Final Report Appendices

Impacts of Border Delays at California-Baja California Land Ports of Entry

Appendices for Volume 1: Background and Summary of Findings

San Diego, CA
September 25, 2020

In Coordination with T. Kear Transportation Planning and Management, Inc.

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Assessment of Existing "Gaps" on Border Data (including Wait Times)

Impacts of Border Delays at the California-Baja California Land Ports of Entry

San Diego, CA
August 5, 2018

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Introduction

The California – Baja California border region is one of the most important and dynamic economic zones in North America. However, demand is posed to outstrip supply at the region's border crossings. While the crossings have become a critical element of the binational region's economic integration and competitiveness, growing demand has led to increased congestion at border crossings and generated delay and unreliable crossing times for cars, trucks and pedestrians at California-Baja California ports of entry (POE). These delays and unreliability at the border have the potential to reduce the region's economic competitiveness and attractiveness to business, which can translate into lower levels of economic activity and growth.

In 2006, SANDAG and Caltrans conducted studies that showed how border delays cause significant reductions in economic output and employment. These studies highlighted the need for improving border crossings and helped make the case for developing a third crossing between San Diego and Tijuana (the planned Otay Mesa East-Mesa de Otay II border crossing). Similarly, in 2007, the former Imperial Valley Association of Governments and Caltrans conducted an economic delay study for the Imperial County border crossings. Much has changed since these earlier studies – the local economy has rebounded from the Great Recession and there are new emerging industry clusters that depend on crossborder trade.

As a result, SANDAG has commissioned the HDR team to conduct the study on Impacts of Border Delays at the California-Baja California Land Ports of Entry. The current document is part of this effort and focuses on identifying the "data gaps" on key inputs identified by the team as necessary to conduct this study.

Methodology

The HDR team has worked extensively in the California – Baja California border region helping SANDAG, SCAG, ICTC, Caltrans, and other agencies understand border-crossing behavior of private and commercial vehicles and the relevance of the border to the local economies. Therefore, we are well aware of the different efforts undertaken to estimate not only wait times at land Ports of Entry (POEs) in the region but also other border- crossing characteristics such as origins and destinations of trips, purpose, cargo type and frequency of crossing.

Some of these efforts have been led directly by members of the HDR team. Therefore, to create this document, we began by identifying the data required to perform the tasks outlined in the study. After doing that, we combined the information gathered through a literature review with our knowledge of border projects to develop a matrix (see Appendix, Figure 1) that lists available data collected through recent studies[1] and compares it with data needed to conduct the assessment of economic and air quality impacts/emissions of delays at the border for the six land POEs in the California – Baja California region.[2] In addition, a table with the sample sizes for the different data collection efforts found through the literature review is also developed (see Appendix, Figure 2). Areas where data needed to conduct this study is not available are identified as "data gaps," which need to be filled out as part of the data collection task of the current study.

The primary data needed to conduct the assessment of economic and air quality/emissions impacts of delays at the border is divided into four categories: (i) economic information, (ii) emissions information, (iii) border-crossing wait time information; and, (iv) traffic and volume data. The available data and the "gaps" for each one of these categories are explained in the following sections of this document.

[1] Only primary data collection efforts are listed and analyzed, since they collect data that resembles more the data needed for this study.
[2] The Cross Border Xpress is a new hybrid POE that connects Otay Mesa in the San Diego region with the Tijuana International Airport via a tolled pedestrian bridge, which opened in December 2015.

Economic Information

The economic information identified by the HDR team as key to conduct the analysis of Economic Impacts of Delays at the Border consists of Origin-Destination, trip purpose, crossing frequency, trip-related expenditure, productivity loss due to delays, wait time thresholds to cancel binational trips, mode switch and willingness to pay for a faster border-crossing.

Available sources for economic information include the Crossborder Survey conducted for SANDAG in 2011, two surveys performed for SANDAG in late 2011 and early 2012 (General Public Survey and Company Survey) and two surveys conducted as part of SCAG's Goods Movement Border Crossing Study and Analysis, Phase 1 (conducted in 2011) and Phase 2 (conducted in 2015).

Crossborder Survey, 2011

The Crossborder Survey of 2011 was conducted at the San Ysidro, Otay Mesa and Tecate POEs in three main waves (one for each POE) between December 8, 2010 and April 18, 2011. The target population consisted of Baja California residents traveling northbound (crossing into the U.S.) with a destination located within San Diego County. Moreover, the modes captured were automobiles, motorcycles, bicycles, pedestrians and bus/public transportation. Participants were screened to ensure these appropriate characteristics were present before continuing with the interview.

The survey was divided into two parts. Part 1 recorded origin-destination information for the trip being taken for the modes mentioned above. Respondents were asked to participate in a follow-up interview (Part 2) that consisted of filling-out a travel diary with all the destinations they traveled to while in the U.S. during the day Part 1 of the interview was completed.

Data were collected only during weekdays between 5:30 AM and 6:00 PM. The sampling methodology used was clustered sampling based on POE, mode, time of day, and border-crossing procedure (SENTRI[3] vs. Non-SENTRI). A number of border-crossers that met these requirements were asked to participate in the survey.

The sample collected consists of 7,371 records for Part 1 of the survey and 1,517 records for Part 2. The vast majority of the responses correspond to autos and pedestrians.

The variables captured in Part 1 of the survey include:

- Trip Origin (at colonia level when origin is Tijuana or Tecate);
- Main Destination (area / city within San Diego County);
- Perceived time to reach POE from origin of the trip;

[3] Secure Electronic Network for Travelers Rapid Inspection. The SENTRI program provides expedited CBP processing for preapproved, low-risk travelers using their personal vehicle. Travelers must apply to this program, and once approved are issued a Radio Frequency Identification (RFID) card that will identify their record and status in the CBP database on arrival at the POE.

- Trip purpose (for trip when part 1 of the survey took place);
- Crossing frequency;
- Socioeconomic characteristics (employment status, work location, household size, employment in household, vehicles in household);
- Transportation mode (auto, motorcycle, bicycle, pedestrian, bus/public transport);
- Vehicle type (for autos only);
- Vehicle occupancy (for autos only); and
- SENTRI / standard lane.

The variables captured in Part 2 of the survey include:

- Employment status;
- Income range;
- For every place visited during recorded trip: Name & type of place, Purpose of visit/trip to that place, Address, Closest intersection / reference point, City, Arrival time to place, Mode used for trip, Vehicle occupancy during trip, Departure time from place;
- Returning time to Mexico; and
- POE used to return to Mexico.

The Crossborder Survey provides a good level of detail on the origin of the northbound trips by recording information at the “colonia” level. Similarly, the survey records the destination in San Diego County at an adequate level of disaggregation (city level). More importantly, for each response the survey captured the trip purpose associated to the specific origin-destination, allowing a disaggregation of origin-destination pair volumes into trip purposes. Finally, the survey also collected frequency of crossing.

General Public Survey, 2012

The General Public Survey of 2012 was conducted at the San Ysidro and Otay Mesa POEs between November 2011 and March 2012. The target population consisted of travelers going northbound, crossing from Mexico into the U.S. The survey was conducted in two separate exercises, one for passenger vehicles and pedestrians and the other for commercial vehicles.

PASSENGER VEHICLES AND PEDESTRIANS

The passenger vehicle and pedestrian component of the survey consisted of questions about origin-destination for the current trip (including trip purpose) as well as a stated-preference section. The stated-preference section was intended to capture the willingness-to-pay attitudes toward the construction of a new POE and accompanying toll road featuring reduced wait times. To do this, eight different scenarios were presented to each interviewee, and in each scenario they were asked to choose between paying a toll or waiting more at the border-crossing. Two different categories of scenarios were used in the survey, one to collect responses related to the

value of time (VOT) assigned by travelers and the other to capture information on the value of reliability (VOR). The general characteristics of each experiment were as follows:

- VOT scenarios varied by wait time before reaching border crossing without toll, toll rate and wait time before reaching border crossing with toll; and
- VOR scenarios varied by average wait time to cross without toll, amount of further delays without toll, toll rate and average wait time and maximum amount of further delays with toll.

A split-sample approach was used, where approximately half of the participants received the VOT version of the questionnaire, whereas the remainder received a survey in which the stated preference experiments focused on VOR. The values tested in the stated preference experiments varied by POE, type of crossing (broken down into SENTRI or non-SENTRI), direction (northbound or southbound), and mode (automobile or pedestrian). Additionally, within each category of scenarios there were two variations of the stated preference experiments (white or blue) which correspond to different values of wait time and toll rates being tested.

A total of 1,605 responses were collected, with the majority of them (1,437) corresponding to passenger vehicles.

The information collected in the Origin-Destination component of the survey includes the following:

- Trip Origin (at the city & colonia level);
- Trip Destination (place, city, intersection & landmark);
- Reason for POE choice;
- Perceived travel time from origin to border queue;
- Perception of traffic congestion at border during this trip; and
- Anticipated wait time to crossborder.

The variables collected in the Stated-Preference component of the survey include:

- Response to experiments (for value of time or reliability) for expedited border-crossing;
- Preferred payment type or reason for not willing to pay toll;
- Additional trips anticipated under 15- and 30-minute reduction of border-crossing time;
- Household characteristics, including household income range; and
- License plate origin.

COMMERCIAL VEHICLES

The truck component of the survey was collected only in the northbound travel direction at the Otay Mesa POE and consisted of questions about origin-destination for the current trip and a stated-preference section. As in the case of the passenger vehicle and pedestrian survey, the stated-preference section for commercial vehicles was intended to capture the willingness-to-pay attitudes toward the construction of a new POE and accompanying toll road featuring reduced wait times. To do this, eight different scenarios were presented to each interviewee, and in each scenario truck drivers were asked to choose between paying a toll or waiting more at the border-crossing. The stated preference questions were asked only if the truck driver responded that he/she was in charge of making the decision about which POE to use when crossing the border. As in the case of passenger vehicles and pedestrians, two different categories of scenarios were used in the survey, one to collect responses related to the value of time (VOT) assigned by drivers and the other to capture information on the value of reliability (VOR). The general characteristics for each experiment are the same as those described for the passenger vehicle and pedestrian survey.

As in the previous case, a split-sample approach was used, where approximately half of the participants received the VOT version of the questionnaire, whereas the remainder received a survey in which the stated preference experiments focused on VOR. The values tested in the stated preference experiments varied by POE, type of crossing (broken down into empty, loaded Free and Secure Trade (FAST[4]), loaded non-FAST, Pre Arrival Processing System (PAPS) for perishable load), direction (northbound or southbound), commodity transported and ownership type (independently owned, part of a company fleet or part of a trucking/transportation company). Additionally, within each category of scenarios there were two variations of the stated preference experiments (white or blue) which correspond to different values of wait time and toll rates being tested.

A total of 433 responses were collected. The data gathered in the Origin-Destination component of the survey included the following:

- Trip Origin (at the city and colonia levels);
- Trip Destination (place, city, intersection and landmark);
- Truck ownership type (independent, company fleet, trucking company);
- Products transported in trip;
- Travel time to border;
- Expected queue time at border;
- Reason for choosing POE;

[4] The FAST program is a commercial clearance program for known low-risk shipments entering the U.S. from Canada and Mexico. Participation in FAST requires that every link in the supply chain be certified under the Customs-Trade Partnership against Terrorism program, or C-TPAT.

- Person deciding route; and
- Perceived traffic congestion at the border.

The information collected in the Stated Preference component of the survey included:

- Response to experiments (for value of time or reliability) for expedited border-crossing;
- Preferred payment type or reason for not willing to pay toll;
- Advantage of new POE with toll for trucker/company;
- Answers to the question “Who would pay the toll in the new POE?”;
- Importance of reliable crossing time;
- Importance of short crossing time;
- Reason for considering tolled crossing with reduced wait time;
- Attitude toward expanded hours of operation for new POE with toll; and
- Household characteristics, including household income range.

The General Public Survey for passenger vehicles and pedestrians provides a good level of detail on the origin of the northbound trips by recording information at the “colonia” level. Similarly, the survey records specific destination in the San Diego area at an adequate level of disaggregation (name of place with identification of close intersections). However, for southbound flows neither the origin nor the destination is recorded. The survey also captures data on user perception of congestion at the border, the anticipated wait time to cross the border and the reasons for choosing a particular POE to cross the border.

Company Survey, 2012

The Company Survey of 2012 was conducted between January and July 2012. The target population consisted of Baja California companies engaged in international movement of goods through either the Otay Mesa or Tecate POEs. The potential list of interviewed companies was derived from a list of the top users – based on number of vehicle crossings – provided by Mexican Aduanas. The survey consisted on in-depth interviews of company personnel in charge of border-crossing logistics (e.g., logistic managers) for three types of companies: maquiladoras, freight companies and perishable goods companies.

The survey was divided into two parts. Part 1 recorded information on operations (common goods transported across the border, common destinations for the transported goods, seasonality of the volume of trips across the border, perceived competitiveness and delivery scheduling), typical trips (typical destination, travel time, volume, use of POE and factors in selection of route) and attitude toward using a new POE with toll and lower wait times. Part 2 of the interview consisted of a stated-preference exercise where eight different scenarios were presented to each interviewee, and in each scenario they were asked to choose between paying a toll or waiting more time to perform the border-crossing. Two different categories of scenarios were used, one to collect responses related to the value of time (VOT) assigned by respondents and the other to capture information on the value of reliability (VOR).

Data were collected at the company's business address. The sample consists of 99 completed interviews, of which 69 were maquiladora companies, 20 were freight companies and 10 were perishable goods transport companies.

The Company Survey provides information at the aggregate (or representative trip level) on the destination of northbound trips by recording information at the city level. However, since interviewees were centered around typical shipments across the border, in most cases the destination is comprised of more than one city. Similarly, the interviewees were asked about the typical commodities transported, and thus many responses consist of more than one commodity being listed. Additionally, the survey provides insight into perceived congestion levels and wait times at the border, factors in selecting a specific route and border crossing, importance of southbound delays at the border and importance of predictable and short crossing times.

SCAG Goods Movement Border Crossing Study Phase 1, 2011
Data on Origin-Destination (O/D) pairs for the project was collected from two different sources: (i) shipment information provided by manufacturing companies and custom brokers and, (ii) truck information obtained via intercept surveys at the Calexico East POE.

Shipment data was gathered as part of a larger effort to interview managers working at companies established in the region and engaged in international trade. A total of 63 companies were interviewed during April – November of 2011 and each company was asked to submit 40-50 shipments that could be analyzed to obtain O/D and supply chain management information. The total sample collected consists on O/D information for 880 shipments (505 northbound, 375 southbound), including the origin's zip code and type of facility, the destination's zip code and type of facility and, where applicable, the location of intermediary facilities where the cargo stopped on its way to its final destination. The sample collected corresponds to shipments dispatched during the February – October 2011 period, though a large majority concentrates on the months of May, June and July.

Truck intercepts were conducted at the Calexico East POE on both sides of the border, capturing northbound and southbound flows of goods transported by truck. A total of 427 truck drivers were interviewed during August 16, 17, 18 and 20 and September 20, 21, 22, 23, 26, 27, 28 and 29 (all these dates in 2011). Each driver was asked a series of questions related to the type of cargo, origin – destination, frequency of crossing, perceived wait time at the border and use of trusted traveler program (FAST / Customs-Trade Partnership Against Terrorism or C-TPAT). Observations on northbound trips totaled 214 while the total number of surveys collected on southbound trips equaled 213. Intercept surveys for northbound trips were performed between 8:25 am and 5:48 pm, while surveys were collected between 7:45 am and 7:22 pm on southbound trips.

Origin/Destination company surveys and truck intercept surveys included a stated preference section intended to capture the interviewee's willingness-to-pay from hypothetical reductions in border crossing time and improved reliability at the border. Fifty one logistics managers engaged in northbound shipment of goods from an equal number of companies provided answers for the stated preference section of the survey. In the case of the truck intercept survey, 214 truck drivers performing northbound trips responded to the stated preference

section of the survey. Fourteen logistics managers in charge of dispatching southbound shipments across the border responded the stated preference section of the survey. Regarding the truck intercept survey, the 100 drivers who were driving loaded trucks on southbound trips were interviewed.

SCAG Goods Movement Study Phase 2, 2015

In order to gather information on the true origins and destinations for the goods that move across the border, the study interviewed two types of companies involved in border-crossing movement of goods: cargo generators and drayage companies. To do this, the study developed a critical survey focused on international shipments, regional supply chains, and the volume of goods that cross the border. Representatives of the study team interviewed the targeted companies. All company data is confidential and was anonymized during the data entry process to de-link responses from individual company information.

CARGO GENERATOR SURVEY

Data for this phase of the study was collected through interviews with cargo generators in the region that use truck as their primary mode of transportation for border-crossing trips. The interviews were conducted between December 2014 and June 2015 for a total of 53 companies. The interviewees are located in the Tijuana, Mexicali, and Ensenada regions of Mexico.

The data was collected using the “cargo generator survey” instrument approved by SCAG. The survey was divided into four parts. Part A focused on general company information, including:

- Type of cargo generator;
- Number of Employees; and
- Primary Industry Sector.

Part B focused on supply chain questions such as shipment volumes, routes, and transport modes. Interviewees were asked to provide information on:

- Percentage of southbound shipments originating from given locations;
- Percentage of northbound shipments destined for given locations;
- How inbound sourcing has changed over the last 2-5 years in terms of origin, region, and volume;
- Representative suppliers and customers;
- Locations of top end customers;

Part C focused on shipping volume and transportation mode information for border-crossing flows at an aggregate, company-level for each specific company. Specific questions included:

- Total number of monthly inbound and outbound shipments;

- Percentage of shipments entering/exiting Baja California at given facilities (e.g. Otay Mesa land port);
- Percentage of total monthly inbound shipments which come from vendors that store goods locally under a VMI or Vendor Managed Inventory agreement;
- Percentage of shipments which include selected transport modes (e.g.,Truck-Rail).
- Seasonal fluctuations in shipments; and
- Feasibility of using rail service for future shipments.

In the final section, companies were asked to provide detailed information on specific shipments representative of their border-crossing goods movement activities, including:

- Type of good;
- Origin and destination locations;
- Origin and destination facilities;
- Intermediary location and activity/value added; and
- Mode of transport.

DRAYAGE SURVEY

Data were collected between December and June 2015 for a total of twelve (12) companies. The survey is divided into two parts. Part A focuses on company and general shipping information. Interviewees were asked to provide information on the following:

- Fleet size;
- Number of employees;
- Total northbound and southbound drayage shipments from sites in Baja California and California respectively;
- Percentages for drayed shipments by commodity or cluster handled by the company;
- Total dollar value of goods for which the company provides drayage service for during a typical month;
- Type of container used for drayage loads; and
- Percentage of drayage loads shipped via the FAST program.

Part B focuses on supply chain questions such as shipping routes and transport modes. Interviewees were asked to provide information on the following:

- Information on customers that use companies specializing in drayage;

- Percentage of Baja California Shipment Entry/Exit Point for northbound (outbound from Baja California) and southbound (inbound to Baja California);
- Percentage of northbound and southbound border-crossing drayage loads that are picked up or dropped off at selected types of locations (e.g., Truck/Container Parking Lot); and
- Number of monthly drayage shipments handled by the company that either originate from, or are destined for selected locations in Southern California (e.g., Ports of Los Angeles/Long Beach).

Assessment of Available Data

Even though there is a significant number of data that has been collected on origin-destination and frequency of crossing at each of the California/Baja California POEs (Andrade/Los Algodones POE being the exception), this information is rarely available for southbound flows. Therefore, the current study will collect this information for southbound flows to fill out this data gap.

Also, data on expenditures during border-crossing trips, loss of productivity due to delays at the border, wait time thresholds to cancel binational trips and mode switch has not been collected over the past 8-9 years (since the original economic impact of delays at the border studies were conducted). Finally, even though willingness to pay data is available for some POEs, the information was collected about five years ago, which may render it outdated for the purposes of our study.

As a result, it is important to focus the data collection efforts of this study on collecting economic information that can inform the impact of delays at the border on the economic behavior of binational crossers. The information collected as part of this study includes trip purpose, expenditure categories and amounts, degree of expenditure substitution between the two countries, impact of delays on productivity and wait time thresholds for cancelling border-crossing trips.

Emissions Information

The emissions information identified by the HDR team as key to conduct the Air Quality Impacts of Delays at the Border consists of vehicle model year, odometer reading, fuel type, compliance with smog testing and country where fuel is purchased.

Available sources for Emissions Data are the Analysis of Wait-Times, Traffic Related Air Emissions, Operations, and Health Impacts at Selected North American Land Ports-of-Entry (Commission for Environmental Cooperation or CEC Study) and the Imperial County Air Pollution Control District's Vehicle Idling Emissions Study at Calexico Ports of Entry (Border Environment Cooperation Commission or BECC study).

Analysis of Wait-Times, Traffic Related Air Emissions, Operations, and Health Impacts at Selected North American Land Ports-of-Entry (CEC Study), 2015

This project involved significant collection of data from land Ports of Entry (POEs) on the Northern and Southern borders of the U.S. as part of an effort to analyze potential air emission impacts resulting from border delays and vehicle queues. In general, three types of comparable data were collected at each of the POEs:

- Randomly-applied, at-border surveys to collect actual data on the characteristics of motor vehicles (cars or trucks, as applicable) that are crossing the POEs, a driver's border crossing habits, and fuel type;
- Measurements of border crossing times and queue lengths by motor vehicles that are crossing at a POE (in some cases, by using ITS systems such as road loops, or collecting vehicle license plate data manually at queue starting- and end-points); and
- Estimating the daily volumes for motor vehicles crossing through the POE (either by using ITS systems, or manually counting the vehicles).

A summer and a winter datasets were collected as part of this study to try to capture seasonality differences. Of the POEs in the California – Baja California region, data was collected only at the San Ysidro/El Chaparral POE for cars.

The summer data set was collected on July 17-20, 2014 at the San Ysidro/El Chaparral POE, and a limited data set focused on queues and crossings times was performed on July 4-6, 2014 to correspond with the U.S. 4th of July holiday weekend travel peak. Surveys were administered to northbound queued vehicles in the SENTRI, Ready[5], and standard lanes. Vehicle delay was estimated by a combination of probe cars and matching of license time stamped license plate data at several points as vehicles transited the border crossing.

[5] Ready Lanes have as a requirement that all occupants in a vehicle have Western Hemisphere Travel Initiative (WHTI) compliant RFID-enabled travel documents. RFID-enabled documents approved by the Department of Homeland Security include the U.S. Passport Card; the Enhanced Driver's License; the Enhanced Tribal Card; the new Enhanced Permanent Resident Card (PRC) or new Border Crossing Card (BCC); and trusted traveler cards such as NEXUS or SENTRI.

During the July 2014 survey effort, a total of 529 completed surveys were collected, split in the following way:

- General/Regular privately-owned vehicles (POV) surveys: 170
- Ready Lane POV surveys: 185
- SENTRI POV surveys: 174

The winter data set was collected between December 6 and 9, 2014, at the San Ysidro/El Chaparral POE. As in the summer data collection effort, surveys were administered to northbound queued vehicles in the SENTRI, Ready, and standard lanes. Vehicle delay was estimated by the matching of time stamped license plate data at several points as vehicles transited the border crossing.

During the December 2014 survey effort, a total of 560 completed surveys were collected, split the following way:

- General/Regular POV surveys: 175
- Ready Lane POV surveys: 206
- SENTRI POV surveys: 179

Finally, a limited amount of queue length and traffic counts were collected on southbound flows at this POE and included in the two data sets collected.

Imperial County Air Pollution Control District's Vehicle Idling Emissions Study at Calexico Ports of Entry (BECC study), 2015

This study is similar to the Analysis of Wait-Times, Traffic Related Air Emissions, Operations, and Health Impacts at Selected North American Land Ports-of-Entry conducted for the CEC. However, this effort focused on the POEs of Calexico West and Calexico East in Imperial County, California. The project involved collection of data from these two land Ports of Entry (POEs) as part of an effort to assess potential air emission impacts resulting from border delays and vehicle queues. The three types of data collected were:

- Randomly-applied, at-border surveys to collect actual data on the characteristics of motor vehicles (cars or trucks, as applicable) that are crossing the POEs, a driver's border crossing habits (such as frequency, fuel purchases, and awareness/use of Ready Lanes at Calexico East), and fuel type;
- Measurements of border crossing times and queue lengths by motor vehicles that are crossing at a POE (in some cases, by using ITS systems such as road loops, or collecting vehicle license plate data manually at queue starting- and end-points); and
- Estimating the daily volumes for motor vehicles crossing through the POE (either by using ITS systems, or manually counting the vehicles).

Data collected at Calexico West focused on passenger vehicles while data collected at Calexico East focused on commercial vehicles (trucks). The data was collected in three different periods to capture differences in seasonality: Spring (May 2014), Summer (August 2014) and Winter (December 2014). During each one of these periods data was collected typically between 7:00 am and 5:00pm

During the course of the entire field work, the data collection team:

- Surveyed 1,011 POVs driving northbound through Calexico West POE (broken down into 655 General/Regular cars, and 356 SENTRI cars) and 165 trucks through Calexico East POE (broken down into Empty, FAST or Regular through self-reported information provided by the driver);
- Counted over 16,000 POVs at Calexico West and nearly 2,000 trucks at Calexico East POE, to measure arrival volumes in 15-minute increments;
- Counted and characterized the general vehicle type of over 11,431 POVs at Calexico West POE, and 4,486 trucks at Calexico East POE;
- Collected data on over 7,412 POVs and 5,014 truck license plates to estimate border crossing times (to later use a “match” methodology of 5-digits on license plates);
- Recorded the geographic location of the end of POV and truck queues in Mexicali in 802 half-hour increments (347 times for POVs, 455 times for Regular & FAST trucks); and
- Sampled the number of CBP inspection booths open and estimated processing times for vehicles at those booths 180 times (in one-hour increments).

Assessment of Available Data

Efforts at collecting emission information are recent (2014) and therefore some of the information can be used in this study. Unfortunately, the available data does not cover all the six POEs in the California – Baja California region and therefore available data can only be used to “augment” certain locations. In addition, available data does not cover the two directions of flows on those POEs where this information has been collected.

Therefore, it is important to focus the data collection efforts of this study on collecting emission information (vehicle age, class, odometer, domicile, certification standards, fuel type/source, and participation in vehicle emission inspection and maintenance programs) for those POEs where this has not been done.

Border Crossing Wait Time Information

The border-crossing wait time data identified by the HDR team as key to conduct the assessment of Economic and Air Quality Impacts of Delays at the Border consists of wait time by vehicle type (passenger vehicles, including buses, and trucks) during peak and non-peak days, queue lengths by vehicle type and breakdown of wait time by segment of the border-crossing trip.

Available sources for border-crossing wait time data are SANDAG's Bluetooth Survey, SANDAG's Time Stamped survey, CBP's Website data, SCAG's Goods Movement Study Phase 1, SANDAG's SR-11 Wait Time Measurement, and South County Economic Development Council's San Ysidro Pedestrian Crossing Report.

SANDAG's Bluetooth Survey, 2012

A Bluetooth survey at San Ysidro and Otay Mesa was conducted in order to estimate the waiting times at the border for passenger and commercial vehicles. The survey was conducted from February 17 to February 27, 2012. Over the survey period, the stations registered a total of 17,304 matching Bluetooth address pairs.

Due to logistical issues, not all Bluetooth units could be deployed at the locations originally planned. Wait times of U.S. bound trucks at Otay Mesa as well as Mexico-bound passenger vehicles and trucks could not be collected appropriately. At Otay Mesa, Bluetooth units could not be placed as close to the CBP property as desired, hence wait times observed were not as precise as desired.

Overall, the sample size at border crossings (in terms of number of Bluetooth signals read at individual locations and subsequent matches at two locations) was significantly high compared to manual methods that also use a matching methodology. On average at all segments, more than 10 matches were obtained per hour.

SANDAG's Time Stamped Survey, 2012

The timed stamp collection effort focused on the queuing time component: the time it takes a vehicle to enter the inspection line and reach the inspection point. Passenger vehicle and pedestrian wait times were measured at Otay Mesa and San Ysidro. This method was only used to asses travel wait times northbound, from Mexico to the U.S.

The methodology used for the study involved the following steps:

- A card with the time of arrival to the queue was placed in the vehicle's windshield;
- At a location near the primary inspection area, the card was collected and the time of collection was noted; and
- Travel time was estimated using the two times recorded on the card.

CBP Website Data, 2012

Wait time data were collected from the CBP website for a period from December 2010 to July 2012.[6] Data for passenger vehicles were summarized by type of lane, including Standard, Ready and SENTRI, while wait times for commercial vehicles were provided for Standard and FAST lanes.

SCAG Goods Movement Border Crossing Study Phase 1, 2011

Data on border-crossing times was collected for both passenger vehicles and commercial vehicles at the two main POEs in Imperial County, namely Calexico West and Calexico East. Of the two POEs where data was collected, only Calexico East allows commercial vehicles and therefore all information about commercial traffic border-crossing times comes from it. On the other hand, passenger vehicles are allowed both at the Calexico West and Calexico East POEs and therefore data for this vehicle type was collected at both locations.

