Commercial Border Crossing and Wait Time Measurement at Santa Teresa in Santa Teresa, New Mexico

Final Report

Prepared by
Texas A&M Transportation Institute

Prepared for
New Mexico Department of Transportation

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**List of Abbreviations**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOTA</td>
<td>Bridge of the Americas</td>
</tr>
<tr>
<td>CBP</td>
<td>U.S. Customs and Border Protection</td>
</tr>
<tr>
<td>FAST</td>
<td>Free and Secure Trade</td>
</tr>
<tr>
<td>FHWA</td>
<td>Federal Highway Administration</td>
</tr>
<tr>
<td>INDAABIN</td>
<td>Instituto de Administración y Avalúos de Bienes Nacionales (National Asset Management and Valuation Institute)</td>
</tr>
<tr>
<td>IP</td>
<td>Internet Protocol</td>
</tr>
<tr>
<td>LPOE</td>
<td>Land Port of Entry</td>
</tr>
<tr>
<td>MTPD</td>
<td>Motor Transportation Police Division</td>
</tr>
<tr>
<td>NMDOT</td>
<td>New Mexico Department of Transportation</td>
</tr>
<tr>
<td>POE</td>
<td>Port of Entry</td>
</tr>
<tr>
<td>RFID</td>
<td>Radio Frequency Identification</td>
</tr>
<tr>
<td>SAT/Aduana</td>
<td>Mexican Customs</td>
</tr>
<tr>
<td>TTI</td>
<td>Texas A&amp;M Transportation Institute</td>
</tr>
<tr>
<td>UDP</td>
<td>User Datagram Protocol</td>
</tr>
<tr>
<td>XSELNT</td>
<td>Crossing Selection Tool</td>
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</table>
Chapter 1:
Background and Overview

BACKGROUND

Through a grant from the Federal Highway Administration (FHWA), the New Mexico Department of Transportation (NMDOT) funded the installation of radio frequency identification (RFID) equipment to measure border wait and crossing times of commercial vehicles traveling from northbound Mexico into New Mexico at the Santa Teresa Land Port of Entry (LPOE).

In March 2017, NMDOT contracted with the Texas A&M Transportation Institute (TTI) to develop and implement a wait and crossing time measurement system (System) for the Santa Teresa LPOE. The System collects, archives, and posts northbound border wait times for commercial vehicles entering the State of New Mexico from Mexico on the Border Crossing Information System, a public website (bcis.tti.tamu.edu). This report covers the work that TTI developed under this contract with NMDOT, which included three phases:

- Phase 1: Design, Purchase, Installation, and Initial Operations of the Border Crossing Time Measuring System.
- Part 2. Integration of the Santa Teresa LPOE into de Border Crossing Selection Tool.
- Part 3. Operation and Maintenance.

The project took 30 months, and during the initial phase of the project the border crossing and wait time from the Santa Teresa LPOE was integrated into the Border Crossing Information System, which is the tool used to disseminate the information. Figure 1 presents the detailed project schedule.

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Months</th>
</tr>
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<tbody>
<tr>
<td>Phase 1. Design, Purchase, Installation, and Initial Operations of the Border Crossing Time Measuring System</td>
<td></td>
</tr>
<tr>
<td>Task 1. Radio Frequency Identification (RFID) Penetration Analysis</td>
<td>1</td>
</tr>
<tr>
<td>Task 2: Implementation Plan</td>
<td>2-3</td>
</tr>
<tr>
<td>Task 3: Procurement, Installation and Tests</td>
<td>4-5</td>
</tr>
<tr>
<td>Task 4: Integration with the BCIS Web tool</td>
<td>6-10</td>
</tr>
<tr>
<td>Part 2. Integration of the Santa Teresa LPOE into de Border Crossing Selection Tool</td>
<td></td>
</tr>
<tr>
<td>Task 5. Integrate the Santa Teresa into de Border Crossing Selection tool</td>
<td></td>
</tr>
<tr>
<td>Part 3. Operation and Maintenance</td>
<td></td>
</tr>
<tr>
<td>Task 6: Operate &amp; Maintain the CV BCIS</td>
<td></td>
</tr>
<tr>
<td>Task 7: Provide Recommendations for Project Sustainability</td>
<td></td>
</tr>
<tr>
<td>Task 8: Prepare and presentation of Final Report</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Project Schedule.
The border crossing and wait time measurement system is based on RFID technology and typically includes four RFID reader stations in the truck path from Mexico into New Mexico. To be consistent with other similar border wait time and crossing measurement system implementations along the U.S.-Mexico border, the installation of RFID readers and antennas was proposed at Santa Teresa at the following locations:

- Entrance of the Mexican Customs (SAT/Aduana) facility (R1).
- SAT/Aduana Export Lot (R2).
- Primary inspection facility of the U.S. Customs and Border Protection (CBP) (R3).
- Motor Transportation Police Division (MTPD) (R4).

This distribution of readers allows measurement of crossing and wait times. Wait and crossing times are defined as:

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

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

Figure 2 depicts the location of the readers. Travel time between R2 and R3 is the CBP wait time, while the time between R1 and R3 is wait time, and the travel time between R1 and R4 is the crossing time.

![Figure 2. General RFID Reader Location Diagram.](image-url)
ORGANIZATION OF THE REPORT

The report is organized as follows:

- Chapter 2 presents a description of the characteristics of New Mexico LPOEs and the El Paso LPOEs for commercial vehicles.
- Chapter 3 describes the technology implementation process, including the technology evaluation and reader station location processes.
- Chapter 4 presents a description of the equipment procurement and installation.
- Chapter 5 describes the data collection and analysis process that was conducted with the information that was collected at Santa Teresa LPOE.
- Chapter 6 presents a description of the Crossing Selection Tool (XSELNT).
- Chapter 7 presents the results from the data captured at the Santa Teresa LPOE and proposal for future operation of the System.

The report includes two appendices. Appendix A presents the equipment list and Appendix B includes the detailed report of the equipment test and evaluation at the U.S. side of the border.
Chapter 2: New Mexico Border Crossing Sites Description

NEW MEXICO INTERNATIONAL PORT-OF-ENTRY SYSTEM

The bordering region between New Mexico and Mexico is made up of six counties: Lea, Eddy, Otero, Dona Ana, Luna, and Hidalgo. International ports of entry (POEs) are crucial for the development of the region and day-to-day operations of the bi-national region. There are two international POEs capable of commercial vehicles in the state of New Mexico. Figure 3 illustrates these two POEs in New Mexico.

