data were collected from both border crossing areas and the results showed that there are enough readable RFID tags in current circulation to yield good quality results in an RFID tag-based border crossing time system. The commercial vehicle tag penetration numbers are approximately 70% at the World Trade Bridge and the tractor trailer tag numbers at Colombia-Solidarity International Bridge are even higher.

STAKEHOLDER INPUT

Once the technology to measure commercial vehicle crossing and wait times was defined, a preliminary implementation plan was defined and a stakeholder meeting was organized. The objective of the stakeholder meeting was to present to key stakeholders the project plan and receive input from them. On October 21, 2009, a meeting was held at the Texas A&M International University Student Center, in Laredo Texas.

Representatives from 10 public agencies and private sector stakeholders, from the U.S. and Mexico participated in the meeting. Agencies and groups that participated in the meeting include:

- Aduana Nuevo Laredo.
- Asociación de Agentes Aduanales de Nuevo Laredo (AAANLD).
- Association of Laredo Forwarding Agents (ALFA).

- Central de Servicios de Carga de Nuevo Laredo (CENSOCAR).
- Corporación para el Desarrollo de la Zona Fronteriza de Nuevo León (CODEFRONT).
- Puente Comercio Mundial, Gobierno del Estado de Tamaulipas.
- Texas Department of Public Safety (DPS).
- Texas Department of Transportation (TxDOT).
- Texas Transportation Institute (TTI).
- Transit Nuevo Laredo.

The meeting agenda in English and the list of participants is presented in Appendix A of this report. The key topics that were discussed during the meeting were:

- Technology Overview.
- How the Proposed System Will Work.
- World Trade International Bridge Layout and Proposed Measuring Locations.
- Colombia-Solidarity Bridge Layout and Proposed Measuring Locations.
- Equipment installation examples at other bridges.
- Information dissemination.

After the presentation, stakeholders were engaged in discussion regarding the information, and the organizers posted questions such as:

- Would better information change these decisions?
- What would be the impact of additional access to border wait time information on the supply chain?
- Would real-time information help add value?

The meeting was very productive and stakeholders expressed their interest in receiving information on travel and crossing times in various formats, including electronic messages as well as monthly reports. The Customs Broker Association (AAANLD) offered to operate the system once it was operational.

Follow up one-on-one meetings with several of the participants were identified, and TTI staff met with CODEFRONT, Puente Comercio Mundial, Aduana de Nuevo Laredo, and DPS to present the detailed plan once it was developed.

READER STATION LOCATION

Interviews with the Mexican representatives at both crossings enabled the TTI staff to find acceptable deployment locations for the northbound collection points. While power might be available sometime in the near future at the WTB entrance from Mexico, it is suggested that solar power be planned for all the locations in Mexico, other than at the toll plazas themselves. Figure 17 shows potential locations for RFID equipment deployments at the WTB.

World Trade Bridge Potential Reader Location

Figure 17. World Trade Bridge Potential RFID Locations.

The analyses of traffic flows and existing infrastructure at the WTB lead to four potential locations for the installation of RFID reading stations:

- R1. The most southern location where trucks travel at free flow speed before reaching the end of the queue. There is an abandoned bridge that could be used to install readers and antennas. There is no power source at that location, so a solar panel would be required. Antennas could be installed at three lanes.
- R2. This location is at the exit of the toll booth at the Mexican side of the border. The toll booth canopy could be used to support readers and antennas. There were six lanes at that time with A/C power.
- R3. Once trucks cross into the U.S. side, there are two alternatives for the installation of readers. Two alternatives were identified because at the time of the development of the Implementation Plan, there was no assurance that CBP would allow the installation of readers at its premises. R3A was identified before the entrance to the federal compound. Readers would be installed in a gantry crossing three traffic lanes. R3B would be at CBP primary inspection booths, installing antennas on eight lanes.
- R4. There is no BSIF at the WTB, therefore the plan was to install a reader once trucks exited the federal compound. The original location that was identified was to mount a reader on pole at the weigh in motion (WIM) on ramp to LP20. There is A/C power at this location.

Colombia Solidarity Bridge Potential Reader Location

Figure 18 shows potential locations for RFID equipment deployments at the Colombia-Solidarity Bridge.

Figure 18. Colombia-Solidarity Bridge Potential RFID Locations.

The four points are as follows:

- R1. This station would be located within the CODEFRONT compound and will use the existing sign structure. A solar panel would be required, as there is no power available. Antennas could be installed at three lanes.
- R2. This location is at the exit of the toll booths operated by CODEFRONT at the Mexican side of the border. The toll booth canopy could be used to support readers and antennas. There are four lanes with A/C power.
- R3. Using the same assumption as at the location of R3 at WTB, two alternatives were identified. The first one at the entrance to the federal compound. Readers would be installed in a gantry crossing three traffic lanes. R3B would be at CBP primary inspection booths, installing antennas on eight lanes..
- R4. The last reader at this crossing would be installed at the temporary BSIF. There is A/C power and the readers could be installed at the exit of the facility.

CONCEPT OF OPERATIONS

The concept of operations (ConOps) that was previously developed under the FHWA-Bridge of the Americas in El Paso project was modified to meet the Laredo region border crossing time measurement requirements. A summary of the ConOps that describes the organization and operation of the system for the Laredo World Trade Bridge and Colombia-Solidarity Bridge project is described in this Chapter.

The border crossing measurement system is organized into three subsystems representative of each component's function:

- Field Subsystem.
- Central Subsystem.
- User Subsystem.

The Field Subsystem is comprised of the tag detection stations including the communication equipment. A minimum of two detection stations are required, one in Mexico and one in the United States. The detection station reads RFID tags and passes the data to the Central Subsystem via the communication equipment. The Central Subsystem receives tag reads from the field detection stations and performs all processing to derive and archive the aggregate travel times between the stations. The User Subsystem interacts with the Central Subsystem to provide an Internet web portal for data users (stakeholders, the public, etc.) to access current border crossing times and, if given proper credentials, to access archived crossing time data. Figure 19 shows the system's organization.

Northbound commercial vehicles (trucks in Mexico destined to cross the border into the United States) pass an RFID tag reader installed at a point sufficiently ahead of the end of any queue on the Mexican Export Lot. This reader station is defined as R1. The RFID tags on the trucks are read as they pass the reader stations. The tag query process recovers a unique identifier for each vehicle similar to a serial number. The reader stations applies a time stamp to the tag read and forwards the resulting data record to a central location for further processing via a data communication link. On the U.S. side of the border, two tag reading stations were installed, one at the CBP primary inspection booths (R2) and at the exit of the BSIF (R3). As mentioned earlier, the WTB does not have a BSIF, so the R3 station was installed at the exit of the CBP federal compound.

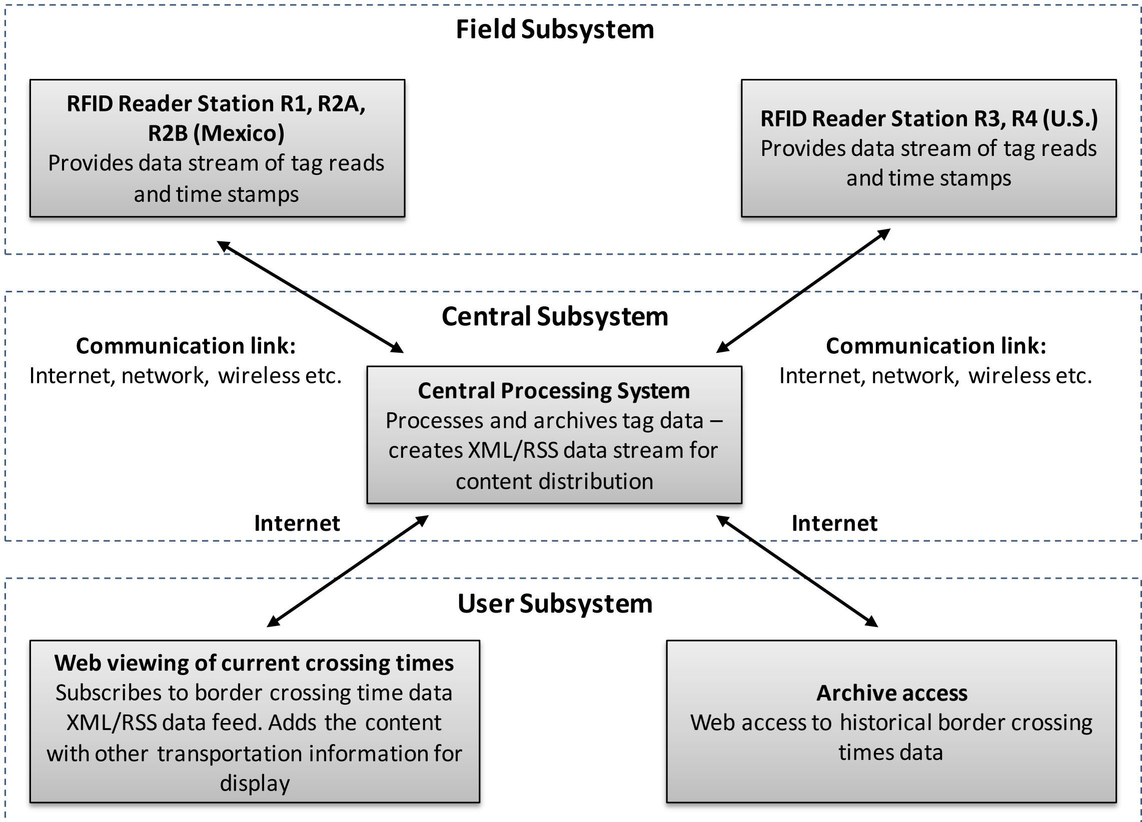


Figure 19. Subsystem Organization Diagram.

The central facility receives data from all tag reading stations associated with the project. As of now the central facility is a secured database server located at TTI office in El Paso. The database server stores all inbound raw reader station data and subsequent processed data in an archive for future access and use by regional transportation agencies and other authorized stakeholders. In essence, the database server acts as a data center for the system. The database server has enough storage space to archive several years of data from the system and the server is expandable if additional storage space is required in the future.

The raw data are processed to match tag reads of individual trucks at the entrance point on the Mexican side and the exit point on the U.S. side. The difference in time stamps yields a single truck's progression as a function of time through the POE. The tag matching process is executed periodically to obtain a reasonable sample of trucks to produce an average.

Because the Colombia port of entry has mix of cars and trucks with toll tags, the database in the server also includes an algorithm to separate out crossing times of trucks only.

The User Subsystem manages access border crossing time data for? the users. As of now, the most recent average crossing time data are available to the public via an RSS subscription. TTI has developed a prototype border crossing information system through funding from the FHWA. The prototype includes a map-based website to view the most recent average crossing time data and segment travel times and will also include interfaces to query archived border-crossing data

FINAL IMPLEMENTATION PLAN

At the time that the final implementation plan was being developed, CBP internally sent forward a recommendation for approval of RFID installation at the primary inspection facility locations. This recommendation was originally made for the Pharr-Reynosa International Bridge and the Bridge of the Americas in El Paso. In order to provide the final approval for installation, CBP requested an interference test to verify that there was no interference between the equipment installed by CBP and the proposed border crossing and wait time equipment. After the test was conducted successfully at the Pharr-Reynosa International Bridge, CBP approved the installation of RFID readers at the primary inspection booths.

With this approval, the TTI research team proceeded to develop a final implementation plan. Based on site visits and discussions with stakeholders in Mexico and the U.S., it was decided that three RFID reading stations will be required to measure crossing and wait times at both international bridges in the region:

- **R1** at the most southern end of the truck travel path.
- **R2** at the CBP primary inspection booths.
- **R3** at the DPS BSIF in the Colombia Bridge, and at the exit of the CBP compound at the WTB.

The TTI team worked with TxDOT and FHWA to secure authorization from the General Service Administration (GSA) and CBP to install RFID devices at the primary inspection booths of the two crossings in the Laredo area, and at the exit of the CBP compound of the WTB. The document that was prepared for GSA to obtain authorization is presented in Appendix B.

The final configuration of the reader stations is presented in the following table. The two reader stations in Mexico require solar energy, as they are located where there is no power source. The list of equipment for this project is presented in Appendix C.

Table 6. Final Reader Station Configuration.

Reading Station	Number of Readers	Number of Antennas	Solar Power
R1 - WTB Mexico	2	3	Yes
R2 - WTB CBP Primary Inspection Booths	4	8	
R3 - WTB CBP Exit Booths	2	4	
R1 - Colombia Mexico	1	2	Yes
R2 - Colombia CBP Primary Inspection Booths	2	4	
R3 - Colombia BSIF	1	1	
TOTAL	**12**	**22**	**2**

Chapter 4:
Equipment Procurement and Installation

EQUIPMENT PROCUREMENT

With the final list of equipment required for all six reading stations, the equipment was procured following the Texas A&M University guidelines. The RFID equipment has the longest lead time, which goes between 2 and 3 months. Once the RFID equipment was ordered, the other communication equipment and solar panels and batteries were purchased. The equipment cabinets were assembled in College Station and tested before sending them to Laredo.

The equipment destined for the two sites in Mexico had to be imported. A Mexican customs broker was retained to perform this and TTI prepared all the required material for the importation into Mexico.

INSTALLATION

TTI retained two different contractors to work on the Mexican and the U.S. sides of the border. The U.S. contractor had to be vetted by CBP in order to work on federal property and also requires special insurance as required by GSA. TTI secured permission and coordinated with the operator of the WTB, the Fideicomiso Puente III, with CODEFRONT for the Colombia Bridge, with CBP and GSA to work on the federal compounds and with the Texas DPS for the installation at the BSIF in Colombia.

Installation in Mexico

Once the equipment was imported into Mexico, the installation in Mexico was performed in November 2010. At the WTB installation was done originally at the abandoned bridge in the road that leads to the Mexican export lot and toll booths. Figure 20 shows the final installation with solar panel and three antennas.

Figure 20. Original WTB R1 Installation.

A visit to the site was performed in December 2010 and it was noticed that traffic was queuing well beyond the original reader station (Figure 21). Northbound truck traffic at the WTB grew 18.4% between 2009 and 2010, creating congestion at this border crossing. In order to accurately measure travel time, the first reader had to be installed at a location where trucks are traveling at free flow speed, therefore it was decided that the reader at the WTB in Mexico had to be moved farther south. The IAC contract was amended and the reader was relocated farther south and installed using poles at each side of the road, as shown in Figure 22.

Figure 21. Truck Queues at WTB R1 Original Location.

Figure 22. Final WTB R1 Installation.

The installation of the R1 reading station at the Colombia Bridge was done at the sign structure that leads to the Mexican export lot and toll booths (Figure 23). On January 21, 2011, a strong wind brought down the solar panel and the battery and equipment cabinets. These were re-installed using a stronger structure at the same location.

Figure 23. Colombia R1 Installation.

Installation at the Colombia BSIF

The RFID station was installed at the Colombia Bridge DPS primary inspection platform on August 25, 2010. The team first checked in with DPS and briefed them on our work plan. The facility was essentially shutdown for the day to allow for the DPS crew to receive training. The team hired a local electrician to tap into an outside duplex electrical outlet and run conduit and electrical cabling to the RFID cabinet. The installation went smoothly and was ready for testing by the end of the day.

Figure 24. RFID Station at Colombia Bridge DPS BSIF.

Testing/Verification of Performance

The RFID installation was finalized and tested on August 26, 2010. As trucks approached the inspection platform a team member identified RFID tags on the truck windshield while another member verified the tags were read. Vehicles without tags were noted. For unread tags, a brief description of the tag condition was included.

Figure 25. RFID Tag Reading at Colombia Bridge DPS.

The team conducted tests during two periods of time:

- Test 1: 10:15 a.m. to 11:43 a.m.
- Test 2: 3:07 p.m. to 4:00 p.m.

The data show that there are very few trucks without some kind of tag and approximately half of the truck samples have multiple tags. On 148 trucks with tags, 249 tags were read. The reader read as many as 3 tags per truck in numerous cases. If trucks had only a single tag or a 3 tag set, then 50 out of the 148 trucks would have multiple tags (34%). If trucks had only a single tag or a 2 tag set, then 101 trucks would have multiple tags or 68%. The true number is somewhere in between with 50% of the trucks having multiple tags a reasonable estimate.

