Measuring Border Delay and Crossing Times at the U.S.–Mexico Border—Part II

Guidebook for Analysis and Dissemination of Border Crossing Time and Wait Time Data

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16. Abstract

The purpose of this guidebook is to describe to local, regional, and State agencies how to analyze and disseminate data collected by a radio frequency identification (RFID)-based system to measure travel times of commercial vehicles, which is referred to in this document as the RFID-based border crossing time and wait time measurement system. The guidebook includes recommended statistical analyses that can be used to support monitoring the performance of border crossings. The guidebook also describes available mechanisms to disseminate crossing times and wait times. These data include traveler information (e.g., current crossing and wait times) and archived information (e.g., performance measures, pre-coded reports and charts). The guidebook is not specific to one port of entry and hence is applicable to any border crossing deriving crossing time and wait time data similar to those collected by RFID-based systems that have been implemented at various U.S.–Mexico land border crossings in Texas.

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INTRODUCTION

Background

In 2001, the Federal Highway Administration (FHWA) conducted research that resulted in a report entitled *Evaluation of Travel Time Methods to Support Mobility Performance Monitoring*. That project involved manual crossing time measurements on commercial vehicles transiting four northern and three southern border crossings. The research also produced another report—*Assessment of Automated Data Collection Technologies for Calculation of Commercial Motor Vehicle Border Crossing Travel Time Delay*—which was published in 2002 and evaluated candidates to automate the collection of border delay and crossing time data. There were 22 vehicle-sensing technologies screened against factors such as availability of appropriate software, volume count flexibility, minimization of privacy invasiveness, ruggedness/all-weather operation, low infrastructure cost, and positive identification capability.

Of the 21 technologies initially screened, 11 were chosen for closer examination. These 11 technologies had a multitude of desirable attributes overall but in particular had the potential to meet the following three essential criteria:

- Make positive identification of both inbound and outbound trucks at a matched pair of two points (upstream and downstream) that correspond to where data collectors are stationed for manual readings.
- Time-stamp each vehicle that is positively identified at its detected location to enable travel time calculations.
- Operate in all weather conditions found at a border crossing.

Subsequently, 11 of the 22 screened candidate-sensing technologies that met those three basic criteria were assessed against the additional criteria of accuracy of geo-location/travel time, percent of vehicles recorded, requirement for cross-border installation, maturity of technology for application, cost of infrastructure, and ability to count every vehicle crossing. The major deliverable of that research was a documented trade-off comparison of the advantages and disadvantages of the most promising sensor technologies that could potentially be used in an automated system to calculate truck travel times at border crossing sites. The report also noted that "a modest follow-on study to determine the most appropriate sensor technologies for the FHWA's needs could produce benefits."

As a follow up to the work described above, in 2006, the FHWA initiated a research effort entitled *Measuring Border Delay and Crossing Times at the U.S.–Mexico Border*. This research, namely the identification of suitable technologies, was a foundational component for the subsequent development of a systematic approach to automate the measurement of border crossing time, a term defined in the Setting Basic Definitions of Border Crossing and Wait Times section.

In 2007, FHWA's research on measuring border delay and crossing times at the U.S.–Mexico border expanded to involve two specific objectives: (1) selecting a final technology for the border crossing time measurement system at two ports of entry (POEs) on the U.S.–Mexico border, and (2) implementing a border crossing time measurement system. To meet research objectives, FHWA initiated two projects, one of which became the deployment of radio frequency identification (RFID) technology at the Bridge of the Americas (BOTA), a land border crossing between El Paso, Texas, and Ciudad Juárez, Mexico. This project initially implemented two RFID reader stations at BOTA to measure crossing times of northbound commercial vehicles. The system at BOTA became operational in July 2009.

In February 2008, the Texas Department of Transportation (TxDOT) started a similar project to measure crossing times. The project implemented RFID technology at the Pharr-Reynosa International Bridge to measure crossing times of northbound commercial vehicles. The system includes four RFID reader stations—two in Mexico and two on the U.S. side of the border. The deployment of RFID reader stations and other communication equipment was completed and the system became operational in October 2009.

RFID reader stations were subsequently installed at the U.S. Customs & Border Protection (CBP) Primary Inspection booths at the Pharr and BOTA POEs in March and April 2011, respectively. This provided the RFID systems at those POEs with the additional capability to measure wait time, a term defined in the Setting Basic Definitions of Border Crossing and Wait Times section.

The key reason RFID technology was selected at both the BOTA and Pharr POEs to measure crossing times (and later, wait times) was due to the relatively high percentage of commercial vehicles crossing at those locations that already had RFID transponders, or tags. For example, passive RFID tags were widely used by trucks enrolled in CBP's Free and Secure Trade (FAST) Program, and many trucks also had CBP user fee or toll tags. Also, the Texas Department of Public Safety (DPS) installed RFID reader stations to provide identifying information that could be used to retrieve information needed to facilitate passage of commercial vehicles through the DPS's Border Safety Inspection Facilities (BSIFs). It was emphasized to system users and other stakeholders that the intended RFID system implementation needed to be designed to read tag identification numbers (IDs) and time-stamp the IDs when the tags passed particular RFID reader stations. The design did not need to provide capability for the system to identify a driver, vehicle, or carrier, which was not information of interest. Further, the RFID system did not need to be integrated with any other system that provided access to that type of information. Key deliverables of FHWA's research on measuring border delay and crossing times at the U.S.–Mexico border include supporting documents that describe to local, regional, and State agencies how to deploy similar RFID-based border crossing time and wait time measurement systems on the U.S.–Mexico border. These documents include:

- *Step-by-Step Guidelines for Implementing RFID to Measure Border Crossing and Wait Times*.
- *Guidebook for Analysis and Dissemination of Border Crossing and Wait Time Data*.

This document is the second listed above and includes traveler information (e.g., current crossing and wait times) and archived information (e.g., performance measures, pre-coded reports and charts). This guidebook is not specific to one POE and hence is applicable to any border crossing deriving crossing time and wait time data similar to data collected by RFID-based systems at various U.S.–Mexico land border crossings in Texas. In addition to the supporting documents, a prototype Web tool has been developed. The Web tool is (a) a centralized repository of border wait times and crossing time data from multiple POEs, and (b) an efficient platform to archive, process, and disseminate traveler information (current wait times and crossing times of commercial vehicles) as well as archived data related to performance of POEs.

Purpose and Audience for the Guidebook

The purpose of this document is to describe to local, regional, and State agencies how to analyze and disseminate data collected by a system to measure travel times of commercial vehicles, which is referred to in this document as the RFID-based border crossing time and wait time measurement system. This term presumes that RFID reader stations have been implemented in the configuration necessary to yield both crossing and wait time measurements.

The guidebook includes a recommended statistical analysis that can be used to support monitoring the performance of border crossings and disseminating traveler information. The guidebook also describes available mechanisms to disseminate crossing time and wait time data as traveler information and archived data in the form of performance measures.

This description assists agencies with RFID-based border crossing time and wait time measurement systems to develop meaningful output from the data analysis, which then can be used by stakeholders for planning and decision-making as well as disseminating information to support a variety of stakeholder needs.

The audience for this guidebook includes State departments of transportation, metropolitan planning organizations (MPOs) and agencies, cities, councils of governments, or any other entity that typically is responsible for planning, designing, implementing, operating, and maintaining an RFID-based border crossing time and wait time measurement system. The guidebook can also help freight carriers, shippers, factory owners, and agencies involved with cross-border freight movement better understand the types of information that might be available to them with an RFID-based border crossing time and wait time measurement system.

For the purpose of this document, an agency (public or private) planning and procuring a project to deploy an RFID system is referred as an implementing agency, which may seek the services of consultants and contractors to design and deploy the system. The scope of the RFID-based border crossing time and wait time measurement system described in this document is commercial freight vehicles inbound to the United States. In this document, the terms *commercial vehicle* and *truck* are used interchangeably, as are the terms *transponder* and *tag*.

Organization of the Guidebook

The Creating a Framework section of the guidebook describes how an implementing agency needs to go about creating a framework to analyze crossing time and wait time data and disseminate the information (real-time and archived) to stakeholders. The section describes stakeholder involvement in gathering needs and developing data analysis outputs related to traveler information and performance measures, as well as identifying preferred dissemination media.

The Data Analysis section describes processes for filtering the raw data obtained from the RFID-based border crossing time and wait time measurement system. It also describes the process for aggregating data in temporal granularities (e.g., hourly, daily, weekly, or monthly). Finally, it describes numerical methods to compute recommended performance measures in the context of mobility at the border.

The Information Dissemination describes key concepts and techniques for disseminating both traveler information and archived data. The chapter also describes ways to identify proper dissemination media and the need for establishing policies and procedures for data dissemination.

The Conclusions section provides summary of the guidebook.

CREATING A FRAMEWORK

Key Steps for Developing a Framework

A general framework for analyzing and disseminating crossing time and wait time data at border crossings needs to start by defining the characteristics and scope of the raw data that are to be generated by the RFID-based border crossing time and wait time measurement system deployed by the implementing agency. The characteristics and scope of raw data also depend on how parameters such as crossing time and wait time are defined by the implementing agency and by the stakeholders. The characteristics of the raw data are also dependent on the characteristics of the POE where the RFID-based border crossing time and wait time measurement system is deployed. Each POE is different and has features unique to its setting. For example, some POEs may have separate lanes to process FAST-compliant trucks in addition to separate inspection booths for FAST processing, while others may not have separate lanes. This makes a difference if separate crossing times and wait times are being reported for FAST versus non-FAST trucks.

A critical need is obtaining stakeholder input as to what data and other information are most helpful in meeting their needs. As there are no existing standards for reporting this type of information, it is up to the implementing agency to develop its own policies and procedures. However, stakeholder input and agreement are critical.

Key steps for developing a framework for data analysis and dissemination are illustrated in Figure 1.

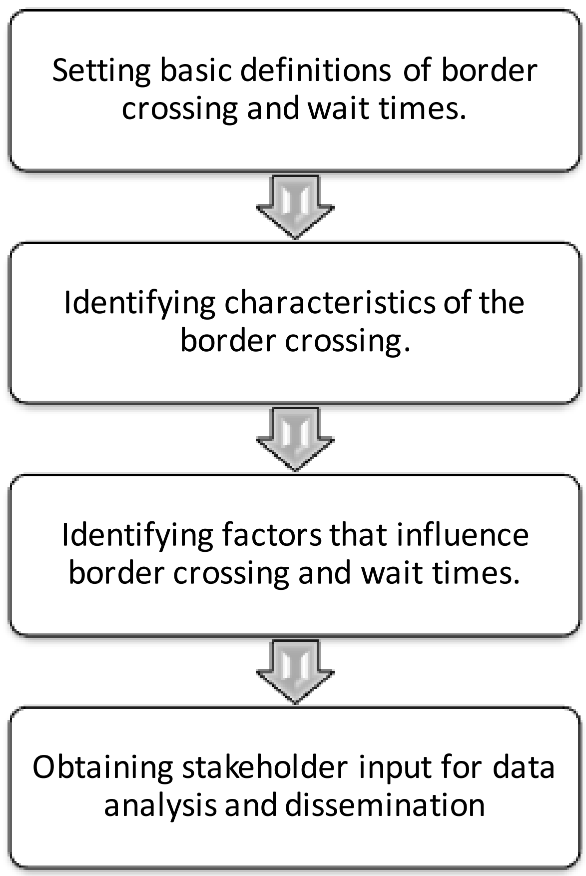


Figure 1. Flowchart Describing Key Steps for Developing a Framework.

Setting Basic Definitions of Border Crossing and Wait Times

The following generally accepted definitions of wait time and crossing time are used throughout this document. Wait time is defined as "the time it takes, in minutes, for a vehicle to reach the CBP's primary inspection booth after arriving at the end of the queue."[1] This queue length is variable and depends on traffic volumes and processing times at each of the inspection facilities throughout the border crossing process. Crossing time has the same beginning point in the flow as wait time, but its terminus is the departure point from the last

[1] Border Wait Time Working Group presentation, April 2009, http://www.thetbwg.org/meetings/200904/1_-_border%20wait%20times%20update.ppt.

compound that a vehicle transits in the border crossing process. Time limit thresholds can be set so that an unusually long time spent by a vehicle in one part of the crossing process (e.g., vehicle mechanical breakdown or overnight stay in the inspection compound) can be discarded so that its crossing or wait time data do not skew aggregated average crossing or wait times. The Filtering Raw Data Section talks about a related concept: use of the fixed time window to filter out times of drayage truck crossings.

Identifying Characteristics of the Border Crossing

Characteristics and configuration of the border crossing where an RFID-based border crossing time and wait time measurement system is deployed need to be considered while performing data analysis and disseminating real-time and archived data because characteristics and configuration of the border crossing influence scope of crossing time and wait time data. For example, many POEs have designated booths for processing FAST-compliant trucks and shipments. However, some POEs allow non-FAST trucks to use the booth as well when heavy queuing is present. In such a situation, separating the wait times of FAST versus non-FAST trucks is not feasible. At some POEs, there are no dedicated lanes for FAST trucks, but there are separate booths for such vehicles. Thus, while it is desirable to separately measure crossing times and wait times of FAST and non-FAST trucks, infrastructure and/or operational practices at a POE may preclude the capability to accomplish that. Design documents and specifications for an RFID-based border crossing time and wait time measurement system need to address such issues.

Identifying Factors That Influence Border Crossing and Wait Times

Crossing and wait times of commercial vehicles are influenced by a wide variety of factors. Some factors are tied to operational changes related to Federal and State inspection processes, while others are external, such as approaching volume and major incidents around the border crossings. When interpreting crossing time and wait time data, a user needs to be informed of these influences and seek to correlate their effects in order to best understand variations that occur.

The factors included below were learned from experiences at the BOTA and Pharr POEs but are illustrative and thus expected to affect data at other POEs. These factors are helpful in both (a) informing users of influences they need to be aware of while interpreting data, and (b) understanding the correlation of as many of these factors as possible during data analysis.

- **Time of day and day of week—**Commercial vehicles crossing the border follow a temporal trend and show a distinct peak and off-peak volume. Intuitively, a temporal trend of crossing and wait times might follow a similar trend for volumes.
- **Approaching volume—**Volume of vehicles approaching the Federal inspection facility has a significant impact on crossing and wait times. Approaching volume of vehicles is also a function of time of day and week, special events and holidays, and other factors. The number of transponders read by the RFID readers on the Mexican side can be taken as a proxy to the approaching truck volume.
- **Number of inspection lanes open—**The number of inspection lanes open during any given time is correlated with crossing and wait times of vehicles. Vehicles that go

through the secondary inspection have much higher crossing times than the rest. However, it is not clear what percentage of total vehicles goes through secondary inspection in a day. Also, the number of lanes used at the State inspection facility influences the crossing and wait times of trucks.

- **Shipment type—**Depending on the type of shipment, crossing and wait times could vary significantly, especially for shipments that are empty and are enrolled in the FAST program.
- **Type of commodities—**Many POEs experience significantly higher crossing and wait times during seasons when particular agricultural products are imported into the United States from Mexico.
- **Flow control—**Design of the RFID-based border crossing time and wait time measurement system needs to ensure that commercial vehicles do not leak from the flow. This can happen when commercial vehicles are able to divert from the crossing by exiting a side road after passing the RFID reader station at the head of the queue. It there are multiple RFID readers that segment the trip, this leakage can be detected and accounted for in the data. Leakage can also happen if unanticipated road construction diverts the flow away from readers, diminishing their rate of tag ID capture.
- **Flow segmentation—**The ability to use additional RFID reader stations to segment travel time increments of a commercial vehicle's path through the POE, especially its approach to CBP Primary Inspection, can allow greater insight into where congestion is originating. Indeed, the ability to provide wait time is a type of segmentation assuming crossing time is also provided. Segmentation preserves the ability to measure crossing time or wait time. Scope of raw data is directly related to the core capabilities of the deployed system and factors such as those just mentioned.

Obtaining Stakeholder Input for Data Analysis and Dissemination

Stakeholder needs for real-time and archived data help in defining input and output values and algorithms for analyzing the data. To create archived data, including performance measures, input and output variables and algorithms need to be clearly described. While some stakeholders may be able to provide input on the statistical techniques, all need to be interested in the definition of the outputs and measures. It is also important that the scope of underlying data allows for estimation of such performance measures. The implementing agency needs to inform stakeholders of acceptable data analysis techniques (e.g., statistical methods, sampling techniques, error reporting) through the following:

- Ad-hoc and formal meetings with high-level decision makers.
- Literature review on past best practices studies.

The implementing agency needs to also identify applications for which the data analysis is performed. Some of the known applications of the archived data are as follows:[1]

- Monitor current and past trends in crossing time and wait time performance indices.
- Assess deficiencies and potential improvements at border crossings.
- Establish funding and programming priorities.
- Consider alternative improvement measures.
- Calibrate planning models.

- Determine freight cost due to delay.
- Be aware that air quality analysis and fuel consumption use much detailed data.
- Monitor congestion trends at the border using archived information.
- Establish cause-and-effect relationships.
- Use before-and-after analysis to gauge the effect of transportation improvements, policy changes, and resource mobilization at inspection facilities.
- Use non-technical travel-time-based measures to communicate with the public.