Table 1 presents historical data of northbound trucks crossings from Mexico into New Mexico POEs.

Table 1. Northbound Truck Crossings in New Mexico.

<table>
<thead>
<tr>
<th>Port of Entry</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Santa Teresa</td>
<td>102,771</td>
<td>114,301</td>
<td>114,921</td>
<td>114,988</td>
</tr>
<tr>
<td>Columbus</td>
<td>14,160</td>
<td>14,890</td>
<td>14,114</td>
<td>14,502</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Transportation, Bureau of Transportation Statistics

In 2018, the Santa Teresa LPOEs handled 89 percent of the total incoming trucks from Mexico to New Mexico.
EL PASO, TEXAS, AND SANTA TERESA LAND PORT-OF-ENTRY SYSTEM

The Santa Teresa LPOE is located 42 miles south of Las Cruces, the second largest city in New Mexico, and 20 miles from Downtown El Paso, Texas. This POE is equipped with three commercial lanes, four passenger lanes, and pedestrian crossing.

The Santa Teresa LPOE began operations in 1992 and it was renovated in 1997 to relieve pressure from the busy El Paso bridge crossings. Figure 4 shows the location of the Santa Teresa LPOE in relation to the EL Paso LPOE System.

Table 2 presents historical data of northbound trucks crossings from Mexico into New Mexico POEs.

Table 2. Northbound Truck Crossings in El Paso-Santa Teresa LPOE System.

<table>
<thead>
<tr>
<th>Port of Entry</th>
<th>Number of Northbound trucks 2017</th>
<th>Number of Northbound trucks 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Santa Teresa</td>
<td>114,921</td>
<td>115,664</td>
</tr>
<tr>
<td>BOTA</td>
<td>269,886</td>
<td>591,229</td>
</tr>
<tr>
<td>Zaragoza-Ysleta</td>
<td>509,287</td>
<td>2,274,017</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Transportation, Bureau of Transportation Statistics

Figure 5 shows 2018 northbound truck crossings in the El Paso, Texas, and Santa Teresa LPOE System. The Santa Teresa POE handled 4 percent of the total international trucks in the Santa Teresa/El Paso area.
The Santa Teresa LPOE serves passenger and commercial vehicles as well as pedestrians. Incoming truck crossings from Mexico have steadily increased since 2016 by 1 percent. In 2018, there were more than 115,000 northbound crossings as shown in Figure 6.

The Santa Teresa LPOE is the second POE in New Mexico that handles commercial traffic flow. In 2018, it handled an average of 9,579 northbound trucks per month. August was the highest month, with a volume of 10,728 truck crossings, while February registered the lowest truck volume (Figure 7).
The border crossing process for commercial vehicles entering the United States requires several steps in which the vehicles need to stop for security and vehicle safety inspections. The time it takes a truck to cross the border would depend on the time spent at each of these points of inspection and traveling from one station to the next, which is a function of traffic volume and the number of available staffed booths.

At the Santa Teresa POE, the northbound commercial border crossing process begins at the entrance of the San Jeronimo compound on the Mexican side of the border. After clearing export customs inspections on the Mexican side, performed by Aduana, a truck proceeds to crossing the U.S.-Mexico border. Immediately upon entering the United States, the truck continues to the U.S. Federal Compound. Entrance to the Federal Inspection Compound is accessed through the primary inspection booths. At these primary inspection booths, a CBP agent determines whether the truck requires a secondary inspection and directs the driver to it, or otherwise instructs the driver to simply proceed to the exit. Final clearance to exit the Federal Inspection Compound is given at booths at the exit of the premises.

After leaving the federal premises, the truck proceeds to the New Mexico MTPD. The MTPD is located at the north side of the federal inspection complex and is connected by an access road. Upon leaving the access road and entering the MTPD facility, trucks continue moving toward inspection booths. Weigh-in-motion sensors measure the weight of every truck that pass through the MTPD booth. Trucks departing the inspection booth are instructed by the MTPD officials to proceed either to the exit of the facility or to a secondary vehicle safety inspection.

During the initial phase of the project, the Santa Teresa LPOE commercial crossing operates from 8:00 a.m. to 8:00 p.m. Monday through Friday and 10:00 a.m. to 2:00 p.m. on Saturday. As of August 2019, the Santa Teresa LPOE operates from 6 a.m. to 8:00 p.m. Monday through Friday.
only. Figure 8 presents an aerial view of Santa Teresa LPOE. The oversize lane has a slight detour east of the regular lane.

Source: TTI using Google Earth

**Figure 8. Satellite View of Santa Teresa LPOE and Typical Northbound Truck Route.**
Chapter 3:  
Border Crossing and Wait Time Technology Implementation

READER STATION LOCATION AND STAKEHOLDER INPUT

The TTI research team traveled to Santa Teresa, New Mexico, and San Jerónimo, Chihuahua, on March 22, 2017, to perform a site visit and meet with local stakeholders. During the visit, a visual inspection of potential sites for the installation of the RFID readers was performed. The research team met with CBP field office, NMDOT, NM Department of Public Safety, Instituto de Administración y Avalúos de Bienes Nacionales (INDAABIN; National Asset Management and Valuation Institute), and Mexican SAT/Aduana.

Based on the site visit and discussion with stakeholders, the following locations were initially proposed for the installation of RFID readers:

- R1. Mexico Export Lot.
- R2. Border Gate.
- R4. MTPD facility.

The research team prepared an implementation plan, and the project concept was presented during a stakeholder meeting that was held on July 6, 2017, in New Mexico. A presentation was prepared that included the following:

- Technology overview.
- How the proposed system will work.
- Santa Teresa LPOE proposed RFID station measuring locations.
- Equipment installation examples at other bridges.
- Information dissemination.

During the meeting, stakeholders recommended changes to the proposed RFID reader location, particularly the following changes:

- Moving R1 to the End of the Queue close to the entrance gate of the Santa Teresa LPOE.
- Moving R2 to the Aduana Facility.
- Add one additional reader at CBP Primary inspection to separate Free and Secure Trade (FAST) and non-FAST travel times.
With stakeholders’ comments, the TTI research team proceeded to develop a final implementation plan that included the final location for the installation of RFID reading stations:

- R1. This station is located at the entrance of the export lot. It would require the installation of a structure at the end of the queue.