Many of the no-tag trucks were construction vehicles working on the new DPS BSIF. This situation skews the true number of border crossing trucks without tags since these vehicles do not cross the border and are temporarily operating in the area. With these vehicles removed from the counts the percentage of trucks at the Colombia Bridge crossing with some identification tag is in the 90% range or better.

The network settings were configured and a connectivity test showed that tag read data from the Colombia Bridge DPS site was being transmitted to servers in El Paso and College Station. Table 7 documents the raw data from the tag read testing.

Table 7. Colombia Bridge BSIF Tag Test.

Start Time	Trucks without Tag	Trucks with Tag(s)	Tags Not Read	Tags Read
10:15	3	19	2 - torn tags not read	29
10:30	1	20	1 - tag coming off	34
10:45	2	20	0	35
11:00	1	33	0	56
11:15	1	35	0	57
11:30	1	21	0	38
11:43	11:30 to 11:43 time frame - not a full 15 minutes			
15:07	2	5	0	9
15:15	2	35	0	66
15:30	2	25	0	39
15:45	0	16	0	27
16:00	End test			
Totals	9	148	3	249

The RFID system read every tag that was readable. The few misses were tags that were improperly applied, damaged, or in dire need of replacement. In conclusion, Colombia Bridge DPS install was a total success. We encountered very few problems and the system is up and running.

Installation at CBP – WTB and Colombia

The TTI team installed RFID equipment at the WTB and Colombia primary inspection booths and at the WTB exit booths between May 5 and May 12, 2011. A complete report of the installation is presented in Appendix D. A summary of the installation is described in this Chapter.

WTB Primary Inspection Booths

The contractor team outfitted the original eight lanes at the WTB primary inspection booths with tag reading capability. A recent expansion at WTB has increased the number of Primary lanes. A panel antenna was installed over each of the eight lanes. Pairs of antennas were assigned to each of the four readers with the readers being installed on the conduit in between their associated antennas. The Primary lanes reader/antenna installation is shown in the following figure.

Figure 26. RFID Installation at the WTB Primary Inspection Booths.

Installation at WTB Exit Booths

A second installation was done at the WTB exit booths. Here the older four lanes (of five lanes total) were selected for detection with each lane receiving an overhead panel antenna hung from conduit just as in the primary lanes. The antennas were positioned at the exit end of the overhead canopy (Figure 27).

Figure 27. RFID Installation at WTB Exit Booths.

Installation at the Colombia Bridge

The team installed antennas over the four busiest lanes at the Colombia Bridge Primary inspection booths. The connection was made permanent by using appropriate electrical enclosures at the canopy connection point and electrical conduit between the canopy and the control cabinet (Figure 28).

Figure 28. RFID Installation at the Colombia Primary Inspection Lanes.

Chapter 5:
Data Collection and Analysis

This Chapter highlights some of the key findings of the data collection and analysis portion of the project. These data were collected from when the project went online on May, 2011 through March, 2012. That period was considered to have yielded 6 months of data, since there was a cumulative interruption of several weeks due to circumstances discussed in the following Chapter.

DATA COLLECTION AND WIRELESS TRANSMISSION

Each RFID station has an antenna located over each lane at the location. The antenna positioning is such that vehicles passing underneath that have readable tags and pass under both reader stations should receive a tag match. The location of each reader was chosen to limit the number of antennae required for site coverage. The antenna connects with a traditional tolling quality RFID tag reader that can reliably read the protocol of a variety of tags carried by trucks crossing the border. The tag reader continually scans for a passing tag. (NOTE: it is important for the tag to be correctly positioned and under the windshield's glass for best readability results.) As a tag passes the reader's antenna, a unique code is recovered from the tag via an exchange of radio frequency energy. The code is converted into a digital message and forwarded to the RFID station's onsite data logging component. The reader's data communication protocol is such that few or no end to end communications and additional data transmissions are required during normal operation (tag read mode). The conceptual design does not currently include any additional processor or computer platform to manage the RFID reader at the local level.

The onsite logger is used to capture, time-stamp, and store all tag messages (tag reads with vehicle identification code) from the reader and can also be accessed either remotely or locally if a problem in communication interrupts data flow from the site. The logger can be considered a backup to secure the vital data needed to accomplish the main goals of the project in the event of communication failure. The logger then passes data moving both from the RFID reader and toward the reader. All data coming from the reader (tag data) are time-stamped and logged.

The tag read messages are routed out of the field site and toward a central server at a project office in El Paso, Texas, in near real-time. A communication solution was implemented for each field location. The communication setup included data transmission between the RFID station and the central server via cellular data.

RFID readers send data to the fixed Internet Protocol (IP) address on a fixed User Datagram Protocol (UDP) port number using a cell modem. The UDP listener on the central server monitors the UDP port for any incoming data packets. When the UDP listener detects any data packets on the incoming port, it reads the data packets, associates a time-stamp with the data read, and invokes a stored procedure on the database. This stored procedure then inserts the data read into the raw data table. A trigger is fired whenever any new data are inserted into the raw data table. This trigger verifies whether the data are coming from a valid combination of reader ID and IP address. If a valid combination is detected, then the tag number is parsed out of raw data and the tag number and associated time-stamp are inserted in the processed data table. If the combination is not valid, then the raw data and time-stamp are inserted into the error data table. Figure 29 illustrates the entire data transmission and archiving process.

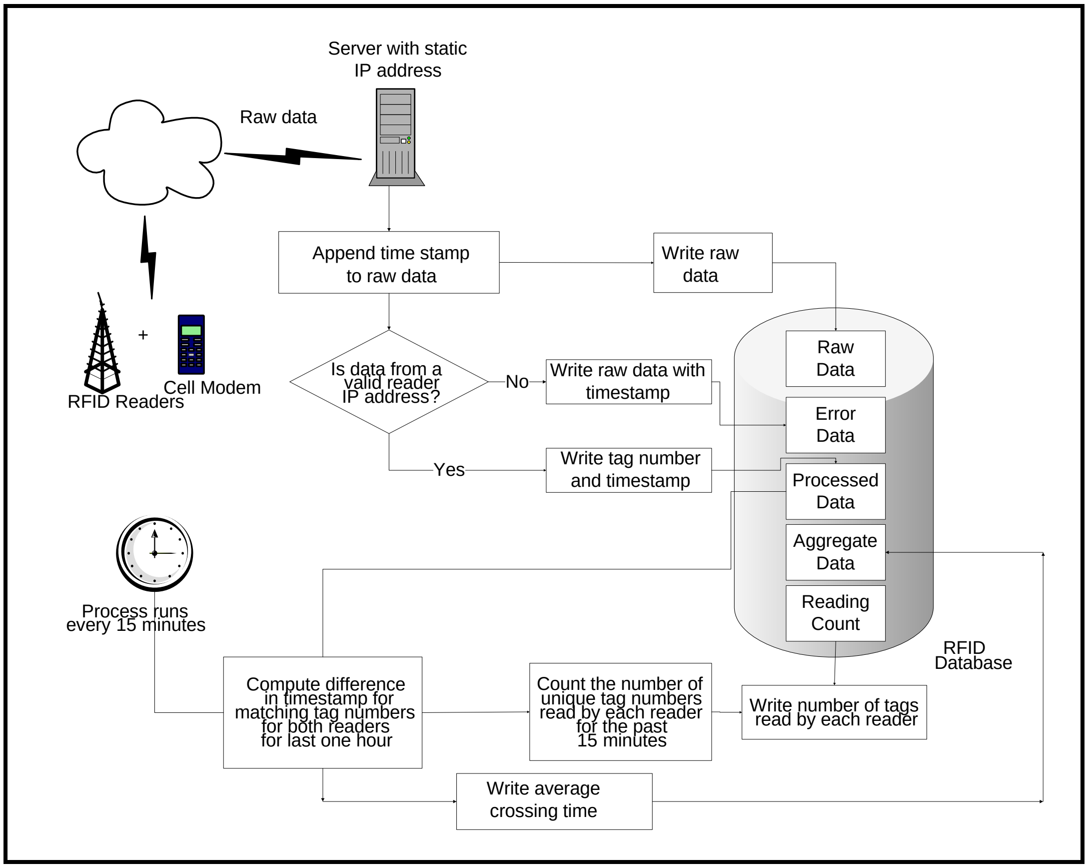


Figure 29. Data Communication and Archiving Process.

AUTOMATED MEASUREMENT OF CURRENT TRUCK CROSSING TIMES

To calculate crossing times, an aggregation process that runs on the database server every 15 minutes was developed. The server after receiving the raw tag identification data calculates the average crossing times of trucks every 15 minutes using a 2-hour time window. The average travel times between the readers are determined using the following procedure:

- The average travel times are calculated every 15 minutes (e.g., 9:00 a.m., 9:15 a.m., and 9:30 a.m.)
- The procedure uses 120 minutes as time window, meaning this value is used as a maximum travel time that could occur at any given segment and total crossing time.
- For example, to calculate average travel time between R1 and R2 at 9:00 a.m., all the tags that were read between 7:00 a.m. and 9:00 a.m. are matched and travel times of matched tags are averaged (simple mean).

The average truck crossing time determined by the above-mentioned procedure is also used to update XML data files, which are shared via the RSS process. Using RSS, external users can obtain the most recent truck crossing time via the Internet.

DATA ARCHIVE

The central database server maintained at an El Paso, Texas project office includes several database tables where raw and processed data are archived. At present, the archived data are not available to external users. However, archived data can be provided to stakeholders off-line at their request. As of the date of this report, the database has been successfully archiving data collected from the readers since the system became operational on May, 2011.

DATA ANALYSIS AND TRENDS FOR CROSSING TIMES OF TRUCKS

This information will be presented in two Chapters: (1) unmatched tag reads with analysis, and (2) matched tag reads with analysis. Unmatched tag reads are the total number of tag IDs detected by a RFID reader station within a certain period (e.g., a day or month of operation), regardless of whether they were detected by other reader stations in the system during that same period. For measuring northbound crossing time on this project there were two reader stations: R1 on the Mexico side and R3 on the U.S. side. For measuring northbound wait time on this project there were two reader stations: R1 on the Mexico side and R2 on the U.S. side at CBP primary inspection booths. Graphs for data collected by each reader are portrayed as the Mexico side or U.S. side. Some tags were not readable for various reasons, which resulted in a smaller number of unmatched tag readings for either side of the border compared to the total volume of truck crossings for the same period reported by government border crossing operators.

Events both external and internal to the system occurred during this more than 6-month period that affected the tag reads. The analysis includes an explanation of what root causes were known to have brought about an anomaly, or if not conclusively proven, speculation as to the root cause. The analysis also includes trends observed regarding wait time and crossing time of U.S. bound trucks.

UNMATCHED TAG READS

A central database server housed at an El Paso office receives transponder (tag) identification data from the field RFID readers. In addition to the algorithms used to measure crossing times, the database contains a separate table to store highly detailed information from which the number of transponders read each day on both sides of the border can be retrieved.

One key objective in analyzing the daily transponder count is to understand the trend of commercial vehicle traffic flow during normal times, planned, and unplanned events that might impact the demand at the port of entry. Another key objective is to keep a log of when hardware failure occurred, for how long, and why.

The following graphs in Figure 30 and 31 shows transponder read information for each of the months from May 2011 through March 2012 for World Trade Bridge and the Columbia Bridge. The information shows that there are at least 6 months of data, as expressed in the contract. Some "blackout" periods exist as the system on the field malfunctioned for several reasons.

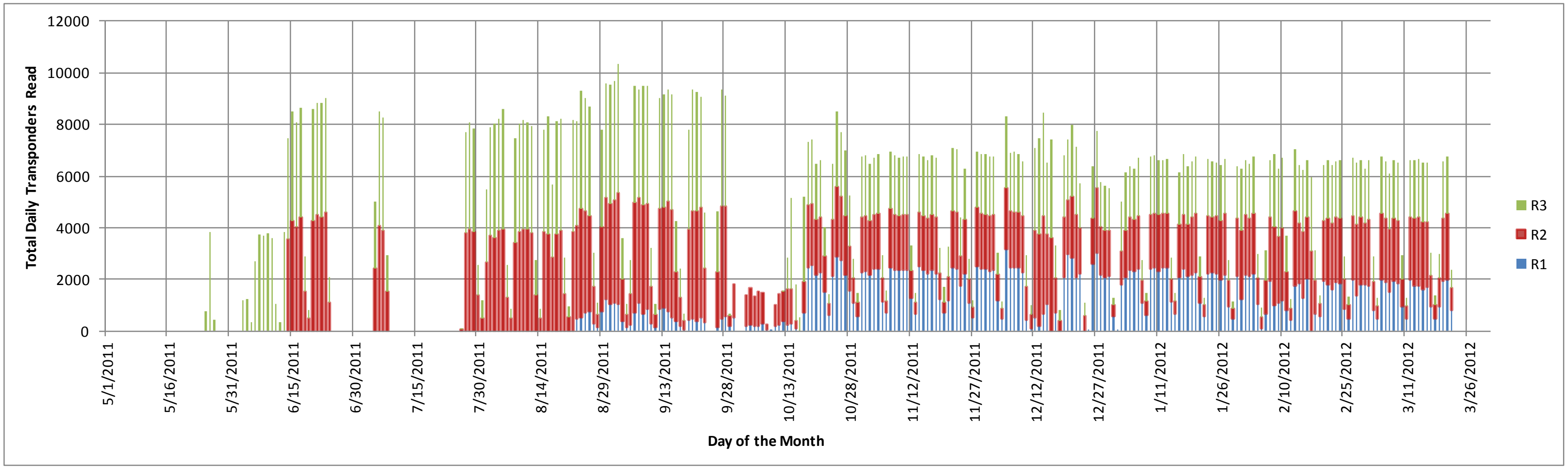


Figure 30. Transponder Count Summary for World Trade Bridge.

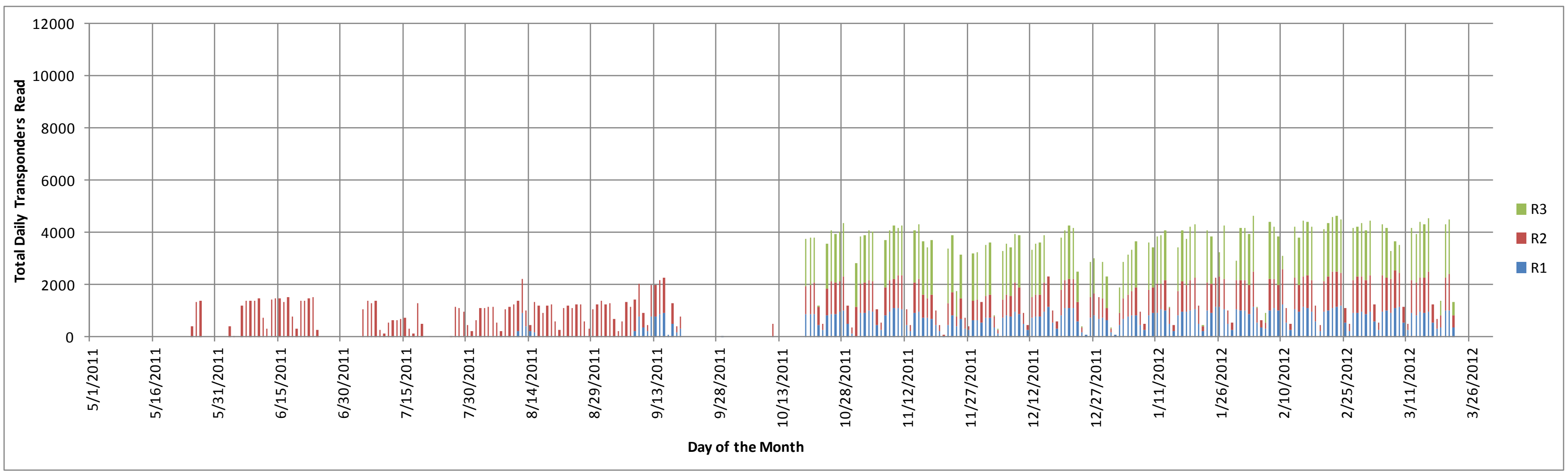


Figure 31. Transponder Count Summary for the Colombia Bridge.