DATA ANALYSIS

Key Steps for Analyzing the Data

Analysis of RFID-based border crossing time and wait time measurement system data, both real-time and archived, revolves around two main objectives: (1) creating advanced traveler information, and (2) developing performance measures about an individual border crossing. For both purposes, data analysis starts with processing raw data, which is defined for the purposes of this guidebook as segment travel time, crossing time, or wait time of an individual truck (detected through its RFID transponder) based on its re-identification by the RFID readers at different locations of the border crossing.

Processing the raw data needs to include a filtering process to eliminate erroneous and duplicate data prior to converting real-time data into either traveler information or performance measures (if real-time data are correct, then archived data are also). Once a filtered collection of raw data is obtained, it then needs to be aggregated into different temporal granularities, which then are used to create traveler information and performance measures. It is recommended that visibility and traceability of the raw data processing be maintained for quality assurance and to validate data analysis results.

Key steps for analyzing the data, including processing raw data, aggregating the processed data, and determining performance measures, are illustrated in Figure 2.

The data analysis approach utilizes four key dimensions of congestion—duration, extent, intensity, and reliability—to characterize performance of freight movements at a border crossing.[2] Duration is the length of time during which congestion at the border affects the freight movement. It is measured by determining the number of hours the facility operates below acceptable conditions, such as off-peak or optimal speed/travel time. Extent is described by estimating the number of vehicle/trips affected by congestion. This can be measured by determining the number of trips that experience crossing time or wait time above an acceptable condition or an established baseline. Intensity is the severity of congestion and is measured by average travel time and delay. Reliability measure variation in the amount of congestion for buffer time and buffer index is used.

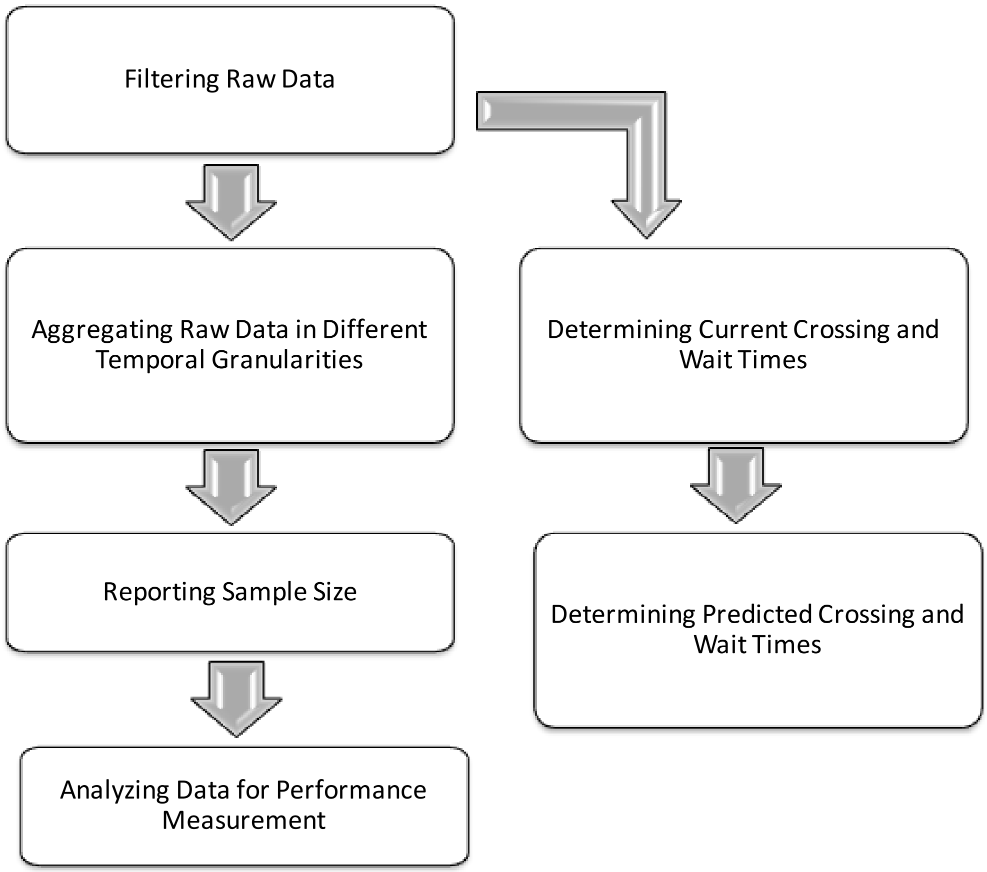


Figure 2. Flowchart Describing Key Steps for Analyzing the Wait Times and Crossing Times Data.

This project's final report includes detailed information about the tools (i.e., hardware, software, and tables) used for data analysis for the BOTA POE. Table 1 gives examples of the archived and aggregated data used at the BOTA and Pharr POEs.

Table 1. List of Tables Used for Archiving and Aggregating Data from BOTA and Pharr Poes.

Table Name	Description
Raw Crossing Time	Stores crossing time of individual commercial vehicles.
Average Crossing Time, 15 and 60 Minutes	Stores average crossing time of northbound commercial vehicles calculated every 15 and 60 minutes.
Raw Wait Time	Stores wait time of individual commercial vehicles.
Average Wait Time, 15 and 60 Minutes	Stores average wait time of northbound commercial vehicles calculated every 15 and 60 minutes.
15- and 60-Minute Tag Count	Stores, in 15- and 60-minute intervals, total count of transponders identified by individual RFID readers.
Monthly Performance (Dashboard)	Stores monthly performance indicators for northbound commercial vehicles at POEs. Indicators include average crossing and wait time, buffer index,[2] 95th percentile,[3] and incoming volume.
Daily and Monthly Total Crossing Time Delay	Stores total crossing delay calculated at daily and monthly intervals based on average and 95th-percentile values as optimal crossing time.
Daily and Monthly Total Wait Time Delay	Stores total wait delay of commercial vehicles calculated at daily and monthly intervals based on average and 95th-percentile values as optimal crossing time.
Daily and Monthly Average Delay per Truck	Stores daily and monthly average delay of commercial vehicles calculated based on average and 95th-percentile values as optimal crossing time. It includes two separate fields to reflect wait time as well as crossing time delay.
Daily and Monthly Percentage of Trucks Congested	Stores daily and monthly percentage of trucks congested, which is calculated based on average and 95th-percentile values as optimal crossing time. It includes two separate fields to reflect wait time as well as crossing time delay.
Monthly Incoming Freight Volume	Stores monthly total freight containers entering the United States by various modes of transportation and container type (empty and loaded).
Monthly Import-Export Volume by Mode	Stores monthly total trade value and weight with origin as Mexico and destination States in the United States by mode of transportation.
Monthly Import-Export Volume by Commodity	Stores monthly total trade value and weight with Mexico by commodity.
Monthly Incoming Vehicle Volume	Stores monthly total vehicles entering the United States by various modes of transportation through various border regions in the State of Texas.

Subsequent sections describe additional details about the data analysis approach.

[2] Buffer index is the extra time that is required to cross the border (average) and indicates reliability of the service. Buffer index expresses the amount of extra buffer time needed to be "on time."

[3] The 95th percentile is a widely used mathematical calculation that can be used for border crossing and wait time measurement applications. Simply put, in this context, it refers to the amount of time within which 95 percent of commercial vehicles cross the border from queue to departure in the case of crossing time measurement, or queue to CBP Primary Inspection in the case of wait time measurement. Even though the 95th percentile is widely used, stakeholders can choose different percentiles in place of the 95th percentile.

Processing Raw Data

The RFID-based border crossing time and wait time measurement stations in the field send identification and time stamps of individual transponders from the remote stations to a central server, and the data are stored in database servers in a relational database structure. For the purposes of this guidebook, raw data represent crossing times, wait times, and segment travel times of individual trucks (i.e., transponders). As the transponder information arrives in the central server, individual crossing and wait times are calculated after identification of transponders are matched by subsequent RFID readers. Raw data are then stored in a table, which is constantly updated using a trigger mechanism in the database as new transponders are re-identified. The RFID-based border crossing time and wait time measurement system is involved in more than just data collection. It also plays a role in data analysis and dissemination.

Filtering Raw Data

Depending on the characteristics of border crossings, a significant number of trucks could be part of drayage or other operations that result in their crossing the border several times in a day. Hence, it is imperative that a process to filter raw data be able to distinguish individual one-way trips inbound to the United States. This can be achieved by using a fixed time window. This is the minimum value a truck needs before the truck can join the queue again for making subsequent trips across the border. For example, if this time window is 120 minutes, it is assumed that a truck typically takes more than that amount before returning to join the queue to cross the border again. However, this value needs to be reflective of the crossing time at the POE and thus needs to be much higher than crossing time of trucks even if some of them go through secondary inspection. It should be noted that the current filtering technique most likely filters out secondary inspection. Also, the value must not be so high that it is possible that trucks can cross the border again within that time period.

Table 2 illustrates some examples of how the fixed time window filtering set at 120 minutes might work.

Table 2. Example of Automated Filtering of Crossing Time Data.

Vehicle Transponder ID	Measured Crossing Time	Data Acceptance
Transponder A	45 minutes	Yes
Transponder B	110 minutes	Yes
Transponder C	135 minutes	No

In some cases, transponders can be read more than once by the RFID readers at the same instance (or within a span of a few seconds), resulting in multiple records of raw data. The reason why RFID readers do that is unknown; however, such duplicate records need to be removed from the database using built-in query functions.

Aggregating Raw Data

Depending on the performance measures to be calculated, raw data need to be aggregated into different temporal granularities. Average crossing and wait times from the raw data can be determined using the following techniques:

- Determine average crossing and wait times at a predefined frequency (e.g., every 15 minutes). For example, determine average crossing and wait times at 7:00 AM, 7:15 AM, and so on. This technique requires using a block of raw data, the span of which could be a fixed time window (e.g., 120 minutes), to calculate the average crossing and wait times. In addition to average values, standard deviation can also be part of the calculation. Average values reported every 15 minutes can be used to monitor trends within a day or week or within a predefined time period. They can also be used to identify peak and off-peak periods. Figure 3 shows 15-minute average crossing time measured at BOTA.
- Aggregate travel time by averaging the raw data for an entire day, week, and month. This technique is useful in monitoring long-term trends of border crossing performance but dampens the peaks and off-peak values of crossing and wait times.

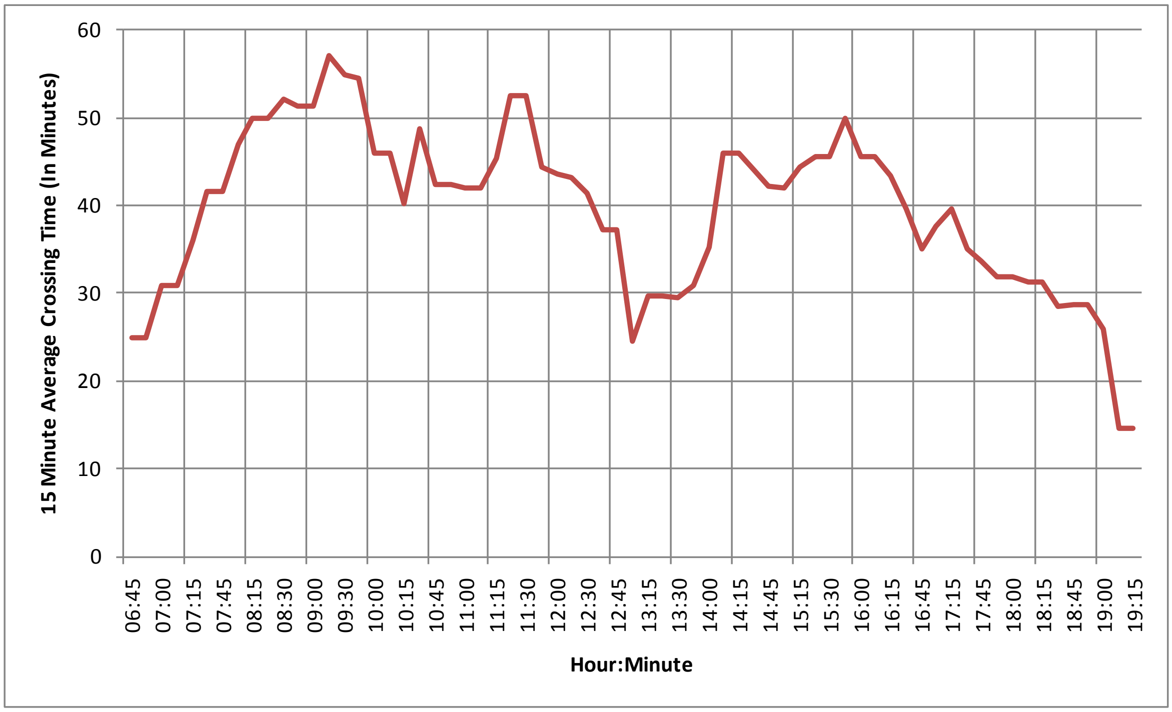


Figure 3. 15-Minute Average Crossing Time Measured at BOTA.

Reporting Sample Size

For the purpose of this guidebook, a sample is referred to as a filtered set of crossing or wait time values of one or more trucks. When aggregating crossing and wait time values, it is a good practice to also report the sample size used in the calculation. This demonstrates the representativeness of the calculation.

Sample size for individual reporting periods, such as hourly, daily, weekly, and monthly, also assists in understanding the performance of the RFID system as well as the underlying trend of truck volume crossing the border.

One of the questions stakeholders frequently ask is, "What is the minimum sample size needed to aggregate border crossing and wait times to remain statistically significant?" While that number has not been established scientifically for trucks passing RFID reader stations at POEs, a minimum sample size can be approximated by using a mathematical technique known as the coefficient of variation (CV).

It is common knowledge that sample size is a function of variability in the data, also measured by the CV, which is a ratio of standard deviation of the sample and the mean. The higher the CV, the more samples required to represent the population. Using the following relationship (t-statistics), a quick analysis of minimum sample size required in a day can be determined by using the following equations:

Minimum sample size = $(\text{t-statistics x coefficient of variation/relative error})^2$

Coefficient of variation = (standard deviation/sample mean)

Relative error = (maximum allowed error/sample mean)

While these equations are widely used, an implementing agency needs to verify their appropriateness for the agency's purpose. Figure 4 shows daily minimum sample size, estimated using the coefficient of variation, and actual sample size (for crossing times) obtained from the RFID-based border crossing time and wait time measurement system deployed at BOTA in October 2009. The actual sample size was well above the minimum sample size. However, two key concepts need to be recognized:

1. If the system allows, minimum sample size needs to be separately estimated for individual types of shipments (e.g., FAST, non-FAST) because the coefficient of variation most likely is smaller for individual types of shipments than when combining the crossing times or wait times for all shipment types.

2. Sample size required to relay traveler information within an hour of the timeframe is not the same as calculating daily performance measure.

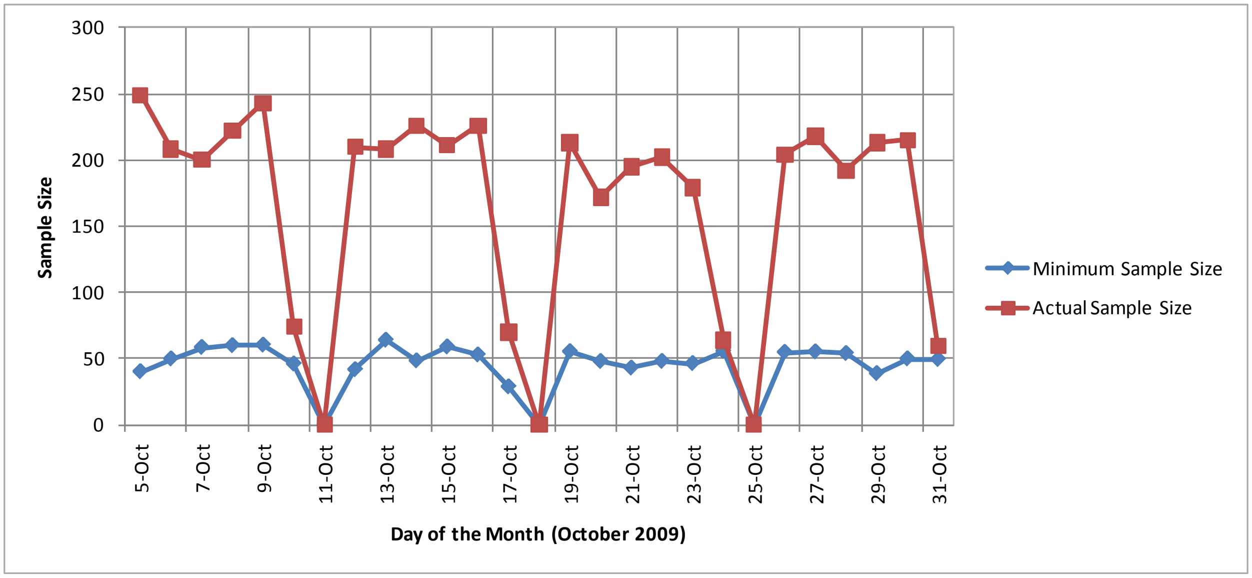


Figure 4. Comparison of Daily Minimum and Actual Sample Size of Crossing Times at BOTA.