COMMERCIAL VEHICLES

In order to actually measure border travel times for commercial vehicles (both northbound and southbound), the project's team relied on a method used successfully at seven ports of entry along the U.S.-Mexico border: a photographic time stamp[7]. This method involved using high-resolution cameras (with synchronized internal clocks) to record a trucks' passage to "time stamp" the event.

Sampling was made by randomly choosing every second or third truck passing a location. During nonpeak times, it was often possible to sample every vehicle; during peak times, the project staff was trained to undertake random selection of target vehicles. On northbound trips, staff also alternated between FAST and regular trucks to ensure sampling of both. Staff was rotated on a regular basis each day to also record northbound and southbound vehicle traffic, to capture wait time data on both directions each day that surveys were in progress.

The sample consists of 2,754 observations of border-crossing times for commercial vehicles collected during the months of May through October of 2011. Data collection for northbound trips was performed uniformly throughout the entire data collection period, while data on southbound trips was concentrated during the months of September and October. Of the entire sample collected 1,597 observations correspond to northbound trips (58 percent) and the remaining 1,157 are southbound trips (42 percent).

PASSENGER VEHICLES

Collection of border crossing time for passenger vehicles was done at the Calexico West and the Calexico East POEs. Sampling was made randomly using an intercept survey approach

[6] Data collected during this period was used for the planning of the SR 11/Otay Mesa East facility. However, SANDAG has indicated the collection of this data is still occurring.
[7] The POEs where this methodology was successfully applied include Laredo (TX), El Paso (TX), Otay Mesa (CA), Hidalgo (TX), and Nogales (AZ) as part of the Improving Economic Outcomes by Reducing Border Delays study for the U.S. Department of Commerce. It also included Calexico West (CA) and Calexico East (CA) as part of the Economic Delay Study for the Imperial Valley Association of Governments.

targeting every third vehicle. Where multiple lanes were present, staff rotated amongst lanes to ensure that data was captured from various lanes of travel.

The total sample consists of 5,164 observations collected on both POEs during months of April through September, 2011. In the case of the Calexico West POE, the sample was collected during April, May, June and September. In the case of Calexico East POE, the majority of the data collection efforts took place during the month of July and only a small portion of the sample was gathered during August and October. Of the total number of observations included in the sample 3,445 observations (67 percent) correspond to northbound trips and the remaining 1,719 observations (33 percent) are associated to southbound trips. When the sample is disaggregated by POE, the observations collected at Calexico West represents 58 percent of the total sample while the remaining 42 percent corresponds to the observations collected at Calexico East. Furthermore, the sample contains an important amount of SENTRI crossings on both POEs.

SANDAG's SR-11 Wait Time Measurement, 2012 & 2013

The study collected border-crossing times at the different POEs in the San Diego – Tijuana region for both passenger vehicles and commercial truck traffic. The primary objective was to provide a reliable sample of existing border crossing wait time data for San Ysidro and Otay Mesa in order to establish an independent border wait time dataset that includes wait times by hour of operations for these POEs by different lane types.

2012 DATA COLLECTION

Data was collected on northbound (NB) and southbound (SB) passenger vehicle and commercial traffic for different lane types (namely Regular, Ready, SENTRI and FAST) at the San Ysidro and Otay Mesa POEs. For passenger vehicles, collected crossing time data was disaggregated into Regular, Ready and SENTRI lanes. For trucks, data was collected on crossing time of empty and loaded trucks using regular and FAST lanes.

The study team used two different techniques for data collection based on the two different vehicle types targeted. For passenger vehicles, a manual license-plate logging using Personal Digital Assistant (PDA) technology was used, whereas for commercial traffic the photographic timestamp technique was used. At the San Ysidro POE, data was collected on passenger vehicle traffic crossing the border from October 22 to November 1 between 7 AM and 6 PM. In total, data was collected on 586 passenger vehicles crossing the border northbound using the Regular lanes; 693 passenger vehicles crossing the border northbound using the Ready lanes; and 1,239 passenger vehicles crossing the border northbound using the SENTRI lanes. In addition, data was collected on a total of 1,494 passenger vehicles crossing the border southbound using the Puerta Mexico facility. Between October 28 to November 17, 2012, data was also collected on a total of 1,210 cars crossing the border southbound using the newly opened El Chaparral facility.

At the Otay Mesa POE, data was collected on passenger vehicle traffic crossing the border from October 12 to October 19, 2012 between 7 AM and 6 PM. In total, data was collected on 528 passenger vehicles crossing the border northbound using the Regular lanes; 1,105 passenger vehicles crossing the border northbound using the Ready lanes; and 888 passenger vehicles crossing the border northbound using the SENTRI lanes. In addition, data was collected on 816 passenger vehicles crossing the border southbound.

For commercial trucks, the study collected data on 116 empty commercial trucks crossing the border as well as on 452 commercial trucks with cargo using the FAST lanes and on 528 commercial trucks with cargo using the Regular lanes to cross the border northbound at Otay Mesa POE.

2013 DATA COLLECTION

The primary objective of the 2013 data collection effort was to collect a more up-to-date sample of existing border crossing wait time data for San Ysidro in order to verify that the border wait time characteristics had not changed significantly since 2012.

Wait time data was collected on northbound (NB) passenger vehicles for different lanes (namely regular, Ready and SENTRI) at the San Ysidro POE. The crossing time data was disaggregated into regular, Ready and SENTRI lanes.

The study used a manual license-plate logging system for passenger vehicles that involved manually recording the vehicle's license plate number and the time at which it entered the queue. This data set was passed on to CBP, who matched the license plate reading and returned the data set with the time of entry at the processing station (at the end of the queue). The study calculated the queue wait time for each vehicle from these two time records.

Data was collected on passenger vehicle traffic crossing the border at the San Ysidro POE from August 17 to August 20, 2013. Data collection was limited to day light hours between 7 AM and 7 PM. In total, 1,046 passenger vehicles were recorded crossing the border northbound using the regular lanes; 1,175 passenger vehicles crossing the border northbound using the Ready lanes; and 1,055 passenger vehicles crossing the border northbound using the SENTRI lanes. On August 17th and 18th, CBP conducted a capacity test by opening all lanes and booths. This resulted in wait times that were significantly below average for the POE.

South County Economic Development Council's San Ysidro Pedestrian Report, 2016

In 2016, the South Country Economic Development Council (EDC) conducted a pedestrian survey at the San Ysidro POE in San Diego, California. The objective of the survey is understand the experience of pedestrians crossing the border and make recommendations for improvements. The survey builds on a similar study conducted in 2011, and is also meant to assess improvements made in reducing wait times and improving the experience of pedestrians crossing the border since that date.

South County EDC surveyed pedestrians leaving the San Ysidro POE facility on the United States side of the border. It carried out surveys between March 2015 and February 2016, Monday through Friday from 6:00 a.m. to 6:00 p.m. A total of 3,283 pedestrians were interviewed. Approximately 7.9 million pedestrians crossed from Mexico into the United States through San Ysidro POE in 2014.[8] Assuming that a similar number of pedestrians crossed the border from March 2015 to February 2016, the number of pedestrians surveyed represents 0.04 percent of the total pedestrian population crossing the border that year.

The surveys collected information on the following areas:

- Average border wait times and suggestions for reducing wait times
- Crossing frequency (how often the respondent crosses the border)
- Reasons for crossing the border
- Points of origin
- Method of transportation upon arrival to the U.S.
- Enrollment in the Secure Electronic Network for Travelers Rapid Inspection (SENTRI). For those respondents not enrolled in SENTRI, the survey also asked for the reasons for not being enrolled.

Assessment of Available Data

Collection of wait time data in recent years has been significant, in particular on the San Diego – Tijuana border due to studies related to SR-11/Otay Mesa East POE. However, improvements at POEs in the region are constantly being introduced and therefore an update on this information is needed. In addition, little has been done on “breaking down” wait times by the different segments that comprise the border-crossing process.

Therefore, the focus of the data collection efforts should be on capturing wait times for both northbound and southbound flows that appropriately reflect the current conditions and that provide a better segmentation of the border-crossing wait time by using GPS devices that help track specific vehicle locations at different points in time.

[8] ”Border Crossing/Entry Data: Query Detailed Statistics, U.S. Department of Transportation, Research and Innovative Technology Administration, refer to http://transborder.bts.gov/programs/international/transborder/TBDR_BC/TBDR_BCQ.html”

Traffic and Volume Data

An additional set of traffic and volume data has been identified by the HDR team as key to conduct the assessment of Economic and Air Quality Impacts of Delays at the Border. In particular, this data consists of volume/traffic counts for passenger vehicles, trucks and pedestrians at the six POEs in the California – Baja California Border.

Data collection on traffic and volume data (including traffic counts, vehicle classification and occupancy rate) was conducted on both sides of the border as part of the SR-11 Investment Grade Traffic and Revenue (IGT&R) study conducted by SANDAG.

SANDAG Traffic Analysis, 2011

TRAFFIC COUNTS

Mexico

Automatic traffic counts (ATR) in Mexico were conducted in October 2011. ATR counters were installed at 24 locations within the project's area of influence; 15 locations were on San Ysidro and Otay Mesa POEs access roads and the remaining 9 locations at other major roads. Data collected includes location and ADT.

Additionally, manual counts were performed to calibrate the ATR counts and the travel demand model (TDM). The counts were done at nine stations located at major highways over a 12-hour period, including Stations 15, 16 and 17, located near the Otay Mesa POE. Counts were conducted on Friday October 28, 2011 or on Thursday, November 3, 2011 for all stations except Stations 15, 16 and 17, which were conducted on Tuesday, October 5, 2011 and on Sunday, October 23, 2011.

United States

Traffic counts in the U.S. were conducted at 12 different locations and involved two phases, with both automatic and manual traffic counts for each phase:

- In Phase 1, manual traffic counts were conducted November 15-17, 2011 at three locations. Automatic traffic counts were conducted during the period November 13-20, 2011 at four locations.
- In Phase 2, manual counts were conducted at two locations on February 22, 2012. Automatic traffic counts were conducted at six locations during the period February 20-26, 2012.

Data collected included weekday, direction, number of autos and trucks.

VEHICLE CLASSIFICATION

Vehicles were classified as either autos or trucks on both sides of the border for both automatic and manual counts. On the U.S. side, automatic counts recorded 13 vehicle types. Manual counts classified traffic into three broad types, each consisting of several of the categories used in the automatic counts. On the Mexican side, automatic counts recorded 13 vehicle types. Similarly, manual counts recorded 14 vehicle types that were grouped into five broad categories: automobiles (private autos and taxis), local public transportation (van, minibus and bus), intercity buses (B2 and B3), trucks (C2 through C6, and C7 or more) and motorcycles.

It was not possible to determine if the 13 categories used in the automatic counts in the U.S. matched the categories used on the Mexican side, although the likelihood is high that they do match. Data on manual classifications were collected differently on both sides of the border, with the U.S. side providing a lesser degree of disaggregation.

VEHICLE OCCUPANCY

Mexico

Traffic counts and vehicle occupancy were collected at the San Ysidro, Otay Mesa and Tecate POEs in October (Saturday, October 22 and Wednesday, October 26, 2011) for northbound flows. The data collected consisted of vehicle counts in 5-minute intervals from 7 a.m. to 6 p.m. at selected locations, and identified the number of passengers aboard each vehicle. Vehicles were classified into autos, pick-ups and mini vans. Counts were also based on lane type.

United States

Vehicle occupancy data were collected in the origin-destination surveys conducted by SANDAG in 2011 and 2012 and listed in the Economic Information Section of this document (i.e., the Crossborder Survey, General Public Survey and Company Survey).

Assessment of Available Data

Collection of primary data on traffic and volume data is not as prevalent as that for wait times. This is not surprising due to the availability of secondary sources such as CBP, PeMS and BTS on traffic volumes and border-crossing trips.

Therefore, the intent of the study team is to use these secondary sources as much as possible and limit the primary data collection efforts to some key elements such as vehicle occupancy, which can be included in the efforts to collect economic information for this study.

Summary of Findings

An assessment of the primary data collected through studies in the area shows a lack of available or recent information for the following key inputs for the economic and air quality study:

- Economic information
    - Expenditures during border-crossing trips
    - Productivity loss due to delays at the border
    - Wait time threshold for cancelling border-crossing trips
    - Mode switch due to congestion levels experienced at POEs
- Wait time data
    - Breakdown of wait times by segments of the border-crossing process
    - Wait times collected using GPS devices

These deficiencies are observed in the matrix presented in Figure 1 of the Appendix as columns with no “X”s on them. However, a closer assessment at the data collected in those studies shows that for all the input categories the availability of southbound data is very limited (including the category of emissions information). Therefore, this study will include the collection of southbound data across all input categories to remedy this shortage.

APPENDIX

Figure 1. Tabular Representation of Gap Assessment

		Economic Information								Emissions Information					Wait Time Data									Volume / Traffic Counts			
LPOE	Source	O-D	Trip Purpose	Crossing Frequency	Expenditures	Productivity Loss	Trip Cancelling Threshold	Mode Switch	Willingness to Pay	Model Year	Odometer	Fuel use	Smog Check	Fuel country	POV - Peak	POV - Non-Peak	CV - Peak	CV - Non-Peak	Breakdown by segment	POV - GPS	CV - GPS	POV - Queue Length	CV - Queue Length	POV	Trucks	Pedestrians	Comments/Lane Breakdown
SY - NB	SANDAG's Crossborder Survey (2011)	X	X	X																							POV (broken down by GP or SENTRI lane) and pedestrian
	SANDAG's General Public Survey (2012)	X	X						X																		POV, pedestrian; SENTRI & non-SENTRI
	SANDAG's Traffic Analysis (2011)																							X	X		No lane breakdown
	SANDAG's Bluetooth Survey (2012)														X	X											No lane breakdown
	SANDAG's Time Stamp Survey (2012)														X	X											Breakdown by lane
	CBP Website Data (2012)														X	X											Standard, Ready, SENTRI
	SANDAG's SR-11 Surveys (2012 & 2013)														X	X											Standard, Ready, SENTRI
	CEC Survey (2014)									X	X	X	X	X	X	X						X					Standard, Ready, SENTRI
	San Ysidro Pedestrian Report (2016)		X	X																						X	Pedestrians only (included wait time data collection)
SY - SB	SANDAG's General Public Survey (2012)								X																		No lane breakdown; small number of observations
	SANDAG's Traffic Analysis (2011)																							X	X		No lane breakdown
	SANDAG's SR-11 Surveys (2012 & 2013)														X	X											No lane breakdown
	CEC Survey (2014)																					X		X			Not as robus as SY NB collection
OM - NB	SANDAG's Crossborder Survey (2011)	X	X	X																							POV (broken down by GP or SENTRI lane) and pedestrian
	SANDAG's General Public Survey (2012)	X	X						X																		POV, pedestrian & CV; SENTRI & non-SENTRI
	SANDAG's Company Survey (2012)	X							X																		No lane breakdown
	SANDAG's Traffic Analysis (2011)																							X	X		No lane breakdown
	SANDAG's Bluetooth Survey (2012)																X	X									No lane breakdown
	SANDAG's Time Stamp Survey (2012)														X	X											Breakdown by lane
	CBP Website Data (2012)														X	X	X	X									Standard, Ready, SENTRI; standard and FAST
	SANDAG's SR-11 Surveys (2012 & 2013)														X	X	X	X									Standard, Ready, SENTRI; loaded, standard and FAST
	SCAG Phase 2 Survey (2015)	X																									CV only; no lane breakdown
OM - SB	SANDAG's Traffic Analysis (2011)																							X	X		No lane breakdown
	SANDAG's SR-11 Surveys (2012 & 2013)														X	X											No lane breakdown
Tecate - NB	SANDAG's Crossborder Survey (2011)	X	X	X																							POV (broken down by GP or SENTRI lane) and pedestrian
	SANDAG's Company Survey (2012)	X							X																		No lane breakdown
	SCAG Phase 2 Survey (2015)	X																									CV only; no lane breakdown
Tecate - SB																											
Calexico - NB	SCAG Phase 1 Survey (2011)	X		X					X						X	X											GL & SENTRI (POV)
	SCAG Phase 2 Survey (2015)	X																									CV only; no lane breakdown
	Imperial County Air Quality Study (2014)									X	X	X		X	X	X						X		X			Passenger vehicles only; SENTRI/GL
Calexico - SB	SCAG Phase 1 Survey (2011)	X		X					X						X	X											GL (POV)
Calexico East - NB	SCAG Phase 1 Survey (2011)	X		X					X						X	X	X	X			X	X	X				GL & SENTRI (POV); Empty, Empty FAST, loaded, FAST (CV)
	SCAG Phase 2 Survey (2015)	X																									CV only; no lane breakdown
	Imperial County Air Quality Study (2014)									X	X	X		X			X	X					X				Trucks only; Empty/FAST/Regular (self-reported)
Calexico East - SB	SCAG Phase 1 Survey (2011)	X		X					X						X	X											GL (POV); Empty, loaded (CV)
Andrade - NB																											
Andrade - SB																											

Figure 2. Sample Sizes of Studies Found Through Literature Review, by Data Category

Data Category	Study	Sample Size	Target
Economic Information	SANDAG's Crossborder Survey (2011)	7,371 (Part 1) 1,517 (Part 2)	Passenger vehicles, motorcycles, bicycles, pedestrians and bus/public transportation
	SANDAG's General Public Survey (2012)	1,605	Passenger vehicles and pedestrians
		433	Commercial vehicles
	SANDAG's Company Survey (2012)	99	Baja California companies engaged in international movement of goods
	SCAG Phase 1 Survey (2011)	880	Shipments from companies established in the region and engaged in international trade
		427	Commercial vehicles
	SCAG Phase 2 Survey (2015)	53	Cargo generator companies
		12	Drayage companies
Air Quality Information	CEC Survey (2014)	1,089	Passenger vehicles
	Imperial County Air Quality Study Surveys (2014)	1,011	Passenger vehicles
		165	Commercial vehicles
Wait Time Information	SANDAG's Bluetooth Survey (2012)	17,304	Passenger and commercial vehicles
	SANDAG's Time Stamp Survey (2012)	N.A. (subsample of SR-11 Surveys)	Passenger vehicles and pedestrians
	CBP Website Data (2012)	In Progress	Passenger and commercial vehicles
	SCAG Phase 1 Survey (2011)	5,164	Passenger vehicles
		2,754	Commercial vehicles
	SANDAG's SR-11 Surveys (2012 & 2013)	8,559	Passenger vehicles (2012)
		1,096	Commercial vehicles (2012)
		3,276	Passenger vehicles (2013)
	San Ysidro Pedestrian Report (2016)	3,283	Pedestrians
Traffic & Volume	SANDAG's Traffic Analysis (2011)	36	Traffic Count Locations
		36	Vehicle Classification Locations
		N.A.	Vehicle Occupancy

Appendix B: Survey Methodology and Plan

Survey Methodology and Plan

Impacts of Border Delays at the California-Baja California Land Ports of Entry

San Diego, CA
August 11, 2016

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Contents

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Introduction

The California – Baja California border region is one of the most important and dynamic economic zones in North America. However, demand is posed to outstrip supply at the region's border crossings. While the crossings have become a critical element of the binational region's economic integration and competitiveness, growing demand has led to increased congestion at border crossings and generated delay and unreliable crossing times for cars, trucks and pedestrians at California-Baja California land ports of entry (LPOEs). These delays and unreliability at the border have the potential to reduce the region's economic competitiveness and attractiveness to business, which can translate into lower levels of economic activity and growth.

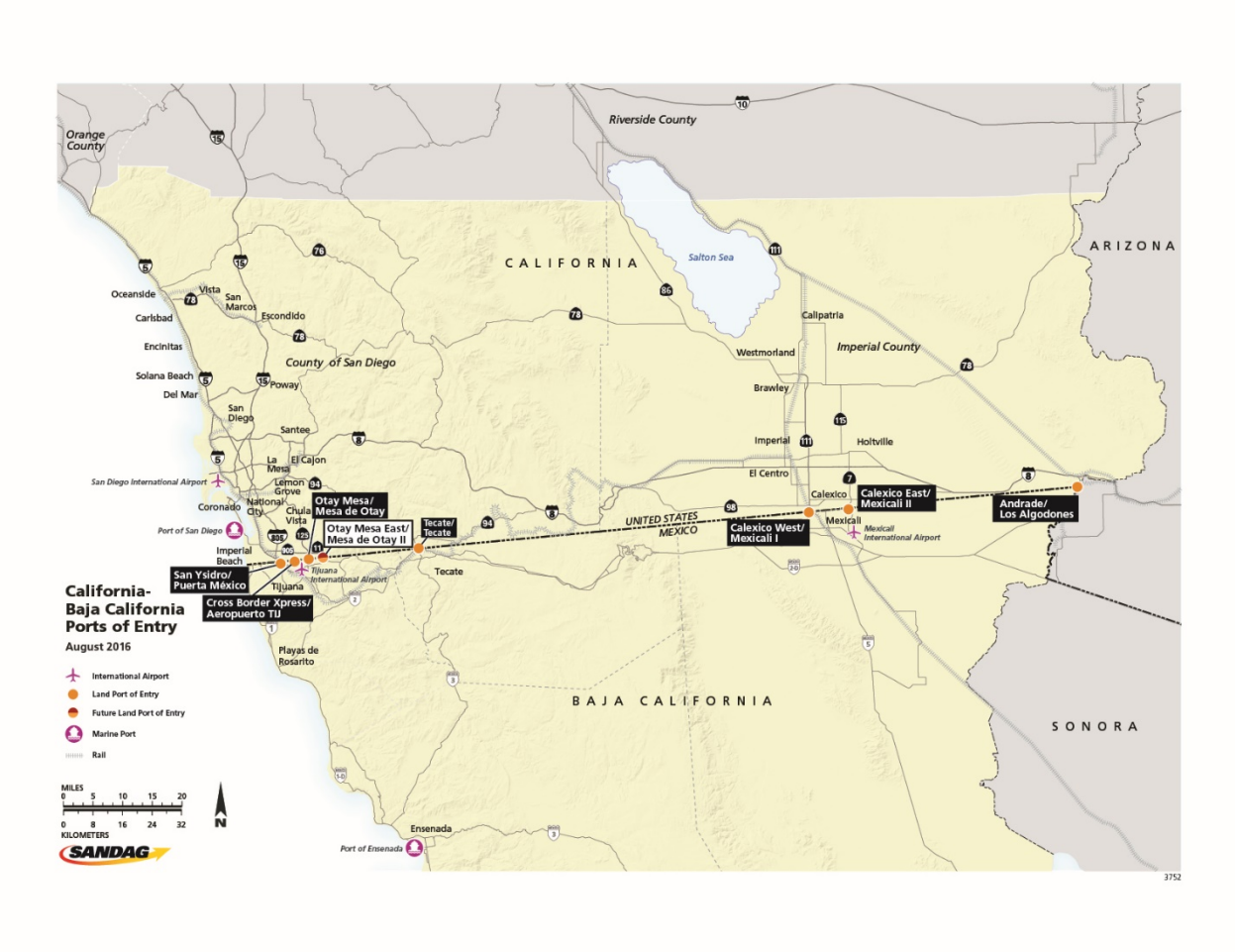
In 2006, SANDAG and Caltrans conducted studies that showed how border delays cause significant reductions in economic output and employment. These studies highlighted the need for improving border crossings and helped make the case for developing a third crossing between San Diego and Tijuana (the planned Otay Mesa East-Mesa de Otay II border crossing). Similarly, in 2007, the former Imperial Valley Association of Governments and Caltrans conducted an economic delay study for Imperial County border crossings. Much has changed since these earlier studies – the local economy has rebounded from the Great Recession and there are new emerging industry clusters that depend on crossborder trade.

As a result, SANDAG has commissioned the HDR team (led by HDR Inc., and supported by T. Kear Transportation Planning and Management, Inc., Crossborder Group and Sutra Research) to conduct the study on Impacts of Border Delays at the California-Baja California Land Ports of Entry. The current document was developed by Crossborder Group and is part of this effort, providing an overview of the survey activities that will be undertaken as part of the study. The surveys will be used to collect key information necessary to assess the economic and air quality/emissions impacts of delays at the border.

Overview of Project At-Border Survey Activities

As part of this study, the consulting team led by HDR Inc., worked with staff from SANDAG, Caltrans, and ICTC to develop a data collection approach and survey instruments that maintain consistency with previous SANDAG and ICTC efforts (including the 2006 study, *Economic Impacts of Wait Times at the San Diego - Baja California Border*), while addressing several new factors. These factors include border wait time and queue data, air emission modeling, and regional changes in border infrastructure (including not only major improvements implemented between San Diego and Tijuana at El Chaparral and San Ysidro POEs, but also the opening of the Cross Border Xpress [CBX] airport terminal in Otay Mesa).

A map of the seven Land Ports of Entry between California-Baja California that are central to this study are shown below, with the survey goals and at-border sampling activities outlined on the following pages.



Sampling Strategy

In order to adequately survey the broad range of crossers along the California-Baja California border by geography, mode (privately-owned vehicle or POV, pedestrian, or commercial), and crossing type (General, Ready, SENTRI; or, for commercial crossings, FAST or *Free and Secure Trade*, Regular and Empty), it is necessary to divide the population of each of these into groups – or clusters. For purposes of this study, the first-stage cluster is essentially the LPOE; the second-stage cluster is the mode or vehicle type; and the third-stage cluster is the lane or classification type (when applicable).

In all cases, each of the individual survey targets in these clusters and subunits are sampled in a similar fashion, to increase randomization and avoid potential survey bias (as much as possible). In the case of northbound POVs and pedestrians, border queues are utilized to provide access to potential participants; in the case of commercial vehicles, either queues or dedicated pull-out areas can provide the opportunity to apply questionnaires. Although for safety and logistical reasons surveys are not conducted on southbound flows, economic and GHG information from U.S. residents visiting Mexico is collected as part of the returning leg of their trip.

Consistent with past at-border surveys undertaken by SANDAG and others, the two- and three-stage cluster sampling selection procedure will have some variation based on each POE's conditions and locations of queues; however, the core selection process includes choosing a preliminary target, then counting to the *n^{th} target* (2^{nd} or 3^{rd}, depending on the volumes of potential participants) following that one (to reduce selection bias). Should that n^{th} target be unresponsive, each subsequent vehicle/pedestrian is asked to participate until a response is positive (at which point, the survey is applied). This method balances reducing possible selection bias, while also increasing efficiency by not skipping too many potential survey participants.

Timing of At-Border Surveys

The current study includes two specific types of at-border survey targets: passenger vehicles and pedestrians (many of whom schedule their border crossings in relation to seasonal patterns that vary during the Summer, Fall/Spring and Winter seasons), as well as commercial shipments whose border crossing patterns tend to follow more consistent production schedules (although there are seasonal variations, not necessarily consistent with those of individual crossers). The content and aim of each survey is also slightly different:

- For pedestrian crossers, the focus is on the economic impacts created by delays.
- For POVs, the focus is on economic impacts and air emissions related to the vehicles, created by delays.
- For commercial vehicles, the focus is on air emission impacts created by delays.

In order to secure both samples that reflect seasonal variations of individual crossers, as well as take into account increased commercial crossings toward the end of each year, the timing of at-border economic and air emission surveys for POVs and Pedestrians (including at the CBX airport facility) is proposed for late-Summer, Fall, and peak Holiday time periods as shown below. Likewise, commercial truck (and bus) surveys (which, again are focused more on green house gas emissions or GHG and air emission topics) are proposed for the two time periods of early-September and mid-November:

Border Survey Target Periods	Aug-16					Sep-16				Oct-16				Nov-16					Dec-16			
	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 1	Wk 2	Wk 3	Wk 4	Wk 1	Wk 2	Wk 3	Wk 4	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 1	Wk 2	Wk 3	Wk 4
Imperial County-Mexicali Metro - POVs/Pedestrians																						
San Diego-Tijuana Metro - POVs/Pedestrians																						
Cross Border Xpress (CBX)																						
Imperial County-Mexicali Metro - Trucks/Bus																						
San Diego-Tijuana Metro - Trucks/Bus																						

From a logistical perspective to accommodate field work needs, at-border surveys have been grouped into general regions – combining San Ysidro-El Chaparral, Otay Mesa-Mesa de Otay, and Tecate-Tecate LPOEs into the “San Diego-Tijuana Metropolitan” region, and the Calexico West-Mexicali I, Calexico East-Mexicali II, and Andrade-Los Algodones LPOEs into the “Imperial County-Mexicali Metropolitan” region.

Each wave of POV/pedestrian surveys will include at least 3-4 weekdays and one weekend (Saturday, Sunday) of data collection; commercial truck/bus surveying will occur during 4-5 weekdays (coinciding with associated data collection of border wait time and queuing data, which is discussed elsewhere). Data collection waves have been adopted to account for seasonal changes in border crossing motivations and economic impacts that have varying peaks during the year; field data collection occurs during daylight hours, with surveys being applied relatively equally throughout the day (typically from approximately 6:00am to 7:00pm). For security purposes, non-daylight surveying is not anticipated.