MATCHED TAG READS

Matched tag reads for the system are the total number of tag IDs that were detected at R3 after having been previously detected at R1 within a certain buffer period to measure crossing time and tag IDs that were detected at R2 after having been previously detected at R1 within a certain buffer period to measure wait times of US bound trucks. This period, which was generally set at 120 minutes, is adjustable. The buffer period is necessary so that trucks detained in secondary inspection for a long time and trucks that make multiple trips in which they are missed by a reader during a trip, do not cause the average crossing time to be longer than is representative of the operation. The matched tag read numbers are also known as the sample size.

The number of matched tag reads during a certain period will typically be lower than the unmatched tag reads for either side of the border. That is because of factors such as trucks that divert and do not cross the border after crossing R1 and trucks held in the Mexican Export Lot of or U.S. secondary inspection or BSIF.

Histogram of Wait Time of U.S. Bound Trucks

Histogram is a summary graph showing a count of data points falling in different ranges of values. The following figures shows histogram of truck wait times data for 30 day period and a single weekday period. Both figures show that 95th percentile of trucks takes approximately 70 minutes or less for WTB and 100 minutes or less for Colombia Bridge to wait at the border, and the 50th percentile of trucks requires approximately 30 minutes or less for WTB and 20 minutes or less for Colombia Bridge to wait at the border. It also illustrates highly variable wait times during different times of day. Obviously, empty trucks require less processing time at the CBP than non-empty trucks, and trucks enrolled in the FAST program require less processing time than trucks not enrolled in the program. Being able to distinguish the type of trucks (empty versus loaded) and FAST versus Non-FAST by additional RFID readers will provide a better way of distinguishing wait times of different types of trucks.

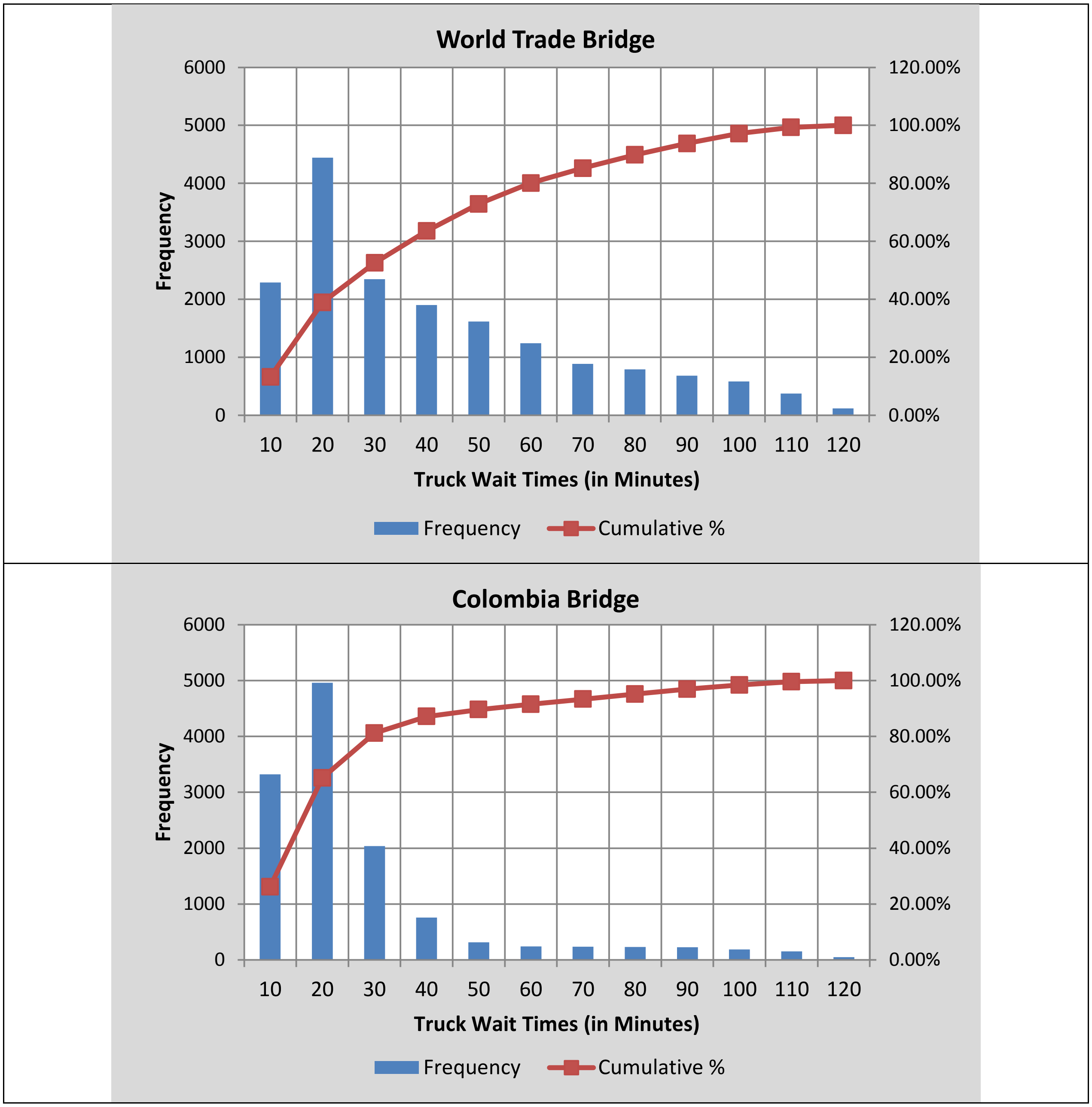


Figure 32. Histogram of Truck Wait Times over a 30-Day Period (January 2012).

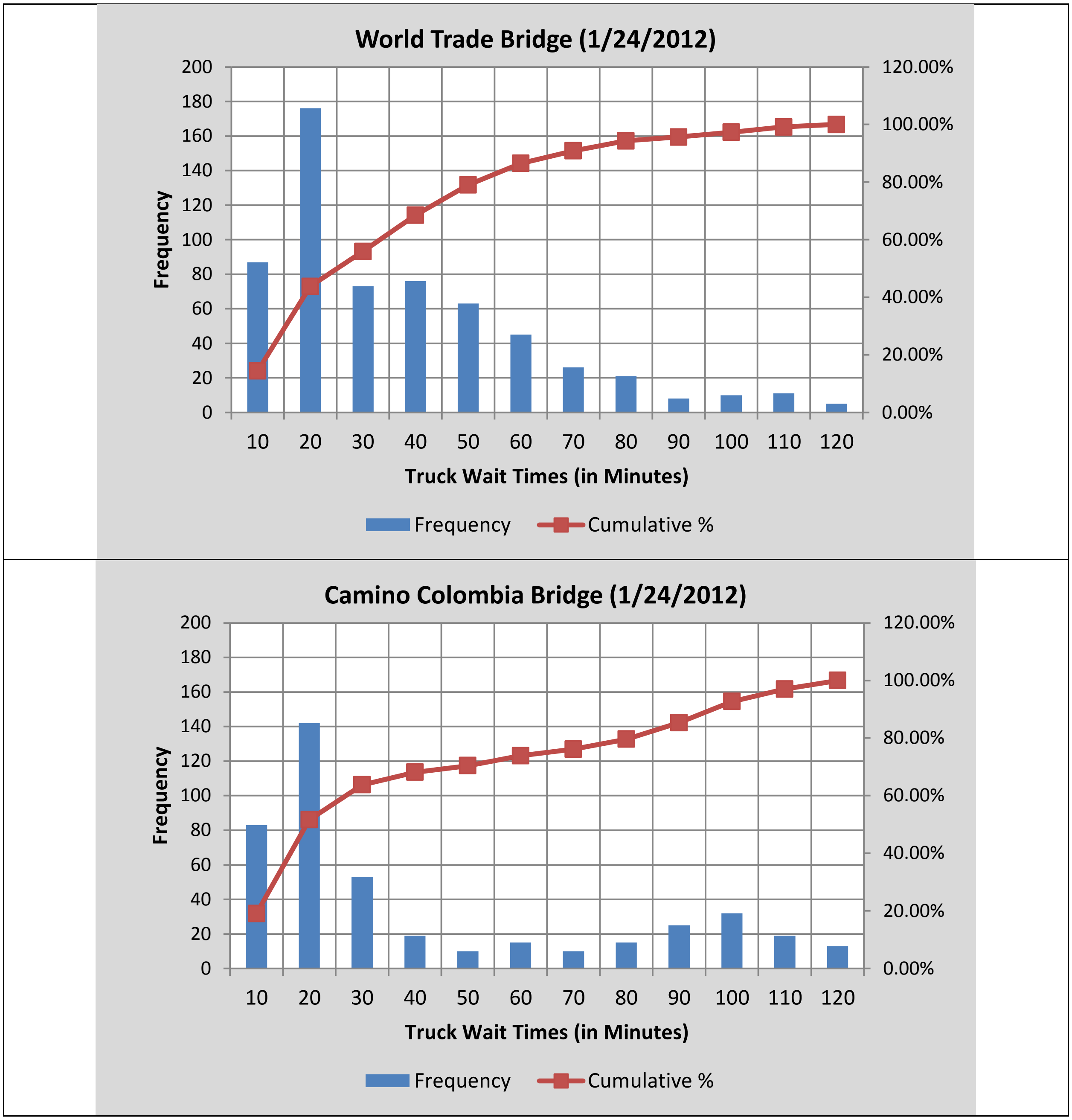
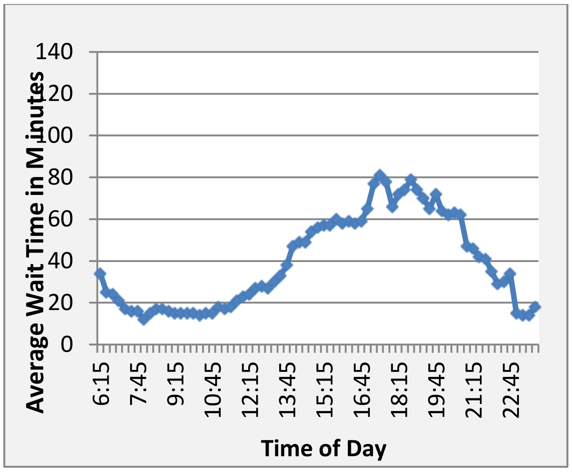


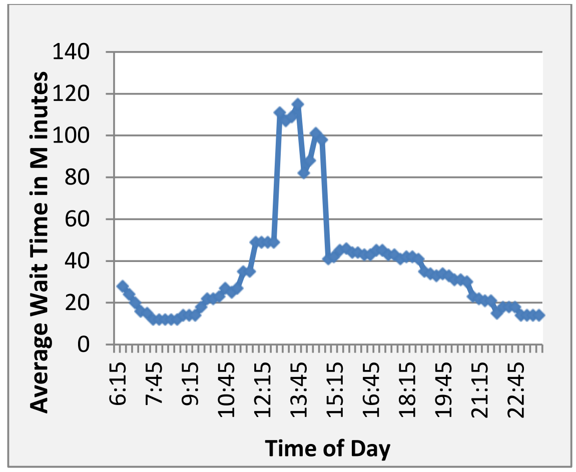
Figure 33. Histogram of Raw Truck Wait Times Collected over a Weekday.

Hourly and Daily Variation of Average Wait Times

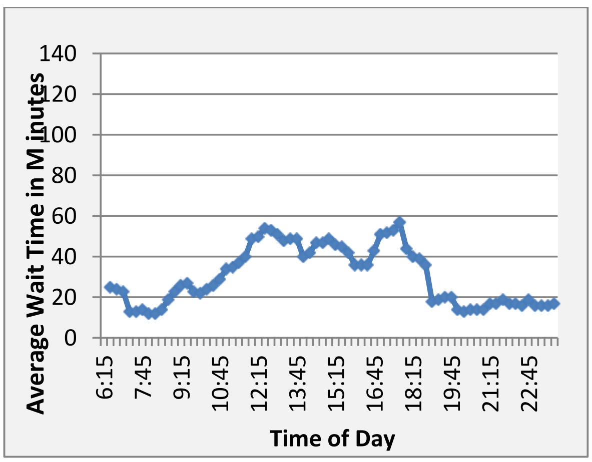
Figure 34 presents a snapshot of hourly and daily variation of average wait times of commercial vehicles at World Trade Bridge for Monday through Saturday, the week of January 24, 2012. These graphs show that average wait times are higher on Mondays and Tuesdays than rest of the week, typically the least busy days of the week at WTB. These higher wait times on Mondays and Tuesdays most likely occurs because shippers rush to close out the week's sales by getting as many orders off their docks as possible, which causes northbound truck traffic at WTB to increase. These figures also illustrate a noticeable spike in average wait times on during the mid-afternoon hours.



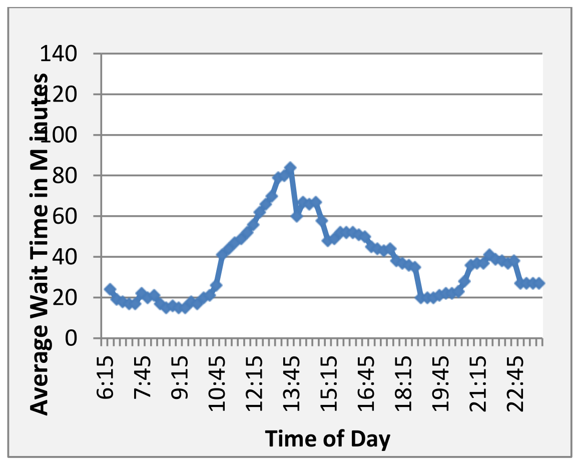
(a) Monday



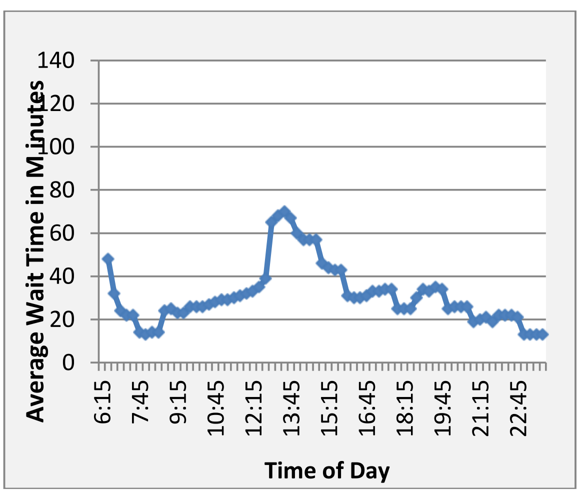
(b) Tuesday



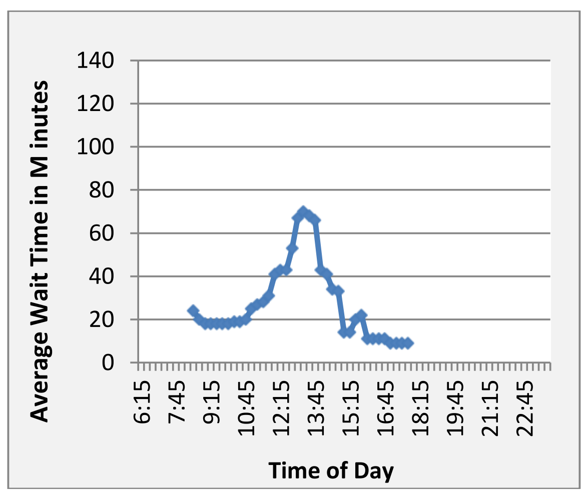
(c) Wednesday



(d) Thursday



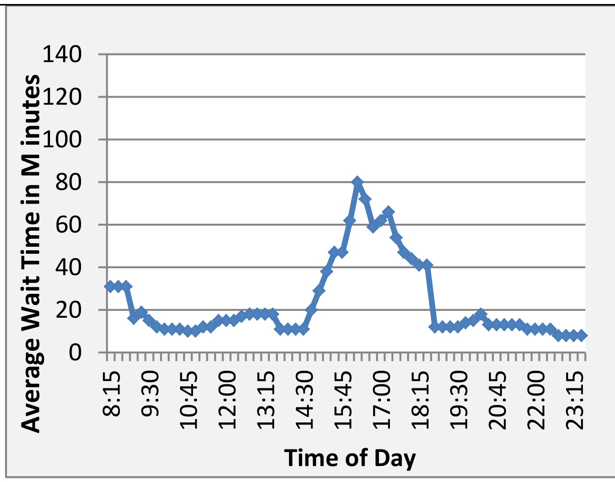
(c) Friday



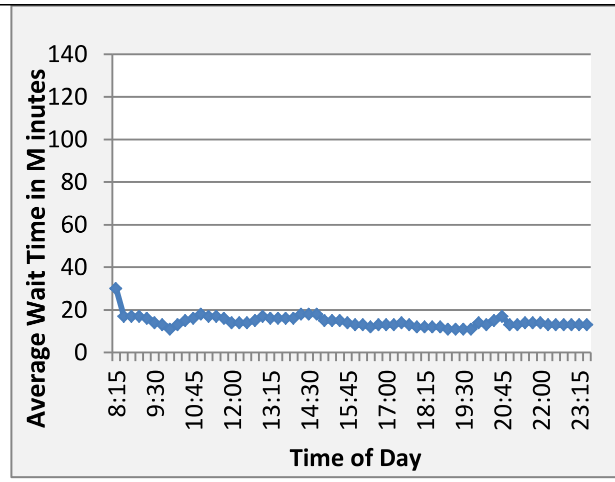
(c) Saturday

Figure 34. Daily Variation of Average Wait Times of Trucks Vehicles during the Week of January 24, 2012, at World Trade Bridge.