During the writing of this guidebook, the RFID-based border crossing time and wait time measurement systems deployed at BOTA and Pharr cannot separate crossing times and wait times for individual shipment types since non-FAST shipments are known to use lanes to FAST Primary Inspection booths.

Analyzing Data for Traveler Information Purposes

The main goal of providing traveler information to stakeholders (e.g., freight carriers, dispatchers) is to be able to let the stakeholders know current and future conditions at border crossings. The RFID-based border crossing time and wait time measurement system has the capability to inform the stakeholders about current and predicted values of crossing and wait times and to indicate extreme events such as unplanned closure of a border crossing. Also, crossing and wait time information can be integrated with number of lanes open and closed to give the stakeholders a sense of what is to be expected at the border in terms of long or short crossing and wait times. Figure 5 shows questions for which freight carriers and dispatchers seek answers from current and predicted crossing and wait times. Certainly, it is technically feasible to refine the questions to seek current and predicted crossing and wait times for the type of load freight carriers are to be moving (e.g., empty, non-FAST, FAST).

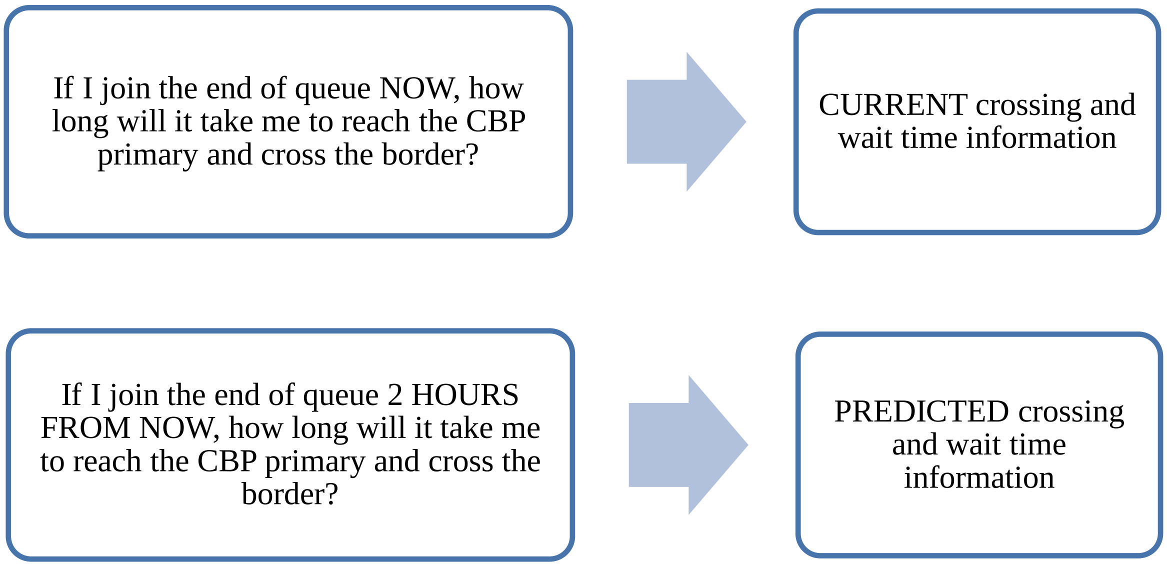


Figure 5. Information Freight Carriers and Dispatchers Seek from Current and Predicted Crossing and Wait Times At Border Crossings.

Determining Current Crossing and Wait Times

Current crossing and wait time information provides freight carriers advanced information on the current condition at the border crossing. A simple algorithm to average the most recent block of raw data is sufficient to estimate current crossing and wait times. At a predefined interval (or update frequency), the algorithm finds a block of filtered raw data and calculates the average crossing or wait times of trucks using a predefined time window. Another method is to find the block of transponders that were read between the start and end time and then filter the crossing or wait time data and calculate a simple average. At BOTA, the current crossing time is determined using the following procedure:

- Average crossing times are calculated every 15 minutes (e.g., 9:00 AM, 9:15 AM, 9:30 AM.).
- The procedure uses 120 minutes as the time window, meaning this value is used as a maximum crossing time.
- To calculate average crossing time at 9:00 AM, all the transponders that were read between 7:00 AM and 9:00 AM are matched and travel times of matched tags are averaged.

Unfortunately, there are no standard procedures based on which update frequency can be established. It is up to the discretion of the implementing agency to establish frequency at which to update the information. However, it needs to be consistent with updating frequency that can be achieved by field display devices (e.g., dynamic message signs [DMSs]). While DMS updates are typically made by operators and thus limited in update frequency, Web sites and Real Simple Syndication (RSS) feeds do not have limitations as to how frequently information can be updated. Agencies also use different update frequencies depending on peak and congested condition versus off-peak conditions, e.g., higher frequency during peak and congested conditions and lower frequency otherwise. This is because travelers and freight carriers tend to be more anxious for information during peak and congested conditions.

Determining Predicted Crossing and Wait Times

Predicting crossing and wait times of trucks crossing the border is challenging in terms of finding efficient analysis techniques. Implementing agencies need to be cognizant that developing such a prediction model might constitute a separate project or a major task by itself. Hence, the implementing agency needs to confer with stakeholders on identifying benefits of providing predicted crossing and wait times at the border. Some of the key questions that need to be answered before attempts are made to develop prediction algorithms are the following:

- What is the appropriate prediction horizon? Accuracy and reliability of prediction algorithms decrease as prediction horizon increases. The implementing agency needs to consult with the affected freight shippers and dispatchers to determine appropriate prediction horizon.

- What is the impact of variability of data? Very high variability in raw data results in unreliable and less-than-accurate prediction values. Also, it is difficult to define thresholds for high and low variability that produce reasonably accurate predicted crossing and wait times. However, variability can be reduced if the RFID-based border crossing time and wait time measurement system can distinguish crossing and wait times for different types of truck loads.

- What is the perception of accuracy among stakeholders? Perception of accuracy of the predicted crossing and wait times after the fact vary depending on individual carriers unless the prediction algorithm is sensitive to external factors such as type of shipment being transported, time of day, and day of week. Hence, over time, motor carriers may complain about accuracy and reliability of the predicted values.

The majority of prediction models use historical (archived) data with an assumption that day-to-day trends remain similar over a short period of time (e.g., weeks instead of years). Time-series models rely on historic trends and do not use input/output or parametric estimation to predict future values. They are easier to compute and easier to implement but are not sensitive to sudden changes in operational conditions at the border. Prediction models based on queuing theory may not be efficient because of highly random (and often unknown) inspection times.

Analyzing Data for Performance Measurement

From a planning and long-range performance monitoring perspective, archived data can be used to determine four key dimensions of congestion—duration, extent, intensity, and reliability. The following performance measures are recommended to measure those four dimensions of congestion:

- Summary statistics on raw crossing and wait time data.
- Average crossing and wait times.

- Buffer time and buffer index.
- Delay.
- Length of peak periods.
- Percentage of total trips that were congested.

Implementing agencies can then present the above measures in different temporal granularities for use in various transportation applications (see Obtaining Stakeholder Input for Data Analysis and Dissemination section for examples).

Summary Statistics about Raw Data

Summary statistics of raw crossing and wait time data include histograms of raw data collected on a typical day/week/month. Summary statistics provide two very important observations on the conditions of freight movement across the border—average (and other percentile) crossing and wait times and variability of crossing and wait times at the border. By having quantified values of crossing and wait times, there is no need to depend on anecdotal values of actual crossing and wait times at the border. Reliability of crossing and wait times can be a powerful tool for trade groups and other stakeholders concerned with transportation improvements to be made at the border. Figure 6 shows histograms of crossing times obtained from the RFID system deployed at BOTA. The histograms show that 95 percent of trucks take approximately 100 minutes or less to cross the border, and 50 percent of trucks require approximately 40 minutes or less to cross the border.

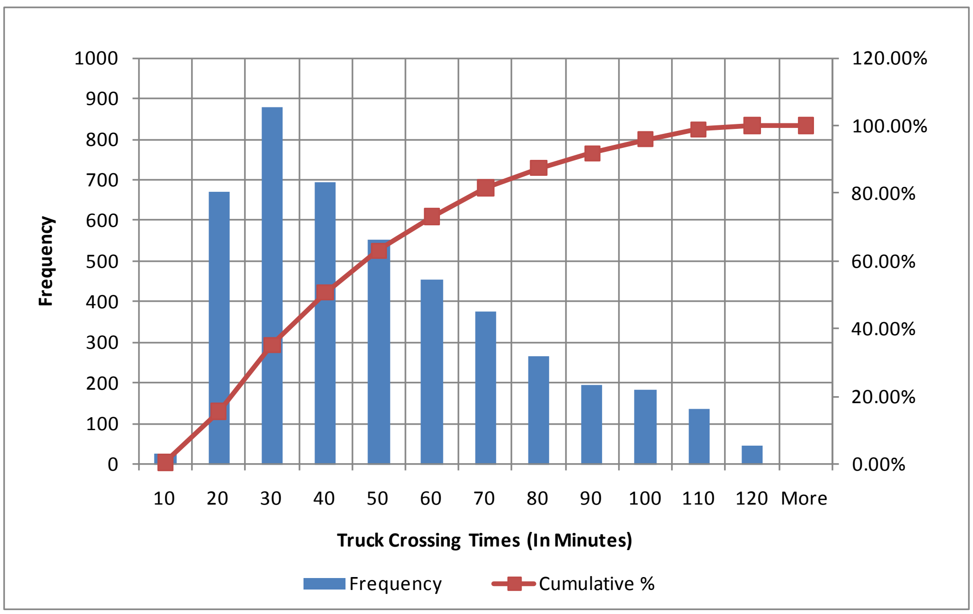


Figure 6. Histograms of Crossing Times of Trucks Entering the United States during October 2009.

Aggregating Raw Crossing and Wait Time Data

Raw crossing and wait time data can be aggregated by calculating averages of blocks of raw data at predefined time intervals using the following procedure.

For example, to calculate average travel time between entry and exit reader stations at 9:00 AM, all the tags that were read between 7:00 AM and 9:00 AM are matched and travel times of matched tags are averaged (simple mean). The entry reader station is located at the end of the queue of trucks inbound to the United States, and the exit reader station is located where the trucks exit on the U.S. roadway system after all inspections. The average travel time is calculated every 15 minutes (e.g., 9:00 AM, 9:15 AM, 9:30 AM). The procedure uses 120 minutes as the time window, meaning this value is used as a maximum travel time that could occur at any given segment and total crossing time. However, the length of the time window is unique to each border crossing and is adjustable.

Figure 7 shows daily variation of hourly average crossing times at BOTA for an entire week.

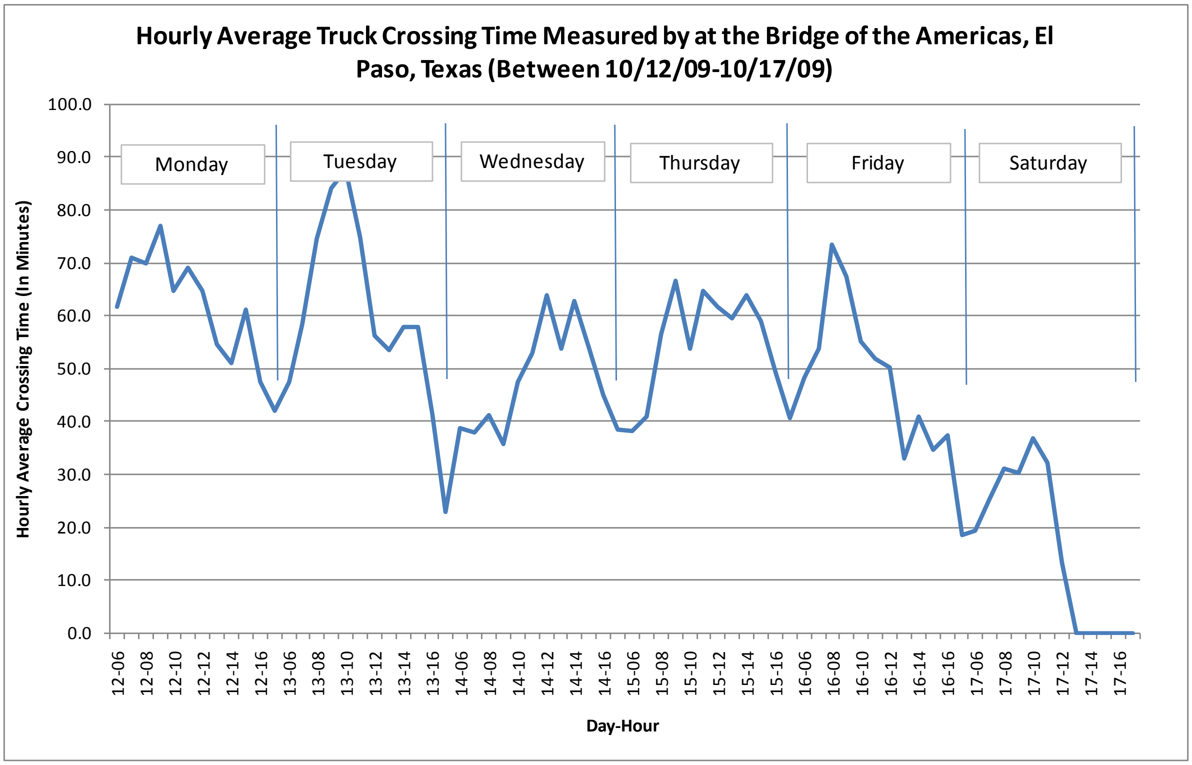


Figure 7. Daily Variation of Hourly Average Crossing Times of Trucks Measured at BOTA.

It is important to understand the nature of the data collected in order to be able to factor in trends needed to support proper analysis. For example, average crossing and wait times determined by taking the average of an entire month or week of data may downplay the peak and off-peak values of crossing and wait times. Differences in monthly averages of crossing times and wait times from one year to the next may be subtle and insignificant unless a major improvement or event occurred between those years. However, it is entirely possible that when viewing monthly averages over a longer period (e.g., several years), the data might show a definitive trend. One way to ensure the peaks and valleys are reflected in the analyses is to compare small blocks of data (e.g., same week of year, same month of year).

Determining Buffer Time and Indices

For freight carriers, significant variation in travel time can impact inventory planning and the efficient use of transportation infrastructure, particularly for time-sensitive goods due to value, perishability, or business operating characteristics (such as just-in-time delivery operations). Specifically, delays in crossing the border are likely to have significant adverse economic effects. Longer travel times are an important issue, but the assembly process can be adjusted to accommodate them; it is more difficult to accommodate unpredictable crossing and wait times. However, freight shippers and manufacturers are also concerned about travel time variability (the variation in travel time) and reliability (which relates to reaching destinations at expected times) because those factors are beyond their capability to influence.

Two performance measures that gauge variability and reliability are buffer time and buffer index.

Buffer time is a measure of travel (any percentile could be used) and the average time for all trucks—it represents the extra time a driver must budget to cross the border at the average time with a 95 percent certainty. This percentage is used for illustration purposes and can be varied based on user expectations, e.g., 75 percent or 50 percent. Increasing buffer times reduces the possibility that the driver arrives late for an appointment. Buffer time can also be reported for time of day, day of week, month, and so forth.

Buffer index is the extra time that is required to cross the border than usual (average) and indicates reliability of the service. Buffer index expresses the amount of extra buffer time needed to be on time for 95 percent of the trips (e.g., a late shipment on one day per month). (Again, 95 percent is used for illustration and can be varied based on user expectations.)

Buffer index can also be reported for time of day, day of week, month, and so forth. This is the measure that is most comparable on an annual basis and between crossings, as it standardizes the measure by removing variables such as crossing length.

$$\text{Buffer Index (\%)} = \frac{\text{(95th-Percentile Crossing Time-Average Crossing Time)}}{\text{Average Crossing Time}} \times 100\%$$

Figure 8 shows monthly variation of buffer index coupled with volume and 95th-percentile crossing time for BOTA. The left vertical axis represents indices related to crossing time (average, 95th percentile, and median) in minutes and the truck volume in thousands, which was provided by CBP. The right axis represents buffer index, which measures the reliability of travel service and is calculated as the ratio between the difference of the 95th-percentile crossing time and the average crossing time divided by the average crossing time.