Survey Goals and Data Collection

Regional Border Crossings

An appropriate survey sampling plan must take into account the scale of border crossings between California and Baja California. In 2015, over 72 million individuals[9] crossed northbound from Mexico into the United States through the six Land Ports of Entry (LPOEs) of San Ysidro-El Chaparral, Otay Mesa-Mesa de Otay, Tecate-Tecate, Calexico West-Mexicali I, Calexico East-Mexicali II, and Andrade-Los Algodones[10]:

	2015 Northbound Border Crossings (CBP/BTS data)				
Land Port of Entry (California)	Vehicles		Individuals		
	Cars/POVs	Buses	Car/POV Passengers	Pedestrians	Bus Passengers
San Ysidro	14,435,252	51,693	25,646,073	7,056,022	440,033
Otay Mesa	6,933,472	38,303	12,225,410	3,411,485	138,590
Tecate	908,482	176	1,776,948	608,359	4,306
Andrade	523,059	0	1,036,699	817,866	0
Calexico West	4,294,156	0	7,644,148	4,498,322	0
Calexico East	3,622,215	3,064	6,744,400	223,374	122,873
Total	**30,716,636**	**93,236**	**55,073,678**	**16,615,428**	**705,802**

As seen above, over 99% of non-cargo related vehicles crossing northbound into California in 2015 were cars or POVs. Also notable, approximately 76% of individuals crossed northbound in POVs, while approximately 23% entered as pedestrians, and just under 1% of arriving individuals entered as bus passengers. This data demonstrates both the scale of border crossings between California and Baja California as well as the significant role that POVs play at LPOEs.

In addition to personal crossings at California-Baja California LPOEs, in 2015 there were also over 1.2 million northbound border crossings made by commercial vehicles[11] (typically trucks and cargo vans):

		2015 Northbound Border Crossings (CBP/BTS data)		
Commercial Land Port of Entry (California)	Total	By Lane/Classification		
	Commercial Vehicles	FAST	Standard	Empty
Otay Mesa	829,581	165,956	474,802	188,823
Tecate	52,090	*NA*	33,947	18,143
Calexico East	337,474	78,461	115,270	143,743
Total	**1,219,145**	**244,417**	**624,019**	**350,708**

[9] Based on historic data from U.S. Customs and Border Protection (CBP) and the U.S. Department of Transportation's Bureau of Transportation Statistics (BTS).
[10] Note: The CBX airport terminal was opened in late-2015, and as such is not included here.
[11] Again, using CBP and BTS historic data sets.

While approximately 20% of cargo vehicles entered California utilizing the FAST pre-clearance program for low-risk shipments, over 51% of northbound commercial entries took place through LPOE "standard" lanes, and nearly 29% of commercial crossings were of "empty" vehicles (i.e.: vehicles with no cargo). Also of note, over two-thirds of commercial traffic was concentrated at the Otay Mesa LPOE, followed by over 27% at Calexico East, and approximately 4% at the Tecate LPOE.

Survey Goals

This project includes two major types of survey instruments: an economic impact survey (to provide key information necessary to inform the economic modeling for the project), and a GHG/air emission survey for vehicles (to provide data necessary for air emission modeling related to border crossings and delays). Survey goals for each of the core surveys are shown below, based on consideration of volumes at each of the LPOEs, the various modes (vehicles or pedestrians), and the types of lanes at each of the LPOEs (Regular, Ready, SENTRI), when applicable.

While using volumes of border crossings allows for calculating the mathematical proportions of surveys for each LPOE and type of crosser, in some cases it is necessary to adjust these numbers in order to assure a basic level of statistical validity for data collected at low-volume LPOEs. As such, in addition to showing the approximately 2015 volumes of each lane type by LPOE[12] and the calculated Proportional Sample Goals that would result, also shown are Adjusted Oversampling Goals (that increase the sampling at certain LPOEs, and of specific lane types). In addition, GHG/air emission survey goals were also adjusted to reflect the planned use of comparable, recently-collected air emission surveys from 2014 at the San Ysidro and Calexico West POEs for cars (over 2,100 surveys total), and the Calexico East POE for trucks (over 200 surveys total). A copy of those previous survey questionnaires can be found in the Appendix.

POVS & PEDESTRIANS

Below are the proposed Survey Goals for POV and pedestrian surveying – first for the economic survey:

Land Port of Entry (California)	2015 Northbound Border Crossings (CBP/BTS data)								
	Cars/POVs					Pedestrians			
	Total	% of Total	General / Regular %	ReadyLane %	SENTRI %	Total	% of Total	General / Regular %	ReadyLane %
San Ysidro	14,435,252	47%	34%	32%	34%	7,056,022	42%	*NA*	*NA*
Otay Mesa	6,933,472	23%	23%	53%	24%	3,411,485	21%	*NA*	*NA*
Tecate	908,482	3%	100%	*NA*	*NA*	608,359	4%	*NA*	*NA*
Andrade	523,059	2%	100%	*NA*	*NA*	817,866	5%	*NA*	*NA*
Calexico West	4,294,156	14%	58%	*NA*	42%	4,498,322	27%	*NA*	*NA*
Calexico East	3,622,215	12%	26%	58%	16%	223,374	1%	*NA*	*NA*
Total	**30,716,636**					**16,615,428**			

[12] Source: HDR data based on information provided by U.S. Customs and Border Protection. Please note: Volumes by lane type were not available for pedestrian crossings at the time this document was developed; as such, survey samples of Regular/General and ReadyLane pedestrians is applied evenly (where such facilities exist). Because of the relatively small number of SENTRI pedestrians, this flow type is not considered a potential target for surveying.

Land Port of Entry (California)	Calculated Proportional Sample Sizes - Economic Surveys								
	Cars/POVs - Calculated Samples					Pedestrians - Calculated Samples			
	Proportional Sample	% of Total	General / Regular	ReadyLane	SENTRI	Total	% of Total	General / Regular-50%	ReadyLane-50%
San Ysidro	2,538	47%	868	806	864	934	42%	467	467
Otay Mesa	1,219	23%	283	647	289	452	21%	226	226
Tecate	160	3%	160	*NA*	*NA*	81	4%	81	*NA*
Andrade	92	2%	92	*NA*	*NA*	108	5%	108	*NA*
Calexico West	755	14%	439	*NA*	316	596	27%	298	298
Calexico East	637	12%	167	370	100	30	1%	30	*NA*
Total	**5,400**		**2,009**	**1,822**	**1,569**	**2,200**		**1,209**	**991**

Land Port of Entry (California)	Adjusted Oversampling Survey Goals - Economic Surveys								
	Cars/POVs - Final Samples					Pedestrians - Final Samples			
	Oversampling Goals	% of Total	General / Regular	ReadyLane	SENTRI	Oversampling Goals	% of Total	General / Regular @50%	ReadyLane @50%
San Ysidro	2,050	38%	800	800	450	800	36%	400	400
Otay Mesa	1,300	24%	400	600	300	500	23%	250	250
Tecate	400	7%	400	*NA*	*NA*	100	5%	100	*NA*
Andrade	300	6%	300	*NA*	*NA*	100	5%	100	*NA*
Calexico West	700	13%	500	*NA*	200	600	27%	300	300
Calexico East	650	12%	200	300	150	100	5%	100	*NA*
Total	**5,400**		**2,600**	**1,700**	**1,100**	**2,200**		**1,250**	**950**

Land Port of Entry (California)	Approximate Confidence Levels for Oversampling Goals								
	Cars/POVs					Pedestrians			
	Oversampling Goals		General / Regular	ReadyLane	SENTRI	Oversampling Goals		General / Regular @50%	ReadyLane @50%
San Ysidro	95% +/-3%		95% +/-4%	95% +/-4%	95% +/-5%	95% +/-4%		95% +/-5%	95% +/-5%
Otay Mesa	95% +/-3%		95% +/-5%	95% +/-4%	95% +/-6%	95% +/-5%		95% +/-7%	95% +/-7%
Tecate	95% +/-5%		95% +/-5%	*NA*	*NA*	95% +/-10%		95% +/-10%	*NA*
Andrade	95% +/-6%		95% +/-6%	*NA*	*NA*	95% +/-10%		95% +/-10%	*NA*
Calexico West	95% +/-4%		95% +/-5%	*NA*	95% +/-7%	95% +/-5%		95% +/-6%	95% +/-6%
Calexico East	95% +/-4%		95% +/-7%	95% +/-6%	95% +/-8%	95% +/-10%		95% +/-10%	*NA*
Total	**95% +/-1%**		**95% +/-3%**	**95% +/-3%**	**95% +/-3%**	**95% +/-2%**			

Below are the proposed survey goals for the GHG/air emissions survey (limited to POVs, and not to be applied to pedestrians)[13]:

[13] Please note: While these goals and associated confidence levels do not include approximately 2,100 air emission surveys collected for studies by the BECC/IVAPCD at Calexico West POE, and the CEC at San Ysidro POE in 2014, they do affect the proposed adjusted goals for these two POEs (they are reduced, given the existing 1,000+ vehicle profiles that already exist for each of those LPOEs).

Land Port of Entry (California)	2015 Northbound Border Crossings (CBP/BTS data)				
	Cars/POVs				
	Total	% of Total	General / Regular %	ReadyLane %	SENTRI %
San Ysidro	14,435,252	47%	34%	32%	34%
Otay Mesa	6,933,472	23%	23%	53%	24%
Tecate	908,482	3%	100%	*NA*	*NA*
Andrade	523,059	2%	100%	*NA*	*NA*
Calexico West	4,294,156	14%	58%	*NA*	42%
Calexico East	3,622,215	12%	26%	58%	16%
Total	**30,716,636**				

Land Port of Entry (California)	Calculated Proportional Sample Sizes - GHG/Air Emission Surveys				
	Cars/POVs - Calculated Samples				
	Proportional Sample	% of Total	General / Regular	ReadyLane	SENTRI
San Ysidro	1,222	47%	418	388	416
Otay Mesa	587	23%	136	311	139
Tecate	77	3%	77	*NA*	*NA*
Andrade	44	2%	44	*NA*	*NA*
Calexico West	363	14%	211	*NA*	152
Calexico East	307	12%	80	178	48
Total	**2,600**		**967**	**877**	**756**

Land Port of Entry (California)	Adjusted Oversampling Survey Goals - GHG/Air Emission Surveys				
	Cars/POVs - Final Samples				
	Oversampling Goals	% of Total	General / Regular	ReadyLane	SENTRI
San Ysidro	800	31%	250	300	250
Otay Mesa	750	29%	200	300	250
Tecate	100	4%	100	*NA*	*NA*
Andrade	100	4%	100	*NA*	*NA*
Calexico West	350	13%	250	*NA*	100
Calexico East	500	19%	150	200	150
Total	**2,600**		**1,050**	**800**	**750**

Land Port of Entry (California)	Approximate Confidence Levels for Oversampling Goals				
	Cars/POVs				
	Oversampling Goals		General / Regular	ReadyLane	SENTRI
San Ysidro	95% +/-3%		95% +/-7%	95% +/-6%	95% +/-6%
Otay Mesa	95% +/-3%		95% +/-7%	95% +/-6%	95% +/-6%
Tecate	95% +/-10%		95% +/-10%	*NA*	*NA*
Andrade	95% +/-10%		95% +/-10%	*NA*	*NA*
Calexico West	95% +/-6%		95% +/-7%	*NA*	95% +/-10%
Calexico East	95% +/-5%		95% +/-8%	95% +/-7%	95% +/-8%
Total	**95% +/-2%**		**95% +/-3%**	**95% +/-4%**	**95% +/-4%**

TRUCKS/COMMERCIAL VEHICLES

Similar to the approach taken to calculate survey goals for cars and pedestrians, commercial traffic at California-Baja California LPOEs also must take into consideration different geographies and lane types, as well as modify calculated survey goals to oversample enough participants to generate statistically relevant results. Below are the overall commercial vehicle volumes, the proportion of trucks by lane/classification at each LPOE, and both the calculated survey goals (assuming 400 total surveys) plus the modified survey goals incorporating oversampling:

			2015 Northbound Border Crossings (CBP/BTS data)		
Commercial Land Port of Entry (California)	Total		% By Lane/Classification		
	Commercial Vehicles	%	FAST	Standard	Empty
Otay Mesa	829,581	68.0%	20%	57%	23%
Tecate	52,090	4.3%	*NA*	65%	35%
Calexico East	337,474	27.7%	23%	34%	43%
Total	**1,219,145**				

			Calculated Proportional Sample		
Commercial Land Port of Entry (California)	Total		Calculated Samples - By Lane/Classification		
	Proportional Sample	%	FAST	Standard	Empty
Otay Mesa	272	68.0%	54	156	62
Tecate	17	4.3%	*NA*	11	6
Calexico East	111	27.7%	26	38	47
Total	**400**		**80**	**205**	**115**

			Adjusted Oversampling Goals		
Commercial Land Port of Entry (California)	Total		Final Samples - By Lane/Classification		
	Oversampling Goals	%	FAST	Standard	Empty
Otay Mesa	200	50.0%	60	100	40
Tecate	90	22.5%	*NA*	50	40
Calexico East	110	27.5%	30	40	40
Total	**400**		**90**	**190**	**120**

			Approximate Confidence Levels for Oversampling Goals		
Commercial Land Port of Entry (California)	Total		By Lane/Classification		
	Oversampling Goals		FAST	Standard	Empty
Otay Mesa	95% +/- 7%		90% +/-11%	90% +/-8%	90% +/-13%
Tecate	95% +/-10%		*NA*	90% +/-12%	90% +/-13%
Calexico East	95% +/-10%		90% +/-15%	90% +/-13%	90% +/-13%
Total	**95% +/- 5%**		**95% +/-10%**	**95% +/-7%**	**95% +/-9%**
			Note: does not include impact of additional 203 data samples from trucks at Calexico East collected in 2014 from previous BECC/IVAPCD study, which would increase the confidence levels for Calexico East		

CBX AND BUSES

Given the relative size of the current flows of CBX passengers using the airport terminal, as well as the relatively small number of buses that use the California-Baja California border (in context to their air emission impacts relative to both POVs and trucks), the Team proposes undertaking a modest economic survey sample of CBX users (400 total over the course of the project, for a confidence level of 95% +/-5%), as well as for applying the GHG/air emission surveys to a total of 120 buses (50 at San Ysidro, 50 at Otay Mesa, and 20 at Calexico East LPOEs; providing a confidence level from a statewide perspective of 95% +/-5% [albeit only an estimated 90% +/-10% at San Ysidro and Otay Mesa, and 90% +/-20% at Calexico East], which is sufficient for air emission modeling under this project.

Data Collection Monitoring & Post-Survey Cleansing

In order to ensure proper data collection, survey workers undergo two training sessions: an in-office training, where bilingual capabilities are assessed, participants are provided an overview of the project and the questionnaire (including its purpose), as well as survey selection and safety protocols for the field work. These in-office session are approximately two hours, and include applying the survey using field equipment (Android-based tablets), as well as confirming and understanding of the survey procedures and safety issues.

Field supervisors are present at all times during actual field data collection activities to ensure that security and safety protocols are followed, as well as to provide continuous review and assessment of the application of the surveys from a quality perspective. While survey training occurs prior to fielding a survey, additional in-field training is also undertaken during the first hours of a project to confirm understanding of the sampling methodology and that questions are applied correctly using electronic tablets (both with several initial “test” surveys, and supervised application of the actual survey to the public).

In addition, each day data is uploaded from the field and checked to measure daily survey production, and to assess various metrics (including length of time of survey application, and time between surveys) within the survey software that can identify potential errors and/or application problems. Such errors (as well as normal “test surveys” which are conducted during field training) are deleted from project analysis during the post-survey data cleansing process and prior to data delivery.

Security & Safety Protocols

Another critical aspect of planning for at-border surveys relates to the unique conditions and security issues that are present at LPOEs. Not only do data collection activities have to take into consideration the strict need of not interfering with the work of law enforcement and border agencies, but they must also ensure that field crews operate with the lowest-risk possible (in terms of vehicle safety and interactions with the public). As such, standard at-border security and safety protocols include staff training, safety equipment, hydration and respiratory breaks, and limiting operations to daylight hours (which, during Summer periods can include surveying between approximately 6:30am through 7:00pm; and during Fall and Winter, from approximately 7:00am through 6:00pm). Field worker safety is a primary consideration when conducting at-border surveys, and field crews are instructed to pull-back from survey locations should any security incidents or concerns arise (which on rare occasions may impact survey plans).

APPENDIX

Copies of the approved survey instruments are included in the next pages.

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Final Summer Econ/GHG Questionnaire – San Diego/Tijuana Metro POVs/Pedestrians/CBX
Version 5

The following is the proposed final version of the survey questionnaire for the San Diego-Tijuana Metro surveys for the study, A Fresh Look at Impacts of Border Delays at California-Baja California Ports of Entry. It incorporates input and changes following feedback and activities of the Otay Mesa Pre-Test in late-June, 2016. Changes from the previous version are highlighted.

Section A: Initial Core Questions (All Participants)

A-1: For demographic purposes, if you are 18 or over, in what year were you born?: _____

A-2: On average, how frequently do you cross the border to the U.S.? [PAUSE, READ OPTIONS ONLY TO PROMPT; ONE WAY]

[ ] 7+ times/wk	[ ] 6 times/wk	[ ] 5 times/wk
[ ] 4 times/wk	[ ] 3 times/wk	[ ] 2 times/wk
[ ] 1 times/wk	[ ] 3 times/month	[ ] 2 times/month
[ ] 1 time/month	[ ] Less than 1/month	[ ] 1st time crossing
[ ] Other:_____	[ ] DK/NA	

A-3: In what city or county do you have your primary residence or do you live most days? [IF RESPONDENT STATES THAT THEY LIVE EQUALLY IN TWO LOCATIONS, MARK BOTH]

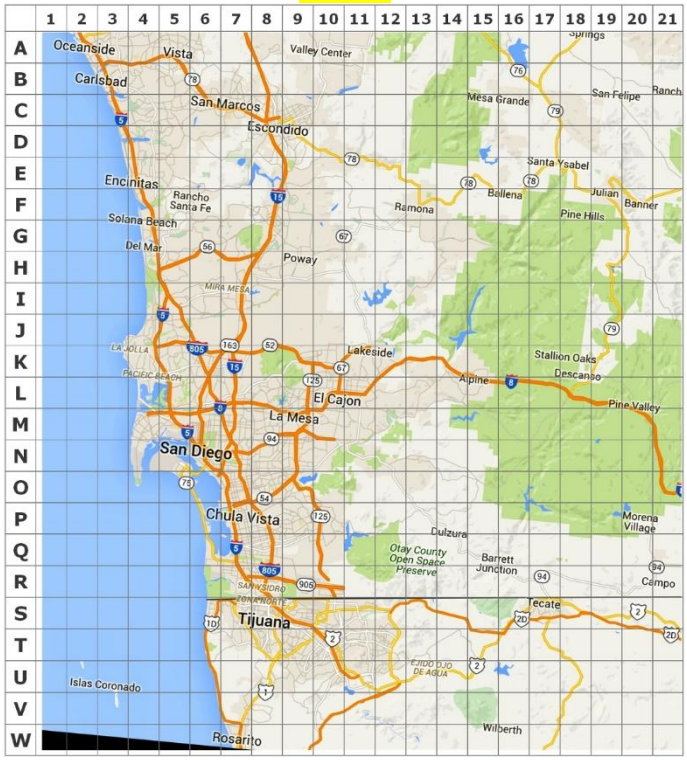
[ ] Tijuana	[ ] San Diego County	[ ] Tecate
[ ] Rosarito	[ ] Ensenada	[ ] Mexicali
[ ] San Luis Rio Colorado	[ ] Imperial County	[ ] Los Angeles County
[ ] Orange County	[ ] Riverside County	[ ] Arizona [Yuma, Maricopa, Pima]
[ ] Other:_____	[ ] DK/NA	

A-4: What is the zip code or *colonia* of your principal residence?:_____

A-5a: Looking at the maps [SEE NEXT PAGE; SURVEYOR WILL HAVE LAMINATED, LETTER-SIZED VERSION, WITH LOCAL REGION ON ONE SIDE, SOCAL/AZ ON OTHER]**, what zip code or from approximately where did you start your trip from today?:** _____ [OPEN ENDED; SURVEYOR WILL RECORD COORDINATES; IF OUTSIDE OF MAP, WILL RECORD STATED CITY/LOCATION]

A-5b: …and approximately where will your trip end today?: _____ OPEN ENDED; SURVEYOR WILL RECORD COORDINATES OR STATED; IF OUTSIDE OF MAP, WILL RECORD CITY/LOCATION MENTIONED]

Grid SD



Grid SoCal-AZ

A-6: ***[SURVEYOR INSTRUCTION: BASED ON QUOTA ASSIGNMENT, CHOOSE ECONOMIC, EMISSIONS OR CBX SURVEY]***

[ ] SDTJ-Economics (JUMP TO SECTION B)
[ ] SDTJ-Emissions (JUMP TO SECTION C)
[ ] CBX (JUMP TO SECTION D)

Section B: Economic Impact Questions

B-1: To confirm, in which country do you typically live: Mexico, the US, or another?

[ ] Mexico (JUMP TO *Mexico-Residing Only*)
[ ] United States (JUMP TO *US-Residing/Intl Visitor Only*)
[ ] Other Country (JUMP TO *US-Residing/Intl Visitor Only*)

Mexico-Residing Only (All MX Residents)

B-2: What is the principal reason for your trip today to the US? [NOTE: OPTIONS WILL BE RANDOMIZED, BUT READ IF PARTICIPANT HESITATES TO ANSWER]

[ ] Shopping
[ ] Work or business [JUMP TO SUBSAMPLE SECTION BW]
[ ] Family or Social Visit
[ ] Medical or Health
[ ] Recreation/Vacation
[ ] School
[ ] Airport
[ ] Other: _____

B-3: [Using those same options] Is there another or secondary reason for your trip today? [NOTE: OPTIONS WILL BE RANDOMIZED]

[ ] Shopping
[ ] Work or business
[ ] Family or Social Visit
[ ] Medical or Health
[ ] Recreation/Vacation
[ ] School
[ ] Airport
[ ] No Secondary Reason
[ ] Other: _____

B-4: During this trip, approximately how many hours or days do you plan to stay in the US?:
_____ ❒HR ❒DAY [OPEN ENDED, WITH HOUR/DAY CHECKBOX]

B-5: Before you started this trip, did you look for information on border wait times, for example on a website, radio, television, a smartphone app, or other?

[ ] No
[ ] Yes-Website
[ ] Yes-Radio
[ ] Yes-TV
[ ] Yes-App on Smartphone
[ ] Yes-Other:_____

B-6: Did that border wait time information cause you to change the time of your trip to the US or use a different border crossing?

[ ] No
[ ] Yes-Change Time
[ ] Yes-Change POE
[ ] Yes-both Time/POE

B-7: Before arriving at the border today, how long did you think your border wait would be?

[ ] 0-9 MIN
[ ] 10-19 MIN
[ ] 20-29 MIN
[ ] 30-39 MIN
[ ] 40-49 MIN
[ ] 50-59 MIN
[ ] 1 HOUR
[ ] 1.5 HOURS
[ ] 2 HOURS
[ ] 2.5 HOURS
[ ] 3 HOURS
[ ] 3.5 HOURS
[ ] 4 HOURS
[ ] MORE THAN 4 HOURS

B-8: If today you knew the border wait would be longer, how many additional minutes of delay would cause you to decide NOT to cross the border?

[ ] WOULD CROSS ANY WAY
[ ] 1-9 MIN
[ ] 10-19 MIN
[ ] 20-29 MIN
[ ] 30-39 MIN
[ ] 40-49 MIN
[ ] 50-59 MIN
[ ] 1 HOUR
[ ] 1.5 HOURS
[ ] 2 HOURS
[ ] 2.5 HOURS
[ ] 3 HOURS
[ ] 3.5 HOURS
[ ] 4 HOURS
[ ] MORE THAN 4 HOURS

B-9: In dollars, approximately how much do you estimate you will spend during this trip to the US? _____

B-10: [NOT ASKED] DEPENDING ON LENGTH OF QUEUE, SURVEYOR CHOOSES BETWEEN OPTION 1 & OPTION 2

[ ] Option 1 [SHORT LINES – JUMP TO END/SECTION O]
[ ] Option 2 [LONGER LINES – CONTINUES TO SECTION BX]
[ ] Option 3 [ANSWERED 'ZERO' EXPENDITURE IN B-9, JUMP TO END/SECTION O]

Section BX: Mexico-Residing Sub-Sample – Economics/Shopping

BX-1: Of the amount you just mentioned, approximately how much will you spend on the following:

BX-1A – …how much on Groceries? _____
BX-1B – … how much on Restaurants? _____
BX-1C – … how much on Gas? _____
BX-1D – … how much on Shopping? _____
BX-1E– … how much on Entertainment? _____
BX-1F – … how much on Hotels? _____
BX-1G – … how much on Public Transportation (bus, trolley, taxis)? _____
BX-1H - … how much on Other:_____

BX-2: Imagine you had decided NOT to take your trip to the US today because of extremely long border waits. Of the amounts you just mentioned for each category, how much would you have spent in Mexico instead of the US – or would you have spent the same in the US another day? [SURVEYOR WILL HAVE BOTH BX-1 & BX-2 ON SAME SCREEN TO ALLOW CROSS-REFERENCING]**:**

Sector	Would Spend in MX Instead	Same Spend in US Other Day	Zero/0 Spent on This	Don't Know/NA
Groceries	❒	❒	❒	❒
Restaurants	❒	❒	❒	❒
Gas	❒	❒	❒	❒
Shopping	❒	❒	❒	❒
Entertainment	❒	❒	❒	❒
Hotels	❒	❒	❒	❒
Public Transportation	❒	❒	❒	❒
Other	❒	❒	❒	❒

BX-3: In a normal month, how many times do you cross the border to go shopping in the US?:
_____

[JUMP TO SECTION O – OBSERVATIONALS]

Section BW: Mexico-Residing Sub-Sample – Work/Business & Economics

BW-3: [Using those same options] Is there another or secondary reason for your trip today?
[NOTE: OPTIONS WILL BE RANDOMIZED]

[ ] Shopping
[ ] Work or business
[ ] Family or Social Visit
[ ] Medical or Health
[ ] Recreation/Vacation
[ ] School
[ ] Airport
[ ] No Secondary Reason
[ ] Other: _____

BW-4: During this trip, approximately how many hours or days do you plan to stay in the US?:
_____ ❒HR ❒DAY [OPEN ENDED, WITH HOUR/DAY CHECKBOX]

BW-5: Before you started this trip, did you look for information on border wait times, for example on a website, radio, television, a smartphone app, or other?

[ ] No [JUMP TO BW-7]
[ ] Yes-Website
[ ] Yes-Radio
[ ] Yes-TV
[ ] Yes-App on Smartphone
[ ] Yes-Other:_____

BW-6: Did that border wait time information cause you to change the time of your trip to the US or use a different border crossing?

[ ] No
[ ] Yes-Change Time
[ ] Yes-Change POE
[ ] Yes-both Time/POE

BW-7: Before arriving at the border today, how long did you think your border wait would be?

[ ] 0-9 MIN
[ ] 10-19 MIN
[ ] 20-29 MIN
[ ] 30-39 MIN
[ ] 40-49 MIN
[ ] 50-59 MIN
[ ] 1 HOUR
[ ] 1.5 HOURS
[ ] 2 HOURS
[ ] 2.5 HOURS
[ ] 3 HOURS
[ ] 3.5 HOURS
[ ] 4 HOURS
[ ] MORE THAN 4 HOURS

BW-8: If today you knew the border wait would be longer, how many additional minutes of delay would cause you to decide NOT to cross the border?

[ ] WOULD CROSS ANY WAY
[ ] 1-9 MIN
[ ] 10-19 MIN
[ ] 20-29 MIN
[ ] 30-39 MIN
[ ] 40-49 MIN
[ ] 50-59 MIN
[ ] 1 HOUR
[ ] 1.5 HOURS
[ ] 2 HOURS
[ ] 2.5 HOURS
[ ] 3 HOURS
[ ] 3.5 HOURS
[ ] 4 HOURS
[ ] MORE THAN 4 HOURS

BW-9: In dollars, approximately how much do you estimate you will spend today in your trip to the US? _____

BW-10: [NOT ASKED] DEPENDING ON LENGTH OF QUEUE, SURVEYOR CHOOSES BETWEEN OPTION 1 & OPTION 2

[ ] Option 1 [SHORT LINES – JUMP TO END/SECTION O]
[ ] Option 2 [LONGER LINES – CONTINUES TO BW-11]

BW-11: Previously, you mentioned you were crossing for work or business reasons. Would you say you are visiting the US on a business trip, or you are commuting to work?

[ ] Business Trip [JUMP TO BW-18] [ ] Commuting to Work

BW-12: In what industry or sector is your job? _____

BW-13: In dollars, what is your approximate monthly wage or salary? _____

BW-14: Approximately how many hours per week do you work at your job? _____

BW-15: If you arrive to work one hour late because of a long border wait, can you make up that one hour of work, will you be paid one hour less, or will you lose a day of work?