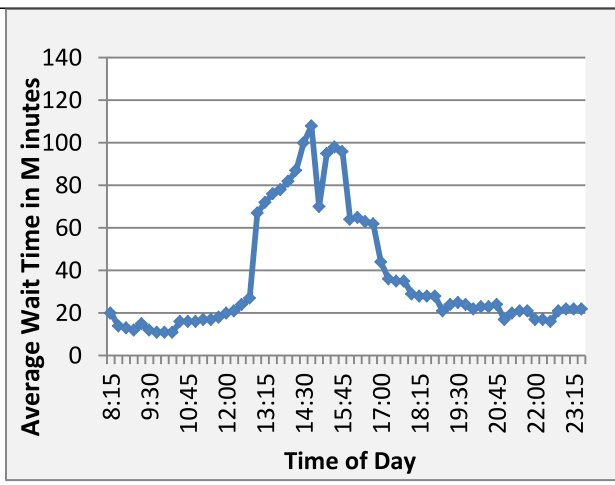
The following figure presents a snapshot of hourly and daily variation of average wait times of commercial vehicles at the Colombia Bridge for Monday through Saturday, the week of January 16, 2012. These graphs show that average wait times are the highest on Tuesdays, which is also a common occurrence at the World Trade Bridge. Similar to World Trade Bridge, wait times peak during mid afternoon hours.



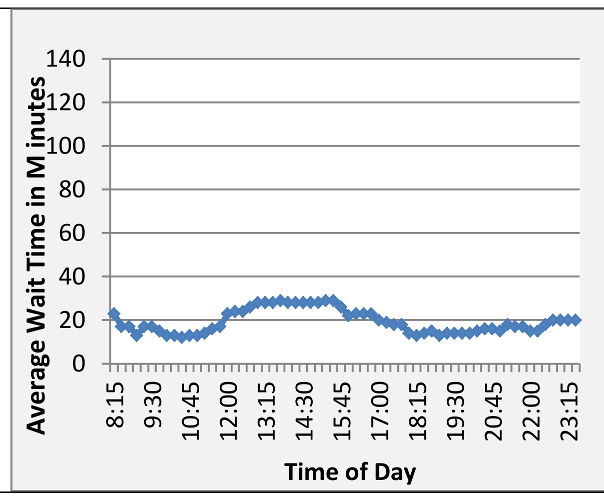
(a) Monday



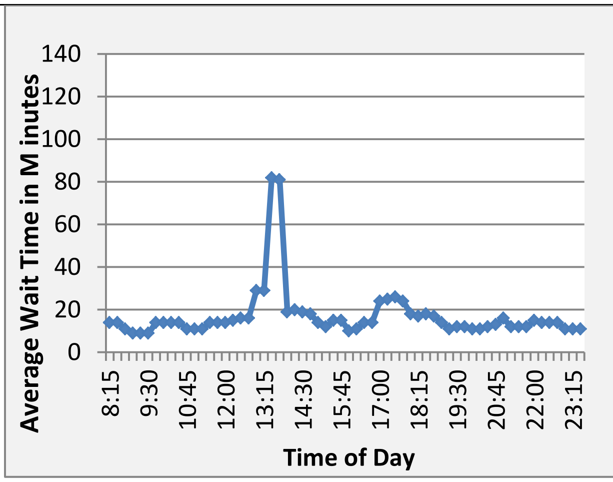
(b) Tuesday



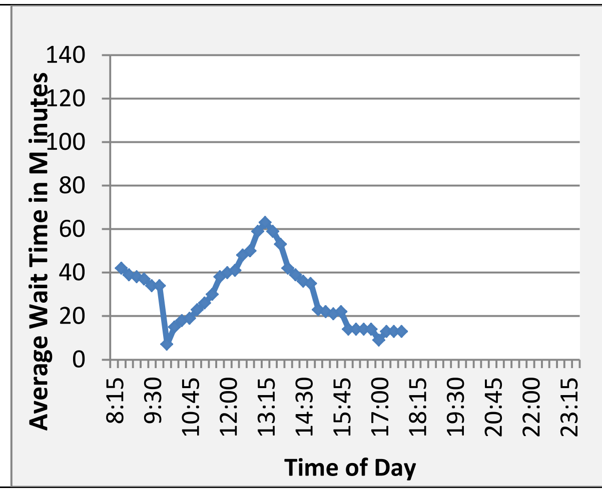
(c) Wednesday



(d) Thursday



(c) Friday



(c) Saturday

Figure 35. Daily Variation of Average Wait Times of Trucks Vehicles during the Week of January 16, 2012, at the Colombia Bridge.

Histogram of Crossing Time of U.S. Bound Trucks

The highly variable crossing times seen in this project were due to factors such as the reality that the trucks that go through secondary inspection, are part of the expedited FAST program, or are empty have very different crossing times from trucks not in those categories. When the mean crossing time was calculated, it did not distinguish among the crossing times of these trucks; all crossing times are used in calculating the histograms. The following figure is a histogram of raw crossing times over a 30-day period (January 2012).

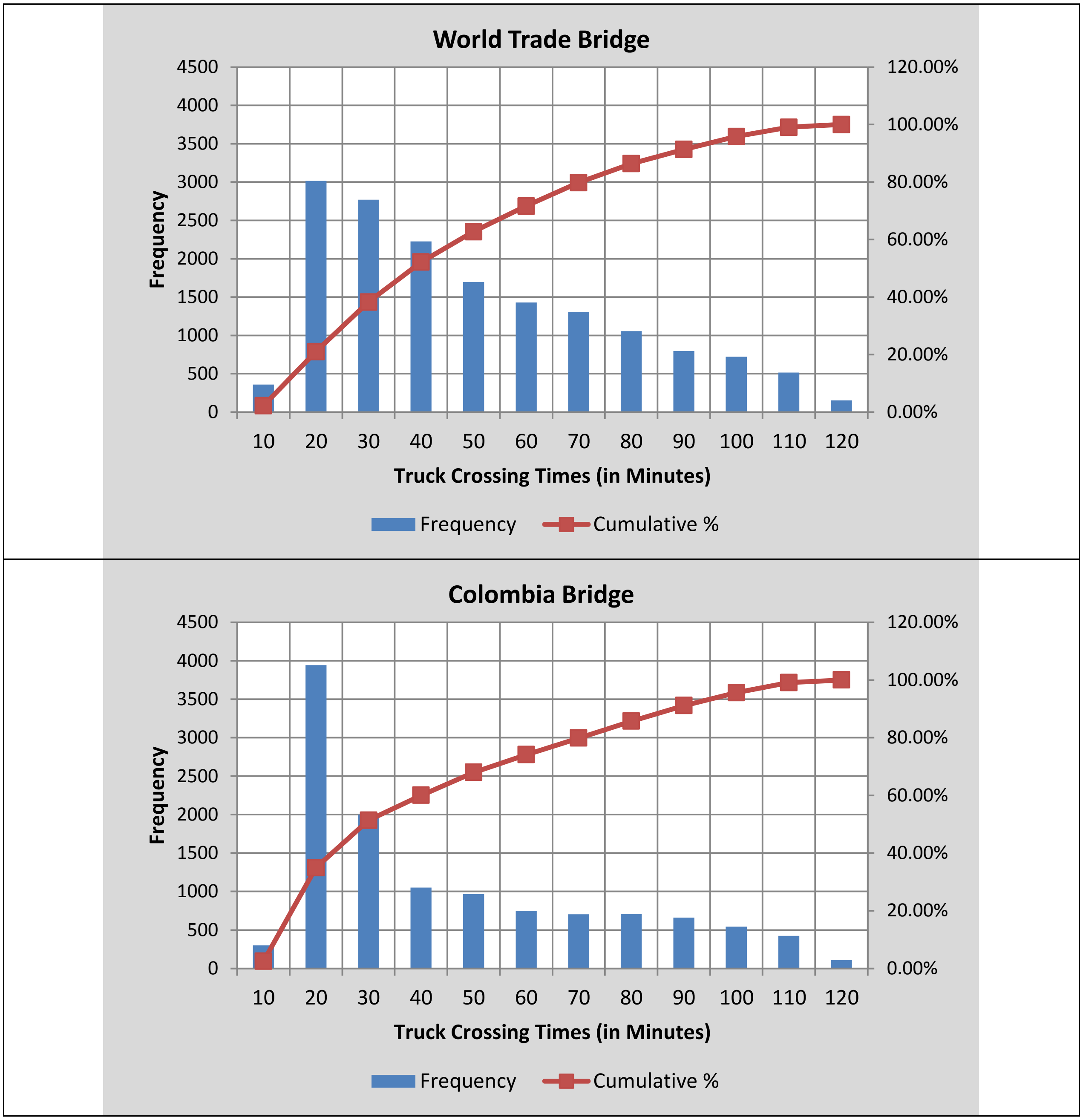


Figure 36. Histogram of Truck Crossing Times over a 30-Day Period (January 2012).

From the histogram of raw truck crossing time for the month of Month Year, a histogram for a single weekday (January 24, 2012) was prepared and appears as Figure 37, which shows that 95th percentile of trucks takes approximately 90 minutes or less for WTB and 100 minutes or less for Colombia Bridge to cross the border, and the 50th percentile of trucks requires approximately 50 minutes or less for WTB and 30 minutes or less for Colombia Bridge to cross the border. It also illustrates highly variable crossing times during different times of day. Obviously, empty trucks require less crossing time than non-empty trucks, and trucks enrolled in the FAST program require less crossing time than trucks not enrolled in the program. Being able to distinguish the type of trucks (empty versus loaded) and FAST versus Non-FAST by additional RFID readers would provide a better way of distinguishing crossing times of different types of trucks.

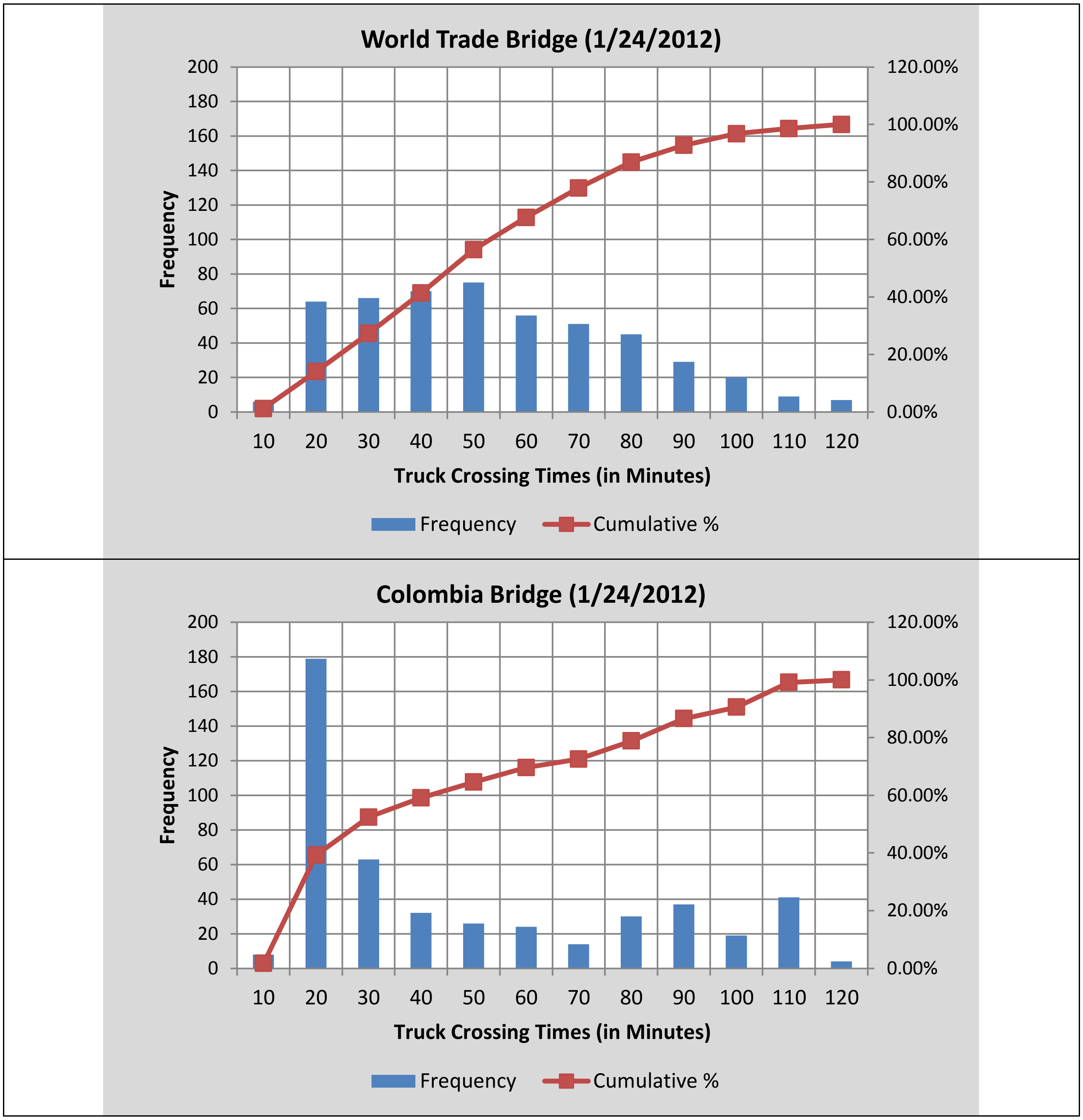
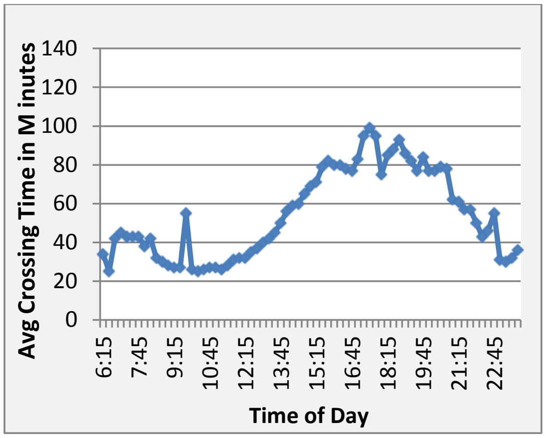


Figure 37. Histogram of Raw Truck Crossing Times Collected for a Weekday (January 24, 2012).