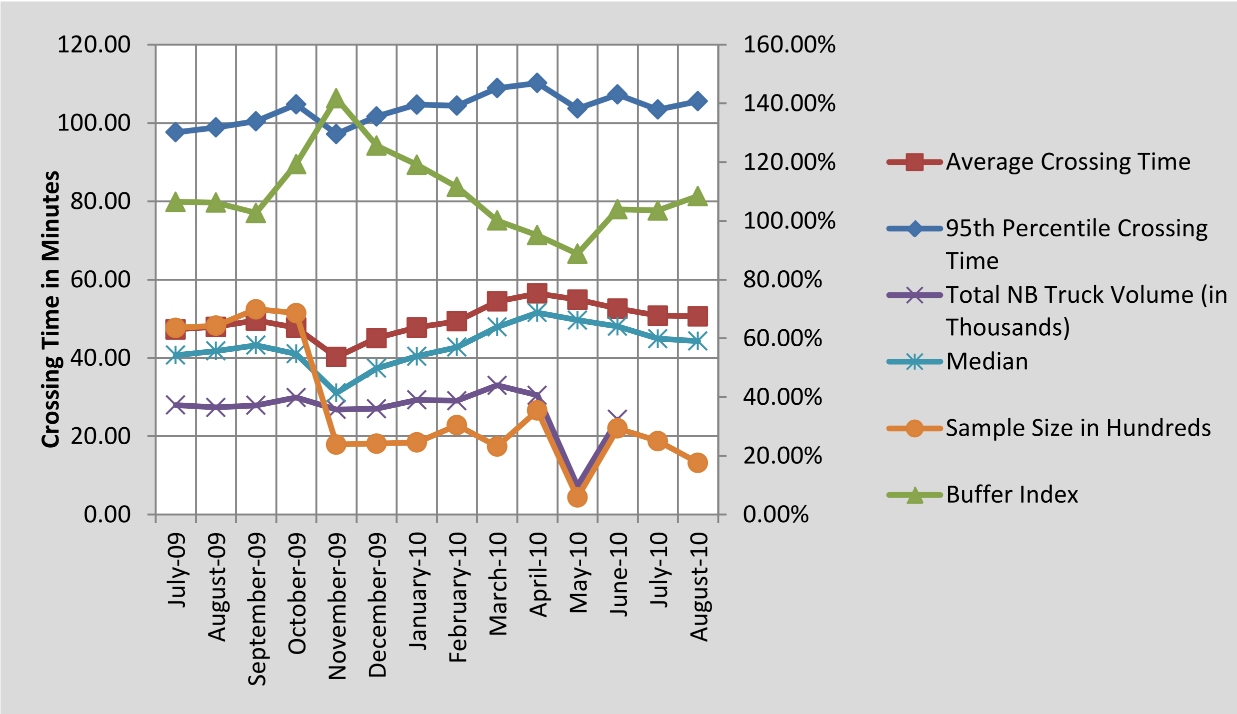


Figure 8. Monthly Variations of Northbound Volume, Average Crossing Times, and Buffer Index.

Determining Delay Measures

For the purposes of this document, border delay is defined as the difference between actual crossing time and the optimal crossing time, which is set as a base value since it represents the case where there are minimal queues. This optimal crossing time is achieved under very low traffic volume conditions and takes into account the processing time at all inspection facilities. Despite the fact that low volume conditions occur several times a day, the optimal crossing time can be identified as the smallest crossing time value observed for that day. However, this is not a definite measure of optimal crossing time, and arguments can be made to use other values such as median or 50th percentile as an optimal crossing time. Stakeholders may choose to establish the crossing and wait time goal for their region as the optimal crossing time.

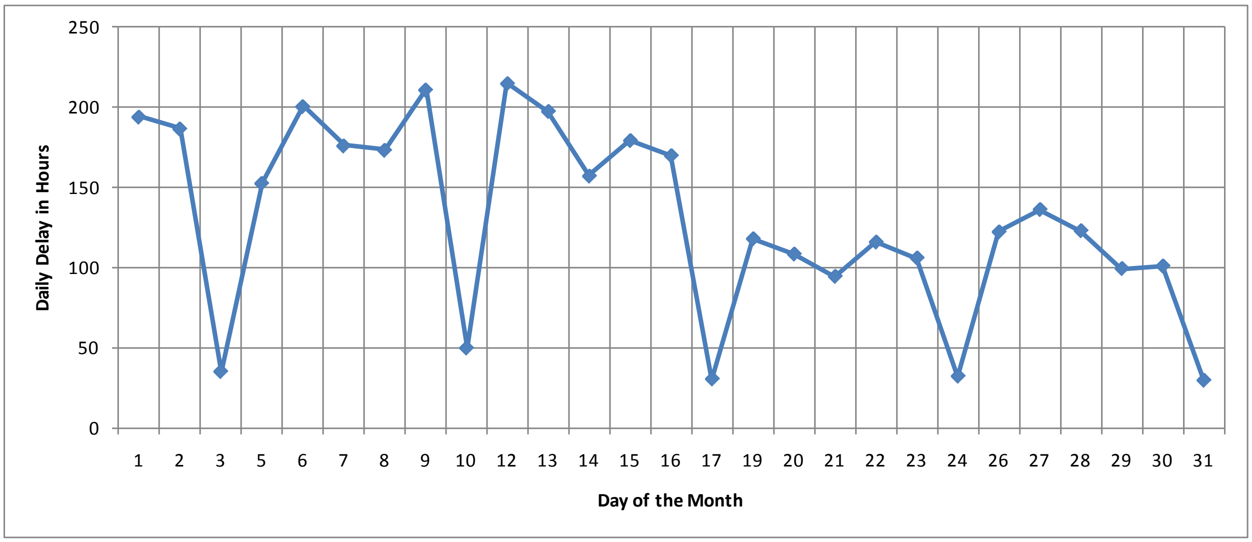
Estimation of delay requires a successive aggregation that includes summing delay of individual trucks to obtain total hourly, peak and off-peak periods, daily, weekly, and monthly delay. Average delay can also be determined using the techniques described in the Aggregating Raw Data section, but there needs to be a process in place to define the baseline value above which the crossing and wait times value is flagged as delay. Total delay at an individual border crossing can be expressed as a summation of delay (actual crossing time minus optimal crossing time) for each truck. Hence, total delay can be calculated for each day and expressed in hours using the following equation:

$$\text{Total Daily Delay} = \sum_{i=1}^{m} (\text{Actual Crossing Time}_i - \text{Optimal Crossing Time})$$

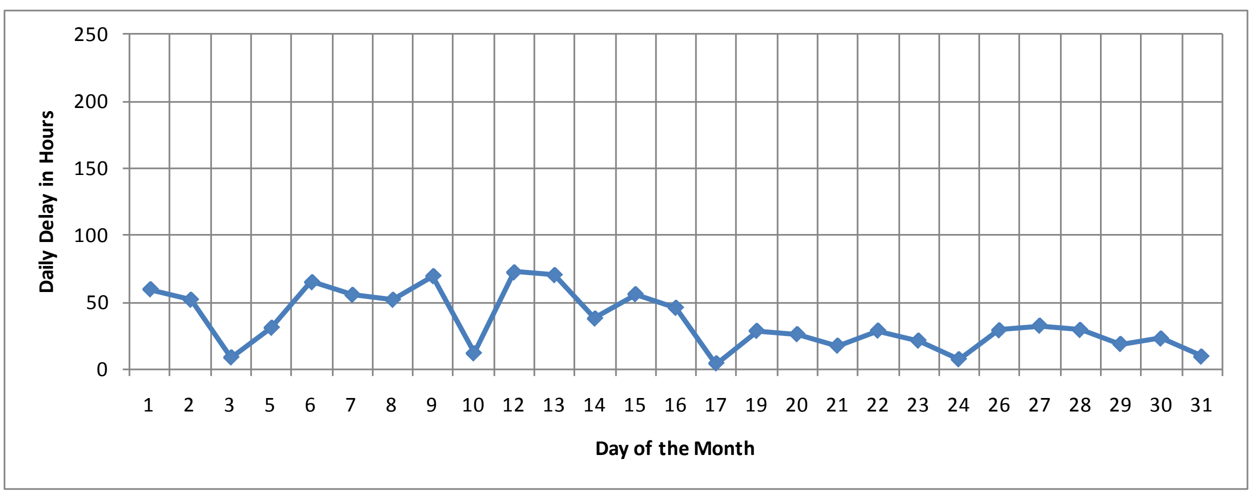
Where,
m = sample size

The definition of optimal crossing time is subject to interpretation by the stakeholders and also depends on the border crossing. For computation purposes, optimal crossing time could be defined as the minimum crossing time observed for a given time period. It can also be defined as a statistical measure such as average crossing time.

Figure 9 shows daily total delay measured at BOTA using minimum crossing time and average crossing time. Total delay is the summation of individual delay of trucks identified by the RFID-based border crossing time and wait time measurement system. The two graphs in Figure 9 show that the total delay is much different depending on whether the optimal crossing time is defined by the minimum crossing time or the average crossing time.



(a) Total daily delay calculated by using minimum crossing time as an optimal crossing time



(b) Total daily delay calculated by using average crossing time as an optimal crossing time

Figure 9. Daily Total Delay of Trucks Measured at BOTA.

If the installed RFID-based border crossing time and wait time measurement system only collects crossing times of a certain portion of the total inbound trucks, then the total delay can be projected to reflect total delay for all inbound vehicles using the following equation:

$$\text{Projected Total Daily Delay} \quad = \frac{(\text{Total Delay} \quad \text{x Total Daily Volume of Trucks})}{\text{Sample Size or m}}$$

$$\text{Total Monthly Delay} \quad = \sum_{j=1}^{d} \text{Projected Total Daily Delay}_j$$

Where,
d = Total number of days RFID collected the data in the month

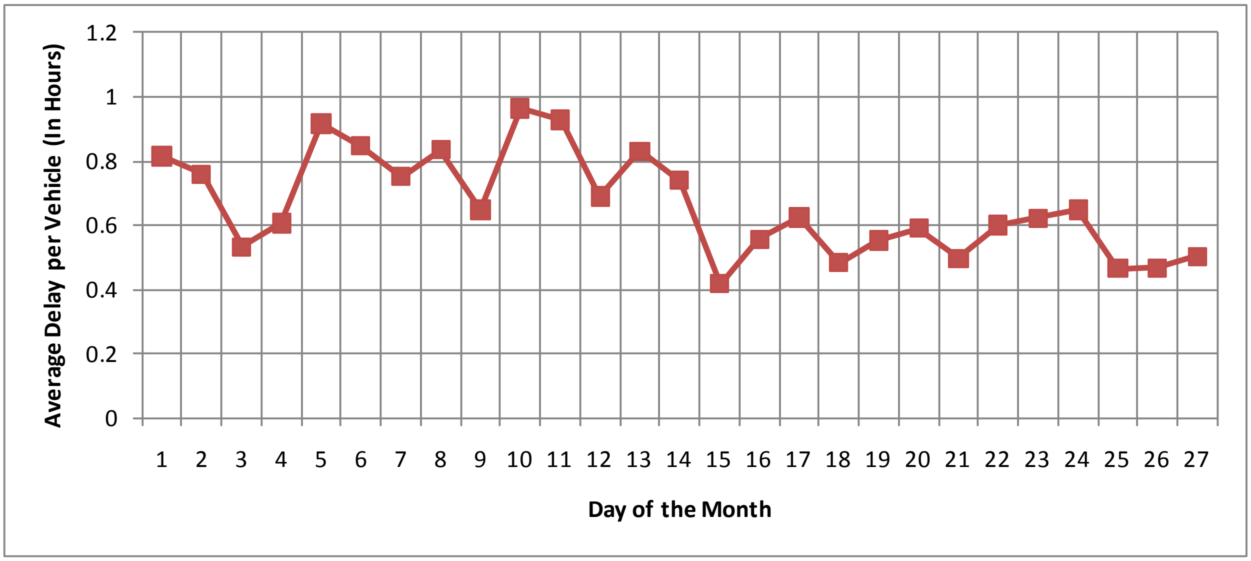
OR

Total Monthly Delay = Projected Total Daily Delay x d

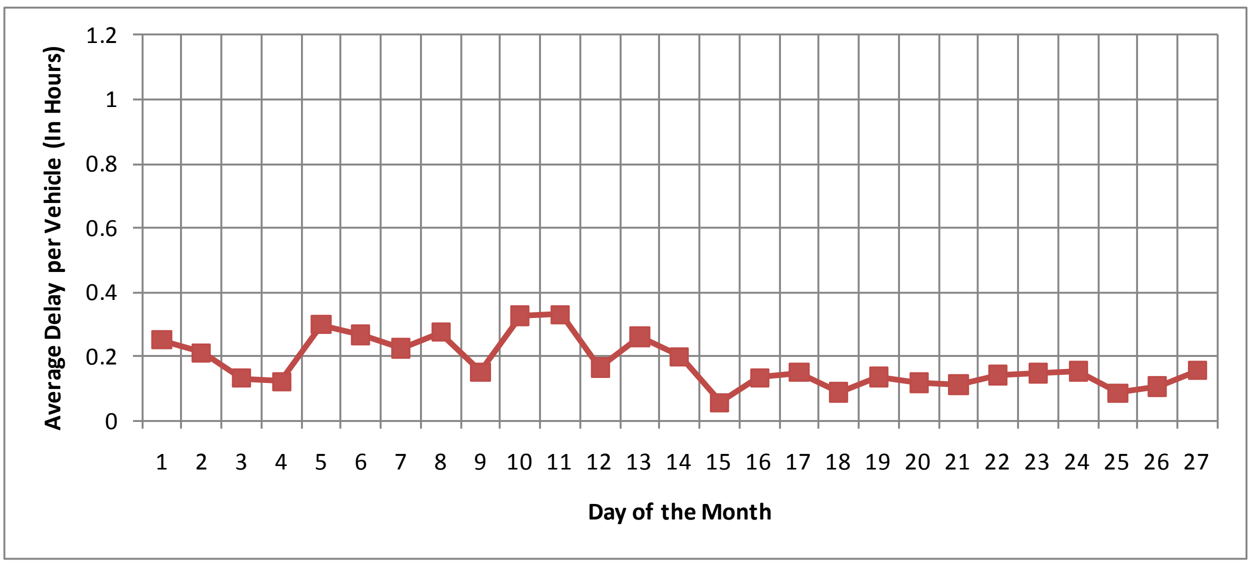
Average delay per vehicle is an average of extra time spent by all trucks while crossing the border and is a powerful tool in communicating to non-technical audiences. Delay per vehicle is estimated by dividing the total delay by the number of vehicles or sample size during the same time. This normalizes the total delay value, and is important when comparing delay with other border crossings. Figure 10 shows average delay per truck for different days in a month measured at BOTA using minimum and average crossing time as optimal crossing time.

$$\text{Average Delay per Vehicle} = \frac{\text{Total Daily Delay}}{\text{m}}$$

Where,
m = sample size



(a) Average delay per truck calculated by using minimum crossing time as an optimal crossing time



(b) Average delay per truck calculated by using average crossing time as an optimal crossing time

Figure 10. Average Delay per Truck at BOTA.

Determining Length of Peak Periods

Historical and current trends showing increased or decreased length of peak periods are excellent indicators for monitoring congestion and system performance.

It is preferable to use 15-minute average crossing or wait time information over a day to identify peak and off-peak hours. Raw data cannot be used because it is difficult to identify peak from off-peak hours, as there may be several trucks that might take longer than other trucks at the same time and hence show false peaks. Measuring the length of peak periods requires establishing some kind of baseline representing off-peak periods—preferably median value for the entire day. Using a visual method, presence and length of peak periods can be identified, as illustrated in Figure 11. Establishment of peak periods can also be done through stakeholder input. Also, it is entirely possible to develop an automated method to determine peak and off-peak periods for a given data set.

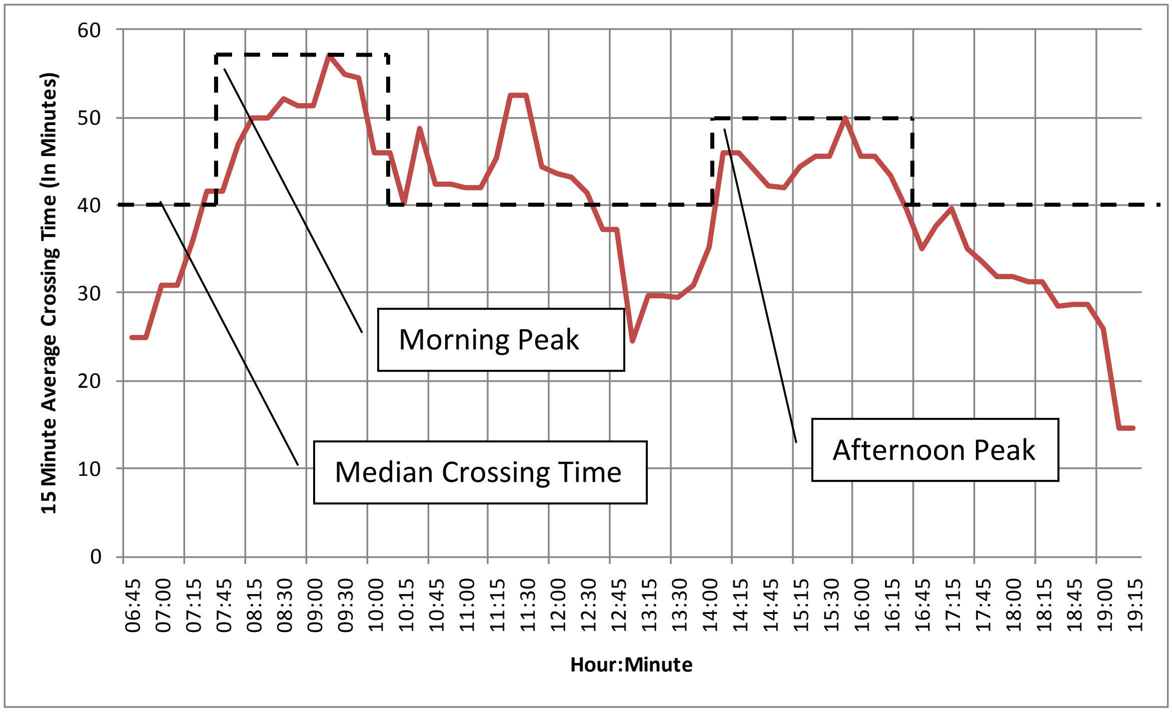


Figure 11. Identification of Peak and Off-Peak Periods from 15-Minute Average Crossing Time Data.