- R2. This station is located at the Mexican custom export booth.

- R3. This station is located at the CBP primary inspection booths.

- R4. This reader will be located at the MTPD booth.

Figure 9 shows the final location for RFID equipment deployments at the Santa Teresa LPOE.
Table 3 presents the final configuration of the reader stations. Appendix A presents the list of equipment for this project.

<table>
<thead>
<tr>
<th>Reading Station</th>
<th>Number of Readers</th>
<th>Number of Antennas</th>
<th>Solar Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1—Entrance Mexico Export Lot</td>
<td>2</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>R2—Mexico Export Lot Booth</td>
<td>2</td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td>R3—US Federal Inspection Compound</td>
<td>2</td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td>R4—MTPD Facility Booth</td>
<td>1</td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>7</strong></td>
<td><strong>9</strong></td>
<td>–</td>
</tr>
</tbody>
</table>

The final implementation plan was presented to INDAABIN, SAT/Aduana, NMDOT, and CBP, and the TTI research team secured authorization from Mexican and U.S. federal agencies to secure authorizations to install RFID devices at the proposed locations in the Santa Teresa POE.

CONCEPT OF OPERATIONS

The RFID-based border crossing and wait time measurement system concept was developed using this technology as most commercial vehicles that cross the U.S./Mexico already have RFID tags installed in the windshield for toll payment or for other purposes such as proof of border crossing annual fee payment to CBP. Figure 10 presents examples of tags located at truck windshields.

![Figure 10. RID Tags in Truck Windshield.](image)

The System is based in the concept that RFID tag readers are installed at four locations in the truck path. The RFID reader captures the unique identifier for each vehicle, similar to a serial number and the reader station applies a time stamp to the tag read and forwards the resulting data record to a central location for further processing via a data communication link. The RFID antenna located above the truck reads the tag in the windshield as illustrated in Figure 11.
The concept of operations, which was previously developed under the FHWA-Bridge of the Americas (BOTA) in El Paso project, was modified to meet the Santa Teresa border crossing time measurement requirements. The border crossing measurement system is organized into three subsystems representative of each component’s function:

- **Field subsystem**: comprised of the RFID tag detection or reading stations and the communication equipment. A minimum of two detection stations are required, one in Mexico and one in the United States. The detection station reads RFID tags and passes the data to the central subsystem via the communication equipment.

- **Central subsystem**: receives tag reads from the field detection stations and performs all processing to derive and archive the aggregate travel times between the stations.

- **User subsystem**: interacts with the central subsystem to provide an Internet web portal for data users (stakeholders, the public, etc.) to access current border crossing times and to access archived crossing time data.

Figure 12 shows the system’s organization.
The central facility receives data from all tag-reading stations associated with the project. The central facility is a secured database server located at TTI’s office in College Station, Texas. The database server stores all inbound raw reader station data and subsequent processed data in an archive for future access and use by regional transportation agencies and other authorized stakeholders. In essence, the database server acts as a data center for the system. The database server has enough storage space to archive several years of data from the system, and the server is expandable if additional storage space is required in the future.

The raw data are processed to match tag reads of individual trucks at the entrance point on the Mexican side and the exit point on the U.S. side. The difference in time stamps yields a single truck’s progression as a function of time through the POE. The tag matching and travel time computation of individual tags happens in real time; however, the aggregation of individual travel times to compute wait time and crossing time for reporting purposes happens every 10 minutes.

The user subsystem manages access of border crossing time data for the users. The most recent average crossing time data are available to the public via an RSS subscription. The Texas A&M Transportation Institute has developed a border crossing information system through funding from FHWA. The system includes a map-based website to view the most recent average crossing time.
data and segment travel times, and will also include interfaces to query archived border crossing data.

RFID PENETRATION TEST

The TTI researchers deployed temporary RFID reading equipment at a location at the exit of the CBP compound on a one-lane road, since all commercial vehicles entering New Mexico at the Santa Teresa LPOE must proceed using this road. Data collection took place from May 12, 2017, to May 17, 2017, in Santa Teresa. Figure 13 shows an aerial view of the data collection site.

The test plan was to setup a temporary RFID reader near the exit lane and capture tags from passing vehicles. The vehicles must be in an adjacent lane for the reading equipment to reliably capture the tag’s identification data. The tag data were logged every hour using a laptop computer.

In addition to the tag reader, the team installed a solar trailer with a video camera that recorded the passage of the vehicles. Both laptop and video camera, date and time were synchronized. Figure 14 shows the data collection setup on the exit lane of the Santa Teresa LPOE CBP facility.

Figure 13. Santa Teresa LPOE Data Collection Location.
Data were collected at the Santa Teresa site from May 12 through May 17 between 8:00 a.m. and 8:00 p.m. The tag reader recorded tags on all vehicles while a member of the team visually counted the passing vehicles. Table 4 and Figure 15 show the results of the data collection effort on May 12. On May 12, the median tag penetration rate was 75 percent.
Table 4. Santa Teresa LPOE, Hourly Tag Penetration Rate (May 12, 2017).

<table>
<thead>
<tr>
<th>Interval Time</th>
<th>Commercial Vehicle Count</th>
<th>Tag Count</th>
<th>Tag Penetration Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 AM–9:00 AM</td>
<td>37</td>
<td>33</td>
<td>89%</td>
</tr>
<tr>
<td>9:00 AM–10:00 AM</td>
<td>4</td>
<td>2</td>
<td>50%</td>
</tr>
<tr>
<td>10:00 AM–11:00 AM</td>
<td>32</td>
<td>24</td>
<td>75%</td>
</tr>
<tr>
<td>11:00 AM–12:00 PM</td>
<td>121</td>
<td>90</td>
<td>74%</td>
</tr>
<tr>
<td>12:00 PM–1:00 PM</td>
<td>44</td>
<td>32</td>
<td>73%</td>
</tr>
<tr>
<td>1:00 PM–2:00 PM</td>
<td>36</td>
<td>31</td>
<td>86%</td>
</tr>
<tr>
<td>2:00 PM–3:00 PM</td>
<td>35</td>
<td>29</td>
<td>83%</td>
</tr>
<tr>
<td>3:00 PM–4:00 PM</td>
<td>37</td>
<td>27</td>
<td>73%</td>
</tr>
<tr>
<td>4:00 PM–5:00 PM</td>
<td>33</td>
<td>24</td>
<td>73%</td>
</tr>
<tr>
<td>5:00 PM–6:00 PM</td>
<td>21</td>
<td>11</td>
<td>52%</td>
</tr>
<tr>
<td>6:00 PM–7:00 PM</td>
<td>39</td>
<td>30</td>
<td>77%</td>
</tr>
<tr>
<td>7:00 PM–8:00 PM</td>
<td>10</td>
<td>8</td>
<td>80%</td>
</tr>
</tbody>
</table>

Median 75%

Figure 15. RFID Tag Penetration at Santa Teresa LPOE (Hourly).