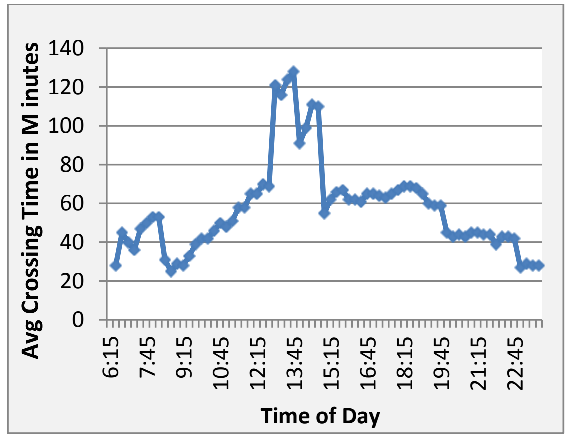
Hourly and Daily Variation of Average Crossing Times

Figure 38 is a snapshot of hourly and daily variation of average crossing times of commercial vehicles at the World Trade Bridge for Monday through Saturday, the week of January 24, 2012.

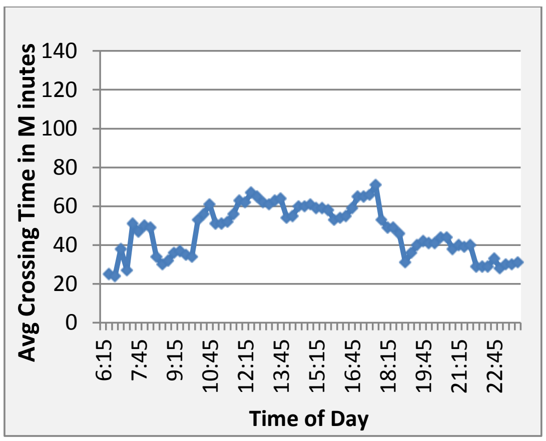
These graphs show that average crossing times are the highest on Mondays and Tuesdays, similar to wait times, and peaks occurring during mid afternoon to later afternoon on all days.



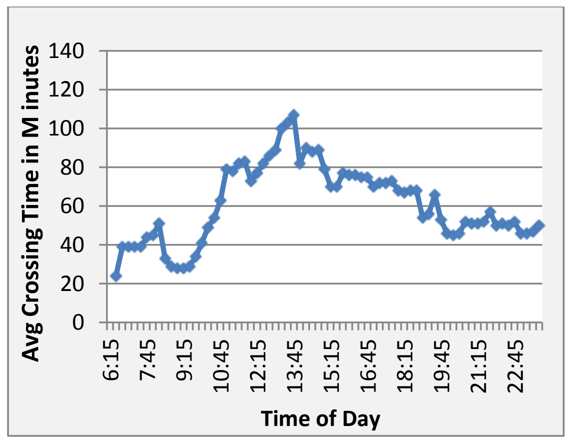
(a) Monday



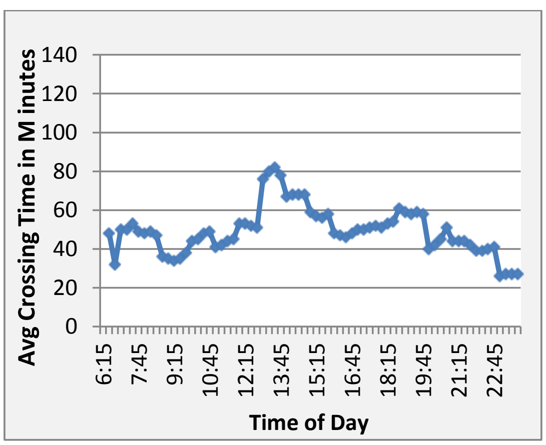
(b) Tuesday



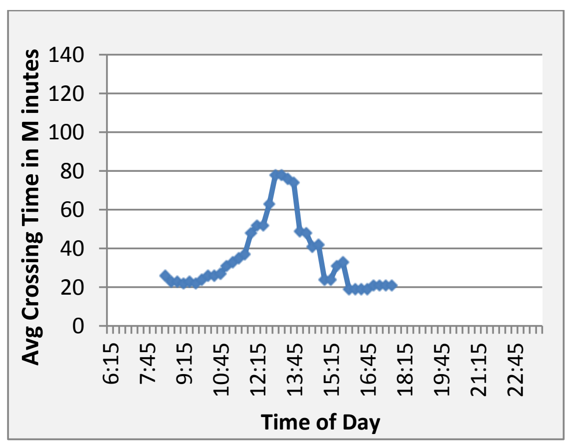
(c) Wednesday



(d) Thursday



(c) Friday



(c) Saturday

Figure 38. Daily Variation of Average Crossing Times of Trucks Vehicles during the Week of January 24, 2012, at World Trade Bridge.

The following figure shows a snapshot of hourly and daily variation of average crossing times of commercial vehicles at the Colombia Bridge for Monday through Saturday, the week of January 16, 2012. These graphs show that average crossing times are the highest on Tuesdays, similar to wait times, and peaks occurring during mid afternoon to later afternoon on all days.

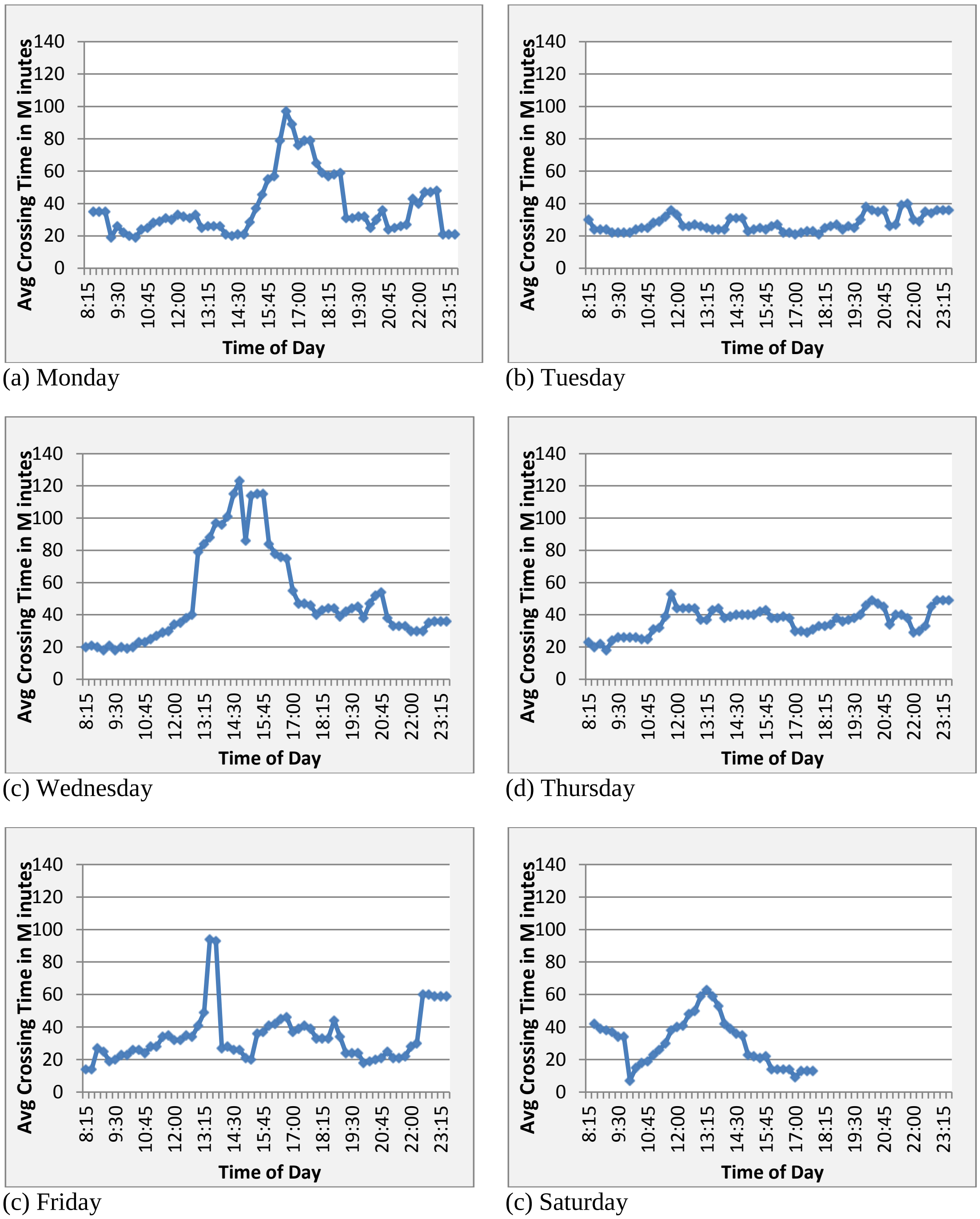


Figure 39. Daily Variation of Average Crossing Times of Trucks Vehicles during the Week of January 16, 2012, at the Colombia Bridge.

Monthly Capture Rates

It is important to recognize that concerning northbound trucks crossing at both border crossing at the time of this report:

- Not all of the trucks had tags.
- Not all of the tags were positioned so as to be readable.
- Not all of the readable tags that passed the R2 or R3 stations were read by the R1 station to yield a match.
- Not all tags that passed both the R1 and R2 or R3 stations were detected by both to yield a match.
- Thus, the capture rate was much less than either the total northbound volume or the number of tags recorded on the U.S. side (by R2 or R3 stations).

Tables 8 and 9 show the calculation of monthly capture rates for WTB and Colombia Bridges. The capture rate is the proportion of matched tags read by the system to the total volume o trucks, as reported by CBP. The table shows that the capture rate is approximately 15% for WTB and 10% for the Colombia Bridg for the monsths of October, November and December 2011.

Table 8. Monthly Capture Rate Calculation at World Trade Bridge.

Month Year	Total NB Truck Volume	Wait Time Sample Size	Crossing Time Sample Size	Capture Rate Based on Wait Time Sample Size	Capture Rate Based on Crossing Time Sample Size
(1)	(2)	(3)	(4)	(5) = (3) x 100/(2)	(6) = (4) x 100/(2)
Oct-11	113,858	9,395	8,857	8.25%	7.77%
Nov-11	111,830	16,975	15,620	15.17%	13.96%
Dec-11	105,864	17,146	15,553	16.19%	14.69%

Table 9. Monthly Capture Rate Calculation at the Colombia Bridge.

Month Year	Total NB Truck Volume	Wait Time Sample Size	Crossing Time Sample Size	Capture Rate Based on Wait Time Sample Size	Capture Rate Based on Crossing Time Sample Size
(1)	(2)	(3)	(4)	(5) = (3) x 100/(2)	(6) = (4) x 100/(2)
Oct-11	32,231	5,313	4,966	4.66%	4.36%
Nov-11	31,456	10,027	10,922	8.96%	9.766%
Dec-11	31,184	9,416	10,794	8.89%	10.19%

Capture rate could be increased by distributing additional RFID tags under the TxDOT/DPS vehicle inspection program, as RFID tags will be used to expedite vehicle screening at the new Colombia Bridge BSIF.

EVALUATION OF RFID MEASURED WAIT TIMES AND CROSSING TIMES DATA

GPS data was obtained from a Laredo drayage carrier consisting of paths for three commercial vehicles, and the GPS positions polling interval was five minutes.

The first path that was considered for analysis starts at 3/23/2012 07:28 a.m. from Mexican Highway 2 (Mex-2) in Nuevo Laredo, Tamaulipas and ends at 3/23/2012 9:43a.m. at TX-20-Loop, Laredo, TX (US).

The second path that was considered for analysis starts at 3/23/2012 3:40 p.m. from Mex-2, in Nuevo Laredo, Tamaulipas and ends at 3/23/2012 5:25 p.m. at TX-20-Loop, Laredo, TX.

The third path that was considered for analysis starts at 3/26/2012 7:43 a.m. from Mex-2, in Nuevo Laredo, Tamaulipas and ends at 3/26/2012 8:43:42 a.m. at TX-20-Loop, Laredo, TX. The following table shows travel times from the GPS devices that were available.

Table 10. GPS Timings

Trip	Trip Date	Time GPS Point Appeared Close to RFID Reader					
		R1		R2		R3	
		Time Before RFID Reader	Time After RFID Reader	Time Before RFID Reader	Time After RFID Reader	Time Before RFID Reader	Time After RFID Reader
Trip 1	23-Mar-12	7:28:00	7:33:00	9:03:00	9:08:00	9:38:00	9:43:00
Trip 2	23-Mar-12	N/A(1)	15:40:00	16:40:00	16:45:00	17:20:00	17:25:00
Trip 3	26-Mar-12	7:43:00	7:48:00	8:03:00	8:08:00	8:38:00	8:43:00

(1) Since the first GPS coordinate available for Trip 2 is after the reader R1, time at which the truck had not crossed reader R1 is unknown.

Table 11 shows the wait and crossing times calculated from the GPS information.

Table 11. Wait Time and Crossing Time from GPS Data

	Travel Time from GPS Data			
	Wait Time / R1-R2 (Minutes)		Crossing Time / R1-R3 (Minutes)	
	Minimum	Maximum	Minimum	Maximum
Trip 1	90	100	125	135
Trip 2	60	N/A(2)	100	N/A(2)
Trip3	15	25	50	60

(2) The time before which the truck had not crossed reader R1 is not available; hence it is not possible to compute the maximum travel time between reader R1 and reader R2. Also, it is not possible to calculate the maximum travel time between reader R1 and reader R3.

Crossing and wait times from the RFID-based system for those dates and time of the day were identified and the comparison between them and the GPS-based times are shown in the following table.

Table 12. Comparison of RFID and GPS Wait Time and Crossing Times

	Data Obtained from RFID			Absolute % Difference	
	Wait Time(Min.)	Crossing Time(Min.)		Wait Time	Crossing Time
	R1-R2	R1-R3		R1-R2	R1-R3
Trip 1	23	99		313%	31%
Trip 2	64	120		6%	17%
Trip 3	18	77		11%	29%

It was observed from the GPS coordinates that the truck travelling on Trip 1 was stationary for more than 1hour at MX Aduana, which implies that it was stopped at secondary inspection. This truck should not be considered a representation of the actual Wait Time or Crossing Time, as the RFID-based system produces average waiting times and deletes this type of outlayer reading.

For the two other trips with valid information, the difference between GPS-based and RFID-based time calculation is between 6 and 11 % for the wait times, and 17 and 29% for crossing times. These percentage differences are very low, confirming that the RFID-based calculation is accurate.

Chapter 6:
Future Operation Plan

DATA DISSEMINATION PLAN

As part of a separate FHWA contract, TTI developed a prototype web tool (hereafter referred to as “the prototype”) to provide an effective and efficient web-based platform for dissemination of real-time traveler information and archived border crossing-related data to stakeholders on the U.S.–Mexico border, along which RFID deployments have spread. Real-time traveler information includes current border crossing and wait times obtained from the RFID system, number of lanes open, and bridge closure information. Archived data includes historic wait times and crossing times, number of lanes open, and total vehicular volume. Presentation of historic data includes trends shown in different temporal and spatial granularities, summarized and aggregated data, and simple summary statistics.

The initial prototype included data from two POEs – Bridge of the Americas and Pharr-Reynosa International Bridge. Subsequently, TxDOT has awarded TTI a new contract on March 2012 to expand the prototype to include data from total of eight U.S.–Mexico POEs, including both border crossings discussed in this report – WTB and Colombia.

In terms of requirements related to traveler information, the prototype web tool:

1. Broadcasts freight border crossing and wait times information to users via Internet and mobile devices.
2. Disseminates personalized border crossing information to users upon request.
3. Provides an interface for mobile device applications and in-vehicle navigation to access the current traveler information.

In terms of requirements related to archived border crossing data, the prototype:

1. Collects and maintains data and data catalogs from one or more data sources and includes quality checks, error notification, and archive coordination.
2. Provides advanced data analysis and mining features to support discovery of information, patterns, and correlations in large archives.
3. Provides ways for users to retrieve data and information through the Internet and mass media storage devices (consistent with Distracted Driver rules and regulations and related safety information).
4. Provides pre-coded or standardized queries.
5. Provides ad hoc queries and data searches.
6. Provides data structured so they are readily available in ways that typical users may want to review, such as by time periods, geographic and political boundaries.