If monitoring the length of peak and off-peak periods becomes difficult to accomplish due to absence of defined peaks and off-peaks, presenting the number of hours the facility operated above the base value is also an excellent mechanism to explain length of congestion at border crossings. This latter value can then be used to make before-after comparisons of performance of border crossings.

Using the logic in Figure 11, the median value is 42 minutes and the number of 15-minute intervals that have an average crossing time higher than 42 minutes is 25 out of 52 total intervals. Hence, the percentage of time periods that exceeded the median values is 48 percent, which is the percentage of time the border crossing operated above the base value (or optimal crossing time) on a typical day.

Determining Percentage of Congested Trips

Comparing percentage of congested trips at different time periods indicates trends about performance of a border crossing. Comparisons can also be done before and after improvements are implemented. To define trips as congested, a baseline has to be identified. The baseline preferably is an average crossing time instead of minimum crossing time, which results in almost all the trips operating as congested trips.

To determine percentage of congested trips, a block of raw data either spanning a full day, week, or month for which the analysis is being performed is required. Then the next steps are to:

- Obtain a baseline value of average crossing time for the analysis period.
- Identify the number of trips that had crossing times above the baseline value, and obtain the percentage of total trips that exceeded the baseline.

Figure 12 shows daily variation of percentage of trips that were congested based on the assumption that average crossing time is an optimal crossing time. As noted earlier, stakeholders may choose to establish the crossing and wait time goal for their region as the optimal crossing time.

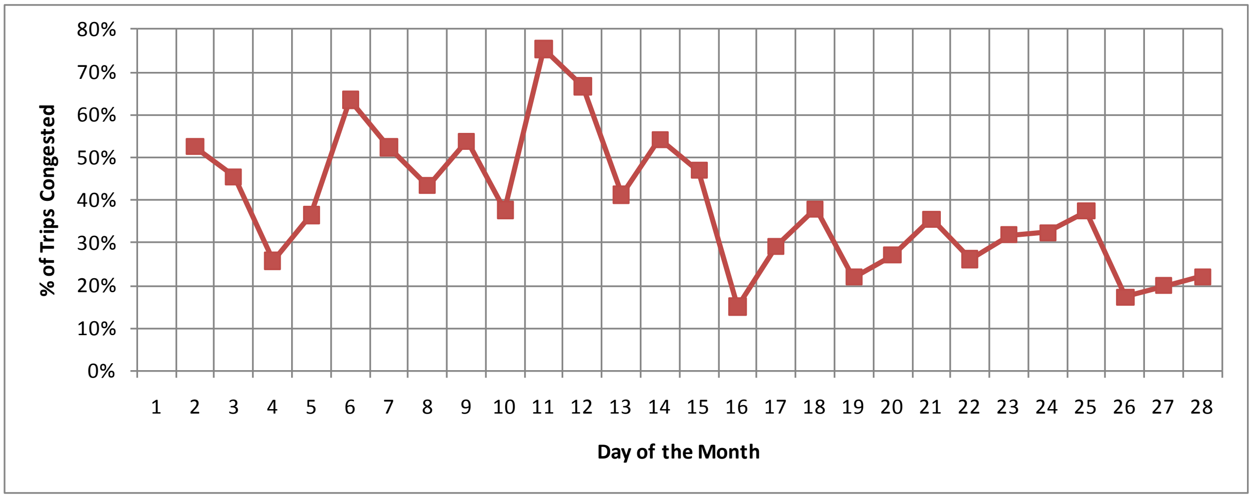


Figure 12. Percentage of Trips Congested Based on Average Crossing Time as Optimal Crossing Time.

INFORMATION DISSEMINATION

Key Steps for Data Dissemination

Traveler information can be disseminated using different mechanisms, which include agency Web sites, DMSs, and highway advisory radio (HAR). One scenario is that the implementing agency may have capabilities to relay traveler information through a majority of sources including field devices. Another scenario is that the implementing agency is only responsible for its RFID-based border crossing time and wait time measurement system and has to share the traveler information generated by the system with other agencies that are responsible for field devices and local media. In the second scenario, the implementing agency needs to be able to share the traveler information data using an open and non-proprietary format so that other agencies can pull the information easily.

For implementing traveler information, the following are some key questions that need to be answered:

- What is the format of the information?
- Does it need to follow industry standards?
- What is the content of the information?
- How often is the information updated?

The implementing agency also needs to put forward policies and procedures prior to relaying information through the field devices and Web sites. Such policies and procedures may cover when and how to relay the information, accuracy of the information, scope, and third-party use of the data. While implementing traveler information at the border, agencies also need to be cognizant of requirements to be compliant with the American with Disabilities Act (ADA), multilingual needs, and limited English proficient callers (especially for 511).

Careful consideration needs to be given to policies and procedures for dissemination of data to ensure stakeholders are aware of data generated and have maximum opportunities to share it.

Figure 13 illustrates the key steps for disseminating real-time and archived data. These steps include identifying preferred mechanisms, developing policies and procedures, and implementing the information dissemination.

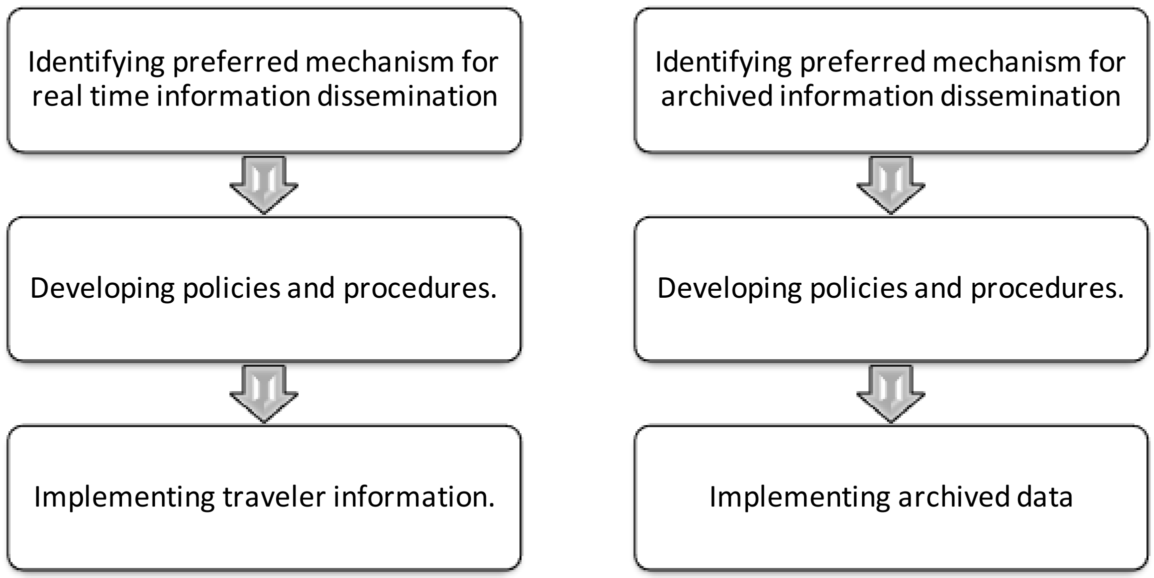


Figure 13. Key Steps for Disseminating Real-Time and Archived Information.

Disseminating Traveler Information

There are two broad categories by which traveler information can be relayed to users—(a) intelligent transportation system (ITS) methods such as DMS, HAR, and 511 systems, and (b) non-ITS methods such as local media and social networking sites. Traveler information provides freight carriers with capabilities to schedule and to choose between border crossings, where possible, to reduce their overall trip time. Each relay mechanism has its inherent strengths and capabilities, and while deciding which mechanism to choose from, the implementing agency needs to clearly outline strengths and capabilities of each mechanism and also resources needed. Under CBP's Automated Commercial Environment (ACE) Program, submission of an e-manifest to CBP includes the port code where the truck is meant to cross. There are certain regions such as El Paso and Laredo where there are multiple crossings within a port code that can be accessed on the same port code, but otherwise the e-manifest must be updated if the truck is diverted to a different crossing. Traveler information can be used for scheduling as well. Providing traveler information on the U.S.–Mexico border could be a joint effort between agencies on both sides of the border. Hence, it is strongly recommended that the data exchange and information display formats (including bilingual requirement) be consistent on both sides of the border so that the freight carriers do not get confused by the messages relayed.

Identifying Preferred Mechanisms

The implementing agency needs to seek stakeholder feedback for identifying preferred mechanisms to relay traveler information. This needs to be based on goals and objectives of the system for providing such information, cost and resource constraints, and technology preference. Table 3 describes advantages and disadvantages of currently available mechanisms to relay border-related traveler information.

At a minimum, the implementing agency needs to provide an RSS feed to relay current (and predicted) crossing and wait times at the border. If an implementing agency does not have resources to deploy field devices such as DMSs or HAR, then at least it can provide a medium to share the data with other agencies. In this way, the systems have potential to integrate with existing field devices based on coordination and approval of the devices' owners (e.g., MPO, city, State). Because an RSS feed uses open and non-proprietary extensible markup language (XML) format, external agencies, private entities, local media, and mobile application developers can obtain the information as soon as the information is updated in the feed.

Table 3. Advantages and Disadvantages of Various Traveler Information Dissemination Mechanisms.

Mechanism	Advantages	Disadvantages
RSS Feed	• Less expensive, since the implementing agency can simply create a uniform resource locator (URL) that shows RSS feed in an XML data format. • Open platform. • Easy to share the data with other agencies.	• Information is displayed in a simple text format without any graphics. Hence, third-party users have to convert it into some sort of graphical format for better representation.
Agency Web Sites	• Widely used and effective for providing pre-trip traveler information to freight dispatchers.	• Slightly more expensive than RSS, since the implementing agency needs to operate and maintain a Web site. • Not effective for providing information en route.
Dynamic Message Signs	• Most effective for providing traveler information en route since DMSs can be installed at several locations and can also show other information when border conditions are not being displayed.	• Hardware is expensive, and so is communication between the field devices and the center. However, cost can be defrayed by using the DMS for relaying other messages such as incidents and amber alerts and by deploying it as part of the roadway construction project. • DMS can only display message at fixed locations and is limited to short messages.
Social Networking Sites (SNSs)	• Less expensive to implement. • Widely used among younger generation of motorists but not effective to relay information while en route. • More effective for relaying extreme events, construction, closures, and so forth than crossing and wait times.	• Not effective as an en-route traveler information relaying mechanism since freight carriers have to use several steps to access the SNS site before accessing the traveler information.

Table 3. Advantages and Disadvantages of Various Traveler Information Dissemination Mechanisms, Continued.

Mechanism	Advantages	Disadvantages
Mobile Devices	• Mobile phones are highly ubiquitous, and so are the applications that can relay crossing and wait times. • Easy and less expensive to develop application for mobile phones.	• Driver distraction due to use of cell phones or other electronic devices is a concern.
In-Vehicle Navigation Devices	• More and more freight carriers are using in-vehicle navigation devices. • Private companies that provide in-vehicle route guidance can easily add border crossing and wait times.	• Needs data-sharing agreements with private companies. If purchasing cost is involved, then such agreement becomes cumbersome and complex.
511 Systems	• Many U.S. States have statewide 511 systems, and Mexico is deploying a nationwide 511 system. • Easily accessible to freight carriers and dispatchers any time during a trip. • Information is accessible via telephone.	• Since the 511 system has to add functions to convert crossing- and wait-time-related text to voice, additional resources are needed to implement it. • Mexican and U.S. State 511 systems have to coordinate on the interoperability to make sure the information is consistent throughout all systems.
Highway Advisory Radio	• Most effective for providing traveler information pre-trip and en route. • HAR stations can be installed at several locations and can also show other information when border conditions are not being displayed. • HARs typically cover a several mile radius, and freight operators can receive information using built-in radio tuner.	• HAR messages are transmitted through low amplitude modulation power, often resulting in poor signal quality, and are affected by other external factors such as weather and interference with other stations.
Local Media and Kiosks	• Widely used and effective for providing pre-trip and en-route traveler information to freight dispatchers. • Many local media already relay border conditions. • Kiosks at truck parking facilities significantly benefit the freight community.	• While en route, freight carriers have to wait for the information to be relayed by radio and television stations. • Kiosks specifically dedicated for traveler information are not available at many locations.

Developing Policies and Procedures

An implementing agency relaying/sharing crossing and wait time information needs to clearly define policies and procedures for other agencies to use shared data as traveler information. The implementing agency needs to enter into agreements with the agencies wanting to share the data. The agreement needs to describe medium of data-sharing protocol (e.g., RSS, hypertext transfer protocol [HTTP]), time of data availability, and update frequency. Two agencies agreeing to share the data need to agree on how each agency plans to use the data. An example of a TxDOT agreement for sharing ITS data is included as the Appendix. Another example, the New York City Department of Transportation's (DOT's) Video and Traffic Flow Data Sharing Agreement, can be accessed at http://a841-dotweb01.nyc.gov/datafeeds/video-partnership-agreement.pdf.

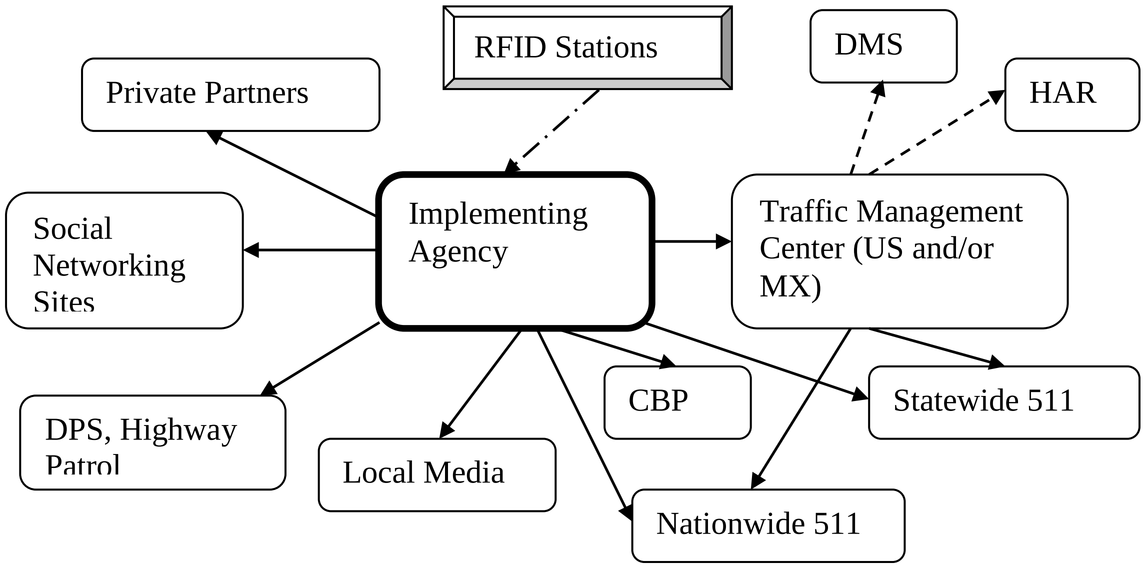
Numerous private entities provide traffic information to in-vehicle navigation and route guidance systems. The implementing agency needs to explore the possibilities of selling and/or bartering border crossing and wait time information with private companies for mutual benefit.