Figure 15 shows the number of commercial vehicles and the number of read tags crossing every hour at the Santa Teresa LPOE on May 12, 2017. The peak hour traffic was observed to be from 11:00 a.m. to 12:00 p.m.
Tag and vehicle count data are organized into 1-hour blocks or bins. During each hour period, the total number of tags recorded is shown and compared to the total number of passing vehicles. From the figure, most vehicles are already equipped with some sort of RFID tag having a median tag penetration rate of 75 percent. This percentage should be considered a maximum percentage with a true percentage likely lower.

Sample RFID tag data were collected, and the results showed that there are enough readable RFID tags in current circulation to yield good quality results in an RFID tag-based border crossing time measuring system. The commercial vehicle tag penetration numbers are approximately 75 percent at Santa Teresa LPOE (Figure 16).

Figure 16. Commercial Vehicles Crossing at Santa Teresa LPOE.
Chapter 4:
Equipment Procurement and Installation

EQUIPMENT PROCUREMENT

With the final list of equipment required for all four reading stations, the equipment was procured following Texas A&M University guidelines. The RFID equipment has the longest lead time, between two and three months. Once the RFID equipment was ordered, the other communication equipment was purchased. The equipment cabinets were assembled and tested before deploying in Santa Teresa at the El Paso TTI office.

INSTALLATION

The TTI research team identified contractors in the Mexican and U.S. side of the border to install the equipment. The installation of equipment at Mexican SAT/Aduanas was finalized in December 2018 (Figure 17). Figure 18 presents a typical electronic equipment cabinet photo.

Figure 17. Completed Installation at Location R2.
The system at R1 had intermittent power from Mexican SAT/Aduanas and the TTI research team replaced the power supply inside the electronic equipment cabinet to have the equipment operational mid-February 2018.

Installation on the Mexico side for R1 began on January 24, 2018, and was completed on February 15, 2018 (Figure 19).
A site visit was done on from February 19 through February 20 to repair and replace the cables connecting the RFID readers.

A General Services Administration–approved contractor was secured to perform the installation on the U.S. side of the border and the RFID equipment installation was completed on January 5, 2018 (Figure 20).
Figure 20. Completed Installation at Location R3.

Installation on the U.S. side for R4 began on January 16, 2018, and was completed on February 19, 2018 (Figure 21).
However, the antennas were positioned at 45 degrees restricting the area of tag capture. A site visit was done on February 26, 2018, to re-position the antennas to 15 degrees (Figure 22).
As of February 27, 2018, all four reading sites were receiving and sending tag reads, but the number of tags did not match with the number of daily processed vehicles. The vehicle count was not consistent throughout the four reading stations. Researchers traveled to Santa Teresa POE to review current border crossing operations. Santa Teresa R1 system was identified as sending fewer tag counts than the other RFID sites. After testing the entire system, it was discovered the distance between two of the antennas and the windshield of the trucks were slightly larger than ideal. A contractor was secured to lower the antennas by 3 feet as shown in Figure 23.
The changes made to the location of the antennas increased the tag count. The total tag counts between R1, R2, and R3 were almost identical.
This chapter highlights some of the key findings of the data collection and analysis portion of the project.

DATA COLLECTION AND WIRELESS TRANSMISSION

Each RFID station has an antenna located over each lane at the location. The antenna positioning is such that vehicles that have readable tags and pass under both reader stations should receive a tag match. The location of each reader was chosen to limit the number of antennas required for site coverage. The antenna connects with a traditional tolling-quality RFID tag reader that can reliably read the protocol of a variety of tags carried by trucks crossing the border. The tag reader continually scans for a passing tag. It is important for the tag to be correctly positioned and under the windshield’s glass for best readability results. As a tag passes the reader’s antenna, a unique code is recovered from the tag via an exchange of radio frequency energy. The code is converted into a digital message and forwarded to the RFID station’s onsite data-logging component.

The tag read messages are routed out of the field site and toward a central server in near real-time. The communication setup at each station includes data transmission between the RFID station and the central server via cellular data.

Radio frequency identification readers send data to the fixed Internet Protocol (IP) address on a fixed User Datagram Protocol (UDP) port number using a cell modem. The UDP listener on the central server monitors the UDP port for any incoming data packets. When the UDP listener detects any data packets on the incoming port, it reads the data packets, associates a timestamp with the data read, and invokes a stored procedure on the database. This stored procedure then inserts the data read into the raw data table. A trigger is fired whenever any new data are inserted into the raw data table. This trigger verifies whether the data are coming from a valid combination of reader ID and IP address. If a valid combination is detected, then the tag number (in human readable format) is extracted from encoded (non-human readable format), and the tag number and associated timestamp are inserted in the processed data table. If the combination is not valid, then the raw data and timestamp are inserted into the error data table. Figure 24 illustrates the entire data transmission and archiving process.
AUTOMATED MEASUREMENT OF CURRENT TRUCK CROSSING TIMES

To calculate crossing times, an aggregation process that runs on the database server every 10 minutes was developed. The server, after receiving the raw tag identification data, calculates the average crossing times of trucks every 10 minutes using a 2-hour time window. The average travel times between the readers are determined using the following procedure:

- The average travel times are calculated every 10 minutes (e.g., 9:00 a.m., 9:10 a.m., and 9:20 a.m.).
- 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. For example, to calculate the average travel time between R1 and R2 at 9:00 a.m., all the tags that were read between 7:00 a.m. and 9:00 a.m. are matched, and travel times of matched tags are averaged (simple mean).