7. Provides a catalog of the data and other information that are available, with the ability to request the desired format and data.
8. Provides capability to execute summarizations, aggregations, and statistical analysis on the archive data.

NEXT STEPS

Assure System Stability

From the monitoring system that was established as part of this project, it was noticed that the system, particularly at the WTB is not stable and reliable. The system shows instability and under the new contract, described above TTI will continue monitoring the system and identifying solutions to bring the system to a stable and reliable state. The TTI team is already testing two solutions to fix the system:

1. Power fluctuations. R1 at WTB has 2 readers and 3 antennas that use more power than a single reader. The system will be retrofitted to include an automatic shut-off system for the night period when the WTB is not in operation. This will allow a full charge of the batteries from the solar panel, under any weather conditions.
2. Shifting to a Mexican cellular carrier. Currently the system is working using Verizon from the U.S., and due to continuous fluctuations of the cellular signal strength in the region (which is typical for border regions) the system sometimes picks up the Telcel signal from Mexico and stops sending information to the server. This is happening at the R1 location, at WTB.

These two solutions should bring the system at WTB to a stable condition.

BSIF at the Colombia Bridge

The system is currently installed at the temporary BSIF station at the Colombia Bridge. TxDOT is finalizing construction work at the new BSIF facility. Once the new facility is in operation, the plan is to use the RFID information that will be captured by the multiple RFID readers at the new BSIF station. TTI has already initiated discussions with TxDOT on how the interconnection will be made. The RFID equipment installed at the BSIF that is operated by DPS is exactly the same brand as the one used in the border crossing and wait time systems, therefore the compatibility is assured. The BSIF system has reader stations installed at the entrance and exit of the facility, therefore average time within the compound could be calculated by the border crossing time system when the systems are interconnected and information from these 2 locations are added to the system.

It would be important to increase the number of RFID tags in the region and this could be done by distributing them to drayage vehicles that will be enrolled in the vehicle inspection program at the new BSIF facility.

Appendix A: Stakeholder Meeting Agenda List of Participants

<u>Measuring Commercial Freight Border Crossing Times at the Laredo Commercial Border Crossings</u>

Stakeholder Meeting Agenda
Texas A&M International University Student Center
Meeting Room SC 231

October 21, 2009
9:30 a.m.

The Texas Department of Transportation (TxDOT) have contracted with the Texas Transportation Institute (TTI) to implement a system to automatically and accurately collect border crossing times for Northbound commercial vehicles at the two international bridges serving Laredo, Texas. In order to accomplish this, TxDOT and its partner are seeking your participation in the program.

If you have any questions regarding the meeting location or the agenda on the next page, please do not hesitate to contact the Texas Transportation Institute. Your TTI contact is:

Juan C. Villa
Program Manager, Economics, Trade and Logistics Program
Texas Transportation Institute
The Texas A & M University System
3135 TAMU
College Station, TX 77843-3135
979-862-3382
j-villa@tamu.edu

Thank you for your participation, and we look forward to seeing you on October 21st.

<u>Agenda</u>

9:30 a.m. – 9:45 a.m.

- Introductions
- Project Background and Meeting Objectives

9:45 a.m. –10:15 a.m.

- Technology Overview
- How the Proposed System Will Work
- World Trade International Bridge Layout and Proposed Measuring Locations
- Colombia-Solidarity Bridge Layout and Proposed Measuring Locations
- Equipment installation examples at other bridges
- Information dissemination
-

10:15 a.m. – 10:30 a.m.
Break

10:30 a.m. – 12:00 noon.
Facilitated Discussions

- Crossing the Border
    - What do we know about typical commercial travel times at the two international bridges in Laredo?
    - Where are delays taking place?
    - Are there any patterns worth noting?
    - How do these delays affect regional travel?
    - How do these delays affect supply chain operations?

- RFID and Other Technology
    - What are your questions / concerns with the proposed technology in general, data collection, and/or data dissemination?
    - What do we know about current and/or planned technology deployment?

- The Proposed System and Your Operations
    - Would better information change these decisions?
    - What would be the impact of additional access to border wait time information on the supply chain?
    - Would real-time information help add value?

List of Participants in the Stakeholder Meeting

	Name		Organization
1	Genaro	Hinojosa	DPS
2	Melisa	Montemayor	TxDOT
3	Felix	Canales	Asociación de Agentes Aduanales de Nuevo Laredo (AAANLD)
4	Agustin	De La Rosa	TxDOT
5	Mariano	Gamboa	Asociación de Agentes Aduanales de Nuevo Laredo (AAANLD)
6	Rene	Garza	DPS
7	Juan Carlos	Gastelum	Codefront
8	Rocio	González	Central de Servicios de Carga de Nuevo Laredo (Censecor)
9	Victor	Peña	Puente Comercio Mundial
10	Ignacio	Pérez	Association of Laredo Forwarding Agents (ALFA)
11	Ignacio	Perez Keith	Association of Laredo Forwarding Agents (ALFA)
12	Jorge	Pineda	Transit Nuevo Laredo
13	Edson	Quezada	Central de Servicios de Carga de Nuevo Laredo (Censecor)
14	Octavio	Ramirez	Central de Servicios de Carga de Nuevo Laredo (Censecor)
15	Raul	Reyes B.	Puente Comercio Mundial
16	Jesus	Rodriguez	Aduana Nuevo Laredo
17	Elvia	Treviño Lopez	Aduana Nuevo Laredo
18	Luis	Treviño M.	Codefront
19	Earl	Vicknair	DPS - CB
20	Juan Carlos	Villa	TTI

Appendix B: GSA Permit Supporting Material and Final Authorization

Amplifying Information for Submission of GSA Form 1583:
Permit for Use of Real Property by Use of Government Agency for
RFID System Installation at the Primary and Exit Booths of the Laredo World Trade Bridge Port of Entry and the Primary Booths of the Colombia Bridge Port of Entry

1. Description of the Border Wait Time Measurement System and why it is important.

The proposed installation of automatic vehicle identification systems using radio frequency identification (RFID) tag reader equipment will enable automated measurement of wait time for northbound commercial vehicles at the World Trade Bridge (WTB) Port of Entry (POE) and at the Colombia POE between Mexico and Texas. Wait time is defined as "the time it takes, in minutes, for a vehicle to reach the U.S. Customs & Border Protection (CBP) primary inspection booth after arriving at the end of the queue." Wait time is a travel time component that is of particular importance to CBP as a metric of border flow. Knowing the accurate wait time helps CBP make informed decisions about how many Primary Inspection booths need to be manned.

TxDOT and CBP collaboration resulted in an agreement to conduct a limited initial installation of readers at the facility primary inspection booths and exit booths at the WTB POE and the primary inspection booths at the Colombia POE. Installation at the POE booths will capitalize on infrastructure (electric power, mounting locations, etc.) that is already in place.

Crossing time is a travel time component that is of particular importance to FHWA as a metric of border flow. The general concept of the current RFID crossing time measurement system is that during its trip across the border at the POE, a northbound truck passes three RFID tag reader stations, one on each side of the border and one at CBP Primary. The station's antennae are mounted above lanes in the roadway; each tag reader detects the truck's RFID tag identification (ID) number, time-stamps and records its ID with the location of the detection. Tags of several types compatible with this system are carried in the vast majority of trucks crossing at WTB.

The initial RFID reader station is located at a site that is at the "upstream" end of the queue of northbound trucks that backs up from the border at the POE. The length of the queue at any given time will vary depending on factors such as truck volume, number of customs primary inspection booths manned and open, time of day, and incidents or accidents at the POE. The first RFID reader station is at a static location that is slightly upstream from the end of the historical queue that will develop on the majority of days on the Mexican side of the border. The second RFID reader station is located at the CBP primary inspection booths. The trip time from the first to the second reader station yields "wait time". The third and final reader station is deployed close to the point at which trucks exit from the gate of the final compound associated with commercial vehicle crossings. At WTB, that point is the exit booths of the CBP facility while at Colombia the third station will be located at the exit of the DPS inspection facility.

2. **Environment and conditions that must exist for the installation to be successful, and options – if any – that will enable accurate border wait time measurement other than installing on GSA property.**

The equipment will be installed above the point where trucks depart the booths at each POE (primary at WTB, exit booths at WTB, and primary at Colombia). Thus, the installation should take place either when the POE is closed to northbound commercial vehicle traffic or is experiencing low demand when lanes can remain closed. The selected installation contractor has stated that he can conduct the installations on weekends if required.

In-depth analysis has been conducted by FHWA to determine the types of technology systems that are appropriate for automated travel time measurement at land border crossings. Only two types of current technology systems were considered viable and have been implemented for this purpose: AVI using RFID and GPS. RFID was considered best for measuring crossing times at Texas POEs, which resulted in implementations in El Paso and Pharr. The exit booths are the last stopping point for trucks before they are released. Installation here captures the entire time the trucks spent inside the facility.

3. **Explanation of how the system will be operated and maintained and how any deficiency that occurs between installation and removal/completion will be addressed. Identification of any known threats or risk in this area that might happen, how they will be mitigated, and whether any safeguards are needed.**

The RFID tag detection system is a self-contained independent system. The system will continually scan the area under the antenna and send any detected tag data to a Border Crossing Time central receiving application in El Paso, TX. There are no local users and no operators. The system uses open road tolling technology that is specifically manufactured for unmanned outdoor operation. The system uses commercial wireless data services and thus does not connect to any communication infrastructure on premises.

There is no programmed maintenance needed for the equipment (i.e., no devices that need scheduled local attention). In the event of system failure, maintenance will be coordinated with CBP by the Texas Transportation Institute (TTI). A representative of TTI will travel to the location to perform repairs. Any activity planned onsite will be coordinated with GSA and CBP prior to staff arrival. Maintenance personnel will check with CBP upon arrival at the facility and provide a briefing on their task and receive any special instructions from CBP.

If the system were not working at all it would not affect the normal operation of the POE. The system is innocuous while in operation. A compatibility test was performed at the Pharr POE to determine whether there was interference with CBP systems, and there was no interference noted for the intended configuration. The nominal 915 MHz frequency of the RFID system can be remotely adjusted within narrow limits to improve performance. The system uses very little electricity. If the system degrades or fails, there will be alert criteria that notify operators of the condition. Since the proposed system has no impact on port operations, a visit by a technician to repair or replace a failed component can simply be coordinated to occur during a time when the POE is not in operation or during reduced volume periods.

There are no known threats or risks involving this technology system. RFID is a very familiar technology at the El Paso and Pharr POEs, and the sight of new reader stations should not arouse suspicion or animosity. There are no hazardous materials at the site, there is no high voltage, and there are no high power radio emissions from the system. All system components will be installed in a manner to minimize risk of personnel or vehicles hitting components.

4. Diagram with full description of all major components, operating frequencies, etc. with discussion of the appropriateness of the frequency for this use.

Major system components onsite include the following:

- RFID reader – Outdoor mounted unit containing all the electronics to interrogate passing windshield RFID tags and return tag data in a computer readable form. The RFID readers use the unlicensed ISM (Industrial, Scientific, and Medical) radio spectrum between 902MHz and 928MHz. The readers are compliant with the requirements of CFR Title 47, Part 15, which is part of the Federal Communications Commission rules and regulations that apply to unlicensed transmissions.
- RFID reader antenna – Rectangular panel type antenna (902-928MHz unlicensed ISM band) mounted over the booth travel lane and used to direct the radio signal from the reader onto the windshield area.
- Cellular wireless router – Receives tag data from the RFID reader as a serial stream and transmits these data to the central office application (El Paso) using a cellular wireless data connection.

Exhibit 1 shows the Installation Diagram. All proposed locations (WTB primary, exit and Colombia primary) will be deployed using the technique/plan shown below.

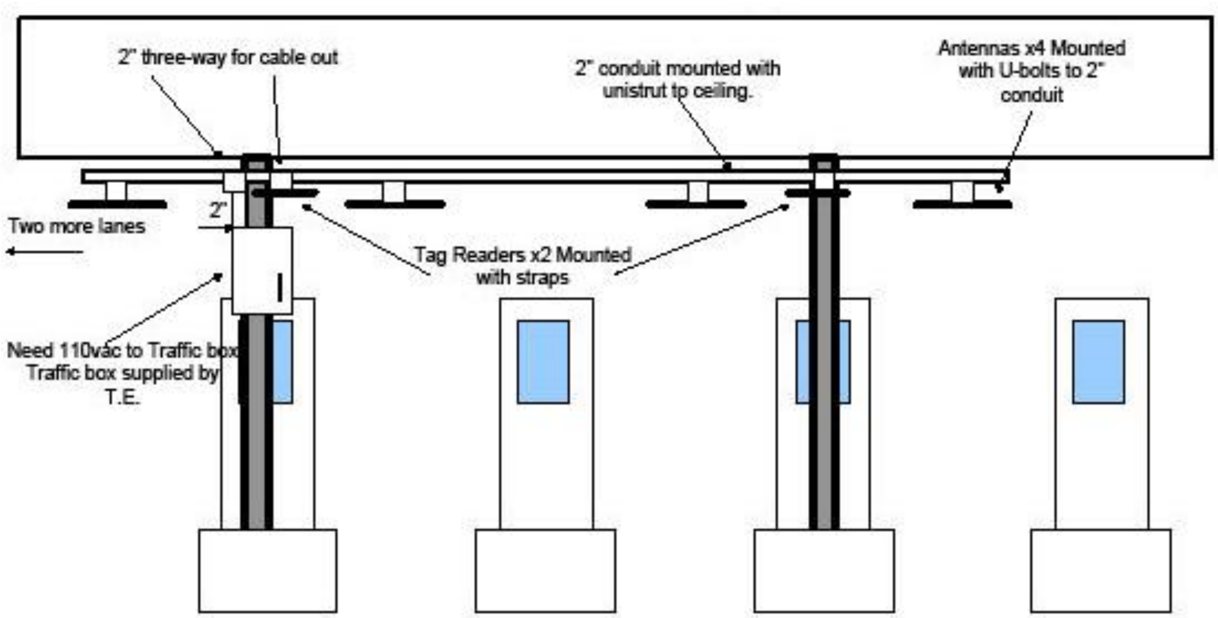


Exhibit 1. WTB Primary and Exit Booths and Colombia Primary Installation Diagram.

Exhibit 2a shows a visualization of the installation at the WTB exit booths.

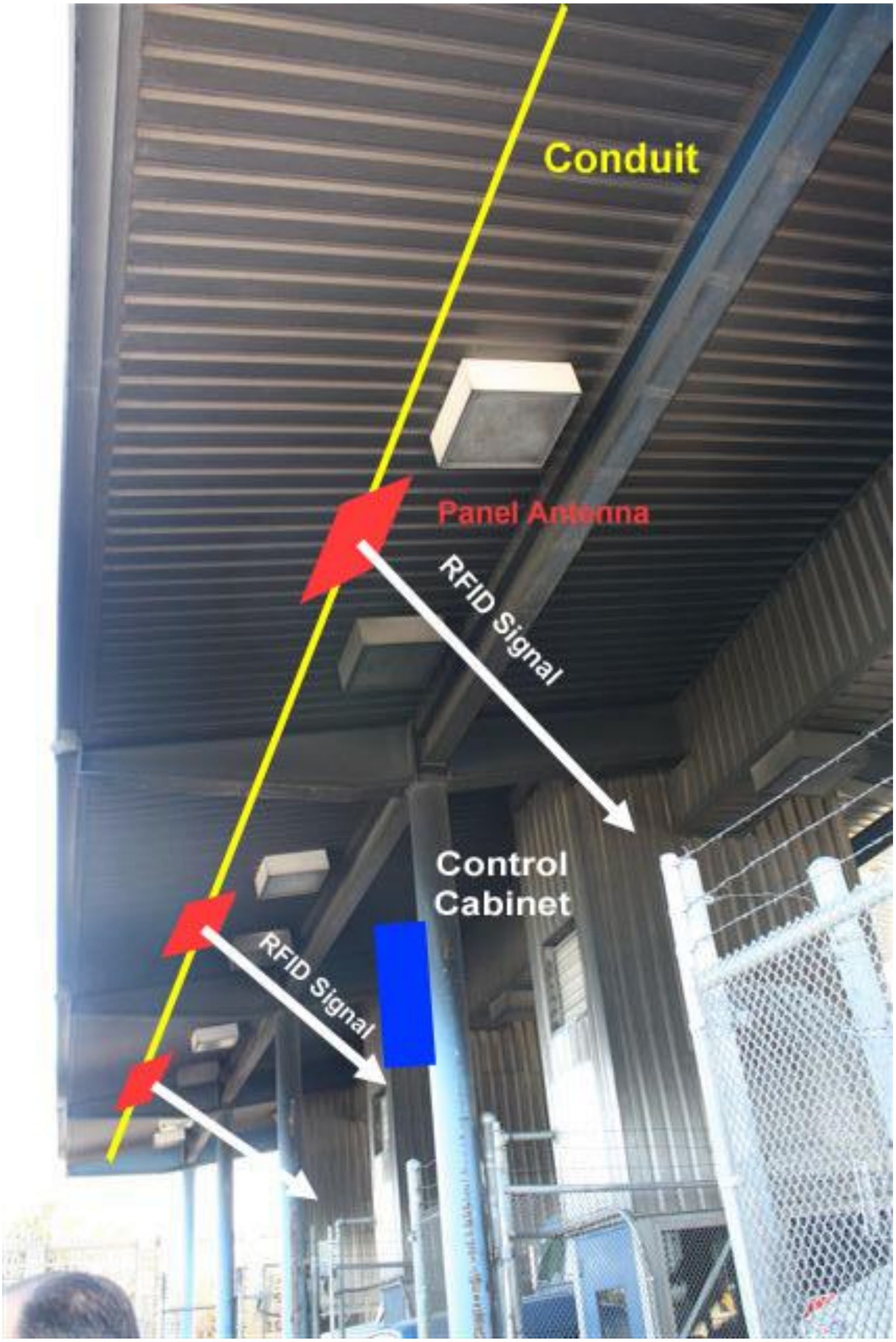


Exhibit 2a. Exit Booth Installation Visualization.