[ ] Can make up hour of work
[ ] Paycheck will be one hour less
[ ] Will lose day of work
[ ] Other: _____
[ ] NA/DK

BW-16: How many additional minutes or hours would your daily border wait have to be for you to decide to either stop working in the US and work in Mexico, or to move to the US? [SURVEYOR TO RECORD MINUTES]

[ ] No Change – Would keep crossing from MX to work
[ ] Additional minutes to stop working in US: _____
[ ] Additional minutes to move to US: _____

BW-17: [SURVEYOR INSTRUCTION: CHOOSE IF POV/CAR OR PEDESTRIAN]

❒ POV/CAR [JUMP TO BW-17A]
❒ Pedestrian [JUMP TO BW-17B]

BW-17A: How many additional minutes or hours would your daily border wait have to be for you to decide to change from crossing the border in a car to another method of crossing – and what would that method be?:[RECORD MINUTES & METHOD, OR NO CHANGE] _____ [JUMP TO SECTION O]

BW-17B: How many additional minutes or hours would your daily border wait have to be for you to decide to change from walking across the border to another method of crossing – and what would that method be?:[RECORD MINUTES & METHOD, OR NO CHANGE] _____ [JUMP TO SECTION O]

[FOR BUSINESS VISITORS ONLY – NOT COMMUTERS]

BW-18: In what industry or sector do you work? _____

BW-19: What title or type of position do you have? _____

[JUMP TO SECTION O]

***Section BU: US-Residing/Intl Visitor Only** [NOTE: FOR US-RESIDING AND NON-US/NON-MX ("INTERNATIONAL") VISITORS]*

BU-2: What was the principal reason for your trip to Mexico? [NOTE: OPTIONS WILL BE RANDOMIZED, BUT READ IF PARTICIPANT HESITATES TO ANSWER]

[ ] Shopping
[ ] Work or business [JUMP TO SUBSAMPLE SECTION BUW]
[ ] Family or Social Visit
[ ] Medical or Health
[ ] Recreation/Vacation
[ ] School
[ ] Airport
[ ] Other: _____

BU-3: [Using those same options] Was there another or secondary reason for your trip to Mexico? [NOTE: OPTIONS WILL BE RANDOMIZED]

[ ] Shopping
[ ] Work or business
[ ] Family or Social Visit
[ ] Medical or Health
[ ] Recreation/Vacation
[ ] School
[ ] Airport
[ ] No Secondary Reason
[ ] Other: _____

BU-4: During this trip, approximately how many hours or days did you stay in Mexico?:
_____ ❒HR ❒DAY [OPEN ENDED, WITH HOUR/DAY CHECKBOX]

BU-5: Before you started your trip to the US, did you look for information on the border wait times, like on a website, radio, television, a smartphone app, or other?

[ ] No
[ ] Yes-Website
[ ] Yes-Radio
[ ] Yes-TV
[ ] Yes-App on Smartphone
[ ] Yes-Other:_____

BU-6: Did that border wait times information cause you to change the time of your return to the US or to use a different border crossing?

[ ] No
[ ] Yes-Change Time
[ ] Yes-Change POE
[ ] Yes-both Time/POE

BU-7: Before arriving at the border today, how long did you think your border wait would be?

[ ] 0-9 MIN
[ ] 10-19 MIN
[ ] 20-29 MIN
[ ] 30-39 MIN
[ ] 40-49 MIN

[ ] 50-59 MIN
[ ] 1 HOUR
[ ] 1.5 HOURS
[ ] 2 HOURS
[ ] 2.5 HOURS
[ ] 3 HOURS
[ ] 3.5 HOURS
[ ] 4 HOURS
[ ] MORE THAN 4 HOURS

BU-8: If today you knew the border wait would be longer, how many additional minutes of delay would have caused you to decide NOT to cross the border?

[ ] WOULD CROSS ANY WAY
[ ] 1-9 MIN
[ ] 10-19 MIN
[ ] 20-29 MIN
[ ] 30-39 MIN
[ ] 40-49 MIN
[ ] 50-59 MIN
[ ] 1 HOUR
[ ] 1.5 HOURS
[ ] 2 HOURS
[ ] 2.5 HOURS
[ ] 3 HOURS
[ ] 3.5 HOURS
[ ] 4 HOURS
[ ] MORE THAN 4 HOURS

BU-9: In dollars, approximately how much do you estimate you spent during this trip to Mexico? _____

BU-10: [NOT ASKED] DEPENDING ON LENGTH OF QUEUE, SURVEYOR CHOOSES BETWEEN OPTION 1 & OPTION 2

[ ] Option 1 [SHORT LINES – JUMP TO END/SECTION O]
[ ] Option 2 [LONGER LINES – CONTINUES TO SECTION BUX]
[ ] Option 3 [ANSWERED 'ZERO' EXPENDITURE IN BU-9, JUMP TO END/SECTION O]

Section BUX: US/Intl-Residing Sub-Sample – Economics/Shopping

BUX-1: Of the amount you just mentioned, approximately how much did you spend in Mexico on the following:

BUX-1A – … how much on Groceries? _____
BUX-1B – … how much on Restaurants? _____
BUX-1C – … how much on Gas? _____
BUX-1D – … how much on Shopping? _____
BUX-1E– … how much on Entertainment? _____
BUX-1F – … how much on Hotels? _____
BUX-1G – … how much on Public Transportation (bus, trolley, taxis)? _____
BUX-1H - … how much on Other:_____

BUX-2: Imagine you had decided NOT to take your trip to Mexico because of extremely long border waits. Of the amounts you just mentioned for each category, how much would you have spent in the US instead of in Mexico – or would you have spent the same in Mexico another day? [SURVEYOR WILL HAVE BOTH BUX-1 & BUX-2 ON SAME SCREEN TO ALLOW CROSS-REFERENCING]:

Sector	Would Spend in US Instead	Same Expend in MX Other Day	Zero/0 Spent on This	Don't Know/NA
Groceries	❒	❒	❒	❒
Restaurants	❒	❒	❒	❒
Gas	❒	❒	❒	❒
Shopping	❒	❒	❒	❒
Entertainment	❒	❒	❒	❒
Hotels	❒	❒	❒	❒
Public Transportation	❒	❒	❒	❒
Other	❒	❒	❒	❒

BUX-3: In the last three months, how many times have you crossed the California-Baja California border northbound to make a trip similar to the one you are returning from now?:
_____

[JUMP TO SECTION O – OBSERVATIONALS]

Section BUW: US-Residing/Intl Visitor Sub-Sample – Work/Business & Economics

BUW-3: [Using those same options] Was there another or secondary reason for your trip to Mexico? [NOTE: OPTIONS WILL BE RANDOMIZED]

[ ] Shopping
[ ] Work or business
[ ] Family or Social Visit
[ ] Medical or Health
[ ] Recreation/Vacation
[ ] School
[ ] Airport
[ ] No Secondary Reason
[ ] Other: _____

BUW-4: During this trip, approximately how many hours or days did you stay in Mexico?:
_____ ❒HR ❒DAY [OPEN ENDED, WITH HOUR/DAY CHECKBOX]

BUW-5: Before you started this trip to the US, did you look for information on border wait times, for example on a website, radio, television, a smartphone app, or other?

[ ] No [JUMP TO BUW-7]
[ ] Yes-Website
[ ] Yes-Radio
[ ] Yes-TV
[ ] Yes-App on Smartphone
[ ] Yes-Other:_____

BUW-6: Did that border wait times information cause you to change the time of your return to the US or to use a different border crossing?

[ ] No
[ ] Yes-Change Time
[ ] Yes-Change POE
[ ] Yes-both Time/POE

BUW-7: Before arriving at the border today, how long did you think your border wait would be?

[ ] 0-9 MIN
[ ] 10-19 MIN
[ ] 20-29 MIN
[ ] 30-39 MIN
[ ] 40-49 MIN
[ ] 50-59 MIN
[ ] 1 HOUR
[ ] 1.5 HOURS
[ ] 2 HOURS
[ ] 2.5 HOURS
[ ] 3 HOURS
[ ] 3.5 HOURS
[ ] 4 HOURS
[ ] MORE THAN 4 HOURS

BUW-8: If today you knew the border wait would be longer, how many additional minutes of delay would have caused you to decide NOT to cross the border?

[ ] WOULD CROSS ANY WAY
[ ] 1-9 MIN
[ ] 10-19 MIN
[ ] 20-29 MIN
[ ] 30-39 MIN
[ ] 40-49 MIN
[ ] 50-59 MIN
[ ] 1 HOUR
[ ] 1.5 HOURS
[ ] 2 HOURS
[ ] 2.5 HOURS
[ ] 3 HOURS
[ ] 3.5 HOURS
[ ] 4 HOURS
[ ] MORE THAN 4 HOURS

BUW-9: In dollars, approximately how much do you estimate you spent during this trip to Mexico? _____

BUW-10: [NOT ASKED] DEPENDING ON LENGTH OF QUEUE, SURVEYOR CHOOSES BETWEEN OPTION 1 & OPTION 2

[ ] Option 1 [SHORT LINES – JUMP TO END/SECTION O]
[ ] Option 2 [LONGER LINES – CONTINUES TO BUW-11]

BUW-11: Previously, you mentioned you were crossing for work or business reasons. Would you say you were visiting Mexico on a business trip, or were you commuting to work?

[ ] Business Trip [JUMP TO BUW-18] [ ] Commuting to Work

BUW-12: In what industry or sector is your job? _____

BUW-13: In dollars, what is your approximate monthly wage or salary? _____

BUW-14: Approximately how many hours per week do you work at your job? _____

BUW-15: If you arrived to work one hour late because of a long border wait, can you make up that one hour of work, will you be paid one hour less, or will you lose a day of work?

[ ] Can make up hour of work
[ ] Paycheck will be one hour less
[ ] Will lose day of work
[ ] Other: _____
[ ] NA/DK

BUW-16: How many additional minutes or hours would your daily border wait have to be for you to decide to either stop working in Mexico and work in the US, or to move to Mexico? [SURVEYOR TO RECORD MINUTES]

[ ] No Change – Would keep crossing from US to work
[ ] Additional minutes to stop working in MX: _____
[ ] Additional minutes to move to MX: _____

BUW-17: [SURVEYOR INSTRUCTION: CHOOSE IF POV/CAR OR PEDESTRIAN]

❒ POV/CAR [JUMP TO BUW-17A]
❒ Pedestrian [JUMP TO BUW-17B]

BUW-17A: How many additional minutes or hours would your daily border wait have to be for you to decide to change from crossing the border in a car to another method of crossing – and what would that method be?:[RECORD MINUTES & METHOD, OR NO CHANGE] _____ [JUMP TO SECTION O]

BUW-17B: How many additional minutes or hours would your daily border wait have to be for you to decide to change from walking across the border to another method of crossing – and what would that method be?:[RECORD MINUTES & METHOD, OR NO CHANGE] _____ [JUMP TO SECTION O]

[JUMP TO SECTION O]

[FOR BUSINESS VISITORS ONLY – NOT COMMUTERS]

BUW-18: In what industry or sector do you work? _____

BUW-19: What title or type of position do you have? _____

[JUMP TO SECTION O]

Section C: Emissions/GHG Impact Questions (10 Questions)

C-1: What is the model year of this vehicle? _____

C-2: Is your odometer in miles or kilometers?

[ ]Miles (JUMP TO C-3A) [ ]Kilometers (JUMP TO C-3B)

C-3A: Approximately how many miles does the odometer of this vehicle currently show?:_____ [SURVEYOR ENTERS NEAREST 1,000]

C-3B: Approximately how many kilometers does the odometer of this vehicle currently show? _____ [SURVEYOR ENTERS NEAREST 1,000]

C-4: Which type of fuel does this vehicle use?

[ ] hybrid electric [ ]Natural Gas [ ] 100% Electric
[ ] Gasoline [ ] Diesel [ ] DK/NA

C-5: The last time you purchased fuel for this vehicle, you purchased it in…?

[ ] Mexico [ ] the United States [ ] Other [ ] DK/NA

C-6: In a typical month, approximately what percentage of the fuel you purchase for this vehicle comes from gas stations in Mexico?

[ ] 0% [ ] 1-9% [ ] 10-19% [ ] 20-29% [ ] 30-39% [ ] 40-49%
[ ] 50-59% [ ] 60-69% [ ] 70-79% [ ] 80-89% [ ] 90-99% [ ] 100%
[ ] DK/NA

C-7: To the best of your knowledge, the country in which this car was sold for the first time as a new car was in…:

[ ] Mexico [ ] the United States [ ] Other/DK/NA

C-8: In the last 12-months, has this vehicle passed a vehicle smog-check or participated in a smog check program?

[ ] Yes [ ] No [ ] DK/NA

C-9: In the last 3-months, how many times have you walked or used a bike to cross the border?:_____

C-10: For you to change from using a car to cross the border to walking, bicycling, or using public transportation (bus, taxi, trolley), how short of a border wait in minutes would the pedestrian crossing need to be?

[ ] Wouldn't change from car [ ] 0 delay [ ] 1-10 minutes [ ]11-20 min
[ ] 21-30 min [ ] 31-40 min [ ] 41-50 min [ ] 51-60 min [ ] 60+ min

[JUMP TO SECTION O – OBSERVATIONALS]

Section D: CBX Economic Impact Questions

D-1: To confirm, which best describes where you live: Mexico, the US, or another country?

[ ] Mexico (JUMP TO *Mexico-Residing Only [DM-2]*)
[ ] United States (JUMP TO *US-Residing/Intl Visitor Only [DU-2]*)
[ ] Other Country (JUMP TO *US-Residing/Intl Visitor Only [DU-2]*)

CBX - Mexico-Residing Only

DM-2: What is the principal reason for your trip today to the US? [NOTE: OPTIONS WILL BE RANDOMIZED, BUT READ IF PARTICIPANT HESITATES TO ANSWER]

[ ] Shopping
[ ] Work or business
[ ] Family or Social Visit
[ ] Medical or Health
[ ] Recreation/Vacation
[ ] School
[ ] Other: _____

DM-3: [Using those same options] Is there another or secondary reason for your trip today? [NOTE: OPTIONS WILL BE RANDOMIZED]

[ ] Shopping
[ ] Work or business
[ ] Family or Social Visit
[ ] Medical or Health
[ ] Recreation/Vacation
[ ] School
[ ] No Secondary Reason
[ ] Other: _____

DM-4: During this trip, approximately how many hours or days do you plan to stay in the US?: _____ ❒HR ❒DAY [OPEN ENDED, WITH HOUR/DAY CHECKBOX]

DM-5: Approximately how many nights during this trip will you stay at a hotel in the US?: _____ [OPEN ENDED, WILL RECORD]

DM-6: In dollars, approximately how much do you estimate you will spend during this trip to the US? _____

DM-7: Of the amount you just mentioned, approximately how much will you spend on the following:

D-7A – … how much on Restaurants/Food? _____
D-7B – … how much on Shopping? _____
D-7C– … how much on Entertainment? _____
D-7D – … how much on Hotels? _____
D-7E – … how much on Public Transportation (bus, trolley, taxis)? _____
D-7F - … how much on Other____

DM-8: What cities or regions of the US do you plan to visit during this trip? _____ [OPEN ENDED, RECORD CITIES/LOCATIONS MENTIONED]

DM-10: In the last 90 days, how many times have you used the CBX Cross Border Xpress airport terminal?:_____

DM-11: Before the CBX binational terminal opened, had you ever flown into the Tijuana Airport before to visit the US?

[ ] No [JUMP TO SECTION O]
[ ] Yes
[ ] Unsure/DK/NA [JUMP TO SECTION O]

DM-12: In the past, when flying to visit the US before the CBX binational terminal opened, would you typically enter San Diego through a border crossing here in Tijuana, would you fly directly into the San Diego or a Southern California airport, or a mix of these? [CHOOSE MULTIPLE OPTIONS BASED ON RESPONSE]

[ ] After flying to TIJ, would cross border from Tijuana
[ ] Would fly directly into San Diego (SAN)
[ ] Would fly directly into other SoCal airport

[JUMP TO SECTION O – OBSERVATIONALS]

CBX - US-Residing/Intl Visitor Only *[CURRENTLY ASSUMES NORTHBOUND INTERVIEWS IN CBX OR TIJ TERMINAL, POST-TRIP]*

DU-2: What was the principal reason for your trip to Mexico? [NOTE: OPTIONS WILL BE RANDOMIZED, BUT READ IF PARTICIPANT HESITATES TO ANSWER]]

[ ] Shopping
[ ] Work or business
[ ] Family or Social Visit
[ ] Medical or Health
[ ] Recreation/Vacation
[ ] School
[ ] Other: _____

DU-3: [Using those same options] Was there another or secondary reason for your trip?

[ ] Shopping
[ ] Work or business
[ ] Family or Social Visit
[ ] Medical or Health
[ ] Recreation/Vacation
[ ] School
[ ] No Secondary Reason
[ ] Other: _____

DU-4: During this trip, approximately how many days did you stay in Mexico?: _____ [OPEN ENDED, WILL RECORD AS APPROPRIATE]

DU-5: Approximately how many nights during this trip did you stay at a hotel in Mexico?: _____ [OPEN ENDED, WILL RECORD]

DU-6: In dollars, approximately how much do you estimate you spent during this trip to Mexico? _____

DU-7: Of the amount you just mentioned, approximately how much will you spend on the following:

DU-7A – … how much on Restaurants/Food? _____
DU-7B – … how much on Shopping? _____
DU-7C– … how much on Entertainment? _____
DU-7D – … how much on Hotels? _____
DU-7E – … how much on Public Transportation (bus, trolley, taxis)? _____
DU-7F – … how much on Other _____

DU-8: What cities or regions of Mexico did you visit during this trip? _____ [OPEN ENDED, RECORD CITIES/LOCATIONS MENTIONED]

DU-9: In the last 90 days, how many times have you used the CBX Cross Border Xpress airport terminal?:_____

DU-10: Before the CBX binational terminal opened, had you ever flown into the Tijuana Airport before to visit Mexico?

[ ] No [JUMP TO SECTION O]
[ ] Yes
[ ] Unsure/DK/NA [JUMP TO SECTION O]

DU-11: In the past, when flying to Mexico before the CBX binational terminal opened, would you typically fly from Tijuana's airport after crossing the border here in Tijuana, would you fly directly to Mexico from the San Diego or a Southern California airport, or a mix of these? [CHOOSE MULTIPLE OPTIONS BASED ON RESPONSE]

[ ] Would fly from TIJ, after crossing border into Tijuana
[ ] Would fly directly from San Diego (SAN)
[ ] Would fly directly from other SoCal airport

[JUMP TO SECTION O – OBSERVATIONALS]

Section O: Observationals (All Participants)

[SAY TO PARTICIPANT: "Thank you for participating!"]

O-1: Language used for survey

[ ]Spanish [ ] English

O-2: Gender/Sex of participant

[ ] Male [ ] Female

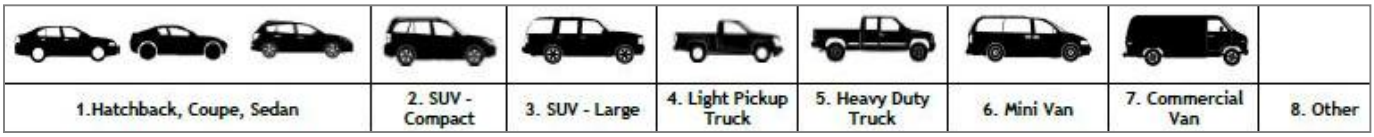
O-3: General location of survey

[ ] San Ysidro [ ] Otay Mesa [ ] Tecate
[ ] Calexico West [ ] Calexico East [ ] Andrade [ ] CBX [Inbound to SD]

O-4: Traveler type

[ ] Pedestrian [JUMP TO O-9] [ ] Ped. w/Bike [JUMP TO O-9]
[ ] Pedestrian at CBX [JUMP TO O-9]
[ ] Car-SENTRI [ ] Car-ReadyLane
[ ] Car-Regular [ ] Car-MedicalLane
[ ] Bus PAX [JUMP TO O-9]

O-5: General POV Type



1.Hatchback, Coupe, Sedan	2. SUV - Compact	3. SUV - Large	4. Light Pickup Truck	5. Heavy Duty Truck	6. Mini Van	7. Commercial Van	8. Other

[ ] Car-Hatchback/Coupe/Sedan [ ] SUV-Compact/Crossover [ ] SUV - Large
[ ] Light Truck [ ] Heavy Duty Truck [ ] Mini Van
[ ] Commercial Van [ ] RV/Recreational Vehicle/Motor Home [ ] Other

O-6: License plate of vehicle

[ ] Baja California [ ] California [ ] Arizona [ ] Sonora [ ] South Dakota
[ ] Other US [ ] Other MX [ ] Canadian [ ] Ped/Bus [ ] Not Observed

O-7: Number of adults in car

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5+

O-8: Number of children in car

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5+

O-9: Day Surveyed

[ ] Saturday [ ] Sunday [ ] Monday [ ] Tuesday [ ] Wednesday
[ ] Thursday [ ] Friday

O-10: Time Survey Started

[ ] 6:00AM-6:59AM [ ]7:00AM-7:59AM [ ] 8:00AM-8:59AM [ ] 9:00AM-9:59AM
[ ] 10:00AM-10:59AM [ ]11:00AM-11:59AM [ ] 12:00PM-12:59PM [ ] 1:00PM-1:59PM
[ ] 2:00PM-2:59PM [ ] 3:00PM-3:59PM [ ] 4:00PM-4:59PM [ ] 5:00PM-5:59PM
[ ] 6:00PM-6:59PM [ ] 7:00PM-7:59PM

O-11: Time to Complete Survey

[ ] 3 minutes [ ] 4 minutes [ ] 5 minutes [ ] 6 minutes [ ] 7+ minutes

O-12: Survey Is

[ ] Complete [ ] Incomplete [ ] Test

END

Final Summer Econ/GHG Questionnaire – Imperial County/MXL Metro POVs/Pedestrians
Version 5

The following is the proposed final version of the survey questionnaire for the Imperial County-Mexicali Metro surveys for the study, A Fresh Look at Impacts of Border Delays at California-Baja California Ports of Entry. It incorporates input and changes following feedback and activities of the Otay Mesa Pre-Test in late-June, 2016. Changes from the previous version are highlighted.

Section A: Initial Core Questions (All Participants)

A-1: For demographic purposes, if you are 18 or over, in what year were you born?: _____

A-2: On average, how frequently do you cross the border to the U.S.? [PAUSE, READ OPTIONS ONLY TO PROMPT; ONE WAY]

[ ] 7+ times/wk	[ ] 6 times/wk	[ ] 5 times/wk
[ ] 4 times/wk	[ ] 3 times/wk	[ ] 2 times/wk
[ ] 1 times/wk	[ ] 3 times/month	[ ] 2 times/month
[ ] 1 time/month	[ ] Less than 1/month	[ ] 1st time crossing
[ ] Other:_____	[ ] DK/NA	

A-3: In what city or county do you have your primary residence or do you live most days? [IF RESPONDENT STATES THAT THEY LIVE EQUALLY IN TWO LOCATIONS, MARK BOTH]

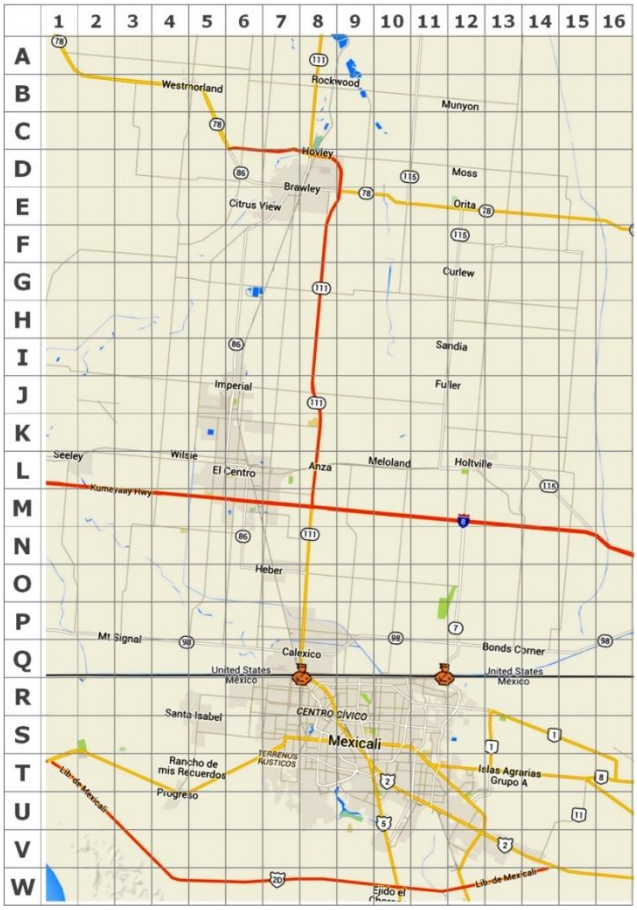
[ ] Tijuana	[ ] San Diego County	[ ] Tecate
[ ] Rosarito	[ ] Ensenada	[ ] Mexicali
[ ] San Luis Rio Colorado	[ ] Imperial County	[ ] Los Angeles County
[ ] Orange County	[ ] Riverside County	[ ] Arizona [Yuma, Maricopa, Pima]
[ ] Other:_____	[ ] DK/NA	

A-4: What is the zip code or *colonia* of your principal residence?:_____

A-5a: Looking at the maps [SEE NEXT PAGE; SURVEYOR WILL HAVE LAMINATED, LETTER-SIZED VERSION, WITH LOCAL REGION ON ONE SIDE, SOCAL/AZ ON OTHER]**, what zip code or from approximately where did you start your trip from today?:** _____ [OPEN ENDED; SURVEYOR WILL RECORD COORDINATES; IF OUTSIDE OF MAP, WILL RECORD STATED CITY/LOCATION]

A-5b: …and approximately where will your trip end today?: _____ OPEN ENDED; SURVEYOR WILL RECORD COORDINATES OR STATED; IF OUTSIDE OF MAP, WILL RECORD CITY/LOCATION MENTIONED]

Grid IV/MXL



Grid SoCal-AZ

A-6: ***[SURVEYOR INSTRUCTION: BASED ON QUOTA ASSIGNMENT, CHOOSE ECONOMIC, EMISSIONS OR CBX SURVEY]***

[ ] IVMXL-Economics (JUMP TO SECTION B)
[ ] IVMXL-Emissions (JUMP TO SECTION C)

Section B: Economic Impact Questions

B-1: To confirm, in which country do you typically live: Mexico, the US, or another?

[ ] Mexico (JUMP TO *Mexico-Residing Only*)
[ ] United States (JUMP TO *US-Residing/Intl Visitor Only*)
[ ] Other Country (JUMP TO *US-Residing/Intl Visitor Only*)

Mexico-Residing Only (All MX Residents)

B-2: What is the principal reason for your trip today to the US? [NOTE: OPTIONS WILL BE RANDOMIZED, BUT READ IF PARTICIPANT HESITATES TO ANSWER]

[ ] Shopping
[ ] Work or business [JUMP TO SUBSAMPLE SECTION BW]
[ ] Family or Social Visit
[ ] Medical or Health
[ ] Recreation/Vacation
[ ] School
[ ] Airport
[ ] Other: _____

B-3: [Using those same options] Is there another or secondary reason for your trip today? [NOTE: OPTIONS WILL BE RANDOMIZED]

[ ] Shopping
[ ] Work or business
[ ] Family or Social Visit
[ ] Medical or Health
[ ] Recreation/Vacation
[ ] School
[ ] Airport
[ ] No Secondary Reason
[ ] Other: _____

B-4: During this trip, approximately how many hours or days do you plan to stay in the US?:
_____ ❒HR ❒DAY [OPEN ENDED, WITH HOUR/DAY CHECKBOX]

B-5: Before you started this trip, did you look for information on border wait times, for example on a website, radio, television, a smartphone app, or other?

[ ] No
[ ] Yes-Website
[ ] Yes-Radio
[ ] Yes-TV
[ ] Yes-App on Smartphone
[ ] Yes-Other:_____

B-6: Did that border wait time information cause you to change the time of your trip to the US or use a different border crossing?

[ ] No
[ ] Yes-Change Time
[ ] Yes-Change POE
[ ] Yes-both Time/POE

B-7: Before arriving at the border today, how long did you think your border wait would be?

[ ] 0-9 MIN
[ ] 10-19 MIN
[ ] 20-29 MIN
[ ] 30-39 MIN
[ ] 40-49 MIN
[ ] 50-59 MIN
[ ] 1 HOUR
[ ] 1.5 HOURS
[ ] 2 HOURS
[ ] 2.5 HOURS
[ ] 3 HOURS
[ ] 3.5 HOURS
[ ] 4 HOURS
[ ] MORE THAN 4 HOURS

B-8: If today you knew the border wait would be longer, how many additional minutes of delay would cause you to decide NOT to cross the border?