Implementing Traveler Information

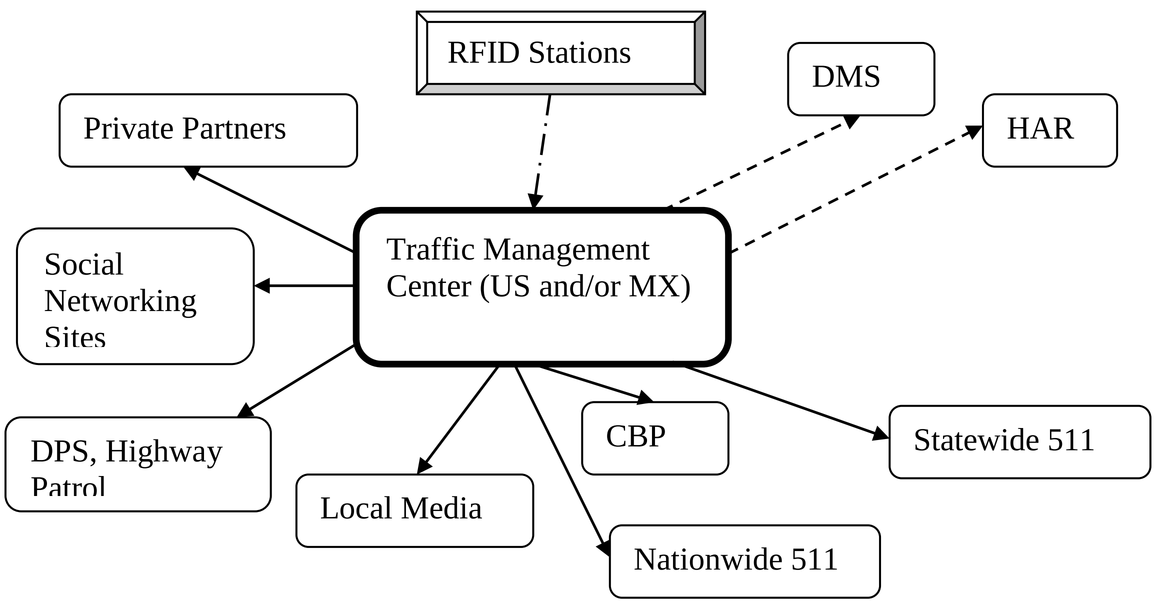
An implementing agency can relay border-related traveler information using various ITS and non-ITS mechanisms. There are two possible scenarios. The first scenario is that the implementing agency has capabilities to relay traveler information through multiple sources including field ITS devices such as DMSs and HARs through its transportation management center (TMC). RFID stations need to be directly connected to the TMCs. Agencies such as State DOTs and multiagency consortia operate and maintain a wide variety of field ITS devices through a TMC and already have the necessary infrastructure in place to relay border-related information, which then essentially becomes just added information.

Another scenario is that the implementing organization does not operate and maintain ITS field devices. These could be an MPO, private company, city agency, or non-profit agency. Hence, the implementing organization has to share the traveler information generated by the RFID-based border crossing time and wait time measurement system with other agencies (e.g., State DOTs) that operate and maintain field ITS devices. In this case, the implementing agency needs to be able to share the traveler information data using an open and non-proprietary format so that other agencies can pull the information easily.

Both implementation scenarios are illustrated in Figure 14.



Scenario 1: Implementing agency does not operate and maintain a TMC (e.g., MPO, research institutions)



Scenario 2: Implementing agency operates and maintains a TMC (e.g., State DOT, multiagency consortium)

RSS feed via Internet

Optical fiber or wireless

Cellular modem

Figure 14. Implementation Scenarios for Relaying Border-Related Traveler Information.

RSS Feeds

RSS has proven to be an extremely cost-effective method to share near-real-time data with external agencies, motorists, local media, and TMCs. RSS includes a standardized XML file format containing information to be published once and viewed by many different programs.

The RSS reader checks the user's subscribed feeds regularly for new work, downloads any updates that it finds, and provides a user interface to monitor and read the feeds. RSS formats are specified using XML, a generic specification for the creation of data formats. RSS feeds can be read using software called an RSS reader, feed reader, or aggregator, or even the latest versions of commercially available Web browsers, which can be Web-based, desktop-based, or mobile-device-based.

A snapshot of an RSS feed developed to relay most recent truck crossing times at BOTA and Pharr is shown in Figure 15. The user subscribes to a feed by entering into the reader the feed's URL or by clicking an RSS icon in a Web browser that initiates the subscription process.

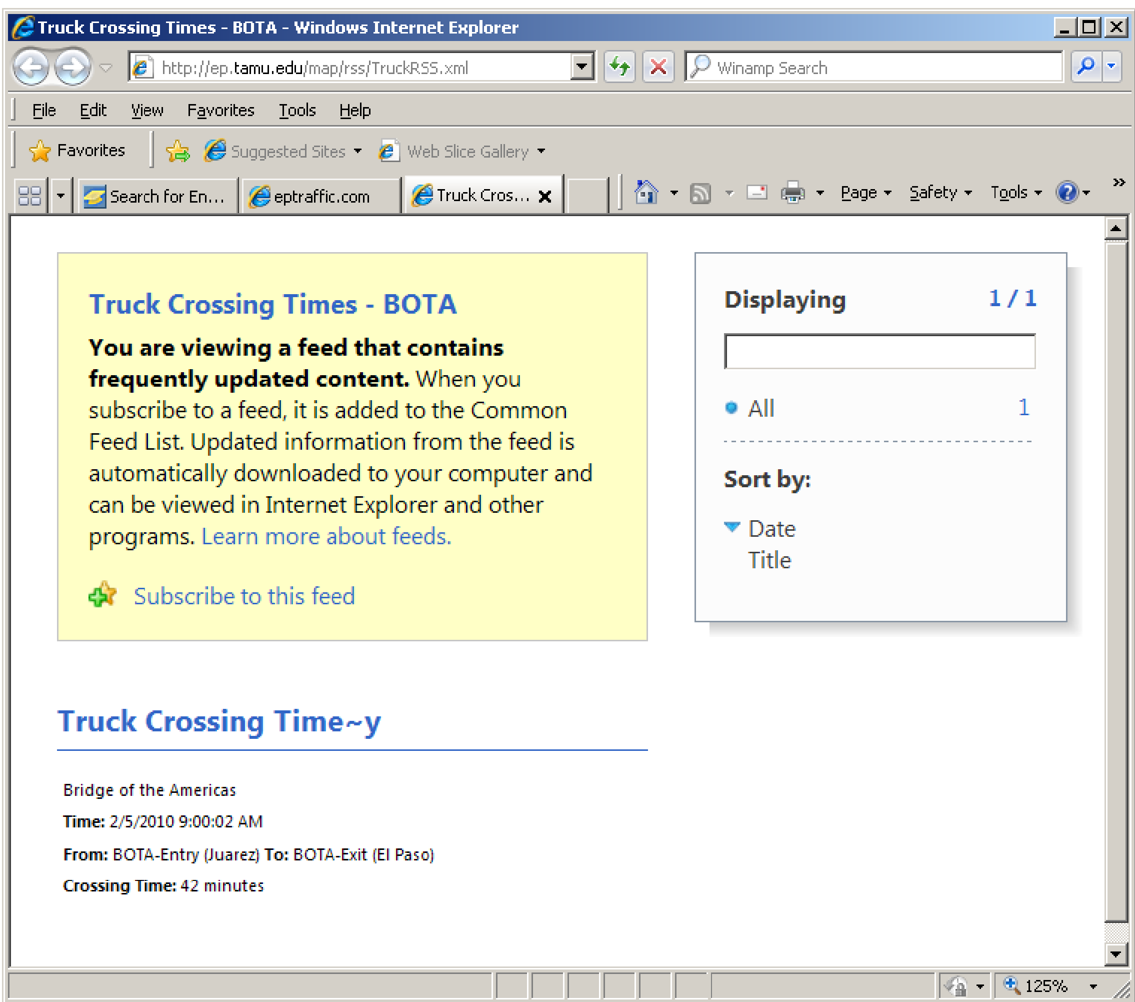


Figure 15. Snapshot of an RSS Feed to Obtain most Recent Truck Crossing Times at BOTA.

Agency Web Sites

Agency Web sites can either pull information from the RSS feed or directly from a database that is part of the RFID-based border crossing time and wait time measurement system and show the crossing and wait time information in graphical, text, and map-based formats. Figure 16 shows a snapshot of a Web site that reads the RSS feed from the RFID-based border crossing time and wait time measurement system deployed at BOTA. The truck crossing time from the RSS feed is shown on the map-based Web site using color-coded line segments as well as in a text. The text format of the information also includes when the information was computed and relayed, thus providing an indication of the data timeliness. RSS feed provides only the data, while the users (data consumers and external agencies) need to design and display the data in an appropriate format.

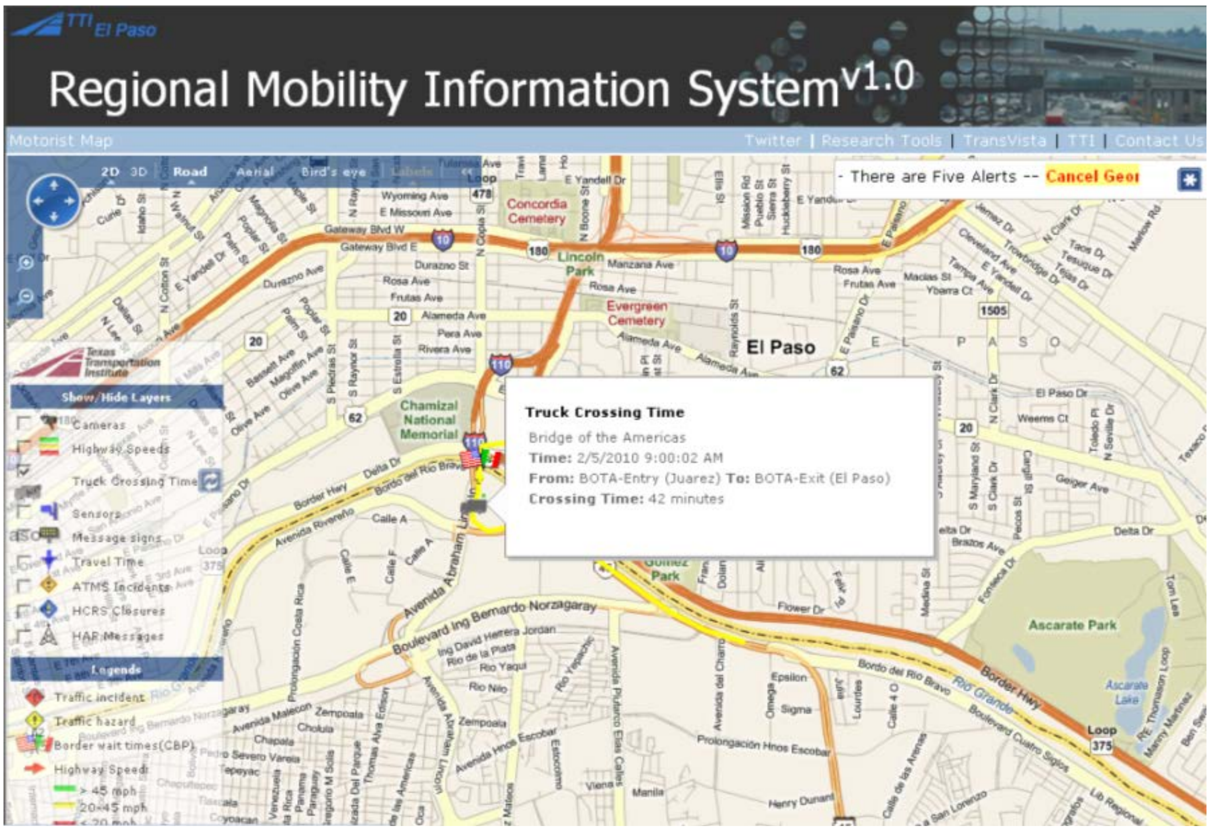


Figure 16. Snapshot of a Web Site Showing Crossing Times for Northbound Trucks at BOTA.

For colorblind users, Web site displays like the one shown above can be modified using icons instead of color-coded segments. The color of the icons change based on the current value of average crossing time, and the icons could use monotone color schemes such as black, dark grey, and light grey instead of red, yellow, and green.

Dynamic Message Signs

DMSs are typically operated and maintained by organizations such as State DOTs (Federal in the case of Mexico) and multiagency consortia. For northbound traffic, DMSs can be located on the

Mexico side of the border, which means Secretaria de Comunicaciones y Transportes (SCT) or some other Mexican governing body needs to develop policies and procedures to display border crossing and wait times via DMSs. State agencies in the United States usually follow internally developed operating guidelines to display messages by DMS and typically comply with the *Manual for Uniform Traffic Control Devices* (MUTCD). FHWA has no specific policy or position on travel time messages on DMSs but encourages following the MUTCD and has encouraged each State to develop its own standard.[3]

Some of the key items regarding display of border crossing and wait time have been derived from the best practices for displaying highway travel times on DMSs and are as follows:

- Information displayed over DMSs adds significant value during special events and incidents.[3]
- Before crossing and wait times are implemented over DMSs, raise public awareness using a message such as “Crossing time and wait time coming in X days.”
- If possible, information needs to be displayed on DMSs without the need for manual input from TMC operators.
- To save power, information can be posted during peak hours and special events only.
- While displaying information over DMSs, also report time of calculation (i.e., @ 4:30 PM).[4]

A recommended format for displaying multiline messages over DMSs is shown in Figure 17.

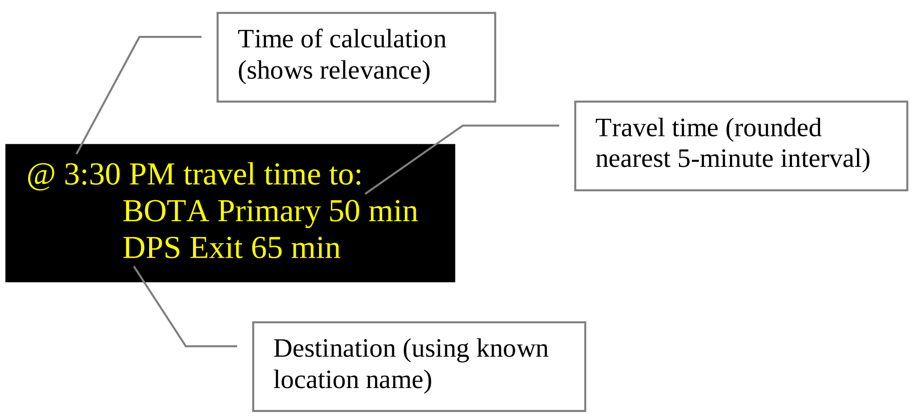


Figure 17. Sample DMS Message to Relay Crossing and Wait Time at the Border for Northbound Trucks.

Social Networking Sites

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

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

The implementing agency wanting to publish the traveler information on its SNS page/account needs to develop a process that involves using the SNS-provided application programming interface (API) to read data from a source at the user's end. This source could be an RSS feed or a database. The application that encapsulates the API then writes messages to its SNS page/account automatically at predefined intervals.

Mobile Applications

Dissemination of border-related traveler information through mobile devices can be implemented in various ways. The implementing agency can develop a mobile version of the agency Web site that shows current and predicted crossing and wait times in a simplified text format without the use of maps and graphics. The implementing agency can also develop a mobile-operating-system-specific application that pulls RSS information from the agency source and displays the information on the phone.

However, the implementing agency has to make a policy decision regarding promotion of mobile use while driving, since driver distraction due to use of cell phones or other electronic devices is a growing safety concern. In light of distracted driver concerns and laws, maximum use needs to be made of hands-free/eyes-free voice applications. For example, the Pennsylvania Turnpike Commission has launched a new iPhone and Droid application called TRIP Talk that reads audio alerts to travelers when there is a closure or delay ahead. The application senses the driver's position and direction on the Turnpike and talks to the driver when it detects trouble spots nearby. Unlike other travel-alert tools, TRIP Talk is hands-free and eyes-free.[5] If an external agency comes forward to develop applications to relay border-related information via mobile devices and requests data from the implementing agency, then it needs to clearly state its policy regarding distribution of such data for mobile use.

In-Vehicle Navigation Devices

An in-vehicle global positioning system (GPS)-based navigation device is essentially either an in-built or an external device that provides real-time route guidance to the motorist. Commonly available navigation devices can provide information on impending traffic conditions such as location of incidents, congestions, travel time to destination, and alternate routes. Navigation devices are fed traffic information supplied by third-party information providers that collect traffic data from multiple sources.

Freight carriers can benefit from the use of navigation devices that can also provide border-related information and door-to-door travel time including crossing and wait times at the border. During a vehicle's trip, recipients of disseminated messages need to consider distracted driver laws in effect.

The implementing agency needs to enter into a data-sharing/selling agreement with interested private entities that provide traffic information to navigation device manufacturers. The revenue can then be used to operate and maintain the RFID-based border crossing time and wait time measurement system.

511 Systems

Telephone services for travelers provide real-time information about work zones, traffic incidents, and other causes of congestion. They allow travelers to make more informed decisions about their travel routes or modes and increase safety by helping motorists avoid areas with congestion or incidents. The U.S. Department of Transportation (USDOT) petitioned the Federal Communications Commission in 1999 for a three-digit dialing code for travel information and was assigned 511 in 2000. Before the 511 dialing code was assigned for travel information, more than 300 different telephone numbers provided travel information in the United States. Nearly 156 million Americans, or almost 54 percent, now have access to 511 services.[6] Phone users who are hearing impaired can call 711, the national three-digit number for access to the Telecommunication Relay Services (TRS), to access 511 hearing-impaired services.

In the United States, the 511 Deployment Coalition offers 511 implementers technical advice on how to deal with callers who logically want information on transportation facilities and services outside of the area served by the local 511 system.