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

The central database server maintained at TTI’s office in College Station includes several database tables where raw and processed data are archived.
DATA ANALYSIS AND TRENDS FOR CROSSING TIMES OF TRUCKS

This information will be presented in two sections: unmatched tag reads with analysis and matched tag reads with analysis. Unmatched tag reads are the total number of tag IDs detected by an RFID reader station within a certain period (e.g., a day or month of operation), regardless of whether they were detected by other reader stations in the system during that same period. A central database server receives transponder (tag) identification data from the field RFID readers. In addition to the algorithms used to measure crossing times, the database contains a separate table to store highly detailed information from which the number of transponders read each day on both sides of the border can be retrieved.

Four reader stations are used to measure crossing time: R1 at the border crossing, R2 at the Mexico export lot booth, R3 at CBP primary, and R4 at MTPD facility on the U.S. side of the border. Wait time measurement requires two reader stations: R2 at the Mexico export lot booth and R3 on the U.S. side at the CBP primary inspection booths. Some tags were not readable for various reasons, which resulted in a smaller number of unmatched tag readings for either side of the border compared to the total volume of truck crossings for the same period reported by government border crossing operators.

One key objective in analyzing the daily transponder count is to understand the trend of commercial vehicle traffic flow under regular conditions, planned events, and unplanned events that might impact the demand at the LPOE.

Figure 25 shows transponder read information for May 2019 for the Santa Teresa LPOE. Some of the dates show trouble with the system at R2 during the second and third week of May. As a result, 90 percent of the tags were read compared to R3.
Figure 25. Transponder Count Summary for Santa Teresa LPOE.
Matched tag reads for the system are the total number of tag IDs that were detected at R3 after having been previously detected at R1 within a certain buffer period to measure crossing time, and tag IDs that were detected at R2 after having been previously detected at R1 within a certain buffer period to measure wait times of U.S.-bound trucks. This period, which was generally set at 120 minutes, is adjustable. The buffer period is necessary so that trucks detained in secondary inspection for a long time and trucks that make multiple trips in which they are missed by a reader do not cause the average crossing time to be longer than is representative of the operation. The matched tag read numbers are also known as the sample size.

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

**Hourly and Daily Variation of Average Wait Times**

Figure 26 and Figure 27 present a snapshot of hourly and daily variation of average wait times of commercial vehicles at the Santa Teresa POE for Monday through Saturday for FAST and regular lanes. The data presented were collected during the week of May 6, 2019. These graphs show that average wait times were higher on Thursday and Saturday. This specific week included a semi-holiday in Mexico, so researchers can conclude this could be the reason for low crossing times on Friday. These figures also illustrate a noticeable decrease in average wait times between 13:00 and 15:00 on most days. The higher wait times were experienced around the closing hours. Also, in Figure 27, the travel time for FAST lane increases dramatically and regular lane is decreased to free flow (2 minutes). This is a result of CBP closing the regular lane and using only the FAST lane for all traffic flow.
Figure 26. Daily Variation of Average Wait Times of Trucks during the Week of May 6, 2019, for FAST Lane.
Figure 27. Daily Variation of Average Wait Times of Trucks during the Week of May 6, 2019, for Regular Lane.
Hourly and Daily Variation of Average Crossing Times

Figure 28 and Figure 29 present a snapshot of hourly and daily variation of average wait times of commercial vehicles at the Santa Teresa LPOE for Monday through Saturday for FAST and regular lanes. The data presented were collected during the week of May 6, 2019. These graphs show that average crossing times are the highest on Mondays and Wednesdays, similar to wait times, and peaks scatter around 16:00 (Monday), early afternoon (Tuesday), and late afternoon (Wednesday).
Figure 28. Daily Variation of Average Crossing Times of Trucks during the Week of May 6, 2019, for FAST Lane.
Figure 29. Daily Variation of Average Crossing Times of Trucks during the Week of May 6, 2019, for Regular Lane.
**Monthly Capture Rates**

The detected sample size on northbound trucks crossing is affected by the following:

- Not all the trucks had tags.
- Not all the tags were positioned correctly.
- Not all the readable tags that passed the R2 or R3 stations were read by the R1 station to yield a match.
- Not all tags that passed both the R1 and R2 or R3 stations were detected by both to yield a match.

Table 5 shows the calculation of monthly capture rates for the Santa Teresa LPOE. The capture rate is the proportion of matched tags read by the system to the total volume of trucks, as reported by CBP. The information reveals that the capture rate was low in February due to a power supply malfunction. March capture rate was back to normal. The system does not require a high capture rate to provide reliable travel time estimates.

**Table 5. Monthly Capture Rate Calculation at Santa Teresa.**

<table>
<thead>
<tr>
<th>Year-Month</th>
<th>Total Northbound Truck Volume</th>
<th>Wait Time Sample Size</th>
<th>Capture Rate Based on Wait Time Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>19-Jan</td>
<td>9,733</td>
<td>7,135</td>
<td>73.31%</td>
</tr>
<tr>
<td>19-Feb</td>
<td>9,117</td>
<td>5,936</td>
<td>65.11%</td>
</tr>
<tr>
<td>19-Mar</td>
<td>9,903</td>
<td>8,207</td>
<td>82.87%</td>
</tr>
</tbody>
</table>
Chapter 6:  
Conclusions and Future Operation Plan  

GENERAL CONCLUSIONS  
The border crossing and wait time measurement system at Santa Teresa is operational, and data have been collected regularly. The system is stable, and there are no major maintenance requirements in the near future, except for any unforeseen natural causes such as storms or tornados. The operation of the system requires payment of communication fees, data storage, and analysis. Figure 30 presents a sample of the monthly reports that are produced by the TTI research team. This report is produced for travel times of trucks handling FAST Program shipments and regular shipments. Each report has a cover page with the crossing hours of operation, contact information, and crossing and wait time definitions.  
The second page of the report presents a calendar with average daily crossing times, the crossing time distribution for the following intervals: less than 30 minutes, more than 30 minutes, more than 40 minutes, more than 50 minutes, and more than 60. The report also includes a comparison of the busiest day of the week for that month and which hours were the busiest in the month. The report also includes a monthly crossing time comparison, monthly average crossing time, and 96 percent of trucks crossing within certain time in minutes. This measure provides a good idea of the travel time reliability.
U.S. - Mexico Border Crossing Profile

Profile of Monthly Border Crossing Times Experienced by Commercial Vehicles Entering the United States from Mexico Through Various Land Ports of Entry in the State of New Mexico.