[ ] WOULD CROSS ANY WAY
[ ] 1-9 MIN
[ ] 10-19 MIN
[ ] 20-29 MIN
[ ] 30-39 MIN
[ ] 40-49 MIN
[ ] 50-59 MIN
[ ] 1 HOUR
[ ] 1.5 HOURS
[ ] 2 HOURS
[ ] 2.5 HOURS
[ ] 3 HOURS
[ ] 3.5 HOURS
[ ] 4 HOURS
[ ] MORE THAN 4 HOURS

B-9: In dollars, approximately how much do you estimate you will spend during this trip to the US? _____

B-10: [NOT ASKED] DEPENDING ON LENGTH OF QUEUE, SURVEYOR CHOOSES BETWEEN OPTION 1 & OPTION 2

[ ] Option 1 [SHORT LINES – JUMP TO SECTION D]
[ ] Option 2 [LONGER LINES – CONTINUES TO SECTION BX]
[ ] Option 3 [ANSWERED 'ZERO' EXPENDITURE IN B-9, JUMP TO END/SECTION O]

Section BX: Mexico-Residing Sub-Sample – Economics/Shopping

BX-1: Of the amount you just mentioned, approximately how much will you spend on the following:

BX-1A – …how much on Groceries? _____
BX-1B – … how much on Restaurants? _____
BX-1C – … how much on Gas? _____
BX-1D – … how much on Shopping? _____
BX-1E– … how much on Entertainment? _____
BX-1F – … how much on Hotels? _____
BX-1G – … how much on Public Transportation (bus, trolley, taxis)? _____
BX-1H - … how much on Other:_____

BX-2: Imagine you had decided NOT to take your trip to the US today because of extremely long border waits. Of the amounts you just mentioned for each category, how much would you have spent in Mexico instead of the US – or would you have spent the same in the US another day? [SURVEYOR WILL HAVE BOTH BX-1 & BX-2 ON SAME SCREEN TO ALLOW CROSS-REFERENCING]**:**

Sector	Would Spend in MX Instead	Same Spend in US Other Day	Zero/0 Spent on This	Don't Know/NA
Groceries	❒	❒	❒	❒
Restaurants	❒	❒	❒	❒
Gas	❒	❒	❒	❒
Shopping	❒	❒	❒	❒
Entertainment	❒	❒	❒	❒
Hotels	❒	❒	❒	❒
Public Transportation	❒	❒	❒	❒
Other	❒	❒	❒	❒

BX-3: In a normal month, how many times do you cross the border to go shopping in the US?:
_____

[JUMP TO SECTION O – OBSERVATIONALS]

Section BW: Mexico-Residing Sub-Sample – Work/Business & Economics

BW-3: [Using those same options] Is there another or secondary reason for your trip today?
[NOTE: OPTIONS WILL BE RANDOMIZED]

[ ] Shopping
[ ] Work or business
[ ] Family or Social Visit
[ ] Medical or Health
[ ] Recreation/Vacation
[ ] School
[ ] Airport
[ ] No Secondary Reason
[ ] Other: _____

BW-4: During this trip, approximately how many hours or days do you plan to stay in the US?:
_____ ❒HR ❒DAY [OPEN ENDED, WITH HOUR/DAY CHECKBOX]

BW-5: Before you started this trip, did you look for information on border wait times, for example on a website, radio, television, a smartphone app, or other?

[ ] No [JUMP TO BW-7]
[ ] Yes-Website
[ ] Yes-Radio
[ ] Yes-TV
[ ] Yes-App on Smartphone
[ ] Yes-Other:_____

BW-6: Did that border wait time information cause you to change the time of your trip to the US or use a different border crossing?

[ ] No
[ ] Yes-Change Time
[ ] Yes-Change POE
[ ] Yes-both Time/POE

BW-7: Before arriving at the border today, how long did you think your border wait would be?

[ ] 0-9 MIN
[ ] 10-19 MIN
[ ] 20-29 MIN
[ ] 30-39 MIN
[ ] 40-49 MIN
[ ] 50-59 MIN
[ ] 1 HOUR
[ ] 1.5 HOURS
[ ] 2 HOURS
[ ] 2.5 HOURS
[ ] 3 HOURS
[ ] 3.5 HOURS
[ ] 4 HOURS
[ ] MORE THAN 4 HOURS

BW-8: If today you knew the border wait would be longer, how many additional minutes of delay would cause you to decide NOT to cross the border?

[ ] WOULD CROSS ANY WAY
[ ] 1-9 MIN
[ ] 10-19 MIN
[ ] 20-29 MIN
[ ] 30-39 MIN
[ ] 40-49 MIN
[ ] 50-59 MIN
[ ] 1 HOUR
[ ] 1.5 HOURS
[ ] 2 HOURS
[ ] 2.5 HOURS
[ ] 3 HOURS
[ ] 3.5 HOURS
[ ] 4 HOURS
[ ] MORE THAN 4 HOURS

BW-9: In dollars, approximately how much do you estimate you will spend today in your trip to the US? _____

BW-10: [NOT ASKED] DEPENDING ON LENGTH OF QUEUE, SURVEYOR CHOOSES BETWEEN OPTION 1 & OPTION 2

[ ] Option 1 [SHORT LINES – JUMP TO END/SECTION D]
[ ] Option 2 [LONGER LINES – CONTINUES TO BW-11]

BW-11: Previously, you mentioned you were crossing for work or business reasons. Would you say you are visiting the US on a business trip, or you are commuting to work?

[ ] Business Trip [JUMP TO BW-18] [ ] Commuting to Work

BW-12: In what industry or sector is your job? _____

BW-13: In dollars, what is your approximate monthly wage or salary? _____

BW-14: Approximately how many hours per week do you work at your job? _____

BW-15: If you arrive to work one hour late because of a long border wait, can you make up that one hour of work, will you be paid one hour less, or will you lose a day of work?

[ ] Can make up hour of work
[ ] Paycheck will be one hour less
[ ] Will lose day of work
[ ] Other: _____
[ ] NA/DK

BW-16: How many additional minutes or hours would your daily border wait have to be for you to decide to either stop working in the US and work in Mexico, or to move to the US? [SURVEYOR TO RECORD MINUTES]

[ ] No Change – Would keep crossing from MX to work
[ ] Additional minutes to stop working in US: _____
[ ] Additional minutes to move to US: _____

BW-17: [SURVEYOR INSTRUCTION: CHOOSE IF POV/CAR OR PEDESTRIAN]

❒ POV/CAR [JUMP TO BW-17A]
❒ Pedestrian [JUMP TO BW-17B]

BW-17A: How many additional minutes or hours would your daily border wait have to be for you to decide to change from crossing the border in a car to another method of crossing – and what would that method be?:[RECORD MINUTES & METHOD, OR NO CHANGE] _____ [JUMP TO SECTION D]

BW-17B: How many additional minutes or hours would your daily border wait have to be for you to decide to change from walking across the border to another method of crossing – and what would that method be?:[RECORD MINUTES & METHOD, OR NO CHANGE] _____ [JUMP TO SECTION D]

[FOR BUSINESS VISITORS ONLY – NOT COMMUTERS]

BW-18: In what industry or sector do you work? _____

BW-19: What title or type of position do you have? _____

[JUMP TO SECTION D]

***Section BU: US-Residing/Intl Visitor Only** [NOTE: FOR US-RESIDING AND NON-US/NON-MX ("INTERNATIONAL") VISITORS]*

BU-2: What was the principal reason for your trip to Mexico? [NOTE: OPTIONS WILL BE RANDOMIZED, BUT READ IF PARTICIPANT HESITATES TO ANSWER]

[ ] Shopping
[ ] Work or business [JUMP TO SUBSAMPLE SECTION BUW]
[ ] Family or Social Visit
[ ] Medical or Health
[ ] Recreation/Vacation
[ ] School
[ ] Airport
[ ] Other: _____

BU-3: [Using those same options] Was there another or secondary reason for your trip to Mexico? [NOTE: OPTIONS WILL BE RANDOMIZED]

[ ] Shopping
[ ] Work or business
[ ] Family or Social Visit
[ ] Medical or Health
[ ] Recreation/Vacation
[ ] School
[ ] Airport
[ ] No Secondary Reason
[ ] Other: _____

BU-4: During this trip, approximately how many hours or days did you stay in Mexico?:
_____ ❒HR ❒DAY [OPEN ENDED, WITH HOUR/DAY CHECKBOX]

BU-5: Before you started your trip to the US, did you look for information on the border wait times, like on a website, radio, television, a smartphone app, or other?

[ ] No
[ ] Yes-Website
[ ] Yes-Radio
[ ] Yes-TV
[ ] Yes-App on Smartphone
[ ] Yes-Other:_____

BU-6: Did that border wait times information cause you to change the time of your return to the US or to use a different border crossing?

[ ] No
[ ] Yes-Change Time
[ ] Yes-Change POE
[ ] Yes-both Time/POE

BU-7: Before arriving at the border today, how long did you think your border wait would be?

[ ] 0-9 MIN
[ ] 10-19 MIN
[ ] 20-29 MIN
[ ] 30-39 MIN

[ ] 40-49 MIN
[ ] 50-59 MIN
[ ] 1 HOUR
[ ] 1.5 HOURS
[ ] 2 HOURS
[ ] 2.5 HOURS
[ ] 3 HOURS
[ ] 3.5 HOURS
[ ] 4 HOURS
[ ] MORE THAN 4 HOURS

BU-8: If today you knew the border wait would be longer, how many additional minutes of delay would have caused you to decide NOT to cross the border?

[ ] WOULD CROSS ANY WAY
[ ] 1-9 MIN
[ ] 10-19 MIN
[ ] 20-29 MIN
[ ] 30-39 MIN
[ ] 40-49 MIN
[ ] 50-59 MIN
[ ] 1 HOUR
[ ] 1.5 HOURS
[ ] 2 HOURS
[ ] 2.5 HOURS
[ ] 3 HOURS
[ ] 3.5 HOURS
[ ] 4 HOURS
[ ] MORE THAN 4 HOURS

BU-9: In dollars, approximately how much do you estimate you spent during this trip to Mexico? _____

BU-10: [NOT ASKED] DEPENDING ON LENGTH OF QUEUE, SURVEYOR CHOOSES BETWEEN OPTION 1 & OPTION 2

[ ] Option 1 [SHORT LINES – JUMP TO END/SECTION D]
[ ] Option 2 [LONGER LINES – CONTINUES TO SECTION BUX]
[ ] Option 3 [ANSWERED 'ZERO' EXPENDITURE IN BU-9, JUMP TO END/SECTION D]

Section BUX: US/Intl-Residing Sub-Sample – Economics/Shopping

BUX-1: Of the amount you just mentioned, approximately how much did you spend in Mexico on the following:

BUX-1A – … how much on Groceries? _____
BUX-1B – … how much on Restaurants? _____
BUX-1C – … how much on Gas? _____
BUX-1D – … how much on Shopping? _____
BUX-1E– … how much on Entertainment? _____
BUX-1F – … how much on Hotels? _____
BUX-1G – … how much on Public Transportation (bus, trolley, taxis)? _____
BUX-1H - … how much on Other:_____

BUX-2: Imagine you had decided NOT to take your trip to Mexico because of extremely long border waits. Of the amounts you just mentioned for each category, how much would you have spent in the US instead of in Mexico – or would you have spent the same in Mexico another day? [SURVEYOR WILL HAVE BOTH BUX-1 & BUX-2 ON SAME SCREEN TO ALLOW CROSS-REFERENCING]**:**

Sector	Would Spend in US Instead	Same Expend in MX Other Day	Zero/0 Spent on This	Don't Know/NA
Groceries	❒	❒	❒	❒
Restaurants	❒	❒	❒	❒
Gas	❒	❒	❒	❒
Shopping	❒	❒	❒	❒
Entertainment	❒	❒	❒	❒
Hotels	❒	❒	❒	❒
Public Transportation	❒	❒	❒	❒
Other	❒	❒	❒	❒

BUX-3: In the last three months, how many times have you crossed the California-Baja California border northbound to make a trip similar to the one you are returning from now?:

_____

[JUMP TO SECTION D – OBSERVATIONALS]

Section BUW: US-Residing/Intl Visitor Sub-Sample – Work/Business & Economics

BUW-3: [Using those same options] Was there another or secondary reason for your trip to Mexico? [NOTE: OPTIONS WILL BE RANDOMIZED]

[ ] Shopping
[ ] Work or business
[ ] Family or Social Visit
[ ] Medical or Health
[ ] Recreation/Vacation
[ ] School
[ ] Airport
[ ] No Secondary Reason
[ ] Other: _____

BUW-4: During this trip, approximately how many hours or days did you stay in Mexico?:
_____ ❒HR ❒DAY [OPEN ENDED, WITH HOUR/DAY CHECKBOX]

BUW-5: Before you started this trip to the US, did you look for information on border wait times, for example on a website, radio, television, a smartphone app, or other?

[ ] No [JUMP TO BUW-7]
[ ] Yes-Website
[ ] Yes-Radio
[ ] Yes-TV
[ ] Yes-App on Smartphone
[ ] Yes-Other:_____

BUW-6: Did that border wait times information cause you to change the time of your return to the US or to use a different border crossing?

[ ] No
[ ] Yes-Change Time
[ ] Yes-Change POE
[ ] Yes-both Time/POE

BUW-7: Before arriving at the border today, how long did you think your border wait would be?

[ ] 0-9 MIN
[ ] 10-19 MIN
[ ] 20-29 MIN
[ ] 30-39 MIN
[ ] 40-49 MIN
[ ] 50-59 MIN
[ ] 1 HOUR
[ ] 1.5 HOURS
[ ] 2 HOURS
[ ] 2.5 HOURS
[ ] 3 HOURS
[ ] 3.5 HOURS
[ ] 4 HOURS
[ ] MORE THAN 4 HOURS

BUW-8: If today you knew the border wait would be longer, how many additional minutes of delay would have caused you to decide NOT to cross the border?

[ ] WOULD CROSS ANY WAY
[ ] 1-9 MIN
[ ] 10-19 MIN
[ ] 20-29 MIN
[ ] 30-39 MIN
[ ] 40-49 MIN
[ ] 50-59 MIN
[ ] 1 HOUR
[ ] 1.5 HOURS
[ ] 2 HOURS
[ ] 2.5 HOURS
[ ] 3 HOURS
[ ] 3.5 HOURS
[ ] 4 HOURS
[ ] MORE THAN 4 HOURS

BUW-9: In dollars, approximately how much do you estimate you spent during this trip to Mexico? _____

BUW-10: [NOT ASKED] DEPENDING ON LENGTH OF QUEUE, SURVEYOR CHOOSES BETWEEN OPTION 1 & OPTION 2

[ ] Option 1 [SHORT LINES – JUMP TO END/SECTION D]
[ ] Option 2 [LONGER LINES – CONTINUES TO BUW-11]

BUW-11: Previously, you mentioned you were crossing for work or business reasons. Would you say you were visiting Mexico on a business trip, or were you commuting to work?

[ ] Business Trip [JUMP TO BUW-18] [ ] Commuting to Work

BUW-12: In what industry or sector is your job? _____

BUW-13: In dollars, what is your approximate monthly wage or salary? _____

BUW-14: Approximately how many hours per week do you work at your job? _____

BUW-15: If you arrived to work one hour late because of a long border wait, can you make up that one hour of work, will you be paid one hour less, or will you lose a day of work?

[ ] Can make up hour of work
[ ] Paycheck will be one hour less
[ ] Will lose day of work
[ ] Other: _____
[ ] NA/DK

BUW-16: How many additional minutes or hours would your daily border wait have to be for you to decide to either stop working in Mexico and work in the US, or to move to Mexico? [SURVEYOR TO RECORD MINUTES]

[ ] No Change – Would keep crossing from US to work
[ ] Additional minutes to stop working in MX: _____
[ ] Additional minutes to move to MX: _____

BUW-17: [SURVEYOR INSTRUCTION: CHOOSE IF POV/CAR OR PEDESTRIAN]

❒ POV/CAR [JUMP TO BUW-17A]
❒ Pedestrian [JUMP TO BUW-17B]

BUW-17A: How many additional minutes or hours would your daily border wait have to be for you to decide to change from crossing the border in a car to another method of crossing – and what would that method be?:[RECORD MINUTES & METHOD, OR NO CHANGE] _____ [JUMP TO SECTION D]

BUW-17B: How many additional minutes or hours would your daily border wait have to be for you to decide to change from walking across the border to another method of crossing – and what would that method be?:[RECORD MINUTES & METHOD, OR NO CHANGE] _____ [JUMP TO SECTION D]

[FOR BUSINESS VISITORS ONLY – NOT COMMUTERS]

BUW-18: In what industry or sector do you work? _____

BUW-19: What title or type of position do you have? _____

[JUMP TO SECTION D]

Section C: Emissions/GHG Impact Questions (10 Questions)

C-1: What is the model year of this vehicle? _____

C-2: Is your odometer in miles or kilometers?

[ ]Miles (JUMP TO C-3A) [ ]Kilometers (JUMP TO C-3B)

C-3A: Approximately how many miles does the odometer of this vehicle currently show?:_____ [SURVEYOR ENTERS NEAREST 1,000]

C-3B: Approximately how many kilometers does the odometer of this vehicle currently show? _____ [SURVEYOR ENTERS NEAREST 1,000]

C-4: Which type of fuel does this vehicle use?

[ ] hybrid electric [ ]Natural Gas [ ] 100% Electric
[ ] Gasoline [ ] Diesel [ ] DK/NA

C-5: The last time you purchased fuel for this vehicle, you purchased it in…?

[ ] Mexico [ ] the United States [ ] Other [ ] DK/NA

C-6: In a typical month, approximately what percentage of the fuel you purchase for this vehicle comes from gas stations in Mexico?

[ ] 0% [ ] 1-9% [ ] 10-19% [ ] 20-29% [ ] 30-39% [ ] 40-49%
[ ] 50-59% [ ] 60-69% [ ] 70-79% [ ] 80-89% [ ] 90-99% [ ] 100%
[ ] DK/NA

C-7: To the best of your knowledge, the country in which this car was sold for the first time as a new car was in…:

[ ] Mexico [ ] the United States [ ] Other/DK/NA

C-8: In the last 12-months, has this vehicle passed a vehicle smog-check or participated in a smog check program?

[ ] Yes [ ] No [ ] DK/NA

C-9: In the last 3-months, how many times have you walked or used a bike to cross the border?:_____

C-10: For you to change from using a car to cross the border to walking, bicycling, or using public transportation (bus, taxi, trolley), how short of a border wait in minutes would the pedestrian crossing need to be?

[ ] Wouldn't change from car [ ] 0 delay [ ] 1-10 minutes [ ]11-20 min
[ ] 21-30 min [ ] 31-40 min [ ] 41-50 min [ ] 51-60 min [ ] 60+ min

[JUMP TO SECTION D]

Section D: ICTC Tolling Questions

[INTRODUCTION] If an express lane existed at the Calexico East border crossing with a delay of twenty minutes or less…

D-1: …how much would you pay each time to use that express lane at Calexico East? [MARK NEAREST AMOUNT]

[ ] Wouldn't Pay/Zero (JUMP TO SECTION O]
[ ] 50 cents
[ ] 75 cents
[ ] $1
[ ] $1.50
[ ] $2
[ ] $2.50
[ ] $3
[ ] $3.50
[ ] $4
[ ] $4.50
[ ] $5 or more

D-2: …and how many times per month would you use it northbound? _____

[JUMP TO SECTION O – OBSERVATIONALS]

Section O: Observationals (All Participants)

[SAY TO PARTICIPANT: "Thank you for participating!"]

O-1: Language used for survey

[ ]Spanish [ ] English

O-2: Gender/Sex of participant

[ ] Male [ ] Female

O-3: General location of survey

[ ] San Ysidro [ ] Otay Mesa [ ] Tecate
[ ] Calexico West [ ] Calexico East [ ] Andrade [ ] CBX [Inbound to SD]

O-4: Traveler type

[ ] Pedestrian [JUMP TO O-9] [ ] Ped. w/Bike [JUMP TO O-9]
[ ] Pedestrian at CBX [JUMP TO O-9]
[ ] Car-SENTRI [ ] Car-ReadyLane
[ ] Car-Regular [ ] Car-MedicalLane
[ ] Bus PAX [JUMP TO O-9]

O-5: General POV Type

							
1.Hatchback, Coupe, Sedan	2. SUV - Compact	3. SUV - Large	4. Light Pickup Truck	5. Heavy Duty Truck	6. Mini Van	7. Commercial Van	8. Other

[ ] Car-Hatchback/Coupe/Sedan [ ] SUV-Compact/Crossover [ ] SUV - Large
[ ] Light Truck [ ] Heavy Duty Truck [ ] Mini Van
[ ] Commercial Van [ ] RV/Recreational Vehicle/Motor Home [ ] Other

O-6: License plate of vehicle

[ ] Baja California [ ] California [ ] Arizona [ ] Sonora [ ] South Dakota
[ ] Other US [ ] Other MX [ ] Canadian [ ] Ped/Bus [ ] Not Observed

O-7: Number of adults in car

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5+

O-8: Number of children in car

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5+

O-9: Day Surveyed

[ ] Saturday [ ] Sunday [ ] Monday [ ] Tuesday [ ] Wednesday
[ ] Thursday [ ] Friday

O-10: Time Survey Started

[ ] 6:00AM-6:59AM [ ]7:00AM-7:59AM [ ] 8:00AM-8:59AM [ ] 9:00AM-9:59AM
[ ] 10:00AM-10:59AM [ ]11:00AM-11:59AM [ ] 12:00PM-12:59PM [ ] 1:00PM-1:59PM
[ ] 2:00PM-2:59PM [ ] 3:00PM-3:59PM [ ] 4:00PM-4:59PM [ ] 5:00PM-5:59PM
[ ] 6:00PM-6:59PM [ ] 7:00PM-7:59PM

O-11: Time to Complete Survey

[ ] 3 minutes [ ] 4 minutes [ ] 5 minutes [ ] 6 minutes [ ] 7+ minutes

O-12: Survey Is

[ ] Complete [ ] Incomplete [ ] Test

END

Final Econ/GHG Questionnaire – Commercial Truck/Bus
Version 5 (Summer Final)

PLEASE SELECT: [ ] Truck [JUMP TO SECTION T]
[ ] Bus [JUMP TO SECTION U]

Section T: For Commercial Trucks Only

T-1: Which of these best describes the ownership of this vehicle?
[ ] Owner/operator of single unit [ ] Part of Fleet 2-9 Trucks
[ ] Part of Fleet 10+ Trucks

T-2: What general type of cargo or products are you currently transporting? [MULTIPLE ANSWER; READ OPTIONS IF PAUSE]
[ ] Electronics/Electrical Goods
[ ] Machinery or Appliances
[ ] Automotive Components or Vehicles
[ ] Fresh Produce
[ ] Plastic Goods
[ ] Paper or Printed Products
[ ] Metal Products
[ ] Processed Foods, Meat or Dairy Products
[ ] Grains, Nuts or Flour Products
[ ] Textiles or Apparel Products
[ ] Furniture
[ ] Rubber Products
[ ] Chemical Products
[ ] Wood Products (non-furniture)
[ ] Other (describe) _____
[ ] Don't Know/NA

T-3: What is this vehicle's model year?: _____ [OPEN –MARK "DK" IF UNSURE]

T-4: What is the model year of the engine?: _____ [OPEN – MARK "DK" IF UNSURE]

T-5: Is your odometer in miles or kilometers?
[ ]Miles (JUMP TO T-6a) [ ]Kilometers (JUMP TO T-6b)

T-6a: Approximately how many miles does the odometer of this vehicle currently show? [NOTE: INPUT NEAREST 1,000 – then JUMP TO T-7]:_____

T-6b: Approximately how many kilometers does the odometer of this vehicle currently show? [NOTE: INPUT NEAREST 1,000]:_____

T-7: What State or States are this vehicle registered in? [READ, SELECT MULTIPLE]
[ ] Baja California [ ] California [ ] Sonora [ ] Arizona [ ] Other:_____

T-8: This vehicle is FAST certified?
[ ] Yes [ ] No [ ] DK/NA

T-9: On this shipment, the vehicle was…? [IF TRACTOR ONLY, JUST MARK – DON'T ASK]
[ ] Loaded (with cargo) [ ] Empty (no cargo) [ ] Tractor-only

T-10: What is this truck's Gross Vehicle Weight Rating (GVWR)?
[ ] 10,000 pounds and less [ ] 10,001-26,000 pounds [ ] 26,001-33,000 pounds
[ ] 33,001+ pounds

T-11: In the last 30-days, how many times have long border delays caused a truck you were driving to arrive too late to Aduanas for a shipment to cross that day, or caused the dispatcher / manager to cancel a border-crossing trip for a truck you were driving?

[ ]0
[ ]1
[ ]2
[ ]3
[ ]4
[ ]5
[ ]6
[ ]7
[ ]8
[ ]9
[ ]10+

[JUMP TO SECTION V]

Section U: For Bus/Transit Vehicles Only

U-1: Which of these best describes the ownership of this vehicle?
[ ] Owner/operator of single unit [ ] Part of Fleet 2-9 Buses
[ ] Part of Fleet 10+ Buses

U-2: What is this vehicle's model year?: _____ [OPEN –MARK "DK" IF UNSURE]

U-3: What is the model year of the engine?: _____ [OPEN – MARK "DK" IF UNSURE]

U-4: Is your odometer in miles or kilometers?
[ ]Miles (JUMP TO U-5a) [ ]Kilometers (JUMP TO U-5b)

U-5a: Approximately how many miles does the odometer of this vehicle currently show?
[NOTE: INPUT NEAREST 1,000 – then JUMP TO U-6]:_____

U-5b: Approximately how many kilometers does the odometer of this vehicle currently show? [NOTE: INPUT NEAREST 1,000]:_____

U-6: What State or States are this vehicle registered in? [READ, SELECT MULTIPLE]
[ ] Baja California [ ] Sonora [ ] California [ ] Arizona [ ] Other:_____

U-7: On this trip, approximately how many passengers is your vehicle carrying?:
_____

Section V: For All Participants

V-1: Does this vehicle use diesel, gasoline, or other? [IF OTHER, ASK WHICH TYPE]
[ ] Diesel [ ]Gasoline [ ]Hybrid [ ]Natural Gas [ ]100% Electric [JUMP TO V-4a]
[ ] Other: _____ [ ]DK/NA

V-2: The last time you purchased fuel for this vehicle, you purchased it in…?
[ ] Mexico [ ] the United States [ ] Other [ ] DK/NA

V-3: In a typical month, approximately what percentage of the fuel used for this vehicle comes from gas stations in Mexico?

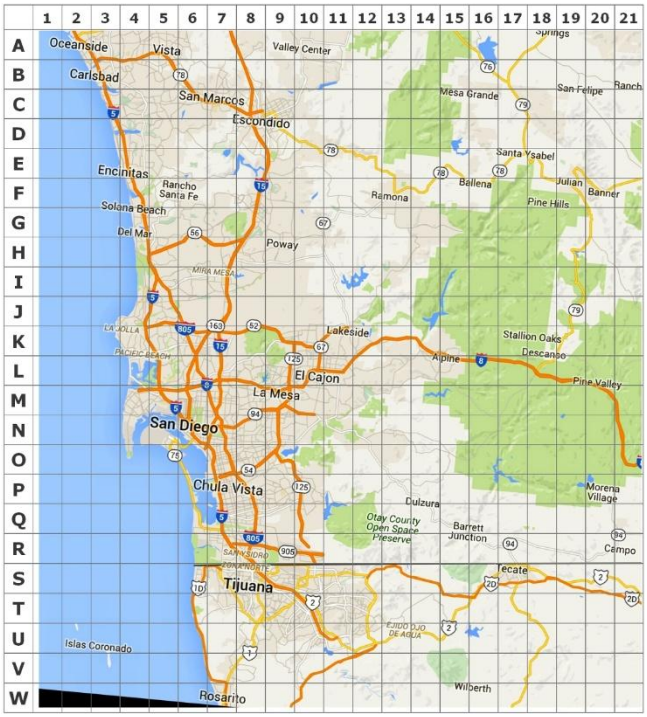
[ ] 0% [ ] 1-9% [ ] 10-19% [ ] 20-29% [ ] 30-39% [ ] 40-49%
[ ] 50-59% [ ] 60-69% [ ] 70-79% [ ] 80-89% [ ] 90-99% [ ] 100%
[ ] DK/NA

V-4a: Looking at the map, what zip code, or approximately where did you start your trip from?: _____ [OPEN ENDED; SURVEYOR WILL RECORD ZIP CODE OR MAP COORDINATES; IF OUTSIDE OF MAP, WILL RECORD CITY/LOCATION OR ZIP CODE]

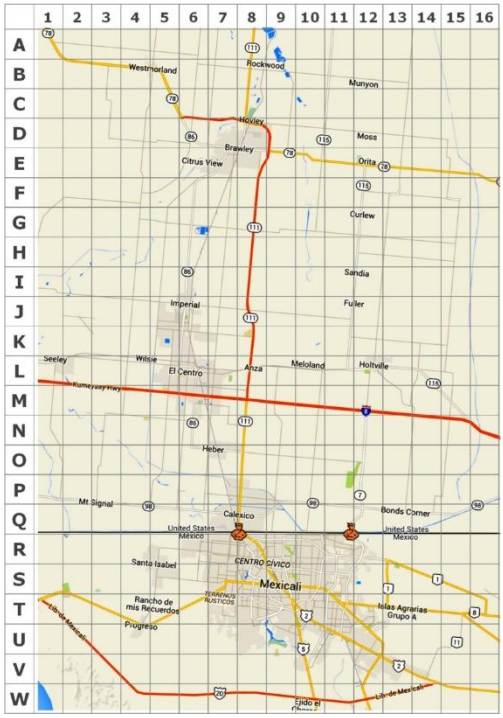
V-4b: …and approximately where will your trip end, or what zip code will your delivery be?: _____ [OPEN ENDED; SURVEYOR WILL RECORD COORDINATES OR ZIP CODE IF PROVIDED; IF OUTSIDE OF MAP, WILL RECORD CITY/LOCATION STATED]

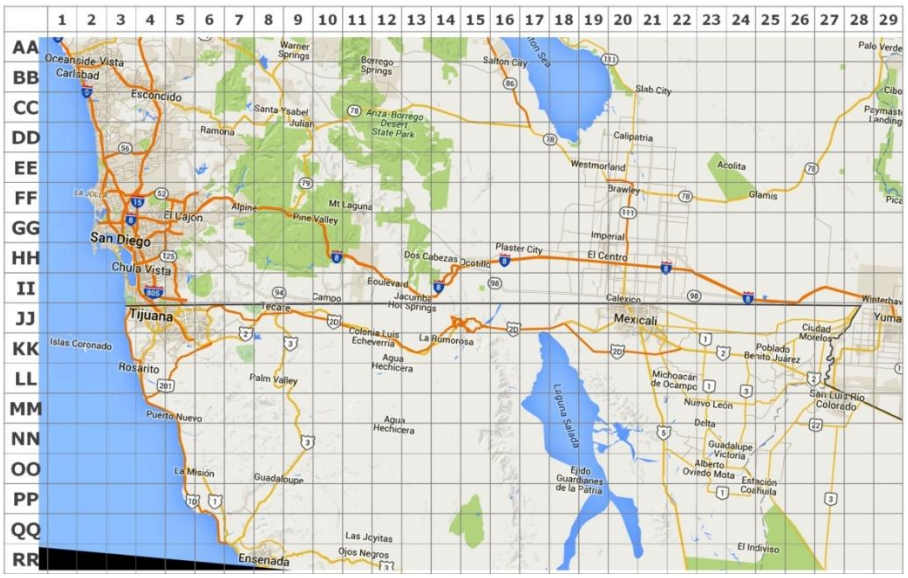
[SURVEYOR WILL HAVE LAMINATED, LETTER-SIZED VERSION WITH SD/TJ FOR SURVEYS IN SDTJ METRO, IMPERIAL/MXL FOR IVMXL METRO; and SoCal/BAJA REGION ON BACK; POST-SURVEY COORDINATES WILL INCLUDE "SD" OR "IV" FOR ANALYSIS]

Grid SD/TJ



Grid IV/MXL





V-5: Before you started this trip, did you look for information on border wait times, like on a website, radio, a smartphone app, from the dispatcher, from other drivers, or other?
[RECORD MULTIPLE IF GIVEN]

[ ] No
[ ] Yes-Website
[ ] Yes-Radio
[ ] Yes-TV
[ ] Yes-App on smartphone
[ ] Yes-Dispatcher
[ ] Yes-Other drivers
[ ] Yes-Other:_____

V-6: Before arriving at the border today, how long did you think your border wait would be?