Mexico is deploying a nationwide system similar to 511 systems that will provide, among other services, border-related traveler information on the U.S.–Mexico border. Except for the State of Texas, all the other States on the U.S.–Mexico border have a regional or statewide 511 system.

There are two broader issues regarding relaying cross-border-related traveler information via 511 systems:

- Mexican and U.S. State 511 systems have to establish a coordination mechanism to make sure the traveler information is provided consistently to cross-border travelers. For example, travelers might be confused if the Mexican 511 system and U.S. system relay different or conflicting crossing and/or wait times for the same border crossing. This confusion can be prevented if both systems use the same data source for the border-crossing-related traveler information.

- Messages relayed by the U.S.-based 511 systems are required by law to be compliant with the ADA, multilingual needs, and limited English proficient callers [6] .

Border-crossing-related traveler information can be shared with 511 implementers using RSS feeds from the RFID-based border crossing time and wait time measurement system implementing agency. The 511 implementer then reformats the data to convert them into digital voice recordings. While providing border-related traveler information through a 511 system, callers need to be given a main menu option to say Border Crossings and then choose a specific border crossing from the menu. Most 511 systems have Web access, and online users need to be given a choice regarding which POE is of interest and that POE’s crossing and wait times. If there is crossing and wait time information available for different modes (e.g., commercial trucks, passenger vehicles) and program types (e.g., FAST, documented commuter lane [DCL]), then crossing and wait times for these specific types and modes need to be relayed. Stakeholders need to be able to recommend specific content of the message during pre-deployment studies.

Highway Advisory Radio

HAR is another means of providing travelers with information in their vehicles. Traditionally, information is relayed to highway users through the AM radio receiver in their vehicles. Upstream of the HAR signal, users are instructed via roadside or overhead signs to tune their vehicle radios to a specific frequency. Usually, the information is relayed to the users by a prerecorded message, although live messages can also be broadcast. HAR is an effective tool for providing timely traffic and travel condition information to the public.

Messages are broadcast in the field from transmitters that play stored messages. Newer HAR systems allow text-to-speech conversions. Hence, TMC operators can type in the text message or load stored text templates and modify the sentence. The text is automatically converted to digital voice and transmitted via HAR stations.

Typically, HAR stations are managed by central software within a TMC. There are no prevailing standards as to how the traveler information message needs to be relayed over HAR stations. Hence, State DOTs and TMCs develop their own operating guidelines. A typical message format includes:

- An introductory statement (agency name, location of HAR, date, and time).
- An attention statement (to address a certain group of motorists or destination).
- A problem statement.
- A location statement.
- An effect statement (e.g., lane closure, delay)..
- An action statement.

A sample message for relaying border-crossing-related traveler information through HAR could be:

> THIS IS THE TEXAS DEPARTMENT OF TRANSPORTATION HIGHWAY ADVISORY RADIO
> ATTENTION TRUCKS TRAVELING SOUTHBOUND TO MEXICO
> MAJOR DELAYS TO ENTER MEXICO THROUGH BOTA
> VIA SOUTHBOUND US54 AND EASTBOUND IH10
> WAIT TIME EXCEEDING TWO HOURS
> USE ZARAGOZA PORT OF ENTRY

Local Media and Kiosks

Local media include radio stations and television stations that are known to relay traffic information. Local media at border cities already provide wait time information and POE closure information as part of their news broadcasts. Many radio and television stations also maintain their own Web sites that show border wait time information. An RFID-based border crossing time and wait time measurement system implementing agency needs to coordinate with local media to share crossing and wait time data, since local media is the most pervasive mechanism to relay traveler information. Studies have shown that local media still remains the number one source of traveler information for motorists. The implementing agency can provide an RSS feed to local radio and television stations, which can then use the feed as a source to relay border crossing and wait times.

Many States and cities have also deployed kiosks or video terminals at tourist information centers, airports, truck parking areas, and transit terminals. Border crossing information can be easily implemented on these kiosks. Another innovative idea is to collaborate with banks to provide traveler information on their automatic teller machines (ATMs) to take advantage of their larger deployment.

Disseminating Archived Data to Stakeholders

Archived border crossing and wait time data has broad applications for planners, decision-makers, engineers, researchers, and the trade community. Archived data presented in the form of different combinations of performance measures, described in chapters 2 and 3, are valuable in decision-making, border crossing performance comparisons, infrastructure improvements, and air quality studies.

Archived data can be released to stakeholders by using Web-based, pre-coded, interactive charts and graphs. However, in the presence of more than one source of archived data (i.e., maintained by multiple agencies), formalized data-sharing mechanisms between archives maintained by agencies in the United States and Mexico are highly desirable. To achieve an efficient data-sharing mechanism, each agency needs to maintain its metadata (e.g., time and date of creation, scope, data quality) and other data catalogues.

However, to bring all the agencies together and agree on mechanisms to share archived data is both complex and resource intensive. All agencies need to agree on such topics as the release of metadata to each other, metadata conventions, and standard data dictionaries. Hence, agencies need to agree on using industry standards for metadata and data dictionaries to reduce cost and increase efficiency of interagency access to archived data. Consortia or groups such as the United States–Mexico Joint Working Committee (JWC) and the United States–Canada Transportation Border Working Group (TBWG) can certainly play a crucial role in laying a framework for achieving interagency archived data-sharing mechanisms.

Other key considerations for disseminating archived data are necessary policies and procedures, especially for releasing large blocks of raw data, compliance with ADA, and bilingual user requirements.

Identifying Preferred Mechanisms

Unlike with traveler information, mechanisms to disseminate archived data are limited. Each mechanism has strengths and capabilities and costs associated with it. The decision to implement one or more dissemination mechanisms depends on what kind of users the archived data are being delivered to. There are two distinct categories of archived data users—regular users and power users.

Regular users typically require high-level summary charts and graphs and dashboards. They are decision makers, policymakers, and high-level planners—possibly members of the public. They have no need to perform complex data analysis on the archived data.

Power users, on the other hand, perform analysis beyond what is typically performed by regular users. They are planners, engineers, statisticians, modelers, and researchers and need to perform functions such as complex data analysis and data mining. They often require blocks of raw and aggregated data for their specific needs.

The implementing agency also needs to be cognizant of requirements for ADA compliance and bilingual users. Fortunately, most software applications provide multilingual support, meaning charts, graphs, and Web contents can be easily duplicated and implemented in a different language.

The implementing agency needs to seek stakeholder feedback for identifying preferred mechanisms to disseminate archived data. This needs to be based on factors such as goals and objectives of providing such information and cost and resource constraints. Table 4 describes advantages and disadvantages of available mechanisms to disseminate archived data to stakeholders.

Table 4. Advantages and Disadvantages of Various Archived Data Dissemination Mechanisms.

Mechanism	Advantages	Disadvantages
Web Site Consisting of Pre-Coded Charts and Graphs	• Is of great benefit to both regular and power users. • Most effective way of disseminating snapshots of performance of border crossings.	• Requires data to be stored in a structured relational database. • Needs a talented team of database designers and software developers to operate and maintain the content in the Web site, which could be expensive.
External Storage Devices	• Effective way of sharing large blocks of raw and aggregated data. • If this is the only mechanism by which the agency desires to share the archived data, then there is no need to maintain a structured database and employ software developers.	• Charts and graphs of performance measures are created using spreadsheets and database programs and need to be copied to external devices for sharing. • Not feasible to share the information with large groups of users at a time.
Printed Reports and Summaries	• Very effective in disseminating the operational trends and performance to high-level decision makers and planners.	• Content is predefined and hence not interactive and dynamic.

Developing Policies and Procedures

An implementing agency relaying/sharing crossing and wait time information needs to clearly define policies and procedures for other agencies to use the traveler information. An implementing agency needs to enter into agreements with other agencies wanting to share the data. The agreement needs to describe details such as medium of data-sharing protocol (e.g., RSS, HTTP), time of data availability, and update frequency.

Implementing Archived Data

Web Sites

Providing archived data via Web sites in the form of predefined performance metrics formatted into pre-coded interactive charts and graphs is perhaps the most common mechanism of disseminating archived data. One of the key requirements to accomplish this is storing the archived data in a highly structured relational database.

Also, complying with ADA requirements and providing the content in multiple languages needs to be considered, given the fact that stakeholders come from bordering countries with two different languages in common use at each border. Fortunately, newer Web content development applications have capabilities to change the language without much effort.

The content of the Web site and presentation of pre-coded charts and graphs can be obtained from the stakeholder input, and some of the groundwork is typically done during the design phase.

The content of the Web site needs to be designed based on which categories of users it serves. Regular users typically require high-level summary charts and graphs and dashboards. Simple but interactive charts and graphs of performance measures suffice for their needs. They have no need to perform complex data analysis on the archived data.

Power users, on the other hand, perform analysis beyond what is typically performed by the regular users. They need to perform complex data analysis or data mining, and they often require blocks of raw and aggregated data for their specific needs. Hence, they often resort to downloading blocks of raw data and performing the analysis offline. Another option is to provide a business intelligence platform (or middleware) that connects directly to the database and the data warehouse and performs complex analysis using functions provided by the middleware. This allows multiple power users to create and save charts and graphs to suit their individual and/or agency needs.

Mobile devices with fully capable Web browsers can also be used to access interactive charts and graphs. As an alternative, a mobile-device-compatible Web site can be created with appropriately sized charts and graphs.

External Storage Devices

Stakeholders may request blocks of raw and/or aggregated data via external storage devices such as CD-ROMs and external hard drives. Typically, implementing agencies can either provide flat files (e.g., comma-separated values [CSV], spreadsheet) or blocks of data stored in flat files without any problem. It is also efficient to maintain a file transfer protocol (FTP) site whereby users with valid credentials (username and password) can download the data with Internet access.

Agencies also have options to use virtual or online storage sites where flat files can be stored for users to download. That way, implementing agencies do not have to maintain an FTP site, and stakeholders can simply download the data from virtual storage sites.

Published Reports and Summaries

Publications in the form of semiannual and annual reports on the state of the border crossings are also an effective way of communicating with stakeholders. These reports needs to contain three key items—overall border crossing trends on the international border, border crossing and district performance comparisons, and individual border crossing performances. Two illustrative examples in circulation are the *Border Barometer*, which is published by the Border Policy Research Institute (BPRI) and the University of Buffalo (UB) for the U.S.–Canada border, and *Northern Traffic Trends*, published by the Texas Transportation Institute (TTI) for the U.S.–Mexico border. *Border Barometer* (available at http://www.regional-institute.buffalo.edu) is a tool that provides a U.S. perspective on northern border performance, and *Northbound Freight Trends* (available at http://tti.tamu.edu) provides a U.S. perspective on southern border performance. Both reports seek to provide researchers, policymakers, and other interested parties with a better understanding of economic conditions and trends along the entire border and at individual ports of entry. A snapshot of both reports is shown in Figure 18.

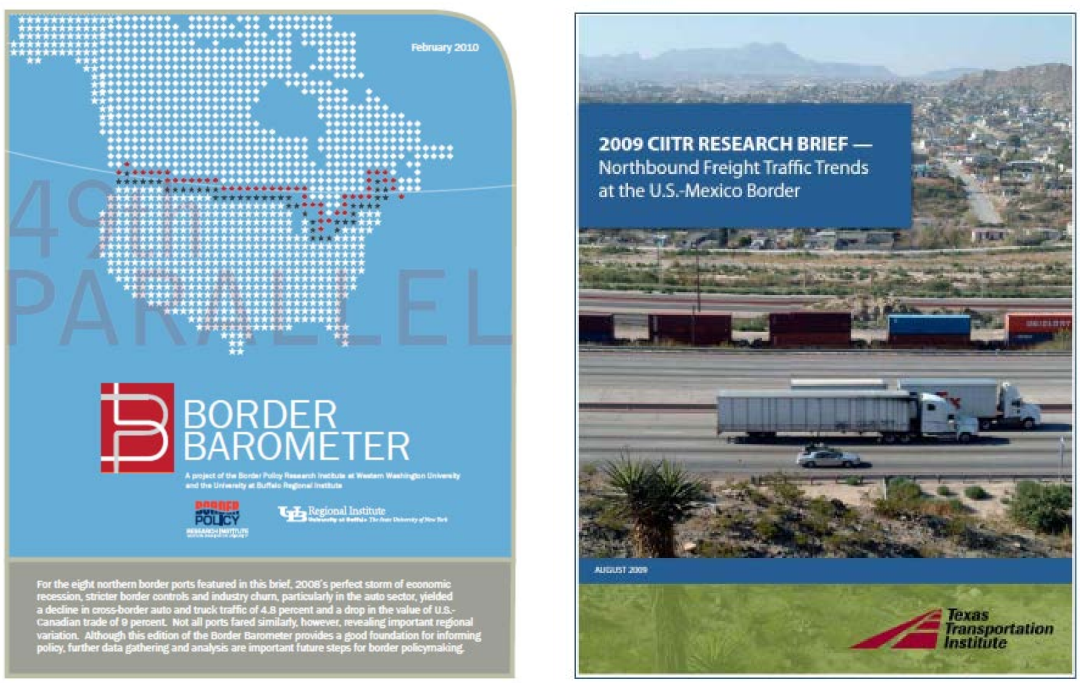


Figure 18. Snapshot of Border Barometer and Northbound Traffic Trends Published Annually By BPRI/UB and TTI, Respectively.

Neither of the reports includes crossing-time-related performance measures yet. However, with deployment of several crossing and wait time measurement projects, addition of these performance measures will significantly raise the value of these reports.

CONCLUSION

Conclusion

The purpose of this document is to describe to local, regional, and State agencies how to analyze and disseminate data collected by RFID-based crossing time and wait time measurement systems. The guidebook provides key steps and related discussions for disseminating real-time information at international land border crossings and for archiving the data (in support of monitoring the performance of border crossings).

The guidebook is not specific to any particular border crossing and hence is applicable to any border crossing where crossing time and wait time data are collected by RFID-based systems. The guidebook was largely based on experiences gathered while deploying RFID-based crossing time and wait time measurement systems in Texas. However, implementing agencies from other States now have information useful for analyzing and disseminating border crossing information for commercial vehicles. The analysis and dissemination of data collected on passenger vehicles or from technologies besides RFID can benefit from the same approach.

Key Steps for Data Analysis and Dissemination

The guidebook starts by describing how an implementing agency needs to go about first creating a framework to analyze crossing time and wait time data and to disseminate the information (real-time and archived) to stakeholders. The framework needs to be part of the design document that needs to be prepared prior to deployment and implementation, as it is crucial to address stakeholder needs and requirements for the information. To achieve stakeholder requirements, system designers have to consider information such as physical layout of the border crossing, operational practices by different State and Federal agencies, and capabilities of the technology being considered. With that in mind, following are key steps necessary for developing such a framework:

1. Setting basic definitions of border crossing and wait times.
2. Identifying characteristics of the border crossing.
3. Obtaining stakeholder input for data analysis and dissemination.

Analysis of both real-time and archived data revolves around two main objectives: (1) creating advanced traveler information, and (2) developing performance measures about individual border crossings. To achieve both objectives, data analysis starts with processing raw data, including filtering and aggregating the data into different temporal granularities, which can then be used to create traveler information and performance measures. It is recommended that visibility and traceability of the raw data processing be maintained for quality assurance and to validate data analysis results. Following are the key steps necessary for analyzing the data for archiving in support of performance measurement:

1. Filtering the raw data.
2. Aggregating raw data in different temporal granularities.
3. Reporting sample size.

4. Analyzing data for performance measurement.

Following are the key steps necessary for analyzing the data to provide real-time information:

1. Filtering the raw data.
2. Determining current crossing and wait times.
3. Determining predicted crossing and wait times.

Real-time and archived information can be disseminated using mechanisms such as agency Web sites, RSS feeds, and mobile devices. The implementing agency needs to put forward policies and procedures prior to relaying real-time information and distributing archived information to users. Such policies and procedures may cover when and how to relay the information, accuracy of the information, scope, and third-party use of the data. The implementing agency preferably needs to enter into data-sharing agreements with private entities such as media and private data providers. Following are key steps necessary to provide real-time and/or archived information to users:

1. Identifying preferred mechanism for dissemination of real-time and/or archived information.
2. Developing policies and procedures, including data-sharing agreements.
3. Implementing real-time and/or archived information dissemination.

Limitations of the Guidebook

Contents of this guidebook are largely based on experiences obtained from implementation of RFID-based border crossing time and wait time measurement systems deployed at international border crossings in the State of Texas on the U.S.–Mexico border. Every border crossing is different; a system that is deployed at a given border crossing may be different in scope and size from the ones that were implemented in Texas. Hence, the guidebook is not and cannot be a comprehensive tool for analyzing and disseminating border wait time and crossing time data. With that in mind, it is important to outline limitations of the guidebook so that implementing agencies can deploy a similar system while acknowledging the need for customization to fulfill local needs and requirements.