July 2019 Outlook for vehicles using CBP FAST lanes

Hours of Operation (Commercial Vehicles Only)

<table>
<thead>
<tr>
<th>Port of Entry</th>
<th>Weekday</th>
<th>Weekend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Santa Teresa Port of Entry, Santa</td>
<td>8:00 AM—8:30 PM</td>
<td>10:00 AM—2:00 PM</td>
</tr>
<tr>
<td>Teresa, NM</td>
<td>(Mountain)</td>
<td>(Mountain), Saturday</td>
</tr>
</tbody>
</table>

Contact Information

<table>
<thead>
<tr>
<th>Name</th>
<th>Agency</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homeroio Bernal</td>
<td>New Mexico Department of Transportation</td>
<td><a href="mailto:homeroio.bernal@state.nm.us">homeroio.bernal@state.nm.us</a></td>
</tr>
<tr>
<td>Juan Carlos Villa</td>
<td>Texas A&amp;M Transportation Institute</td>
<td><a href="mailto:jvila@tamu.edu">jvila@tamu.edu</a></td>
</tr>
<tr>
<td>Swapnil Samant</td>
<td>Texas A&amp;M Transportation Institute</td>
<td><a href="mailto:s-samant@tamu.edu">s-samant@tamu.edu</a></td>
</tr>
</tbody>
</table>

Definitions

CBP FAST Wait Time is defined as the time it takes for a commercial vehicle to travel from the RFID reader at the exit of toll booths in Mexico to the RFID reader at the exit of CBP primary inspection booths designated for FAST shipments.

CBP FAST Crossing Time is defined as the time it takes for a commercial vehicle to pass through the CBP primary inspection lanes designated for FAST shipments to travel from the RFID reader at the end of queue in Mexico to the RFID reader at the exit of CBP vehicle inspection facility.

Figure 30. Sample Monthly Report.
Santa Teresa Port of Entry, Santa Teresa, NM

Busiest Day in July 2019 was Tuesday July 2 with average crossing time of 25 minutes
Least busy day in July 2019 was Saturday July 6 with average crossing time of 13 minutes

Busiest hour in July 2019 was 16:00 - 17:00 on Tuesday July 2 with average crossing time of 72 minutes

Typical Busy Days in July 2019 were Tuesday and Friday

Calendar of average daily crossing times...

Which days were the busiest in July 2019

Crossing time distribution for July 2019

Which hours were the busiest in July 2019

How did average daily crossing time compare to last month’s.

How has average monthly crossing time changed since January 2018...

Figure 30. Sample Monthly Report. Continued.
**FUTURE OPERATION OF THE SYSTEM**

The main user of the information is CBP, who uses the information to program staff requirements and make planning decisions. The border wait time information is being shared with CBP through a direct interface that provides an automatic feed to CBP’s system. CBP has contracted with TTI to continue the operation and maintenance of the system at Santa Teresa for the rest of 2019 and 2020. In the final stage of the project in September 2019, the project will transfer from NMDOT to CBP and TTI will continue operating and maintaining the system. The TTI staff in El Paso will be responsible to maintain the system on a regular basis in coordination with the rest of the TTI team in other locations.

**RECOMMENDATIONS OF SUPPLY CHAINS TO BE INCLUDED IN THE BORDER FLUIDITY INDEX**

The Border Fluidity Index concept is a cross-border-specific freight performance measure with an end-to-end supply chain scope, to aid freight transportation planning at the state and regional levels. The basic set of data elements of the Border Fluidity Index are:

1. Time.
2. Time reliability.
3. Cost.

In order to link the Border Fluidity Index to regional and economic development, it is important to add commodity volume to the three main data elements. TTI developed a plan to implement the Border Fluidity Index, and one of the main recommendations is to Identify key supply chains and geographic dimensions. This step identifies specific supply chains or products that are of interest to the implementation agencies. The characterization of the supply chains includes identifying processes and activities, as well as regions of impact of each supply chain.

The analysis of cross border supply chains at the Santa Teresa POE led to the identification of key commodities that cross from Mexico at that location by truck. These supply chains include:

- Vegetables, fruits and spices
- Plastics
- Iron or steel tubes and pipes
- Electrical equipment

The Border Fluidity Index development requires an important level of effort to collect and analyze the required information at the commodity or supply chain level. A National Freight Fluidity Program will define with more details the methodology and data requirements. The New Mexico Department of Transportation could define a final set of commodities and data sources, once the National Program is released.
Chapter 7: Crossing Selection Tool (XSELNT)

Northbound truck freight crossing in the Santa Teresa-El Paso-Ciudad Juárez region have more than one option to cross the international border. Commercial vehicle drivers usually decide which POE to use for crossing based on toll costs, FAST lanes configuration, border wait times, or any other personal preferences or driving habits. However, other factors such as real-time route traffic congestion (Santa Teresa, El Paso, and Ciudad Juárez), number of operational toll booths at the different POEs, local road closures, incoming demand rate, among others, are not considered to calculate a more accurate travel time all the way from origin to destination.

Moreover, there is no system that offers alternative routes in real-time to help drivers to decide which route and POE to select at any specific time, and no system to estimate future traffic conditions (travel demand forecasting) in a short or long term in Santa Teresa-El Paso border crossing system.

The objective of this part of the project is to extend the crossing selection tool (XSELNT) developed in 2016 to include the Santa Teresa border crossing. The current system helps freight shippers crossing the El Paso–Ciudad Juárez borders to select the most efficient route based on their origin-destination input information, wait times at different POEs, and the local traffic conditions in El Paso, Santa Teresa, and Ciudad Juárez.

XSELNT provides the user with a web-based interface where the users can enter an origin address, destination address, time of departure, and type of lane desired for travel. Figure 31 presents the user interface for the user.

![Figure 31. Crossing Selection Tool-User Interface – Origin and Destination Location Input.](image-url)
Users can click on the Estimate Time button on the user interface after they enter all the required information. Based on the input information, the tool computes the travel time from the origin to the destination using BOTA, Ysleta-Zaragoza, or Santa Teresa crossings. The results are presented to the users in summary format (Figure 33) and present different results of the tool depending of the origin and destination.