Exhibit 2b shows a representative installation at the primary booths.

Exhibit 2b. Primary Booth Implementation Visualization.

Exhibit 3 shows a representative electronics cabinet.

Exhibit 3. Electronics Cabinet.

5. Contractor personnel who will be involved in the installation, their roles, and the frequency and nature of their activities during installation.

Mr. Jeff Hitchings (Transit Electronics) will be the lead installation technician and Leonard Ruback will be the TTI representative on site during installation and test. Mr. Ruback will oversee Mr. Hitchings and insure that the installation is conducted as planned and presented to CBP.

Their contact information is:

- Leonard Ruback, Texas Transportation Institute, 79-862-4343, lruback@tamu.edu
- Jeff Hitchings, Transit Electronics, 972-342-1410, jeffrey@transitelectronics.com

6. Constraints and Assumptions.

Constraints

- GSA and CBP approval of proposed installation and schedule
- Equipment ordered and received (approximately two months lead time involved)
- Contractor availability for installation during a weekend or Mexican holiday when a POE is closed
- CBP authorization for the installation contractor and project personnel to be onsite
- Availability of standard 115V electrical power

Assumptions

- The subject installation has the support of CBP at the WTB POE
- CBP will have access to the wait time data measured at WTB, both real-time and archived data
- A plentiful supply of RFID tags compatible with the system to be installed is already carried by vehicles owned by Mexican carrier fleets that cross at the POEs (this has already been verified)
- Use of GSA facilities will be on a no-cost basis (i.e., no utility costs or rent).
- CBP personnel at WTB will provide all safety briefings necessary for team personnel while on-site at their respective facilities.
- Removal or continuation of equipment will be separately discussed at a scheduled point.
- CBP will notify project contacts if any known physical, operational, or perceptional problems with the equipment on its premises are discovered.

- Some type of separate data collection and measurement (i.e., manual collection or comparison with another technology) may be necessary to verify the results of the automated wait time measurement system.

7. Comprehensive schedule, including opportunity for GSA Program Managers to inspect and approve the installation configuration and a decision point for continued operation and maintenance.

Exhibit 4 is the Proposed Schedule.

Activity	Feb-11	Mar-11	Apr-11	May-11	Jun-11	Jul-11
Submit GSA Permit						
Obtain Authorization to Install Equipment						
Installation at WTB*						
Installation at Columbia						
Test and Evaluation						
Border Crossing and Wait Time Reading						
GSA Inspect Installation Configuration						
FHWA & CBP decides continue operation or removal						

* Installation to wait until construction in complete

Installation during low volume (weekend)

8. Points of contacts for all major activities described in the SOW.

- Juan Villa (Principal Investigator), TTI, 979-862-3382, j-villa@tamu.edu
- Leonard Ruback (Installation Lead), TTI, 979-862-4343, lruback@tamu.edu
- Jeff Hitchings (Installation Contractor), Transit Electronics, 972-342-1410, jeffrey@transitelectronics.com

PERMIT FOR USE OF REAL PROPERTY BY FEDERAL AGENCY	1 PERMIT NUMBER 7PSB-11-12

Permission, revocable at the will of the General Services Administration, is hereby granted the Permittee hereinafter named to use the property described below for the purpose designated, subject to the conditions, special and general, herein prescribed.

2. NAME OF PERMITTEE AGENCY	3. LOCAL REPRESENTATIVE *(Name and address)*
FEDERAL HWY ADMINISTRATION 1200 NEW JERSEY AVE ATTN: HOFM ROOM E84-473 WASHINGTON, DC 20590 CRYSTAL JONES 202.366.2976	LEONARD RUBACK l-ruback@ttimail.tamu.edu TRANSLINK RESEARCH CENTER -GILCHIRST, RM 143 TEXAS TRANSPORTATION INSTITUTE 3135 TAMU - COLLEGE, STATION, TX 77843-3135

4. PROJECT DESIGNATION AND ADDRESS	5. MAXIMUM PERIOD COVERED
CBP - PRIMARY CARGO INSPECTION AND EXIT BOOTHS AT WORLD TRADE BRIDGE LPOE AND PRIMARY INSPECTION BOOTHS AT COLUMBIA LPOE, LAREDO, TX	A. FROM 03/02/2011 B. TO 06/30/2011

6. DESCRIPTION OF PROPERTY AFFECTED

(As shown on Exhibit ________________________ *, attached hereto and made a part hereof.)*

Radio Frequency Identification (RFID) readers system hardware will be installed at each of the northbound cargo lanes and exit booths at World Trade Bridge (WTB) LPOE and at the primary inspection booths at Columbia LPOE.

7. PURPOSE OF PERMIT

To install the equipment described in #6 above and to maintain the equipment that reads RFID tags that trucks already have attached to the windshield.

8. By the acceptance of this permit, the Permittee agrees to abide and be bound by the following conditions:

I. SPECIAL CONDITIONS

PERMIT FOR TEMPORARY CONSTRUCTION PURPOSES

A. Contractor Insurance. Each of Permitee's construction contractors who perform any work on the property shall obtain and maintain insurance policies which meet or exceed the following insurance terms, conditions, requirements and coverages. During the Term of this Permit, including renewals, if any, each of the Permitee's contractors shall obtain and maintain liability insurance in an amount of not less than $1,000,000.00 combined single limit for accidents or occurrences which cause bodily injury, death or property damage to any member of the public caused by or related to the construction, installation, operation, maintenance replacement, removal or other activity related to the property. The insurance policy shall name the General Services Administration, its employees and officials, as their interest may appear, as additional insureds. Any cancellation provision must provide that if the policy is canceled prior to the expiration date of the Permit, materially changed or not renewed, the issuing company will mail thirty (30) days written notice to the General Services Administration, Attention: Contracting Officer, Property Development Division (7PD), 819 Taylor Street, Fort Worth, Texas 76102.

B. Damages and Indemnity. The Permitee shall repair or pay for all actual damages done to the GSA Property and improvements, or to the improvements of the GSA's tenants caused by Permitee's Operations pursuant to any liability determined under the Federal tort Claims Act (28 U.S.C. §§2671 et seq.). Permitee agrees that is will be responsible for damages arising from personal injury or damage to persons or tangible property to the extent they result from Permitee's operations under this permit if liable under the Federal Tort Claims Act.

Permitee agrees to defend and remain responsible (financially and otherwise) for all claims, disputes, appeals and other legal actions arising out of actions of Permitee's personnel, contractors and other agents if liable under the Federal Tort Claims Act.

The liability of the Permitee shall be subject in all cases to the immunities and limitations set out in the Federal Tort Claims Act (28 U.S.C. 2671, et seq.) and shall be subject to available appropriations.

C. Personal Injury or Personal Property Claims. The Permitee acknowledges that GSA will have not responsibility or liability, either directly or indirectly for any personal injury, and/or personal property damage claims against the Government that arise out of or relate to the performance of the work at the Facility under the terms of this permit. Permittee will be the lead federal agency responsible for the administrative handling of any tort claim(s) filed pursuant to the Federal Tort Claims Act.

D. Pre design and construction site surveys will be completed with GSA and local Permitee's Representatives

E. Preliminary construction documents will be furnished to GSA for Review.

F. Final signed and sealed construction documents will be furnished to GSA for review.

G. Construction schedules will be furnished to GSA and updated as milestones change.

H. Final Inspection notes and acceptance documents will be furnished to GSA.

I. Any work that does not meet applicable local and federal codes and/or does not meet GSA standards must be corrected.

J. Permitee is responsible for any interruption of services and must take corrective action immediately. GSA is to be notified if any service is interrupted.

K. Any damage to the existing site caused by the contractor is the responsibility of the Permitee to correct immediately pursuant to the immunities and limitations of the Federal Tort Claims Act. GSA must be notified of the damage and provided with a written plan of correction if Permitee is required to do so pursuant to liability under the Federal Tort Claims Act.

L. All work performed must conform to all applicable local, state and federal codes.
M. Permitee is responsible for obtaining the necessary security clearances for contractors to perform work at the LPOEs.

11. GENERAL CONDITIONS

a. The use and occupancy of the property shall be without cost or expense to the General Services Administration, and under the general supervision of the Regional Administrator, General Services Administration, or his/her authorized representative, and subject to such rules and regulations as he/she may prescribe from time to time.

b. The permittee shall at its own expense and without cost or expense to the General Services Administration, maintain and keep the property in good repair and condition.

c. The use to be made of the property shall be limited to that specified in this permit.

d. The permittee shall pay the cost, as determined by the Regional Administrator, General Services Administration, or his/her authorized representative, of producing and/or supplying any utilities and other services furnished by the General Services Administration for use of the permittee.

e. No additional to or alterations of the property shall be made without the prior consent of the Regional Administrator, General Services Administration, or his/her authorized representative

f. On or before the date of expiration or termination of this permit, the permittee shall vacate the premises, remove its property therefrom and restore the premises to a condition satisfactory to the General Services Administration If however, this permit is revoked, the permittee shall vacate the premises, remove its property therefrom and restore the premises as aforesaid within such time as the General Services Administration may designate.

3-3-2011 DATED (Day, Month, Year)	DATED (Day, Month, Year) 3/3/2011
Crystal C. Jones BY (Signature)	BY (Signature) Tunisia Sadruddin
Crystal C. Jones NAME OF SIGNER	NAME OF SIGNER Tunisia Sadruddin
Transportation Specialist TITLE	TITLE Border Service Center Manager

Appendix C: List of Equipment

Laredo World Trade Bridge (WTB) Border Crossing Travel Time Measurement - Detection Stations - Summary

Border Crossing Travel Time Measurement - Detection Station R1 - 3 lane - solar

Item	Model	Vendor	Quan
Beacon 915MHz antenna	AA-3153 P/N 12-3153-001	TransCore	3
RF power splitter (multi-lane site) 1 to 2	PD1020 (2way)	InStockWireless	1
RF Surge Protection	LABH2400NN	B&B Electronics	2
RFID Reader	Encompass 4 - Ext Antenna - RS422 - ATA/eGO P/N: 10-4014-009	Transcore	2
Cable, 35 foot, with connector	P/N: 58-1620-006	Transcore	2
12-24v DC/DC adjustable output converter	PST-SR700 adj	Powerstream	1
RS-422 converter - DIN rail mount	485LDRC9	B&B Electronics	2
Programmable Logic Relay (12v - 4Relay Out)	SG2-12HR-12D	B&B Electronics	1
Cellular wireless router	ConnectPort WAN	Digi International	1
External cellular antenna		Digi International	1
Remote Reboot	iBoot DC	DataProbe	1
Misc backpanel construction parts	Various	Various	1
Solar Panel	3115 BP Solar module 115 watt 12Vdc	SW Photovoltaic - Tomball	4
Charge Controller	Morningstar ProStar 30M	SW Photovoltaic - Tomball	1
Solar Batteries	MK8G31 Gel battery 96AH with cable kit	SW Photovoltaic - Tomball	8

Border Crossing Travel Time Measurement - Detection Station R2 - 8 lanes - power provided by others

Item	Model	Vendor	Quan
Beacon 915MHz antenna	AA-3153 P/N 12-3153-001	TransCore	8
RF power splitter (multi-lane site)	PD1020 (2way)	InStockWireless	4
RF Surge Protection	LABH2400NN	B&B Electronics	4
RFID Reader	Encompass 4 - Ext Antenna - RS422 - ATA/eGO P/N: 10-4014-009	Transcore	4
Cable, 45 foot, with connector	P/N: 58-1620-007	Transcore	4
Power Supply 24vDC - 240W (Mean Well)	P/N: SDR-240-24	B&B Electronics	1
RS-422 converter - DIN rail mount	485LDRC9	B&B Electronics	4
Programmable Logic Relay (24v - 4Relay Out)	SG2-12HR-D	B&B Electronics	2
Cellular wireless router	ConnectPort WAN	Digi International	2
Terminal Server - 2 port	PortServer TS 2 H MEI	Digi International	1
External cellular antenna		Digi International	1
Remote Reboot	iBoot AC	DataProbe	1
Misc backpanel construction parts	Various	Various	1

Border Crossing Travel Time Measurement - Detection Station R3 - 4 lanes - power provided by others

Item	Model	Vendor	Quan
Beacon 915MHz antenna	AA-3153 P/N 12-3153-001	TransCore	4
RF power splitter (multi-lane site)	PD1020 (2way)	InStockWireless	1
RF Surge Protection	LABH2400NN	B&B Electronics	2
RFID Reader	Encompass 4 - Ext Antenna - RS422 - ATA/eGO P/N: 10-4014-009	Transcore	2
Cable, 35 foot, with connector	P/N: 58-1620-006	Transcore	2
Power Supply 24vDC - 96W	P/N: MDR-100-24	B&B Electronics	1
RS-422 converter - DIN rail mount	485LDRC9	B&B Electronics	2
Programmable Logic Relay (24v - 4Relay Out)	SG2-12HR-D	B&B Electronics	1
Cellular wireless router	ConnectPort WAN	Digi International	1
External cellular antenna		Digi International	1
Remote Reboot	iBoot AC	DataProbe	1
Misc backpanel construction parts	Various	Various	1