Data Analysis

Data analysis and dissemination methods described in this guidebook do not deal with how crossing and wait times of different categories of trucks can be distinguished depending on shipment type (e.g., empty, loaded, FAST, and non-FAST trucks, commodities, and so forth). Such distinctions are plausible only if (a) there are separate lanes for FAST and dedicated booths for processing FAST shipments, (b) there are separate lanes for empty versus loaded trucks, and (c) identification numbers of transponders can point to the categories of trucks. This limitation is not attributed to the RFID technology; rather, systems as they were implemented did not have access to information on trucks' shipment types.

The guidebook mainly focuses on crossing and wait times of trucks. With deployment of additional RFID stations, such information can be further dissected to determine what part of the crossing time or wait time was spent at which agency's facility. Readers of the guidebook need to be cognizant of where and how crossing and wait times are measured before interpreting the data.

The guidebook provides a commonly used method to determine minimum sample size, which need to be associated to archived data being reported. The equations described for determining the sample size are typically used for determining minimum number of probe vehicles required to estimate speed on highways and arterials. While these equations are widely used, implementing agencies need to verify their appropriateness for their purposes. Also, there are no established methods to determine sample size in the context of border wait times and travel times.

While this guidebook touches on the subject of predicting crossing and wait time for traveler information purposes, it does not provide methodologies or algorithms to implement that capability.

Data Dissemination

The guidebook does not endorse any particular standards for dissemination of data (specifically traveler information); it is left to the implementing agency to consider appropriate standards for such purposes. The guidebook includes discussions regarding the importance of having data-sharing agreements in place prior to providing real-time and archived data access to third-party agencies. While there are no standard templates for such agreements, the guidebook does provide key components if agencies desire to develop one. In addition, States and regional agencies may typically have such templates already available that suit their needs and requirements.

Future Improvements

Several future improvements mostly related to obtaining granularity of crossing and wait time information as well as distinction by shipment types will benefit stakeholders. These improvements can be achieved by integrating with other external systems such as electronic manifests and weigh-in-motion systems. However, these improvements will not change the fundamentals of analyzing and disseminating real-time and archived data; they will simply be reported in higher detail.

Identification of shipment type, especially FAST and non-FAST, and hence distinction of wait time and crossing time is highly desirable among stakeholders. Such distinction allows stakeholders to compare crossing- and wait-time-related benefits of the FAST program. This also allows the implementing agency to disseminate separate real-time information for FAST and non-FAST. One way to obtain shipment type information is through the electronic manifest that is filed with the CBP by carriers prior to arrival at the border crossing.

Volume of U.S.-bound commercial vehicles is one of the factors in explaining reasons for changes in crossing- and wait-time-related information. Other factors include changes in infrastructure, processing capacity, and so forth. Increased volume due to improved trade can lend itself to explain increased wait times and increased buffer index. Real-time volume data can be one of the parameters for short-term prediction of wait and crossing times, as volume in many ways may be directly proportional to wait and crossing time, other operational factors remaining constant. At a majority of U.S.–Mexico border crossings, commercial vehicles entering the United States are subject to safety inspection by the Federal Motor Carrier Safety Administration (FMCSA) and/or State highway safety agencies. As part of the safety inspection, these agencies typically have weigh-in-motion devices, which could provide volume as well as gross weights of vehicles. Gross weight can indicate whether the trucks are empty or loaded. Many border crossings have a large drayage operation, and large numbers of empty trucks cross the border moving goods in one direction. Knowing trucks' weights allows for distinguishing crossing and wait times based on weight as well.

Delay at the border is not only because of inspection on the U.S. side by the CBP but may also be the result of inspection by Mexican Aduanas. After the trucks are inspected by the CBP, they are further inspected by one or more Federal agencies such as the Food and Drug Administration (FDA), FMCSA, and, finally, the State's vehicle safety agency. Adding RFID reader stations at interfaces of these agencies provides a better understanding of travel times incurred by trucks due to different inspections performed by different agencies present at the border.

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APPENDIX
DATA-SHARING AGREEMENT

STATE OF TEXAS §

COUNTY OF TRAVIS §

AGREEMENT for SHARING

INTELLIGENT TRANSPORTATION SYSTEMS (ITS) DATA

CONTRACTING PARTIES:

Texas Department of Transportation Houston District	**TxDOT**
Grantee's Name	**Grantee**

TxDOT is the owner of Intelligent Transportation Systems (ITS) infrastructure that consists of:

- an ITS Field Network (including but not limited to sensors, cameras, signs, and communications links constructed along segments of the State highway system); and
- an ITS Business Network that has produced and produces transportation-related information that is used for the purpose of traffic management in which the State owns certain rights, title, and interests related thereto, including copyrights.

The Grantee desires TxDOT to grant rights to receive and use TxDOT transportation-related information ("Traffic Data"). TxDOT is agreeable to grant rights provided the Grantee agrees to the terms and conditions established in this agreement.

This contract incorporates the provisions of **Attachment A**, Descriptions and Specifications of Rights Granted in Article 2, **Attachment B**, Connectivity Diagram.

B A C K G R O U N D

TxDOT, in accordance with Texas Transportation Code, §201.205, may:

1. Apply for, register, secure, hold and protect its intellectual property, patents, copyrights, trademarks, or other evidence of protection of exclusivity; and
2. Enter into non-exclusive license agreements with any third party for the receipt of fees, royalties, or other things of monetary and non-monetary value; and
3. Waive or reduce the amount of fees if it determines that such waiver will further the goal and missions of TxDOT and result in a net benefit to TxDOT; and

Texas Transportation Code, §202.052 authorizes TxDOT to lease highway assets if the area to be leased is not needed for highway purposes during the term of the lease and TxDOT charges fair market value for the leased asset, and authorizes TxDOT to waive such fees for social, economic, and environmental mitigation purposes.

TxDOT—alone or as a stakeholder in Houston TranStar, the regional traffic management center (TMC)—has trademark registrations on marks in accordance with the requirements of Title 15 U.S.C. Section 1051 et seq., as amended:

- Registration Number(s) 2288372 and 2270129, hereinafter identified as the "Houston TranStar Logo."

A G R E E M E N T

In consideration of the mutual promises contained in this agreement, TxDOT and the Grantee now agree as follows:

ARTICLE 1. CONTRACT PERIOD

This agreement becomes effective when signed and dated by the last party whose signing makes the agreement fully executed. This agreement shall terminate five (5) years from that date, or when otherwise modified or terminated, as hereinafter provided.

ARTICLE 2. RIGHTS GRANTED

TxDOT hereby grants the Grantee a non-exclusive right, license, and privilege worldwide to use all or portions of Traffic Data from TxDOT's ITS Field Network and ITS Business Network. The Grantee agrees that this agreement does not transfer or convey any ownership or any rights other than those rights expressly granted by the agreement.

TxDOT further agrees to provide connectivity to Grantee to access TxDOT Traffic Data as described in Attachment A to this agreement, which is attached hereto and incorporated herein for all purposes.

ARTICLE 3. PROVISION OF INFRASTRUCTURE

The Grantee is responsible for providing and maintaining any hardware, software, and additional ITS infrastructure that is necessary to obtain the Traffic Data. TxDOT may provide unused ITS infrastructure and TxDOT facilities to support the additional infrastructure when possible, and when deemed to be in the best interest of TxDOT. Grantee agrees that TxDOT does not guarantee the availability of the Traffic Data or a minimum response time to reestablish the availability of the Traffic Data due to maintenance or network or system failures. A more detailed description of ITS infrastructure to be provided by each party is shown in Attachment A. The Grantee shall not place any objects or equipment in the State Right-of-Way or on any other TxDOT property without advanced written permission from the District Engineer or designee.

ARTICLE 4. FEE

As the use of the Traffic Data will result in social, economic, and environmental mitigation, by increasing mobility and reducing congestion on public highways, TxDOT agrees to waive any monetary fee associated with the use of the Traffic Data. After the initial year, TxDOT reserves the right to charge a fee for the use of the Traffic Data by providing not less than thirty (30) days written notice to the Grantee defining the terms of the fee.

ARTICLE 5. COPYRIGHT INFRINGEMENT

The Grantee shall notify TxDOT of any infringement or potential infringement by a third party, of which it becomes aware, of the copyright or any other rights owned by TxDOT relating to the use of the Traffic Data. The Grantee shall provide TxDOT, if feasible, any information or other assistance requested by TxDOT to assist in TxDOT's prosecution of any breaches or infringements.

ARTICLE 6. TAXES AND FEES

Grantee agrees to report to the appropriate taxation authority and pay all federal, state, and local taxes or fees that may be imposed by any governmental entity for the use of the Traffic Data.

ARTICLE 7. ASSIGNMENT PROHIBITION

The Grantee is prohibited from assigning any of the rights conferred by this agreement, to any third party. Notwithstanding the foregoing, the Grantee may assign the rights of this agreement of the Traffic Data to an affiliated corporate entity or to a purchaser of substantially all its assets without TxDOT's consent, provided that TxDOT's rights under this agreement remain unaffected. Any assignments shall be subject to the terms and conditions of this agreement.

ARTICLE 8. TERMINATION

i) Including the provisions established herein, this agreement may be terminated by any of the following conditions.
   (1) Mutual agreement and consent of the parties hereto.
   (2) By TxDOT for reason of its own and not subject to the approval of the Grantee upon not less than thirty (30) days written notice to the Grantee.
   (3) By the Grantee for reason of its own and not subject to the approval of TxDOT upon not less than thirty (30) days written notice to TxDOT.
   (4) Immediately for breach of this agreement as determined by TxDOT.

ii) Termination of the agreement shall extinguish all rights, duties, obligations and liabilities of TxDOT and Grantee of this agreement. All rights granted to the Grantee shall revert to TxDOT as owner of the Traffic Data. Upon termination of this agreement, the Grantee will immediately cease transmitting, using, distributing and/or modifying the electronic signals of the Traffic Data.

iii) Termination or expiration of this agreement shall not extinguish any of the Grantee's or TxDOT's obligation under this agreement which by their terms continue after the date of termination or expiration.

ARTICLE 9. HOLD HARMLESS

The Grantee shall indemnify and save harmless TxDOT and its officers and employees from all claims and liability due to its materials or activities of itself, its agents, or employees, performed under this agreement and that are caused by or result from error, omission, or negligent act of the Grantee or of any person employed by the Grantee. The Grantee shall also indemnify and save harmless TxDOT from any and all expense, including but not limited to attorney fees that may be incurred by TxDOT in litigation or otherwise resisting the claim or liabilities that may be imposed on TxDOT as a result of such activities by the Grantee, its agents, or employees. The Grantee agrees to indemnify and save harmless TxDOT and its officers, agents, and employees from any and all claims, damages, and attorneys' fees arising from the use of outdated Traffic Data or other information. The Grantee's indemnification of TxDOT shall extend for a period of three (3) years beyond the date of termination of this agreement.

ARTICLE 10. RELATIONSHIP BETWEEN THE PARTIES

Each party acknowledges that it is not an agent, servant, or employee of the other party. Each party is responsible for its own acts and deeds and for those of its agents, servants, or employees.

ARTICLE 11. REMEDIES

Violation or breach of contract by the Grantee shall be grounds for termination of the agreement. Any increased costs arising from the Grantee's default, breach of contract or violation of contract terms shall be paid by the Grantee.

ARTICLE 12. AMENDMENTS

Any changes in the contract period, character, or agreement terms shall be enacted by a written amendment executed by both parties. Amendments must be executed during the contract period established in Article I.

ARTICLE 13. VENUE

This agreement is governed by the laws of the State of Texas.

ARTICLE 14. NOTICES

All notices to either party by the other party required under this agreement shall be delivered personally or sent by certified or U.S. Mail, postage prepaid, addressed to such party at the following respective physical addresses:

STATE: Texas Department of Transportation
ATTN: Houston District Engineer
P.O. Box 1386
Houston, Texas 77251-1386

GRANTEE:

and shall be deemed to be received by the addressee on the date so delivered or so deposited in the mail, unless otherwise provided within. Either party hereto may change the above address by sending written notice of such change to the other.

ARTICLE 15. CONFIDENTIALITY

The Grantee shall not disclose information obtained from TxDOT under this agreement without the express written consent of TxDOT.

ARTICLE 16. COMPLIANCE WITH LAWS

The Grantee shall comply with all applicable federal, state, and local laws, statutes, ordinances, rules and regulations, and with the orders and decrees of any court or administrative bodies or tribunals in any manner affecting the performance of this agreement. When requested, the Grantee shall furnish TxDOT with satisfactory proof of this compliance. The Grantee shall provide or obtain all applicable permits, plans, or other documentation required by a federal or state entity.

ARTICLE 17. PROHIBITION AGAINST VIDEOTAPING OF TxDOT VIDEO FEED
Grantee further agrees that it shall not copy nor duplicate, or allow to be copied, any of the video feeds that are provided by TxDOT in connection with this agreement, but Grantee shall, if it is a media outlet, have permission to maintain recorded footage from the provided video feeds that became part of its regular programming.

ARTICLE 18. STATE AUDITOR'S PROVISION
The State Auditor may conduct an audit or investigation of any entity receiving funds from TxDOT directly under the contract or indirectly through a subcontract under the contract. Acceptance of funds directly under the contract or indirectly through a subcontract under this contract acts as acceptance of the authority of the State Auditor, under the direction of the legislative audit committee, to conduct an audit or investigation in connection with those funds. An entity that is the subject of an audit or investigation must provide the State Auditor with access to any information the State Auditor considers relevant to the investigation or audit.

ARTICLE 19. SIGNATORY WARRANTY
The signatories to this agreement warrant that each has the authority to enter into this agreement on behalf of the party they represent.

IN TESTIMONY WHEREOF, TxDOT and the Grantee have executed duplicate counterparts of this agreement.

THE UNIVERSITY OF HOUSTON, AS LICENSEE OF KUHF

____ ____________________

____

Typed or Printed Name and Title

<u>THE STATE OF TEXAS</u>

Executed for the Executive Director and approved for the Texas Transportation Commission for the purpose and effect of activating and/or carrying out the orders, established policies or work programs heretofore approved and authorized by the Texas Transportation Commission.

By ____ Date ____________________
(Name removed), Houston District Engineer

ATTACHMENT A
DESCRIPTIONS and SPECIFICATIONS of RIGHTS GRANTED

RIGHTS GRANTED	
By TxDOT	**By Grantee**
Provide a connection into TxDOT's traffic management center (TMC), Houston TranStar, for Grantee to obtain all TxDOT traffic camera images to broadcast on-air.	none

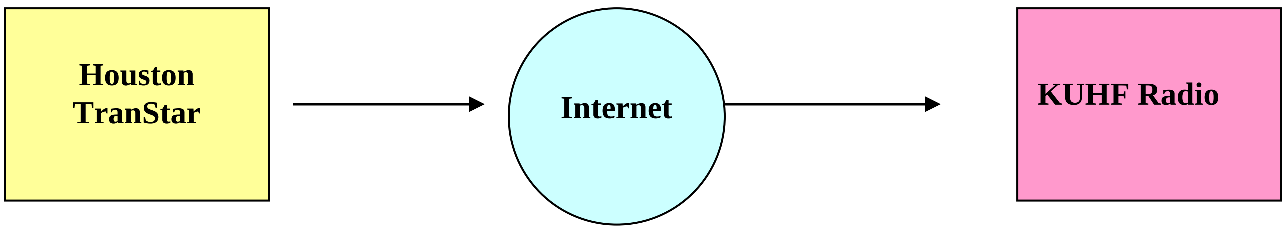
PROVISION OF INFRASTRUCTURE	
By TxDOT	**By Grantee**
Provide space for all equipment required to complete the video connection. May provide support to Grantee between the hours of 8:00 AM and 5:00 PM Monday through Friday, excluding holidays. Provide software to allow Grantee access to and selection of video images.	As described in Article 3-Provision of Infrastructure, the Grantee is responsible for providing and maintaining any hardware, software, and additional ITS infrastructure that is necessary to obtain the video connection.

NON-MONETARY COMPENSATION	
By TxDOT	**By Grantee**
none	The Grantee agrees to give TxDOT name only voice credit (Houston TranStar) for sharing the video data with a minimum of 10 on-air traffic reports at the discretion of the announcer and visual credit (Houston TranStar Logo) online for sharing the Traffic Data. TxDOT may transmit video data to the Grantee with an embedded logo; the Grantee shall not block, modify, or remove the logo. The Grantee agrees to broadcast public service announcements (PSAs) provided by TxDOT. The total number of broadcasts shall equal an average of four (4) minutes per month, including one (1) early evening newscast and one (1) early morning newscast. Each transcript will be 15 seconds in length and meet Grantee guidelines for PSA language. The Grantee shall provide TxDOT with a tape of any TxDOT related stories or any stories that involve any input from TxDOT employees that are aired by the Grantee. TxDOT will be provided one copy of the tape within two weeks of the time the story was aired.

ATTACHMENT B

Connectivity Diagram

Communications Diagram



U.S. Department of Transportation
Federal Highway Administration
Office of Operations
1200 New Jersey Avenue, SE
Washington, DC 20590

Toll-Free "Help Line" (866) 367-7487
Fax: 202-366-3225

http://www.ops.fhwa.dot.gov

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Federal Highway Administration