<table>
<thead>
<tr>
<th>Travel Time Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Origin</strong></td>
</tr>
<tr>
<td><strong>Destination</strong></td>
</tr>
<tr>
<td><strong>Departure</strong></td>
</tr>
<tr>
<td><strong>Time</strong></td>
</tr>
</tbody>
</table>

**Expected Travel Time Using FAST**

<table>
<thead>
<tr>
<th>Crossing</th>
<th>Time (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOTA</td>
<td>65</td>
</tr>
<tr>
<td>Zaragoza</td>
<td>94</td>
</tr>
<tr>
<td>Santa Teresa</td>
<td>34</td>
</tr>
</tbody>
</table>

Click on the details button below to view the outlook for the next 24 hours.

Figure 32. Crossing Selection Tool Results for All Crossings.

The results of the XSELNT are presented as a time-series plot with the expected travel time and crossing time for the next 24-hours (Figure 32). The plot consists of three series. The first series is the prediction of travel time from the origin address to the selected border crossing (Santa Teresa in this example), the second series is the prediction for the crossing time, and the third series is a prediction for travel time from the selected border crossing to the destination address. The plot also shows the confidence interval for the predictions; the confidence shows a minimum and maximum range at the top of each travel time prediction. Using these plots, users can make an informed decision about which crossing to select and departure time for sending their shipments across the international border from Mexico to the United States in the El Paso-Ciudad Juárez region.

Figure 33. Crossing Selection Tool Results for Santa Teresa POE.
In this example, the origin point is located at Calle Chiapas 2919 in Fronteriza, Mexico and the destination point is at 8050 Country Road in La Mesa, Texas. XSELNT provides the estimated travel time for a given departure date. In this case, on May 25 at 10:30 a.m., the travel time if crossing through Santa Teresa POE (Figure 34) would be 34 minutes for a total travel distance of 53 miles. It also shows estimated travel times through the BOTA POE with a total of 65 minutes traveling 80 miles (Figure 35), and 94 minutes for 128 miles when using Ysleta-Zaragoza POE (Figure 36). In this example, the fastest and shortest path from origin to destination was using the Santa Teresa POE. The following figures illustrate the potential routes. XSELNT does not provide this type of map.

Source: TTI using Google Maps. For illustration purpose only, not part of XSELNT

Figure 34. Sample Map with Trip through the Santa Teresa POE.
Figure 35. Sample Map with Trip through the BOTA POE.

Figure 36. Sample Map with Trip through the Ysleta-Zaragoza POE.
# Appendix A: List of Equipment

Santa Teresa Port of Entry Crossing Travel Time Measurement - Detection Stations

## Summary

### Detection Station R1 - 3 lanes
Mounted on own structure at the entrance of the compound

<table>
<thead>
<tr>
<th>Item</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yagi antenna</td>
<td>3</td>
</tr>
<tr>
<td>RF power splitter (multi-lane site)</td>
<td>1</td>
</tr>
<tr>
<td>RFID Reader</td>
<td>2</td>
</tr>
<tr>
<td>Cable, 35 Foot, with connector</td>
<td>3</td>
</tr>
<tr>
<td>12-24 V DC/DC adjustable output converter</td>
<td>1</td>
</tr>
<tr>
<td>RS-422 converted - DIN rail mount</td>
<td>2</td>
</tr>
<tr>
<td>Programmable Logic relay</td>
<td>1</td>
</tr>
<tr>
<td>LTE Wireless router</td>
<td>1</td>
</tr>
<tr>
<td>External cellular antenna</td>
<td>1</td>
</tr>
<tr>
<td>Remote reboot</td>
<td>1</td>
</tr>
<tr>
<td>EMC-1</td>
<td>1</td>
</tr>
<tr>
<td>Solar panel controller</td>
<td>1</td>
</tr>
<tr>
<td>Misc Backpanel construction parts</td>
<td>1</td>
</tr>
</tbody>
</table>

### Detection Station R2 - 2 lanes
Mounted on Fideicomiso booth

<table>
<thead>
<tr>
<th>Item</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yagi antenna</td>
<td>2</td>
</tr>
<tr>
<td>RF power splitter (multi-lane site)</td>
<td>1</td>
</tr>
<tr>
<td>RF Surge Protection</td>
<td>1</td>
</tr>
<tr>
<td>RFID Reader</td>
<td>1</td>
</tr>
<tr>
<td>Cable, 35 Foot, with connector</td>
<td>2</td>
</tr>
<tr>
<td>Power Supply 24VDC -240W</td>
<td>1</td>
</tr>
<tr>
<td>RS-422 converted - DIN rail mount</td>
<td>2</td>
</tr>
<tr>
<td>Programmable Logic relay</td>
<td>1</td>
</tr>
<tr>
<td>LTE Wireless router</td>
<td>1</td>
</tr>
<tr>
<td>External cellular antenna</td>
<td>1</td>
</tr>
<tr>
<td>Remote reboot</td>
<td>1</td>
</tr>
<tr>
<td>Misc Backpanel construction parts</td>
<td>1</td>
</tr>
</tbody>
</table>
**Detection Station R3 - 2 lanes**—mounted on CBP Primary booth

<table>
<thead>
<tr>
<th>Item</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yagi antenna</td>
<td>2</td>
</tr>
<tr>
<td>RF power splitter (multi-lane site)</td>
<td>1</td>
</tr>
<tr>
<td>RF Surge Protection</td>
<td>1</td>
</tr>
<tr>
<td>RFID Reader</td>
<td>1</td>
</tr>
<tr>
<td>Cable, 35 Foot, with connector</td>
<td>2</td>
</tr>
<tr>
<td>Power Supply 24VDC -240W</td>
<td>1</td>
</tr>
<tr>
<td>RS-422 converted - DIN rail mount</td>
<td>2</td>
</tr>
<tr>
<td>Programmable Logic relay</td>
<td>1</td>
</tr>
<tr>
<td>LTE Wireless router</td>
<td>1</td>
</tr>
<tr>
<td>External cellular antenna</td>
<td>1</td>
</tr>
<tr>
<td>Remote reboot</td>
<td>1</td>
</tr>
<tr>
<td>Misc Backpanel construction parts</td>
<td>1</td>
</tr>
</tbody>
</table>