Laredo Colombia Bridge Border Crossing Travel Time Measurement - Detection Stations - Summary			
Border Crossing Travel Time Measurement - Detection Station R1 - 2 lane - solar			
Item	**Model**	**Vendor**	**Quan**
Beacon 915MHz antenna	AA-3153 P/N 12-3153-001	TransCore	2
RF power splitter (multi-lane site) 1 to 2	PD1020 (2way)	InStockWireless	1
RF Surge Protection	LABH2400NN	B&B Electronics	2
RFID Reader	Encompass 4 - Ext Antenna - RS422 - ATA/eGO P/N: 10-4014-009	Transcore	1
Cable, 35 foot, with connector	P/N: 58-1620-006	Transcore	2
12-24v DC/DC adjustable output converter	PST-SR700 adj	Powerstream	1
RS-422 converter - DIN rail mount	485LDRC9	B&B Electronics	2
Programmable Logic Relay (12v - 4Relay Out)	SG2-12HR-12D	B&B Electronics	1
Cellular wireless router	ConnectPort WAN	Digi International	1
External cellular antenna		Digi International	1
Remote Reboot	iBoot DC	DataProbe	1
Misc backpanel construction parts	Various	Various	1
Solar Panel	3115 BP Solar module 115 watt 12Vdc	SW Photovoltaic - Tomball	4
Charge Controller	Morningstar ProStar 30M	SW Photovoltaic - Tomball	1
Solar Batteries	MK8G31 Gel battery 96AH with cable kit	SW Photovoltaic - Tomball	8
misc solar install parts	brackets, mounts,shipping, etc	SW Photovoltaic - Tomball	1
Border Crossing Travel Time Measurement - Detection Station R2 - 4 lanes - power provided by others			
Item	**Model**	**Vendor**	**Quan**
Beacon 915MHz antenna	AA-3153 P/N 12-3153-001	TransCore	4
RF power splitter (multi-lane site)	PD1020 (2way)	InStockWireless	2
RF Surge Protection	LABH2400NN	B&B Electronics	2
RFID Reader	Encompass 4 - Ext Antenna - RS422 - ATA/eGO P/N: 10-4014-009	Transcore	2
Cable, 45 foot, with connector	P/N: 58-1620-007	Transcore	2
Power Supply 24vDC - 240W (Mean Well)	P/N: SDR-240-24	B&B Electronics	1
RS-422 converter - DIN rail mount	485LDRC9	B&B Electronics	2
Programmable Logic Relay (24v - 4Relay Out)	SG2-12HR-D	B&B Electronics	1
Cellular wireless router	ConnectPort WAN	Digi International	1
Terminal Server - 2 port	PortServer TS 2 H MEI	Digi International	1
External cellular antenna		Digi International	1
Remote Reboot	iBoot AC	DataProbe	1
Misc backpanel construction parts	Various	Various	1
Border Crossing Travel Time Measurement - Detection Station R3A - 1 lanes - power provided by others			
Item	**Model**	**Vendor**	**Quan**
Beacon 915MHz antenna	AA-3153 P/N 12-3153-001	TransCore	1
RF power splitter (multi-lane site)	PD1020 (2way)	InStockWireless	1
RF Surge Protection	LABH2400NN	B&B Electronics	1
RFID Reader	Encompass 4 - Ext Antenna - RS422 - ATA/eGO P/N: 10-4014-009	Transcore	1
Cable, 35 foot, with connector	P/N: 58-1620-006	Transcore	1
Power Supply 24vDC - 96W	P/N: MDR-100-24	B&B Electronics	1
RS-422 converter - DIN rail mount	485LDRC9	B&B Electronics	1
Programmable Logic Relay (24v - 4Relay Out)	SG2-12HR-D	B&B Electronics	1
Cellular wireless router	ConnectPort WAN	Digi International	1
External cellular antenna		Digi International	1
Remote Reboot	iBoot AC	DataProbe	1
Misc backpanel construction parts	Various	Various	1

Appendix D: CBP RFID Equipment Installation Report

Laredo World Trade Bride and Colombia Bridge RFID Tag Reader Install
May 6 – May 12, 2011 in Laredo, TX

Installation Planning

The TTI team participated in a planning telephone conference call on April 26, 2011. The purpose of the call was to bring together all parties involved in the World Trade Bridge and Colombia CBP facilities in order to explain the project and understand what actions will be required prior to and during the visit to the Laredo facilities. The call included the following people:

- Mr. Roberto Ramos, Project Manager, GSA Laredo.
- Gabriel Vargas, Property Manager, GSA Laredo
- Mr. Armando Taboada, Supervisory Program Manager, CBP Laredo
- Leonard Ruback, Research Scientist, Texas Transportation Institute
- Juan Villa, Program Manager, Texas Transportation Institute

The general notes and sketch installation plan from the conference call are included below.

General Notes:

- CBP has to clear all onsite staff and contractors. TTI will send the names, date of birth, and last 4 the Social Security Number (or ID card) for all persons expected to be onsite during the installation.
- CBP prefers contractors to work after hours to eliminate any impact upon daily operations at the Primary booths. The World Trade Bride (WTB) opens at 6am and closes as midnight. No lanes will be shutdown at WTB but a lane can be closed for installation at Colombia. WTB closes early on Saturday and is closed on Sunday.
- GSA will do a walkthrough of the facility to review conditions before install.
- The facility has onsite security during the overnight hours. The security team will be given our names as authorized by CBP/GSA. We must carry identification at all times in case security checks.
- Lighting will be on for nighttime installation work.

Contacts:

- GSA contact: Roberto Ramos 956-236-3240 (cell)
- CBP contact: Armando Taboada (956) 753-1773 (office)
- TxDOT contact: Armando Ramirez 956-712-7789 (office)

Work plan:

5/6/2011: Installation contractor travels to Laredo. Contractor goes to TxDOT Laredo District offices and picks up equipment stored there for this project.

5/7: Contractor meets with GSA/CBP people at WTB prior to the facility closing. Any walkthroughs and briefings with facility staff will be done before closing. After closing, the contractors will begin install work on 8 of the Primary lanes.

5/8: Contractors continue installation work at WTB Primary and move to WTB exit booths later in the day. WTB work needs to be completed before the facility opens on Monday (5/9).
5/9: Contractors travel to the Colombia Bridge and meet with CBP staff onsite for a briefing and walkthrough. Contractors will be able to shut down one lane at a time for installation and thus the work can be done while the facility is open. Work at Colombia will complete before the facility opens on Tuesday (5/10).
Leonard Ruback (TTI) travels to Laredo.
5/10: Ruback meets with the installation contractors and site staff at WTB. System final wiring, configuration, test, and commissioning for the installs at WTB Primary and WTB exit booths.
5/11: Ruback and the installation contractor meet with Colombia staff onsite and complete the install, test and commission at Colombia.
5/12: Return travel day.

On-site Installation at the World Trade Bridge

The installation contractor arrived in Laredo on 5/6 as planned and acquired the project equipment (readers, antennas, cabinets) from the TxDOT Laredo District office. The on-site construction work began on Saturday, 5/7, and proceeded as per the work plan with the structure and mechanical installation work done at all facilities by the end of the day Monday, 5/9. Mr. Ruback arrived at WTB on the morning of 5/10 and met with Harlan Bailey, the facility security supervisor. Mr. Bailey required authorization from Mr. Taboada to allow Mr. Ruback onto the facility. Authorization was received in the early afternoon and the finishing work was begun at the WTB Primary lanes.

The contractor team outfitted the original 8 lanes at the facility with tag reading capability. A recent expansion at WTB has increased the number of Primary lanes. The construction used the same methods as at prior facilities (Pharr and El Paso) with 1 ½ inch diameter conduit hung from the canopy ceiling used for antenna mounting and cable routing. The conduit was affixed near the canopy edge on the lane exit side as per prior agreement with CBP. A panel antenna was installed over each of the 8 lanes. Pairs of antennas were assigned to each of the 4 readers with the readers being installed on the conduit in between their associated antennas.   The Primary lanes reader/antenna installation is shown in the following images.

WTB Primary Lanes Tag Reader and Antenna Mounting.

WTB Primary Lanes with Tag Reading Equipment Installed.

The control cabinet was mounted to a vertical steel pole to the right of the rightmost booth in the above picture (cabinet is barely visible at the very right edge of the picture). The cabinet is out of the way and protected by other steel structures (hand rails and support poles). Electrical power was acquired from an adjacent equipment cabinet rack.

WTB Primary Lanes Control Cabinet.

Installation at WTB Exit Booths

A second installation was done at the WTB exit booths. Here the older 4 lanes (of 5 lanes total) were selected for detection with each lane receiving an overhead panel antenna hung from conduit just as in the Primary lanes. Again, the antennas were positioned at the exit end of the overhead canopy.

WTB Exit Booths Tag Reader and Antenna Mounting.

The control cabinet for the exit booth install was mounted on a vertical steel roof support pole and out of the way of foot and vehicle traffic. Electrical power was accessed from the inspection booth directly behind the pole cabinet. Mr. Roberto Ramos, our GSA contact, stopped by WTB on 5/11 to inspect the work at both the Primary and exit lanes. Mr. Ramos indicated verbal approval of the work at the site.

<u>On-site Installation at the Colombia Bridge</u>

The team installed antennas over the 4 busiest lanes at the Colombia Bridge Primary inspection booths. The mechanical construction is similar to the WTB sites where 1 ½ inch conduit was hung from the exit end of the canopy and the antennas and readers were subsequently mounted to the conduit. The conduit also provided an enclosure for the cabling back to the control cabinet. The control cabinet was mounted on a vertical concrete support pole with the bottom of the cabinet being above head height to insure safe passage. The control cabinet gained electrical power by connecting into an existing overhead electrical outlet mounted in the canopy. The connection was made permanent by using appropriate electrical enclosures at the canopy connection point and electrical conduit between the canopy and the control cabinet.

Colombia Bridge Primary lanes tag reader and antenna mounting

Control Cabinet at the Colombia Primary lanes

Testing the Installations

World Trade Bridge

Testing began on the afternoon of 5/10 at the WTB Primary lanes. The test was conducted on the site with the following results.

WTB CBP Primary Test	
Test	**Result**
Solar current	N/A
AC voltage	119.6VAC
24 VDC	24.2VDC
Signal strength	-63dBm 1xRTT -58dBm EV-DO
Tag read	Readers R3A, R3B, R3C, R3D all are reading tags
Read reliability	See captured lane data
Static IP	166.141.126.28 3 times
Comm. Accessibility	Pass - tested using iPhone browser pull of router setup page
Auto Pwr cycle	Pass
Remote Pwr Cycle	Pass
Remote config test	Pass issued #00 and received #Done
System latency	1:00 min:sec
Data Transfer to El Paso	Pass

Test conducted at the WTB Primary lanes installation

The most significant test of the system is the lane by lane measurements of vehicle windshield tag acquisition. The test was conducted by connecting and collecting data from one RFID reader at a time. A single reader gathers tags from 2 lanes. For instance Reader R3A collects from lanes 1 and 2, Reader R3B collects from lanes 3 and 4, and Reader R3C collects from lanes 5 and 6 and Reader R3D collects data from lanes 7 and 8.

While connected to a reader the team monitored both the incoming data and the vehicles in the 2 corresponding lanes. Each vehicle that passed through either of the 2 lanes was classified as one of the following:

- Had a tag and was read by the reader,
- Had what appeared to be a valid, readable tag but was not read, or
- Did not have a tag, had an improperly applied or physically damaged tag.

Note that most of the trucks that pass through the Laredo ports of entry are outfitted with multiple tags. This test procedure simply looks for some kind of tag read from each vehicle. The truck is counted the same if 1 tag is read or 4. Given this, the actual number of tag reads is not an indicator of truck volume. Additionally, with multiple tags displayed on a vehicle the probability that at least one of the tags will be read increases and thus the read reliability is increased.

The following are the test results for each lane at WTB Primary.

Tag Read Reliability by Lane at WTB Primary						
Lane	**Read**	**Miss**	**No Tag**	**With Tag**	**Read %**	**Time Interval**
1	31	0	1	31	100%	00:46:49
2	25	0	0	25	100%	00:46:49
3	35	0	0	35	100%	01:01:21
4	0	0	0	0	n/a	01:01:21
5	23	0	0	23	100%	00:26:48
6	19	0	1	19	100%	00:26:48
7	24	1	2	25	96%	00:18:01
8	0	0	0	0	n/a	00:18:01

WTB Primary lanes tag read reliability results

Where Read % = $\frac{Number\ of\ vehicles\ read}{Number\ of\ vehicles\ read + number\ of\ missed\ vehicles}$

Lane 4 and lane 8 were not active during the read reliability testing periods and thus no data were collected. The tag reading performance should closely follow that of lane 3 and lane 7 respectively. The reader for lane 4 is shared with lane 3 and the reader for lane 8 is shared with lane 7. Results were derived for both of these lanes.

The number of vehicles without tags has no influence on the test results and was included strictly for completeness. The no tag data does indicate that a large percentage of the vehicles have some type of tag applied.

It needs to be noted that the determination of a readable tag is done by remote visual inspection. There will almost assuredly be errors made as this is strictly a judgment call made by a team member inspecting a vehicle. Most vehicles have some type of windshield sticker but many are not RFID tags and some are difficult to tell with the high degree of accuracy. Additionally, tags have been removed and reapplied which impacts their performance.

The tag reading results are very good for the Primary site with essentially every commercial vehicle having some kind of readable tag and most having multiple tags.

Testing then moved to the WTB exit booths. The results are given below.

WTB CBP Exit Booths Test	
Test	**Result**
Solar current	N/A - Not a solar site
AC voltage	120.2VAC
24 VDC	24.2VDC
Signal strength	-66dBm 1xRTT -56dBm EV-DO
Tag read	Readers R3A, R3B are reading tags
Read reliability	See captured lane data
Static IP	166.141.85.96 3 times
Comm. Accessibility	Pass - tested using iPhone browser pull of router setup page
Auto Pwr cycle	Pass
Remote Pwr Cycle	Pass - used iPhone to command iBoot to cycle power via 3G
Remote config test	Pass issued #00 and received #Done
System latency	1:00 min:sec
Data Transfer to El Paso	Pass

TEP test conducted at the WTB exit lanes installation

The traffic is high at the exit booths since there are only 5 total and the delay at the booth itself is typically only seconds. The lane 4 volume is significantly less due to the lane being closed after a shift change during the data collection period.

Tag Read Reliability by Lane at WTB Exit Lanes						
Lane	**Read**	**Miss**	**No Tag**	**With Tag**	**Read %**	**Time Interval**
1	45	1	1	46	98%	00:25:21
2	35	1	1	36	97%	00:25:21
3	34	1	4	35	97%	00:22:23
4	10	0	0	0	100%	00:05:25

WTB exit lanes tag read reliability results

Where Read % = $\frac{Number\ of\ vehicles\ read}{Number\ of\ vehicles\ read + number\ of\ missed\ vehicles}$

The testing results for the WTB exit lanes closely follow the results from the Primary lanes with nearly every truck having at least one tag and being read.

Colombia Bridge
The Primary lanes at the Colombia Bridge were tested and the results are shown below.

Colombia CBP Primary Test	
Test	**Results**
Solar current	N/A - Not a solar site
AC voltage	115.5VAC
24 VDC	24.2VDC
Signal strength	-93dBm 1xRTT -85dBm EV-DO
Tag read	Readers R3A, R3B are reading tags
Read reliability	See captured lane data
Static IP	166.141.126.25 3 times
Comm Accessibility	Pass - tested using iPhone browser pull of router setup page
Auto Pwr cycle	Pass
Remote Pwr Cycle	Pass - used iPhone to command iBoot to cycle power via 3G
Remote config test	Pass issued #00 and received #Done
System latency	00:51 min:sec
Data Transfer to El Paso	Pass

TEP test conducted at the Colombia Bridge Primary lanes

Tag Read Reliability by Lane at Colombia Primary Lanes						
Lane	**Read**	**Miss**	**No Tag**	**With Tag**	**Read %**	**Time Interval**
1	0	0	0	0	n/a	n/a
2	0	0	0	0	n/a	n/a
3	46	0	0	46	100%	01:09:32
4	35	0	1	35	100%	01:09:32

Colombia Primary lanes tag read reliability results

Where Read % = $\frac{Number\ of\ vehicles\ read}{Number\ of\ vehicles\ read + number\ of\ missed\ vehicles}$

Lanes 1 and 2 were not in operation during our testing period and thus no tag was collected. The lanes were tested by repeatedly holding up a pair of sample TransCore RFID tags that the contractor uses for basic acquisition testing. Each tag was read during each attempt.

The cellular signal strength is fairly low at this location (-85dBm). The Colombia facility is in a remote location more than 20 miles from the outer business areas of Laredo. There is little reason in the area for cellular providers to service. Additionally, the Primary lanes were constructed in an excavated area putting much of the booth area below normal ground height thus further impacting cellular reception.

Colombia CBP Primary lanes below ground height

Although the signal strength numbers are weak the site is doing a good job staying online and transmitting data. There is only about a 5dBm fade margin (cushion) for this site and therefore it should be watched for communication outages.

In summation, 3 RFID tag reading sites were brought online in the Laredo area with 2 being at the World Trade Bridge and 1 at the Colombia Bridge. The installations were completed without issue and the test results for all 3 sites verify a successful operation.