[ ] 0-9 MIN
[ ] 10-19 MIN
[ ] 20-29 MIN
[ ] 30-39 MIN
[ ] 40-49 MIN
[ ] 50-59 MIN
[ ] 1 HOUR
[ ] 1.5 HOURS
[ ] 2 HOURS
[ ] 2.5 HOURS
[ ] 3 HOURS
[ ] 3.5 HOURS
[ ] 4 HOURS
[ ] MORE THAN 4 HOURS

V-7: If today you knew the border wait would be longer, how many additional minutes of delay would cause you to decide NOT to cross the border - or would you cross anyway?

[ ] WOULD CROSS ANY WAY
[ ] 1-9 MIN
[ ] 10-19 MIN
[ ] 20-29 MIN

[ ] 30-39 MIN
[ ] 40-49 MIN
[ ] 50-59 MIN
[ ] 1 HOUR
[ ] 1.5 HOURS
[ ] 2 HOURS
[ ] 2.5 HOURS
[ ] 3 HOURS
[ ] 3.5 HOURS
[ ] 4 HOURS
[ ] MORE THAN 4 HOURS

V-8: In dollars, approximately how much do you believe you will spend today in the US?

_____

[THANK PARTICIPANT, FILL OUT OBSERVATIONALS]

Section OC: Observationals - Commercial [All Participants]

OC-1 - Language used for survey
[ ]Spanish [ ] English

OC-2 - Gender/Sex of participant
[ ] Male [ ] Female

OC-3 - General location of survey
[ ] San Ysidro – Bus [JUMP TO OC-8]
[ ] Otay Mesa – Bus [JUMP TO OC-8]
[ ] Calexico East – Bus [JUMP TO OC-8]
[ ] Otay Mesa Commercial
[ ] Tecate Commercial
[ ] Calexico East Commercial

OC-4: Number of axels (count tractor and container/trailer)
[ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6+

OC-5: Number of tires
[ ] 4 [ ] 6 [ ] 8+

OC-6: Refrigerated vehicle?
[ ] Yes [ ] No [ ] DK/NA

OC-7: Single-unit or combination
[ ] Single unit [ ] Combination (with trailer/separate container)
[ ] Tractor only

OC-8: General type of vehicle

[ ] Class 8: Tractor 3+ axles; or w/ Trailer 5+ axles

3 axle Tractor Only

3 axle tractor w/ trailer, container, tank, etc

[ ] Class 7: Tractor 2 axles; or w/ Trailer 3-4 axles

2 axle Tractor Only

2 axle tractor w/ trailer, container; 3-4 axle truck

[ ] Class 3-6: 2 axles; box truck/combo

[ ] Van

[ ] 2 axles shuttlebus

[ ] Bus - 2 axles

[ ] Bus - 3 axles

[ ] Other:

OC-9 - Day surveyed

[ ] Saturday [ ] Sunday [ ] Monday [ ] Tuesday [ ] Wednesday
[ ] Thursday [ ] Friday

OC-10 - Time survey started

[ ] 06:00AM-06:59AM [ ]07:00AM-07:59AM [ ] 8:00AM-08:59AM [ ] 09:00AM-09:59AM
[ ] 10:00AM-10:59AM [ ]11:00AM-11:59AM [ ] 12:00PM-12:59PM [ ] 1:00PM-1:59PM
[ ] 2:00PM-2:59PM [ ] 3:00PM-3:59PM [ ] 4:00PM-4:59PM [ ] 5:00PM-5:59PM
[ ] 6:00PM-6:59PM [ ] 7:00PM-7:59PM

OC-11 - Time to complete survey

[ ] 3 minutes [ ] 4 minutes [ ] 5 minutes [ ] 6 minutes [ ] 7+ minutes

OC-12 - Survey is

[ ] Complete [ ] Incomplete [ ] Test

END

Appendix C: Summary of At-Border Data Collection Results

Summary of At-Border Data Collection Results

Impacts of Border Delays at the California-Baja California Land Ports of Entry

San Diego, CA
December 8, 2017

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Contents

Introduction

The California – Baja California border region is one of the most important and dynamic economic zones in North America. However, demand is poised to outstrip supply at the region's border crossings. While the crossings have become a critical element of the binational region's economic integration and competitiveness, growing demand has led to increased congestion at border crossings and generated delay and unreliable crossing times for cars, trucks and pedestrians. These delays and travel time unreliability at the border have the potential to reduce the region's economic competitiveness and attractiveness to businesses, resulting in lower levels of economic activity and growth.

In 2006, SANDAG and Caltrans completed a study that showed how border delays cause significant reductions in economic output and employment. The study highlighted the need for improving border crossings and helped make the case for developing a third crossing between San Diego and Tijuana (the planned Otay Mesa East-Mesa de Otay II border crossing). Similarly, in 2007, the former Imperial Valley Association of Governments (IVAG) and Caltrans conducted an economic delay study for Imperial County border crossings. Much has changed since these earlier studies – the regional economy has rebounded from the Great Recession and there are new emerging industry clusters that depend on crossborder trade.

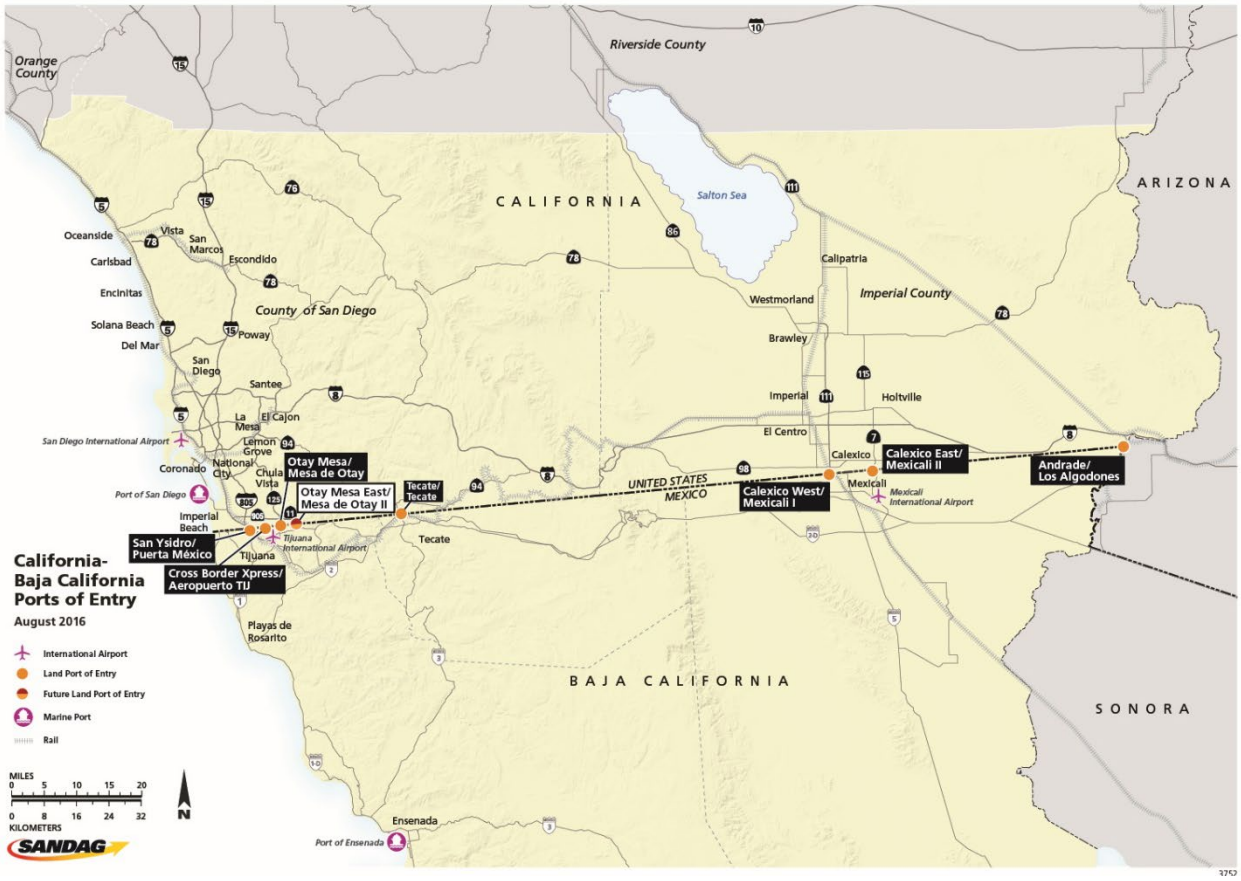
As a result, and coupled with the need to identify cross border wait time impacts on the region's air quality, SANDAG has commissioned the HDR team (led by HDR Inc., and supported by T. Kear Transportation Planning and Management, Inc., Crossborder Group and Sutra Research) to conduct the study on Impacts of Border Delays at the California-Baja California Land Ports of Entry.

The current report was developed by HDR to report the results of the field data collection efforts. In particular, this document summarizes five kinds of data collected in the field related to this study: 1) data collected through at-border surveys at the six main POEs that will be used as inputs into the economic analysis; 2) data collected through at-border surveys at the six main POEs that will be used as inputs into the air quality analysis; 3) data collected on-site for users of the CBX facility; 4) data on total border crossing times collected through at-border observations at the six main POEs that will be used as inputs into both the economic and air quality analyses; 5) data from an earlier (and separate) study collected through at-border surveys at the Calexico West POEs related to the willingness to pay for a faster border crossing lane at that site. The data summarized includes surveys of pedestrians, individuals crossing in private vehicles, individuals crossing in commercial vehicles as well as border crossing time data.

Overview of the Study Area

Figure 1 below shows a map of the crossborder region, including the ports of entry in the study area and where surveys and data collection were conducted as part of this study.

Figure 3: Map of the Crossborder Region



Source: SANDAG.

Overview of Data Collection Efforts

AT-BORDER SURVEYS

The HDR team collected more than 10,000 survey responses from border crossers at all six land POEs along the California – Baja California border from August through December of 2016 and at the Cross Border Xpress facility[14] in April 2017. Collectively, these responses are identified as the SANDAG Border Survey. After removing observations for outliers and missing information, the dataset comprises 11,326 observations. Of those, 10,897 observations correspond to the responses collected at the six land POEs in the region, with the remaining 429 corresponding to responses collected at CBX. About two thirds of these were collected from respondents crossing through San Diego County, and the rest were from people crossing through Imperial County. About three quarters of the total dataset captures people crossing from Mexico to the United States, and the remaining observations capture people traveling south from the U.S. to Mexico.

[14] Cross Border Xpress (CBX) is an enclosed pedestrian skywalk bridge used by Tijuana International Airport ticketed passengers who pay a fee.

All participants were surveyed on the Mexican side of the border, so people who lived in Mexico were questioned about their trip on their way to the United States. People who lived in the U.S. were surveyed on their return trip home, with the questions concerning the trip they had already taken to Mexico. Note that in the survey responses, we assume that country of residence indicates the direction of crossing, so respondents stating they live in Mexico are considered taking a northbound trip, and vice versa for southbound trips from the United States.

The surveys conducted at the six land POEs (excluding CBX) had two components: an economic component and an emissions component. The economic component was geared primarily to understand the expenditure behavior of border crossers that cross either by foot or on privately-owned vehicles (POVs) while the emissions component was geared to collect characteristics of the privately owned and commercial vehicle fleets that impact the amount of air pollution generated in the region from border crossing activities. Normally each participant was asked to provide answers for only one component (the specific component being asked was predetermined for specific days and times of data collection), but surveyors in the field had the discretion to ask POV users for both components if the queue length conditions allowed it. As a result, some participants responded to both components of the survey.

The number of economic component survey responses broken down by country of residence (as reported by the respondents) as well as by the county used to cross the border is provided in Table 1.

Table 1. Number of Economic Surveys Collected, by Country Where Respondent Lives and County of Border-Crossing

Sample size by Self-Reported Country Where Respondent Lives	Imperial County POEs	San Diego County POEs
Mexico	2,361	5,062
United States and Other	925	1,388
Total	**3,286**	**6,450**

The sample size can also be broken down by the number of surveys collected across counties and travel modes. Table 2 below presents that information.

Table 2. Number of Economic Surveys Collected, by Travel Mode and County of Border-Crossing

Sample size by Travel Mode	Imperial County POEs	San Diego County POEs
Pedestrians	1,056	1,764
Privately-owned vehicles	2,230	4,686
Total	**3,286**	**6,450**

The SANDAG Border Survey also collected 4,026 emission component responses from privately-owned and commercial vehicles.[15] The breakdown by vehicle type as well as by the county used to cross the border is provided in the following table.

Table 3. Number of Emissions Surveys Collected, by Vehicle Type and County of Border-Crossing

Sample Size by Vehicle Type recorded	Imperial County POEs	San Diego County POEs
Commercial Vehicles	319	843
Passenger Vehicles	1,070	1,794
Total	**1,389**	**2,637**

The numbers shown in Table 2 and Table 3 are not additive, since a significant number of participants who drove POVs answered both components of the survey. Additionally, for people crossing in a POV, one person per car was interviewed for the survey, and we assume that their answer was applicable to all the persons in the car.

In the case of the CBX surveys, they focused primarily on collecting variables such as trip purpose, expenditure during the trip and behavior related to air transportation before the existence of CBX. The number of responses broken down by country of residence (as reported by the respondents) is provided in Table 4.

Table 4. Number of Surveys Collected at CBX, by Country Where Respondent Lives

Sample size by Self-Reported Country Where Respondent Lives	Number of Responses	% of Total
Mexico	186	43%
United States	243	57%
Totals	**429**	**100%**

[15] Besides the data collected as part of the SANDAG Border Survey, the study will use information from comparable, recently-collected GHG/air emission surveys from 2014 at the San Ysidro and Calexico West POEs for POVs (over 2,100 surveys total; almost 1,100 at San Ysidro and more than 1,000 at Calexico West), and at the Calexico East POE for trucks (over 200 surveys total). The characteristics of this additional survey data are described in the "Assessment of Existing Data Gaps" memo of this study.

EXPANDING THE AT-BORDER SURVEY SAMPLE

To appropriately represent the economic behavior of the underlying border crossing populations in each county, the sample of economic component responses collected through the SANDAG Border Survey was expanded using factors calculated from annual border crossing traffic volumes reported by the Bureau of Transportation Statistics (BTS).[16] These expansion factors allow the sample collected in the field to be statistically comparable to the underlying population of border crossers by adjusting for the differences in volumes across lane types and ports of entry in each county.[17] The results obtained using this scaling process are identified as "weighted statistics" of the corresponding variable. For survey questions that only applied to a certain subset of the respondents (like people crossing for work purposes), the expansion process used was slightly different: we applied proportions estimated from the survey to data reported by BTS to obtain the corresponding expanded samples that were then used in the estimation of weighted statistics.[18] All the summary statistics in this report correspond to weighted statistics, unless explicitly stated otherwise.

OVERVIEW OF BORDER CROSSING TIME MEASUREMENTS

The HDR team recorded data on the total border-crossing time for both passenger vehicles and commercial vehicles at all six POEs in the study area. For passenger vehicles, measurements were conducted at all POEs during the following days: July 1, 4 and 5 and October 16 and 17, 2016, or five days at each POE in total. For commercial vehicles, the measurements were conducted also during five days at each POE on the following days: October 12, 13 and 14 (Tecate POE), October 19, 20 and 21, 2016 (Calexico East POE) and February 10, 13 and 14, 2017 (Otay Mesa POE), March 1-2, 2017 (Calexico East and Tecate POEs), March 8-9, 2017 (Otay Mesa POE).

[16] The number of economic component observations collected through the survey at the POE and lane-type level was scaled-up using the appropriate factors to represent the numbers in the true population. The true population numbers are presented in Appendix 1 by travel mode (i.e., pedestrians or passenger vehicles).
[17] See Appendix 1 for a description of how the expansion factors were used to generate the weighted indicators presented in this document.
[18] This is due to the fact that the true underlying population from which the sample was taken is unknown.

Summary Statistics for Key Economic Survey Variables

There are a handful of variables considered as key inputs into the Economic Impact model that is being developed as part of the Impacts of Border Delays at the California-Baja California Land Ports of Entry study. In general, these key variables are related to trip purpose, measures of expenditure per border-crossing trip and type of goods/services bought during that trip, and an indicator of the attitude of crossers with respect to higher wait times at the border, and were collected through the SANDAG Border Survey.

The (weighted) summary statistics for the key variables identified in this study are presented in this section. In particular, the summary statistics for the following variables are reported in this document:[19, 20]

- Primary and Secondary Trip Purpose
- Average Border-Crossing Trip Spending
- Average Border-Crossing Trip Spending by Category
- Alternate Average Spending in Home Country
- Alternate Average Spending in Home Country by Category
- Average Wage
- Elasticity of Travel Demand with respect to Border Delay

Since the SANDAG Border Survey was applied to different "modes" of transportation used to cross the border (i.e., passenger vehicles and pedestrians), the summary statistics for each variable in this section are presented separately for POVs and pedestrians.

Trip Purpose

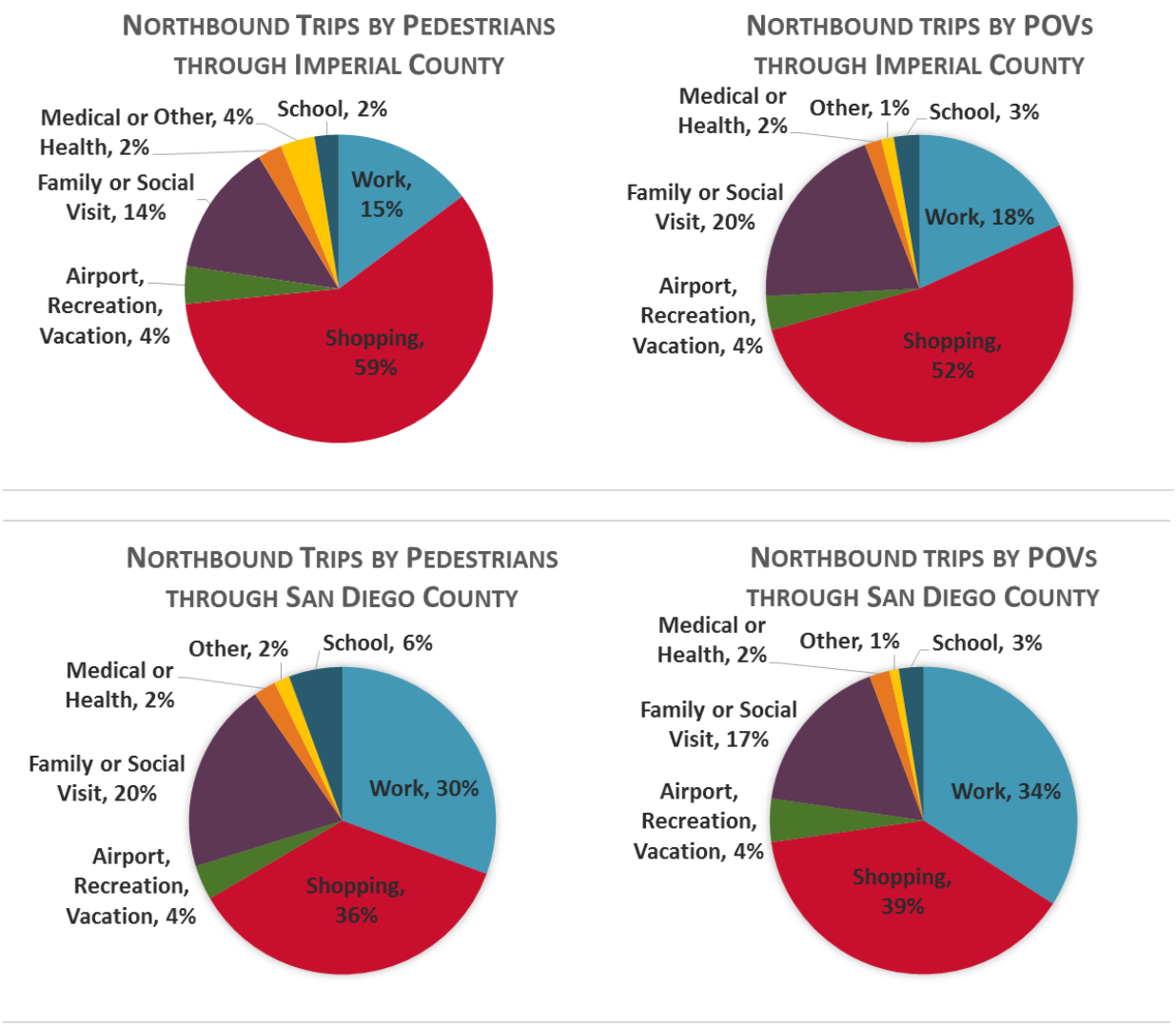
The survey respondents were asked about the primary and secondary purposes for their crossborder trip and we received answers from all respondents.

Primary trip purpose varies depending on country of residence, travel mode, and to a lesser degree, the county used to cross. A majority of northbound trips are taken for work, shopping, or social and family visiting purposes; together these make up 75 to 90 percent of all primary trip purposes listed across POE counties and travel modes (see Figure 2). About one third of pedestrians and one third of POVs crossing north into San Diego County are crossing for work. For Imperial County, the survey shows that 15 to 18 percent of northbound trips are work-related for both POVs and pedestrians, whereas the shopping portion is more than half. Family and social visits are the next most frequently listed primary reason for crossing northbound, comprising 14 to 20 percent of trip purposes across pedestrians, POVs, both in San Diego County and Imperial County.

[19] The variables listed correspond to those variables for which the SANDAG Border Survey was the source of the statistics. These variables were discussed during the Risk Analysis Session of the Economic Peer-Review.

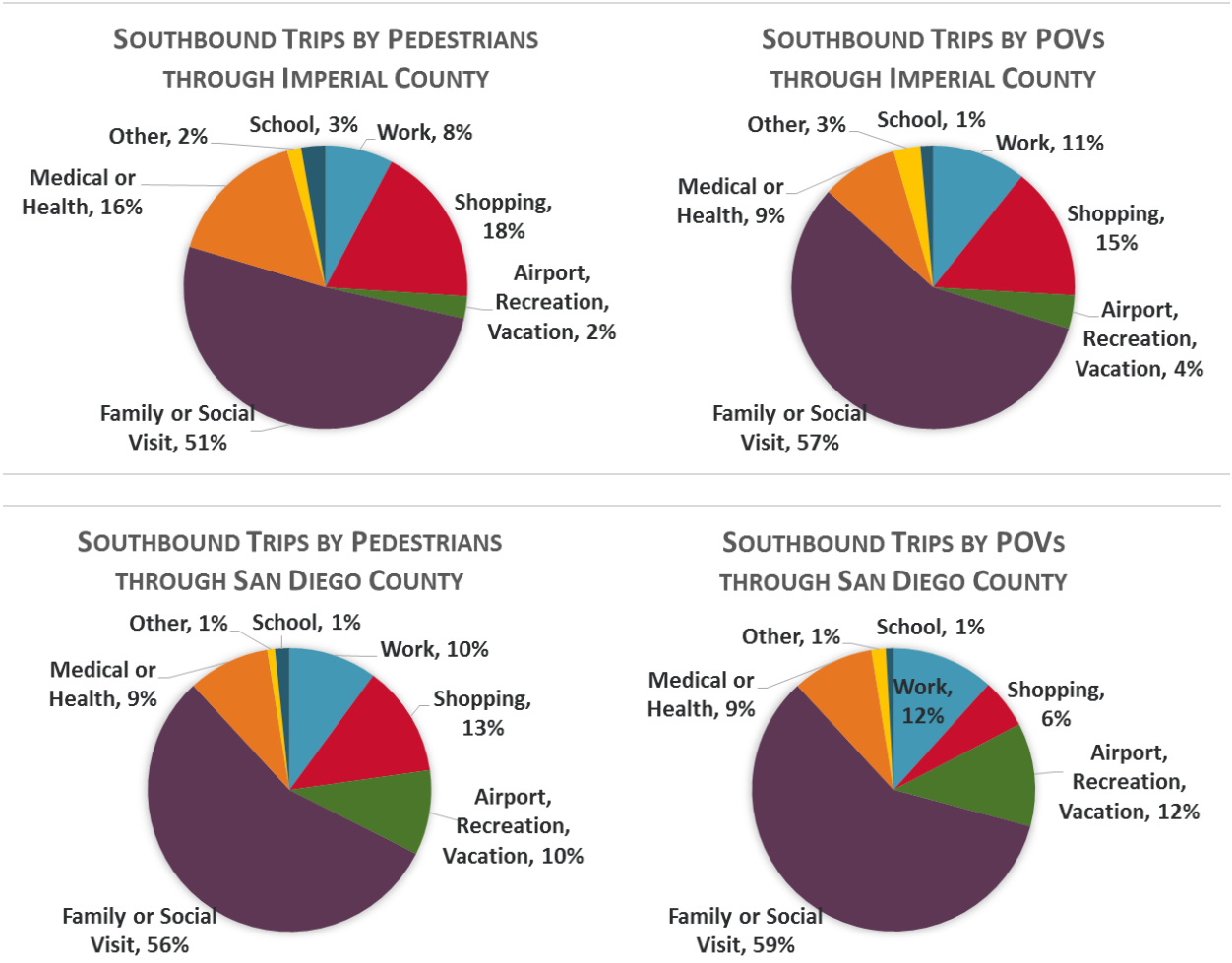
[20] The median results for border-crossing trip expenditure, border-crossing trip expenditure by category, alternate spending in home country, alternate spending in home country by category and wage were also calculated and are presented in the Appendix of this document.

Figure 4. Primary Trip Purposes for Northbound Trips by Mode and County of Crossing



For people crossing into Mexico southbound, family and/or social visits comprise over half of the primary purposes for trips taken for both counties and travel modes, and work or business trips comprise closer to 10 percent of southbound trips. Additionally, for trips in vehicles through Imperial and San Diego County, 10 percent of trips are taken for medical or health reasons. For pedestrians the proportion is similar, but relatively more trips through Imperial County are taken for medical reasons (16 percent), as can be seen in Figure 3.