**Detection Station R4 - 2 lanes**—mounted on CBP Primary booth

<table>
<thead>
<tr>
<th>Item</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yagi antenna</td>
<td>2</td>
</tr>
<tr>
<td>RF power splitter (multi-lane site)</td>
<td>1</td>
</tr>
<tr>
<td>RF Surge Protection</td>
<td>1</td>
</tr>
<tr>
<td>RFID Reader</td>
<td>1</td>
</tr>
<tr>
<td>Cable, 35 Foot, with connector</td>
<td>2</td>
</tr>
<tr>
<td>Power Supply 24VDC -240W</td>
<td>1</td>
</tr>
<tr>
<td>RS-422 converted - DIN rail mount</td>
<td>2</td>
</tr>
<tr>
<td>Programmable Logic relay</td>
<td>1</td>
</tr>
<tr>
<td>LTE Wireless router</td>
<td>1</td>
</tr>
<tr>
<td>External cellular antenna</td>
<td>1</td>
</tr>
<tr>
<td>Remote reboot</td>
<td>1</td>
</tr>
<tr>
<td>Misc Backpanel construction parts</td>
<td>1</td>
</tr>
</tbody>
</table>
Appendix B: RFID Test and Evaluation Results

TESTING AT MTPD BOOTH
The RFID tag-reading system installed at the Santa Teresa MTPD booth was tested to ensure proper operation and configuration. Table 6 documents the tests results.

<table>
<thead>
<tr>
<th>Test</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-VDC reading</td>
<td>23.7 VDC</td>
</tr>
<tr>
<td>Router Signal Quality</td>
<td>−9 dBm</td>
</tr>
<tr>
<td>Router Signal Strength</td>
<td>−102 dBm</td>
</tr>
<tr>
<td>Tag read</td>
<td>PASS</td>
</tr>
<tr>
<td>Tag read reliability</td>
<td>See results below</td>
</tr>
<tr>
<td>Static IP</td>
<td>PASS</td>
</tr>
<tr>
<td>Router accessibility via Internet</td>
<td>PASS</td>
</tr>
<tr>
<td>Auto power cycle</td>
<td>PASS</td>
</tr>
<tr>
<td>Remote request power cycle</td>
<td>PASS</td>
</tr>
<tr>
<td>Remote configuration of reader</td>
<td>PASS (#00)</td>
</tr>
<tr>
<td>Wireless data transfer</td>
<td>PASS</td>
</tr>
<tr>
<td>Data retrieval application</td>
<td>PASS</td>
</tr>
</tbody>
</table>

TESTING AT CBP
The RFID tag-reading system installed at the Santa Teresa primary inspection booth was tested to ensure proper operation and configuration. Table 7 documents the tests results.
Table 7. Test Santa Teresa R3.

<table>
<thead>
<tr>
<th>Test</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-VDC reading</td>
<td>24.2 VDC</td>
</tr>
<tr>
<td>Router Signal Quality</td>
<td>−9 dBm</td>
</tr>
<tr>
<td>Router Signal Strength</td>
<td>−99 dBm</td>
</tr>
<tr>
<td>Tag read</td>
<td>PASS</td>
</tr>
<tr>
<td>Tag read reliability</td>
<td>See results below</td>
</tr>
<tr>
<td>Static IP</td>
<td>PASS</td>
</tr>
<tr>
<td>Router accessibility via Internet</td>
<td>PASS</td>
</tr>
<tr>
<td>Auto power cycle</td>
<td>PASS</td>
</tr>
<tr>
<td>Remote request power cycle</td>
<td>PASS</td>
</tr>
<tr>
<td>Remote configuration of reader</td>
<td>PASS (#00)</td>
</tr>
<tr>
<td>Wireless data transfer</td>
<td>PASS</td>
</tr>
<tr>
<td>Data retrieval application</td>
<td>PASS</td>
</tr>
</tbody>
</table>

TESTING AT ADUANA BOOTH

The RFID tag-reading system installed at Santa Teresa Aduana Booth was tested to ensure proper operation and configuration. Table 8 documents the results.

Table 8. Test Santa Teresa R2.

<table>
<thead>
<tr>
<th>Test</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-VDC reading</td>
<td>24.2 VDC</td>
</tr>
<tr>
<td>Router Signal Quality</td>
<td>−9 dBm</td>
</tr>
<tr>
<td>Router Signal Strength</td>
<td>−96 dBm</td>
</tr>
<tr>
<td>Tag read</td>
<td>PASS</td>
</tr>
<tr>
<td>Tag read reliability</td>
<td>See results below</td>
</tr>
<tr>
<td>Static IP</td>
<td>PASS</td>
</tr>
<tr>
<td>Router accessibility via Internet</td>
<td>PASS</td>
</tr>
<tr>
<td>Auto power cycle</td>
<td>PASS</td>
</tr>
<tr>
<td>Remote request power cycle</td>
<td>PASS</td>
</tr>
<tr>
<td>Remote configuration of reader</td>
<td>PASS (#00)</td>
</tr>
<tr>
<td>Wireless data transfer</td>
<td>PASS</td>
</tr>
<tr>
<td>Data retrieval application</td>
<td>PASS</td>
</tr>
</tbody>
</table>
TESTING AT THE ENTRANCE OF THE MEXICAN IMPORT LOT

The RFID tag-reading system installed at entrance of the Mexican Import Lot was tested to ensure proper operation and configuration. Table 9 documents the results.

Table 9. Test Santa Teresa R1.

<table>
<thead>
<tr>
<th>Test</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-VDC reading</td>
<td>25.9 VDC</td>
</tr>
<tr>
<td>Router Signal Quality</td>
<td>–9 dBm</td>
</tr>
<tr>
<td>Router Signal Strength</td>
<td>–102 dBm</td>
</tr>
<tr>
<td>Tag read</td>
<td>PASS</td>
</tr>
<tr>
<td>Tag read reliability</td>
<td>See results below</td>
</tr>
<tr>
<td>Static IP</td>
<td>PASS</td>
</tr>
<tr>
<td>Router accessibility via Internet</td>
<td>PASS</td>
</tr>
<tr>
<td>Auto power cycle</td>
<td>PASS</td>
</tr>
<tr>
<td>Remote request power cycle</td>
<td>PASS</td>
</tr>
<tr>
<td>Remote configuration of reader</td>
<td>PASS (#00)</td>
</tr>
<tr>
<td>Wireless data transfer</td>
<td>PASS</td>
</tr>
<tr>
<td>Data retrieval application</td>
<td>PASS</td>
</tr>
</tbody>
</table>