Figure 5. Primary Trip Purposes for Southbound Trips by Mode and County of Crossing

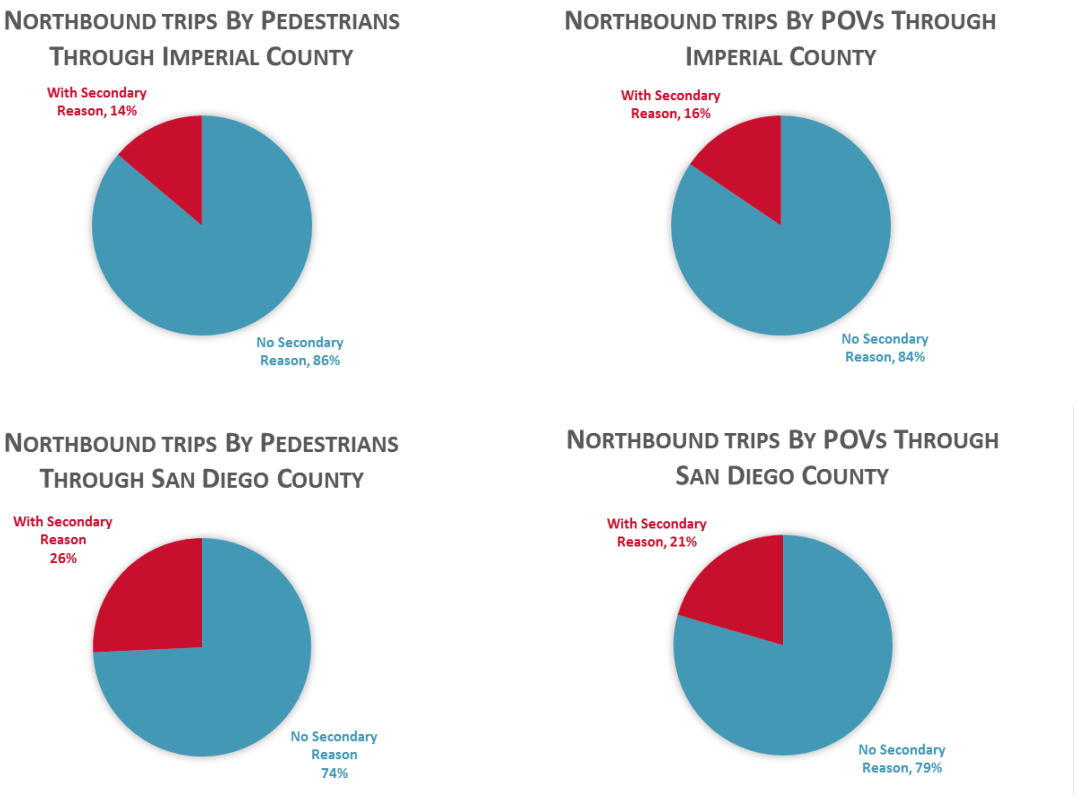


Overall, the survey indicates that relatively more crossborder trips for shopping as a primary purpose are taken through Imperial County than San Diego County, and conversely more work-related crossborder trips are taken through San Diego County than Imperial County.[21]

A majority of respondents (about 80 percent overall) listed that they had no secondary purpose for taking their trip. For northbound trips, this proportion is slightly higher for both pedestrians and POVs at the POEs in Imperial County compared to the POEs in San Diego County.

[21] This is in relative terms because in absolute terms crossborder traffic is much higher through POEs in San Diego County compared to POEs in Imperial County.

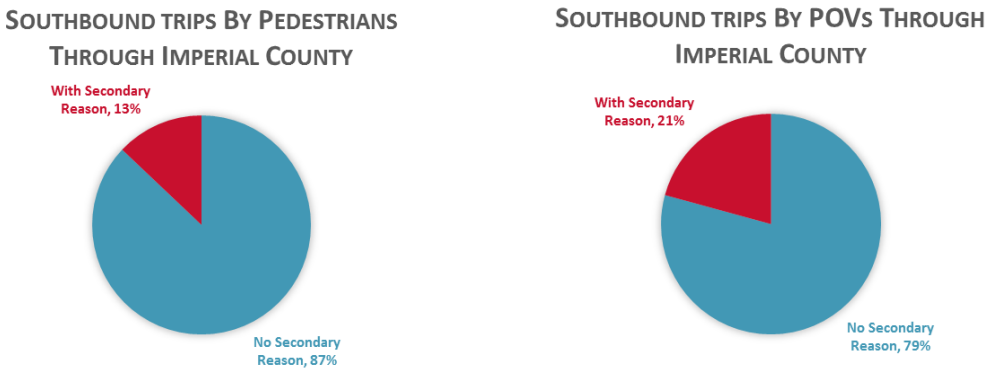
Figure 6. Secondary Trip Purposes for Northbound Trips by Mode and County of Crossing

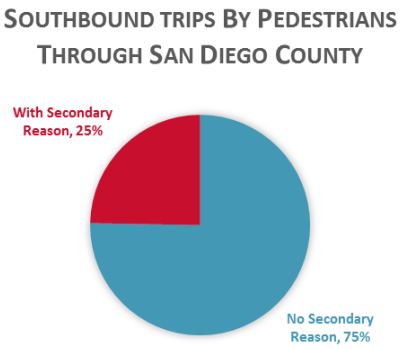


For those northbound crossers that reported having a secondary purpose, family or social visit and shopping were important across the county of crossing and the crossing mode. Table 5 presents the complete breakdown of the answers to the secondary purpose for northbound trips.

For southbound crossings, the highest percentage of trips without a secondary purpose corresponded to those of pedestrians crossing through Imperial County (87 percent), while the lowest percent corresponded to pedestrians crossing through San Diego County (75 percent).

Figure 7. Secondary Trip Purposes for Southbound Trips by Mode and County of Crossing





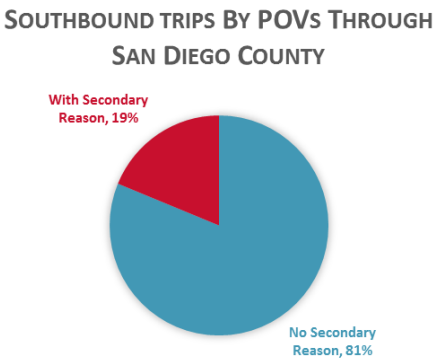


Table 5. Secondary Trip Purposes for Northbound Trips, by Crossing Mode and County

Secondary Trip Purpose, Northbound Trips	Imperial County POEs	San Diego County POEs
Pedestrians		
No Secondary Reason	86%	74%
Airport	0%	0%
Family or Social Visit	5%	8%
Medical or Health	1%	1%
Other	0%	0%
Recreation/Vacation	2%	3%
School	0%	1%
Shopping	4%	11%
Work or business	1%	3%
Private Vehicle Crossers		
No Secondary Reason	84%	79%
Airport	0%	0%
Family or Social Visit	5%	6%
Medical or Health	1%	1%
Other	0%	0%
Recreation/Vacation	2%	2%
School	0%	1%
Shopping	7%	9%
Work or business	1%	1%

Those southbound crossers that reported a secondary trip purpose mentioned family or social visit, shopping, medical or health and recreation / vacation were important across the county and crossing modes. Table 6 presents the complete breakdown of the answers to the secondary purpose for southbound trips.

Table 6. Secondary Trip Purposes for Southbound Trips, by Crossing Mode and County

Secondary Trip Purpose, Southbound Trips	Imperial County POEs	San Diego County POEs
Pedestrians		
No Secondary Reason	87%	75%
Airport	0%	0%
Family or Social Visit	4%	9%
Medical or Health	1%	5%
Other	1%	0%
Recreation/Vacation	1%	5%
School	0%	0%
Shopping	6%	6%
Work or business	1%	1%
Private Vehicle Crossers		
No Secondary Reason	79%	81%
Airport	0%	0%
Family or Social Visit	8%	6%
Medical or Health	2%	2%
Other	0%	0%
Recreation/Vacation	3%	5%
School	0%	0%
Shopping	6%	4%
Work or business	2%	1%

Average Border-Crossing Trip Spending

The SANDAG Border Survey also collected information on expenditure patterns by border crossers. In particular, it elicited information on the amount of expenditure during border crossing trips and the categories of expenditure. Furthermore, it also asked interviewees about their expenditure behavior in case a border crossing trip had to be cancelled (i.e., the degree by which the expenditure would be deferred or substituted in the home country) in order to better understand the impact of foregone trips to the economy on either side of the border.

All respondents were asked how much they spent or will spend on their border-crossing trip to Mexico or the United States. They were also asked to describe how they would spend the money, by listing amounts of expense in several spending categories, such as shopping, gas, groceries, and entertainment. The data was validated by reconciling responses in the overall expenditure question with responses in the expenditure breakdown, disregarding outliers with expenditures of over $10,000.[22] The expenditure data are particularly skewed right (i.e., not normally distributed), meaning that though many respondents listed expenses from $0 to $100,

[22] We also excluded observations with corresponding wage/salary responses above $40,000 per month.

a significant number of respondents also listed more than $500 in expenses, some listing up to thousands of dollars in expenditure. About 80% of the data is contained within the range of $7 to $350. Some but not all of the large expenses may be explained by vacations on either side of the border.

Figure 6 shows the skewedness of the expenditure of southbound trips crossing in a vehicle through Imperial County POEs. This category of crossers features almost 70 percent of their reported border crossing expenditures between $0 and $100 but also shows that approximately 10 percent of their expenditures were reported to be are above $500.[23]

Figure 8. Distribution of Expenditures from Imperial County Southbound Vehicles Subsample

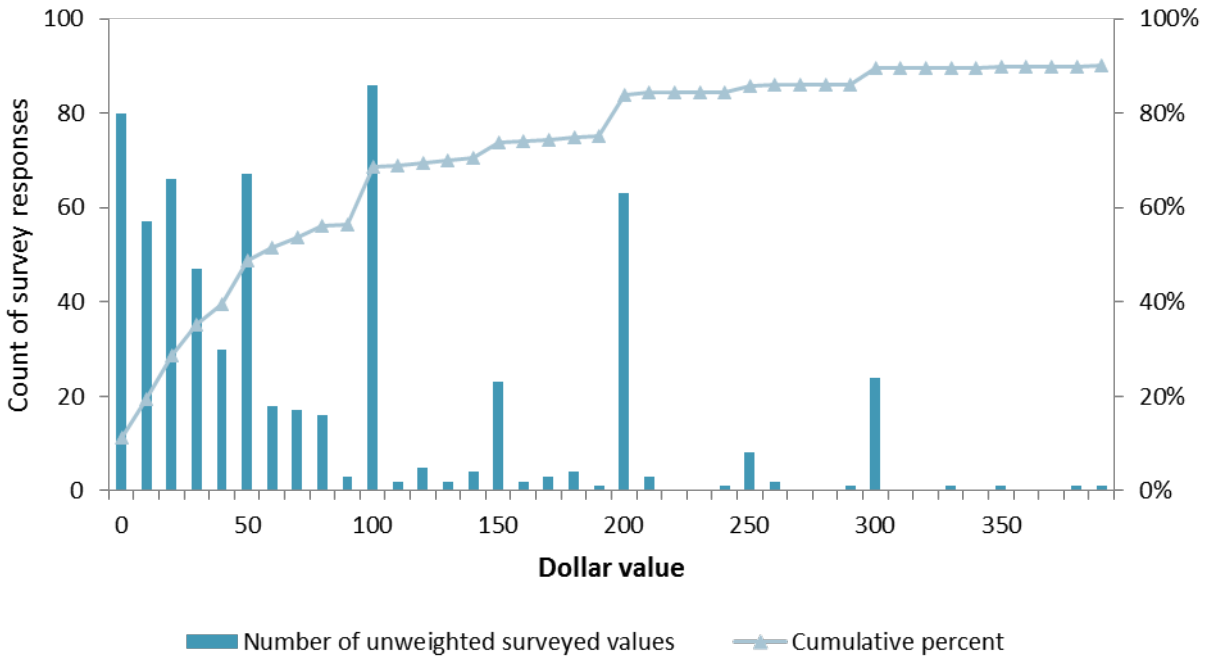


Chart displays only 90 percent of the survey results; the remaining values range from $400 to $10,000.

In general, the survey data indicates that average spending per trip ranges from $112 to $220, across travel modes, border counties, and north and southbound trips. On average, crossers living in Mexico spend less per trip than people living in the U.S., except for vehicle drivers who cross through San Diego County, where spending appears similar for north and southbound trips. People crossing in Imperial County spend less per trip than people crossing in San Diego County, except for people who live in the United States and cross in a vehicle. For border crossers through Imperial County, the average pedestrian spends less than the average person driving across the border, whereas spending patterns across travel mode for crossers in San Diego County display the opposite relationship. Weighted average expenditure per trip is displayed in Table 7.

[23] The median will be used to introduce risk analysis to this variable, since it represents the behavior of the individual at the center of the distribution of possible expenditure levels.

Table 7. Average Spending per Border Crossing Trip

Average Spending per Border Crossing Trip, Dollars	Imperial County	San Diego County
Pedestrians		
Crossers Living in Mexico	$112	$182
Crossers Living in the U.S.	$142	$220
Vehicles		
Crossers Living in Mexico	$147	$166
Crossers Living in the U.S.	$165	$165

Average Expenditures of Border-Crossing Travelers by Expenditure Category

The SANDAG Border Survey asked border-crossing travelers to break down their trip-related expenditures by broad expenditure categories. The categories considered included entertainment, gas, groceries, hotel, public transportation, restaurants, shopping and a category called “other” to capture expenditures not listed in the survey.

The data collected was analyzed using the place where the respondent reported to live, the county where the POE used to cross is located and the type of crossing (i.e., pedestrians and vehicles). An analysis of the survey data shows that the average crosser living in Mexico has different expenditure habits compared to the average crosser living in the U.S. regardless of the mode and the POE used to cross. Crossers living in Mexico have a high concentration of expenditures on shopping, while crossers living in the U.S. diversify their expenditures more across categories such as groceries, restaurants and shopping.

The average pedestrian living in Mexico has similar expenditure patterns regardless of the location of the POE used to cross. The average (weighted) expenditures and the percentage share of each category of expenditure by pedestrians during a single border-crossing trip is presented in Table 8.[24]

[24] Notice that the sum of expenditures across all categories is equal to the average expenditure

Table 8. Average Spending by Pedestrians per Border Crossing Trip by Category

	Imperial		San Diego	
Crossers living in Mexico	**% share**	**$**	**% share**	**$**
Entertainment	5.5%	$6	4.0%	$7
Gas	2.7%	$3	2.3%	$4
Groceries	17.1%	$19	14.6%	$27
Hotel	0.0%	$0	3.8%	$7
Other[25]	1.0%	$1	2.7%	$5
Public Transportation	0.3%	$0	4.3%	$8
Restaurants	8.7%	$10	10.7%	$19
Shopping	64.8%	$73	57.6%	$105
Total, all categories	***100.0%***	***$112***	***100.0%***	***$182***
Crossers living in the U.S.				
Entertainment	2.2%	$3	12.5%	$27
Gas	2.9%	$4	4.0%	$9
Groceries	31.3%	$44	18.9%	$42
Hotel	0.0%	$0	8.9%	$19
Other	7.1%	$10	8.9%	$20
Public Transportation	0.2%	$0	7.2%	$16
Restaurants	25.4%	$36	18.9%	$42
Shopping	31.0%	$44	20.7%	$46
Total, all categories	***100.0%***	***$142***	***100.0%***	***$220***

The average (weighted) expenditures and the percentage share of each category of expenditure by vehicle users during a single border-crossing trip is presented in Table 9.

[25] Some of the POV and pedestrian respondents provided an explanation for the “Other” category. Common answers included: gym, church, paperwork, betting, postal services, and parking.

Table 9. Average Spending by Vehicle Users per Border Crossing Trip by Category

	Imperial		San Diego	
Crossers living in Mexico	**% share**	**$**	**% share**	**$**
Entertainment	6.4%	$9	3.9%	$7
Gas	9.7%	$14	10.3%	$17
Groceries	19.2%	$28	13.4%	$22
Hotel	0.6%	$1	2.1%	$3
Other	3.2%	$5	2.1%	$3
Public Transportation	0.0%	$0	0.0%	$0
Restaurants	10.1%	$15	7.3%	$12
Shopping	50.9%	$75	60.9%	$101
Total, all categories	***100.0%***	***$147***	***100.0%***	***$166***
Crossers living in the U.S.				
Entertainment	12.7%	$21	6.0%	$10
Gas	9.3%	$15	9.0%	$15
Groceries	16.3%	$27	17.2%	$28
Hotel	2.9%	$5	5.8%	$10
Other	15.2%	$25	13.0%	$22
Public Transportation	0.0%	$0	0.2%	$0
Restaurants	14.1%	$23	21.6%	$36
Shopping	29.4%	$49	27.3%	$45
Total, all categories	***100.0%***	***$165***	***100.0%***	***$165***

Alternate Average Spending in Home Country

The SANDAG Border Survey asks questions concerning the respondents' spending patterns in case they were to cancel their current trip (in other words, if they decided not to take the trip due to, for example, border wait times being too long). In particular, interviewees were asked to consider a situation in which their current border-crossing trip would not take place and were asked to choose between spending the amount they were anticipating spending on the trip either at their home country or to defer the expenditure until they performed a future border-crossing trip.

Based on the survey responses, people are generally more likely to defer their spending rather than spend it at their home county, but this varies. Crossers who live in the U.S. are more likely to spend in their home country when a border-crossing trip is not taken. The exception to this are pedestrians in Imperial County, for which crossers living in Mexico are slightly more prone than crossers living in the U.S. to spend in their home country if the trip is not taken.

About half of pedestrians through Imperial County and one third of pedestrians through San Diego stated that they would spend their money at their home country versus deferring their spending for another trip. About one third of vehicle crossers through both counties stated they would spend at their home country instead, except for the one half of vehicle crossers living in the U.S. crossing through San Diego that stated they would defer spending instead. The percent of respondents

that would spend at their home country if the border crossing trip was not taken is presented in Table 10.

Table 10. Respondents that Would Spend at Home Country if Border Crossing Trip was Not Taken

Respondents that would spend at home country if border trip is not taken, percent	Imperial County	San Diego County
Pedestrians		
Crossers Living in Mexico	51.4%	27.7%
Crossers Living in the U.S.	50.6%	38.5%
Vehicles		
Crossers Living in Mexico	31.4%	36.1%
Crossers Living in the U.S.	38.3%	50.4%

The survey also asked those individuals that would not defer their expenditure due to a border crossing trip not taken to report the amount of money they would spend at their home country.[26]

The average expenditure ranges from $79 for pedestrians living in the U.S. and crossing through San Diego County POEs to $167 for vehicle occupants living in Mexico and crossing through POEs in Imperial County.[27] In general, crossers living in Mexico have higher average expenditures in their home country than crossers living in the U.S. across modes when a border crossing trip is not taken. The exception are pedestrian crossers using Imperial County POEs, since crossers living in the U.S. average $111 of home country expenditure when a border trip is not taken compared to $99 for crossers living in Mexico. A possible explanation for this is that the expenditure categories include groceries, shopping and restaurants, which are more expensive in the U.S.

[26] As in the case of the border-crossing trip expenditures variable, the statistic that will be used to introduce risk analysis to this variable is the median, since expenditure values when a trip is not taken tend to be skewed (in a statistical sense) and the median captures the behavior of the individual at the center of the distribution of possible expenditure levels.

[27] It is worth noting that the behavior of home-country expenditure differs by mode and POE location of the forgone crossing. The percentage of respondents that reported that they would spend at their home country in case a border trip is not taken (by travel mode) is presented in the Appendix for each specific expenditure category.

The average spending at home if a border trip is not taken is reported in Table 11.

Table 11. Average Spending at Home if a Border Trip is Not Taken

Average Spending at Home if Border Trip is not taken, per Trip, Dollars	Imperial County	San Diego County
Pedestrians		
Crossers Living in Mexico	$99	$128
Crossers Living in the U.S.	$111	$79
Vehicles		
Crossers Living in Mexico	$167	$130
Crossers Living in the U.S.	$102	$95

Notice that in the majority of the cases the average expenditure at home if a border trip is not taken is smaller than the average spending for border crossing trips made. The exception is vehicle crossers that live in Mexico and cross through Imperial County POEs, whose at-home average spending if a trip is not taken is higher than their average spending while on a crossborder trip. There could be several explanations to this result, including price differences between goods and services that belong to expenditures categories that are less likely to be deferred by this group of border-crossers when a border trip is not taken.

Average Expenditures by Expenditure Category If Trip is Not Taken

As in the case of expenditure for border-crossing trips made, the survey collected information on expenditures at home by category in case a trip was not taken. The same categories of expenditure as those described for border-crossing trips are used for this question. As in the case of a trip taken, the data collected was analyzed using the place where the respondent reported to live, the county where the POE used to cross is located and the mode for crossing (i.e., pedestrian or vehicles).

An analysis of the survey data shows that, in general, the average pedestrian crosser that decides not to take a border-crossing trip has a tendency to spend at home primarily on groceries and shopping, regardless of where the crosser lives or the county of crossing. For crossers living in the U.S. and crossing through San Diego County, a category of home expenditure that is also significant is restaurants. The average (weighted) expenditures and the percentage share of each category of expenditure at home by pedestrians in case a border-crossing trip is not taken are presented in Table 12.

Table 12. Average Spending at Home by Pedestrians, by Category if a Border Trip is Not Taken

	Imperial		San Diego	
Crossers living in Mexico				
Entertainment	3.9%	$4	1.6%	$2
Gas	4.7%	$5	1.6%	$2
Groceries	15.0%	$15	26.3%	$34
Hotel	0.0%	$0	6.9%	$9
Other	3.1%	$3	13.0%	$17
Public Transportation	0.0%	$0	10.3%	$13
Restaurants	5.2%	$5	9.8%	$13
Shopping	68.0%	$68	30.5%	$39
Total, all categories	***100.0%***	***$99***	***100.0%***	***$128***
Crossers living in the U.S.				
Entertainment	0.3%	$0	10.9%	$9
Gas	0.1%	$0	5.0%	$4
Groceries	35.6%	$40	29.6%	$23
Hotel	0.0%	$0	0.0%	$0
Other	7.8%	$9	0.0%	$0
Public Transportation	0.0%	$0	2.2%	$2
Restaurants	7.4%	$8	35.1%	$28
Shopping	48.9%	$54	17.2%	$14
Total, all categories	***100.0%***	***$111***	***100.0%***	***$79***

As in the case of the average pedestrian, the average vehicle crosser that decides not to take a border-crossing trip has a tendency to spend at home primarily on groceries and shopping, regardless of where the crosser lives or the county of crossing. However, other categories that also represent significant home expenditure regardless of where the crosser lives or the POE used are gas and restaurants. The average (weighted) expenditures and the percentage share of each category of expenditure at home by vehicle crossers in case a border-crossing trip is not taken are presented in Table 13.[28]

[28] It is worth noting that the shares of expenditures in the categories of “Entertainment” for crossers living in Mexico and “Other” for crossers living in the U.S. show a significant difference between the San Diego and Imperial County border regions.

Table 13. Average Spending at Home by Vehicle Users, by Category if a Border Trip is Not Taken

	Imperial		San Diego	
Crossers living in Mexico				
Entertainment	13.8%	$23	4.7%	$6
Gas	11.2%	$19	11.9%	$15
Groceries	21.9%	$37	15.9%	$21
Hotel	0.7%	$1	1.2%	$2
Other	4.0%	$7	0.5%	$1
Public Transportation	0.0%	$0	0.0%	$0
Restaurants	12.1%	$20	12.0%	$16
Shopping	36.3%	$61	53.8%	$70
Total, all categories	***100.0%***	***$167***	***100.0%***	***$130***
Crossers living in the U.S.				
Entertainment	4.4%	$4	5.5%	$5
Gas	8.3%	$8	14.1%	$13
Groceries	17.4%	$18	25.4%	$24
Hotel	0.5%	$1	1.7%	$2
Other	18.1%	$19	2.5%	$2
Public Transportation	0.0%	$0	0.0%	$0
Restaurants	17.2%	$18	22.8%	$22
Shopping	34.0%	$35	28.0%	$27
Total, all categories	***100.0%***	***$102***	***100.0%***	***$95***

Average Wages

Respondents who indicated their trip was work related were also asked for their monthly wage. Across all travel modes, counties, and trip directions, we received 677 useful wage responses, 177 from crossers at Imperial County POEs, and the rest from San Diego POEs. This data was validated by transforming numeric responses given for a different time period (i.e., daily wage or yearly salary) to monthly wages and identified two outliers that were greater than $40,000 a month.[29]

The average monthly wage for a pedestrian crossing the border for work is $1,114 in San Diego County and $872 in Imperial County. For people driving across the border, the weighted averages for both counties are around $1,700.

[29] For the purposes of risk analysis, we will be using the median for this variable, since wages tend to have non-symmetric distributions and therefore the median captures the wage of the individual at the center of the distribution of possible salary levels.

Table 14. Average Monthly Wages

Weighted Average Monthly Wage/Salary, Dollars	Imperial County POEs	San Diego County POEs
Pedestrians crossing for work	$872	$1,114
People crossing in vehicles for work	$1,705	$1,685

Elasticities of Travel Demand with respect to Border Delay

A key question of the survey asked respondents to report how much longer (compared to their perception of currently-anticipated wait time) they would be willing to wait before deciding to cancel a cross border trip they had already planned. Respondents were given a series of time intervals representing additional wait times (ranging from 5 minutes to more than 4 hours) that they could choose from. Using this information, an estimate of the elasticity of travel demand with respect to border delays was derived using a standard formula for the estimation of elasticities. In particular, for every time interval included in the survey, the percentage change in the number of respondents that reported would cancel the trip was estimated and compared to the percentage change that the additional wait time represents over the current wait time.

The estimated elasticities show that pedestrians are less sensitive to additional wait times than occupants of vehicles and that crossers motivated by work purposes are less sensitive to additional wait times (i.e., they have higher tolerance to border crossing wait times than those crossing for non-working purposes). Similarly, the estimates show that vehicle crossers in San Diego County are less sensitive to additional border crossing wait times than crossers in Imperial County but the opposite is true for pedestrian crossers (i.e., pedestrian crossers are less sensitive to wait times in Imperial County).[30]

Since this variable represents the percentage change in border crossings associated with a one percent increase in wait time at the border, an elasticity of -0.03 (reported for pedestrians crossing for work or business purposes in Imperial County) means that a 1 percent increase in current wait times at the pedestrian crossings in Imperial would represent a reduction of 0.03 percent in the number of pedestrian crossings through these POEs for this type of crossing purpose.

The estimates of the elasticities derived from the SANDAG Border Survey are presented in Table 15 for different types of crossers, trip purposes and counties where the crossings occur.[31] These elasticities will be combined in the economic model with the average delays estimated in this study (see section Summary of Total Border Crossing Time, Baseline Crossing Time and Delays at Crossing in this document) and the future delays calculated through the Binational Travel Demand Model to assess the impact of delays on future volumes through the POEs.

[30] Since border crossers travel in both directions during any particular border crossing trip, the elasticity is assumed to be equal for crossers living in the U.S. and Mexico.
[31] Since the survey asked about a range of potential additional wait times, several sets of elasticities were estimated based on their answers (one for each potential range). The elasticities listed in the table correspond to the median elasticity, since that represents the most-likely response.

Table 15. Elasticity of Travel Demand With Respect to Border Delays

Elasticity of Travel Demand With Respect to Border Delays	Imperial County	San Diego County
Pedestrians		
Crossing for work or business	-0.03	-0.07
Crossing for a non-work purpose	-0.05	-0.09
Vehicles		
Crossing for work or business	-0.09	-0.08
Crossing for a non-work purpose	-0.12	-0.11

Table 15 shows that the response of border crossers to increased wait times is fairly inelastic across all crossing types and across counties where the POEs are located. For example, a one percent increase in wait times for pedestrians crossing for work or business through Imperial County POEs will translate in a reduction in the number of pedestrians crossing the border through that region of only 0.03 percent. In other words, the increased wait time has a very small impact on the number of border-crossing trips, suggesting that crossers have high tolerance to wait times throughout the area (i.e., the volume of crossings is inelastic with respect to wait times).

Furthermore, when the maximum ranges for this elasticity estimate are analyzed, it shows that the sensitivity of travelers to wait times is slightly higher, but still shows that the responses of travelers at the California-Baja California border are inelastic. The minimum and maximum elasticity estimates are presented in Table 16.

Table 16. Minimum and Maximum Elasticities of Travel Demand With Respect to Border Delays

Elasticity of Travel Demand With Respect to Border Delays	Imperial County		San Diego County	
	MIN	MAX	MIN	MAX
Pedestrians				
Crossing for work or business	-0.02	-0.09	-0.05	-0.15
Crossing for a non-work purpose	-0.03	-0.08	-0.03	-0.08
Vehicles				
Crossing for work or business	-0.05	-0.23	-0.04	-0.11
Crossing for a non-work purpose	-0.08	-0.26	-0.04	-0.15

Summary Statistics for Key Air Quality Variables

There are a few variables considered as key inputs into the Air Quality (Emissions) Impact model that are being developed as part of the study. In general, these key variables are related to the year when the vehicle used to cross the border was manufactured, the condition of the engines for those vehicles as measured by the mileage, the fuel type used by them, the country where fuel is purchased and the adherence to a smog check program. Answers to these questions were collected through the SANDAG Border Survey.

The summary statistics for the key air quality variables identified in this study are presented in this section. In particular, the summary statistics for the following variables are reported in this document:

- Model Year
- Odometer Reading (indicator for condition of engine) and Units of Odometer Measurement (indicator for where vehicle was built)
- Fuel Type
- Share of Fuel Purchased in Mexico
- Adherence to a Smog Check Program
- Willingness to Switch to Non-Motorized Border Crossing Mode

The units for reporting each one of these variables may differ, but are clearly indicated in each one of the corresponding variable descriptions.

Model Year

The relevant statistics related to model year for the commercial and passenger vehicle fleets surveyed, by county where the border crossing occurred, are reported in Table 17.

Table 17. Relevant Statistics on Model Year by County

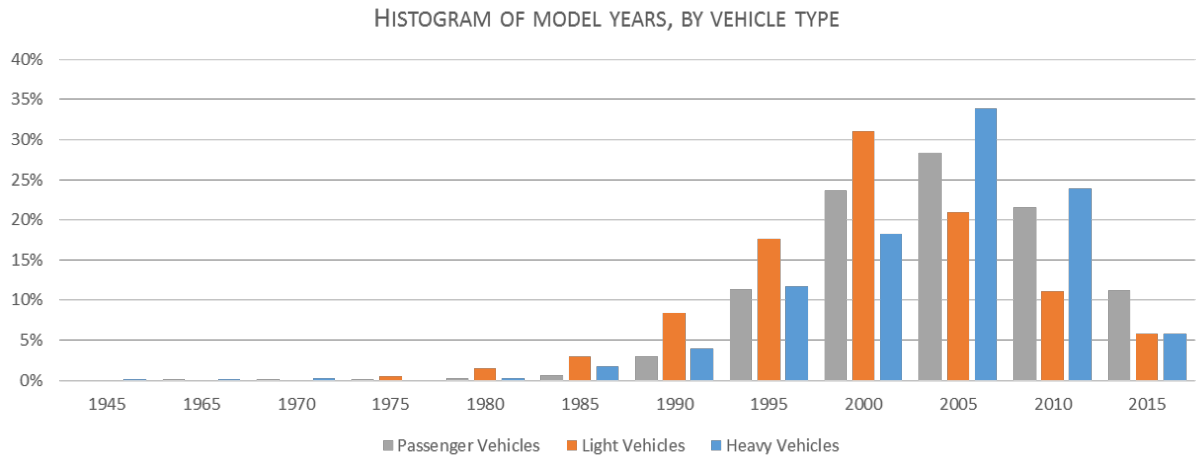
	Imperial County	San Diego County
Commercial Vehicles		
Newest Model Year	2018	2017
Median Model year	2006	2005
Oldest Model year	1945	1965
Average Model year	2005	2004
Passenger Vehicles		
Newest Model Year	2017	2018
Median Model year	2007	2005
Oldest Model year	1976	1965
Average Model year	2007	2006

In general, median and average model years for commercial and passenger vehicles are very similar, indicating that their distributions are relatively symmetric. For commercial vehicles, however, Imperial County seems to have a slightly newer fleet (both newest, median and average model year are more recent than those in San Diego), however, this county also has

the oldest model year in the survey. For passenger vehicles, the situation is similar as that of commercial vehicles (i.e., Imperial has a slightly newer fleet based on median and average model year indicators).

A histogram depicting the shares of 5-year groupings of the model year variable for each one of the different vehicle types considered (i.e., passenger vehicles, light vehicles and heavy vehicles) is presented in Figure 7.

Figure 9. Histogram of Model Year by Vehicle Type



The figure above shows that light vehicles have their largest share in the 2000-2005 model year bin or category, while passenger vehicles and heavy vehicles have their largest share in the 2005-2010 bin.

Odometer Reading and Units

Of the total number of vehicles surveyed, the majority of them have an odometer with units in miles, indicating that a significant share of the vehicles crossing the border was built in the U.S. This is particularly true for commercial vehicles, where more than 90 percent of respondents reported an odometer in miles. The table below summarizes these results. Note that the shares do not differ significantly between geographies, and therefore the results are listed for all POEs in the California-Baja California region.

Table 18. Odometer Units by Vehicle Type

Sample Size by Vehicle Type and Odometer Units	All POEs	
Commercial Vehicles		
Odometer in kilometers	94	8%
Odometer in miles	1,068	92%
Passenger Vehicles		
Odometer in kilometers	448	16%
Odometer in miles	2,416	84%

The actual readings on the odometers were transformed into miles and the average and median odometer reading were calculated for each border region where the crossing took place (i.e., Imperial and San Diego Counties). The results are presented in the table below.[32]

Table 19. Relevant Statistical Measures for the Odometer Reading Variable

Odometer Reading (in miles) by Vehicle Type	Imperial County	San Diego County
Commercial Vehicles		
Average	285,834	403,707
Median	154,000	202,162
Passenger Vehicles		
Average	126,753	164,435
Median	105,000	127,500

The statistics on odometer readings show a similar picture to that of the model year, with vehicles that cross through Imperial County showing less use than those that cross through San Diego County. However, in this case the median estimates are lower than the average estimates, suggesting that some vehicles in the sample have a large number of miles traveled.

Fuel Type

The fuel type has a direct impact on the emissions created by vehicles crossing the border. Table 20 shows the share of fuels used by border-crossing vehicles by vehicle type and county of crossing.

[32] Potential outliers (i.e., odometer readings greater than the equivalent of 5.6 million miles, the maximum passenger vehicle odometer reading) were removed from the sample to create the estimates shown in the table.

Table 20. Fuel Type by Vehicle Type and County of Crossing

Fuel Type by Vehicle Type	Imperial County		San Diego County	
Commercial Vehicles				
100% Electric	0	0.0%	2	0.2%
Diesel	111	34.9%	380	45.1%
Gasoline	203	63.8%	446	52.9%
Hybrid electric	0	0.0%	1	0.1%
Natural Gas	4	1.3%	14	1.7%
Total, all categories	***318***	***100.0%***	***843***	***100.0%***
Passenger Vehicles				
100% Electric	5	0.5%	7	0.4%
Diesel	1	0.1%	4	0.2%
Gasoline	1,041	97.4%	1,707	95.2%
Hybrid electric	9	0.8%	21	1.2%
Natural Gas	13	1.2%	55	3.1%
Total, all categories	***1,069***	***100.0%***	***1,794***	***100.0%***

In the case of commercial vehicles, the vast majority of crossers use diesel and gasoline. However, the share of crossers that uses gasoline through Imperial County is higher than the share of users of this fuel type through San Diego County. In the case of passenger vehicles, the vast majority of crossers use gasoline as their vehicle's fuel. For these type of vehicles, crossers through San Diego County reported significantly larger shares of hybrid and natural gas-powered vehicles than crossers through Imperial County, though the absolute shares of these fuels are small.

Share of Fuel Purchased in Mexico

The share of fuel purchased in Mexico also affects the emissions into the atmosphere. The responses to this survey question are concentrated primarily along the extremes (i.e., the majority of responses correspond to border crossers that do not buy fuel in Mexico or that only buy fuel in Mexico) regardless of the vehicle type considered. Table 21 shows the share of fuel bought in Mexico by vehicle type and county where the crossing occurred.

Table 21. Percent of fuel purchased in Mexico, by Vehicle Type

Percent of fuel purchased in Mexico, by Vehicle Type	Imperial County		San Diego County	
Commercial Vehicles				
0%	108	34%	332	39%
1-9%	12	4%	49	6%
10-19%	16	5%	41	5%
20-29%	16	5%	33	4%
30-39%	6	2%	24	3%
40-49%	9	3%	31	4%
50-59%	33	10%	75	9%
60-69%	10	3%	20	2%
70-79%	7	2%	28	3%
80-89%	22	7%	33	4%
90-99%	9	3%	40	5%
100%	69	22%	137	16%
Total, all categories	***317***	***100%***	***843***	***100%***
Passenger Vehicles				
0%	361	34%	439	24%
1-9%	47	4%	163	9%
10-19%	59	6%	122	7%
20-29%	51	5%	130	7%
30-39%	31	3%	92	5%
40-49%	37	3%	95	5%
50-59%	99	9%	139	8%
60-69%	21	2%	37	2%
70-79%	29	3%	81	5%
80-89%	53	5%	160	9%
90-99%	74	7%	141	8%
100%	208	19%	195	11%
Total, all categories	***1,070***	***100%***	***1,794***	***100%***

The results show that in the case of commercial vehicles, crossers in San Diego County tend to purchase less fuel in Mexico. In particular, the share of border crossers in San Diego that does not buy fuel in Mexico is higher than the share of border crossers in Imperial County that do not buy fuel in Mexico. Similarly, the share of crossers in San Diego County that buy all their fuel in Mexico is lower in San Diego County. In the case of passenger vehicles, both the share of crossers that does not buy fuel in Mexico and the share of crossers that only buys fuel in Mexico is higher in the case of Imperial County.

Smog Check Program

Participation in a smog check program can reduce the emissions related to border crossing trips. In general, both commercial and passenger vehicles in the border region have a high share of participation in these programs. The share of responses to the question about having a smog check inspection during the last 12 months is presented in the table below, by vehicle type and county of crossing.

Table 22. Participation in Smog Check Inspection in Last 12 Months, by Vehicle Type

Responses to a Smog-Check in the last 12 months, By Vehicle Type	Imperial County		San Diego County	
Commercial Vehicles				
DK/NA	2	1%	8	2%
No	47	22%	38	8%
Yes	165	77%	408	90%
Total, all categories	***214***	***100%***	***454***	***100%***
Passenger Vehicles				
DK/NA	22	2%	40	2%
No	192	18%	161	9%
Yes	856	80%	1,593	89%
Total, all categories	***1,070***	***100%***	***1,794***	***100%***

Based on these results, crossers that use San Diego County POEs reported a higher participation on smog check programs over the last 12 months compared to crossers that use Imperial County POEs. Also, the results suggest that the rate of participation in these programs differs primarily between geographies, and not so much between vehicle types in the same geography.

Switch to Non-Motorized Crossing Mode

The emissions component of the SANDAG Border Survey asked participants to report the wait time at pedestrian crossing that would induce them to switch from a motorized crossing to a non-motorized one (i.e., to cross by foot, bicycle or using public transportation). The shares of responses for different time intervals of pedestrian wait times are provided in Table 23 by county of crossing.

Table 23. Ranges of Border Crossing Wait Times that Would Cause Vehicle User to Switch to Pedestrian Crossing

Ranges of wait time at pedestrian crossing[33]	Imperial County		San Diego County	
Passenger Vehicles				
0 delay	161	15%	151	8%
1-10 minutes	160	15%	275	15%
11-20 minutes	56	5%	160	9%
21-30 minutes	37	3%	106	6%
31-40 minutes	13	1%	44	2%
41-50 minutes	8	1%	12	1%
51-60 minutes	13	1%	13	1%
60+ minutes	42	4%	49	3%
Wouldn't change from car	580	54%	984	55%
Total, all categories	***1,070***	***100%***	***1,794***	***100%***

The majority of the respondents for each county of crossing reported they would not switch to a non-motorized mode regardless of how much the wait time is at the pedestrian crossings. Furthermore, crossers in San Diego County are less likely to switch to a non-motorized mode than crossers in Imperial County.

Across geographies, of those respondents that showed a willingness to switch to a non-motorized mode, a significant portion said they would consider the switch only if wait times at pedestrian crossings were 20 minutes or less. The share of those that would switch only if zero delays are experienced at the pedestrian POEs is larger at Imperial County.

[33] This question was also posed to commercial vehicle drivers, and even though over 200 responses were gathered at the Imperial Valley POEs and over 400 responses were gathered at the San Diego POEs, these were not reported since it does not seem plausible that truck drivers can switch to a non-motorized mode and move freight across the border.

Summary Statistics for Key CBX Variables

The surveys collected at CBX as part of the SANDAG Border Survey shed light on the recent change in behavior of border crossers that use airplane as their mode of travel due to the opening of this facility. The short survey conducted at the facility was geared toward capturing responses on the following variables:

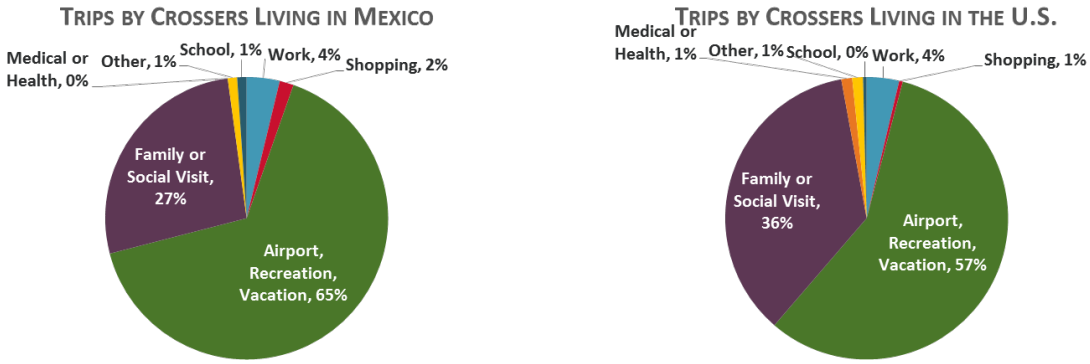
- Trip Purpose
- Expenditure per Trip
- Crossing Behavior Before the Existence of CBX

The summary statistics for these key variables are presented in this section.

Trip Purpose

Survey participants were asked to report their primary trip purpose while using CBX. The share of responses for the different trip purposes is reported in Figure 8, broken down by the place of living given by each respondent.

Figure 10. Trip Purpose by CBX Users by Self-Reported Place of Residence



The vast majority of CBX users, regardless of their self-reported place of residence, reported an airport / recreation / vacation trip purpose, with family or social visit having also an important share of the responses (though the share of this purpose is significantly lower than that of airport / recreation / vacation). The other trip purposes received a low share of responses.

Expenditure per Trip

The participants on this survey were asked to report their expenditure (per person) during the trip. The average and median expenditures estimated from the sample are presented in Table 24.

Table 24. Average and Median Expenditures for CBX Users, by Country of Self-Reported Residence

Expenditure ($) per person	Crossers living in Mexico	Crossers living in the U.S.
Average Expenditure	$1,139	$1,163
Median Expenditure	$1,000	$780

Both the average and the median expenditure by this group of crossers is considerably higher than the average and median expenditure for crossers that use land modes. As in the case of crossings on the other six POEs in the region, median expenditures of CBX users are lower than average expenditures. Even though the average between crossers living in Mexico is similar to that of crossers living in the U.S., the median for CBX users that reported living in Mexico is significantly higher than the median for CBX users that reported living in the U.S.

Crossing Behavior Before CBX

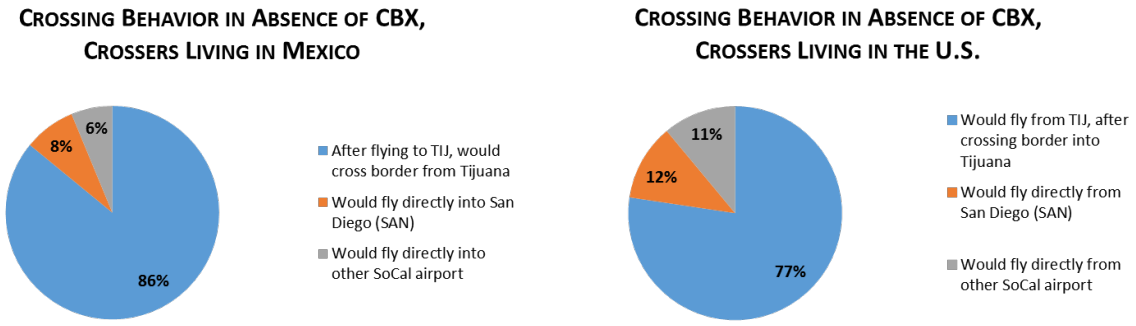
The survey asked respondents about their use of the Tijuana airport before CBX existed. The share of responses by country of self-reported residence is presented in the table below. Note that questions were phrased differently depending on the place of residence to capture the different nature of the trips.

Crossers living in Mexico: Before the CBX terminal opened, had you ever flown into the Tijuana Airport in order to visit the US?	**Number of Responses**	**%**
No	74	40%
Yes	112	60%
Crossers living in the U.S.: Before the CBX terminal opened, had you ever flown into the Tijuana Airport before to visit Mexico?	**Number of Responses**	**%**
No	77	32%
Unsure/DK/NA	5	2%
Yes	161	66%

For CBX users that live in Mexico, approximately 60 percent of them had use the Tijuana airport before CBX opened. A slightly higher percentage (66 percent) of CBX users that live in the U.S. used the Tijuana airport before CBX began operations.

As a follow-up question, respondents were asked to report their border-crossing behavior related to air travel in the absence of CBX. The shares of the responses provided by the survey participants to the different alternatives presented to them are provided in Figure 9, by self-reported place of residence.

Figure 11. Crossing Behavior in Absence of CBX by Self-Reported Place of Residence



Current users of CBX, regardless of their place of residence, reported that they would cross the border before or after flying out of the Tijuana airport instead of flying into or out of other regional airports (i.e., San Diego or other Southern California airports).

Summary Statistics for Other Relevant Variables

The survey captured information on other relevant variables that may not be the key drivers of economic impacts in the region but are relevant to understanding behavioral patterns of border crossers. Two variables are worth mentioning in this report:

- Origin-destination of crossborder trips
- Productivity loss due to delays at the border

The summaries of these variables are presented as simple averages of the responses collected through the SANDAG Border Survey.

Origin-Destination of Crossborder Trips

The SANDAG Border Survey included questions about the origin and the destination of the trip the interviewee was taking at the time he or she was surveyed. Even though the origin and destination of each trip is recorded in the SANDAG Border Survey database, reporting about them by origin-destination pair is complicated due to the long list of possibilities. Therefore, in order to represent these origins and destinations in a simplified way, the results are presented by country where the trip began or ended (i.e., U.S. or Mexico) and by component of the trip (i.e., origin or destination). As such, this document presents the flows of border crossers in the following way: 1) trips originating in Mexico; 2) trips originating in the U.S.; 3) trips ending in Mexico; 4) trips ending in the U.S.[34]

Within each country, we identify a number of relevant zones for reporting origins and destinations. In the case of Mexico, the main areas considered are Tijuana, Mexicali, Tecate, Algodones and Ensenada and an “external zone” that captures origins or destinations outside these cities. In the case of the U.S., the relevant zones considered for reporting are broken down by county to provide further detail. For San Diego County, the areas considered are Carlsbad, Chula Vista, Coronado, Del Mar, El Cajon, Encinitas, Escondido, Imperial Beach, La Mesa, Lemon Grove, National City, Oceanside, Poway, San Diego, San Marcos, Santee, Solana Beach, Vista and the unincorporated areas of San Diego County. For Imperial County, the areas considered are Brawley, Calexico, Calipatria, El Centro, Holtville, Imperial, Westmorland, and unincorporated areas. The U.S. also has an “external” zone that captures origins or destinations outside the areas listed under San Diego and Imperial Counties.

When it comes to origins of border-crossing trips, the survey shows that approximately 88 percent of the trips that begin in Mexico start in either Tijuana or Mexicali. The survey also captured trips (approximately 6 percent of the respondents) that began outside of the main areas considered in Baja California.

For border-crossing trips originating in the U.S., the survey shows that almost 80 percent begin in San Diego County (with the majority of those starting within the City of San Diego), a little over 10 percent begin in Imperial County and approximately 10 percent start outside of San Diego and Imperial Counties (the majority of those start in the State of California).

[34] Maps are presented in Appendix 3.

Regarding destinations in Mexico, Tijuana and Mexicali account for 76 percent of all border-crossing trips captured through the SANDAG Border Survey. Trips ending in areas outside of the regions considered in our list accounted for approximately 16 percent.

Finally, 61 percent of the U.S. destinations listed for border-crossing trips are in San Diego County (primarily within the City of San Diego), 27 percent are in Imperial County and approximately 11 percent are in regions outside of these two counties.

A table capturing the share of origins and destinations in each region considered is presented in Table 25, broken down by country.

Table 25. Share of Origins and Destinations by Region

Region	Share of Origins	Share of Destinations
In Mexico		
Tijuana	47%	44%
Mexicali	41%	32%
Tecate	2%	1%
Algodones	4%	7%
Ensenada	<1%	0%
External	6%	16%
In the U.S.		
In San Diego County	*79%*	*61%*
San Diego	57%	43%
Chula Vista	1%	12%
National City	0%	1%
Solana Beach	0%	1%
Lemon Grove	0%	1%
Santee	0%	<1%
La Mesa	0%	<1%
Carlsbad	0%	<1%
Coronado	0%	<1%
Poway	0%	<1%
Escondido	0%	<1%
Oceanside	0%	<1%
Imperial Beach	5%	<1%
Del Mar	0%	<1%
Vista	0%	<1%
Unincorporated	16%	4%
In Imperial County	*11%*	*27%*
Calexico	6%	17%
El Centro	3%	7%
Imperial	1%	1%
Brawley	1%	1%
Calipatria	0%	<1%
Holtville	0%	<1%
Westmorland	0%	<1%
Unincorporated	<1%	1%
External	*10%*	*11%*

Productivity Loss

Interviewees were also asked to report the impacts on their productivity resulting from delays at the border. In particular, survey participants were asked to identify what would happen to their number of hours worked on a given day if they arrived one hour late to work due to delays at the POEs. The options given were the following: 1) make up the lost hour; 2) see their paycheck reduced by 1 hour; 3) lose the entire day or work; or 4) other.[35]

Pedestrians in general reported being more likely to be able to make up for their hour lost. The exception to this is crossers living in the U.S. and crossing through Imperial, whose response was "other" though the number of responses was only one. However, a significant number (more than 20 percent) of crossers living in Mexico and crossing through Imperial County POEs responded that they could lose their entire day of work if they were an hour late. The share of pedestrian responses by country where the respondent lives and the county where the crossing POE is located is presented in the table below.

Table 26. Productivity Loss Results for Pedestrians

Productivity Loss Responses, percentage	Living in Mexico		Living in the U.S.	
	Imperial	San Diego	Imperial	San Diego
Can make up hour of work	48.3%	69.3%	0.0%	80.0%
Paycheck will be one hour less	31.0%	22.9%	0.0%	20.0%
Will lose day of work	20.7%	5.7%	0.0%	0.0%
Other	0.0%	2.1%	100.0%	0.0%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**

The number of survey respondents that are able to make up the hour of work due to delays at the border is also high for vehicle crossers, but the percentage of interviewees that reported that their paycheck will be one hour less is also considerable. The share of respondents that mentioned they would lose the entire day of work was lower for crossers using Imperial County POEs compared to that share for pedestrians. The share of responses from vehicle crossers is presented in the table below by country where the respondent lives and the county where the crossing POE is located.

Table 27. Productivity Loss Results for Vehicle Users

Productivity Loss Responses, percentage	Living in Mexico		Living in the U.S.	
	Imperial	San Diego	Imperial	San Diego
Can make up hour of work	41.8%	55.5%	40.7%	48.1%
Paycheck will be one hour less	41.1%	35.8%	25.9%	28.8%
Will lose day of work	8.9%	5.2%	7.4%	11.5%
Other	8.2%	3.6%	25.9%	11.5%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**

[35] The survey can be used to create a "proxy" for hours of productivity lost due to increasing wait times, but this estimate is not robust since the respondents were limited by the options of answer given in the survey.

Summary of Total Border Crossing Time, Baseline Crossing Time and Delays at Crossing

The Impacts of Border Delays at the California-Baja California Land Ports of Entry study also included a data collection activity to record total border-crossing times for passenger and commercial vehicles at the six POEs in the region. In particular, total border crossing time was measured for these vehicles using a time-stamp methodology (with one observer placed on one side of the border where vehicles queue and another one at the exit of the Federal inspection complex at the other side of the border). Even though this was a separate effort from the SANDAG Border Survey, a summary of the results for this activity is presented here since it is a key input to the Economic Impact model.

As described in the Overview of Border Crossing Time Measurements section, for passenger vehicles, measurements were conducted at all POEs during the following days: July 1, 4 and 5 and October 16 and 17, 2016, or five days at each POE in total. The hours where data was collected spanned from 7 am until 7 pm. For commercial vehicles, the measurements were conducted also during five days at each POE on the following days: October 12, 13 and 14 (Tecate POE), October 19, 20 and 21, 2016 (Calexico East POE) and February 10, 13 and 14, 2017 (Otay Mesa POE), March 1-2, 2017 (Calexico East and Tecate POEs), March 8-9, 2017 (Otay Mesa POE). The hours where data was collected spanned from 8 am until 6 pm.

The data collection effort included collecting more than 12,000 observations on total border crossing times for passenger vehicles using the General Purpose, Ready Lanes and SENTRI lanes for northbound trips and a representative general lane for southbound trips across all six land POEs in the region.[36] It also included collecting more than 3,700 observations on total border crossing times for commercial vehicles using the Regular and FAST lanes for northbound trips and a representative general lane for southbound trips for those POEs that handle commercial vehicle traffic.[37] At the same time, the effort included collecting information on more than 120 crossings using GPS loggers to accurately capture the total border crossing time for passenger vehicles across the San Ysidro, Otay Mesa, Calexico East and Calexico West POEs.

The average total border-crossing times registered in the field for passenger vehicles are presented in the table below, by POE and lane type (three types of northbound lane types plus southbound). Table 28 lists the total crossing times in terms of the number of average minutes per border-crossing trip.[38]

[36] The method used to collect POV total crossing data is license plate sampling (last 5-digits of a license plate at the beginning of the queue and at the exit of the border crossing compound) as described in the Border Wait Time Data Collection Plan for this study.
[37] The method used to collect truck total crossing data is the same as that used for POVs.
[38] Detailed graphs of total border crossing times collected in the field and used to produce the averages in this section are presented in Appendix 4 by POE and lane type.

Table 28. Average Total Border-Crossing Times for Passenger Vehicles (In Minutes)

Lane Type	San Ysidro	Otay Mesa	Tecate	Calexico East	Calexico West	Andrade
NB General Purpose	79.7	78.6	42.9	76.0	78.5	44.0
NB Ready Lane	42.3	43.2		39.4		
NB SENTRI	9.7	5.3		9.8	9.0	
Southbound	5.9	6.8	1.7	4.3	4.2	1.2

Note: Total border-crossing times were collected on the days mentioned in this section between the hours of 7 am and 7 pm.

POEs in Imperial and San Diego Counties that handle large volumes of passenger vehicles (i.e., Calexico East, Calexico West, San Ysidro and Otay Mesa) have similar average total crossing times for northbound trips for the different lane types available at them. The exception is Otay Mesa for SENTRI crossers, which displays a significantly lower total crossing time compared to the other POEs. Tecate and Andrade, on the other hand, also display similar average total crossing times for the lanes available at them.

The average total border-crossing times for commercial vehicles at the three POEs in the region that handle this type of crossing are displayed in Table 29.

Table 29. Average Total Border-Crossing Times for Commercial Vehicles (In Minutes)

Lane Type	Otay Mesa	Tecate	Calexico East
NB General Purpose	95.4	38.0	60.0
NB FAST	54.2		31.7
Southbound	31.5	29.2	37.3

Note: Total border-crossing times were collected on the days mentioned in this section between the hours of 8 am and 6 pm.

For northbound flows, Otay Mesa has significantly higher average total crossing time compared to the Tecate and Calexico East POEs. For southbound flows, however, Calexico East recorded the highest average total crossing times, while Otay Mesa and Tecate recorded relatively similar measurements.

The information on total border-crossing times collected in the field was used to define a "baseline" border-crossing time that represents an "acceptable time" that vehicles need to cross the border. To do this, a statistical analysis of the total border crossing dataset was used[39] to identify percentiles in the data that would appropriately represent this "acceptable" crossing time. The specific percentiles were discussed with U.S. Customs and Border Protection (CPB) staff to determine their appropriateness and, in general, it was found that the 10th percentile is a good representation of what an acceptable border-crossing time would be.

The preliminary baseline border-crossing times for passenger vehicles are presented in Table 30, by lane type and POE. Notice these baseline times are expressed in minutes per trip.

[39] In the case of the "baseline border-crossing times" for passenger vehicles, the statistical analysis was complemented with information from a small number of GPS runs collected as part of this study.

Table 30. "Baseline" Border-Crossing Times for Passenger Vehicles (In Minutes)

Lane Type	San Ysidro	Otay Mesa	Tecate	Calexico East	Calexico West	Andrade
NB General Purpose	3.0	3.0	3.0	4.0	4.0	3.0
NB Ready Lane	3.7	2.9		5.0		
NB SENTRI	2.4	2.4		2.4	2.4	
Southbound	1.0	1.0	1.0	1.0	1.0	1.0

Note: "Baseline" times were derived from total border-crossing times collected on the days mentioned in this section between the hours of 7 am and 7 pm.

Similarly, the preliminary baseline border-crossing times for commercial vehicles are presented in the table below, expressed in minutes per trip.

Table 31. "Baseline" Border-Crossing Times for Commercial Vehicles (In Minutes)

Lane Type	Otay Mesa	Tecate	Calexico East
NB General Purpose	35.0	9.0	8.7
NB FAST	22.0		8.0
Southbound	8.1	1.0	9.6

Note: "Baseline" times were derived from total border-crossing times collected on the days mentioned in this section between the hours of 8 am and 6 pm.

The identification of a baseline border-crossing time for passenger and commercial vehicles allows for the estimation of average delay times for each lane type at each POE. This is done by subtracting the baseline crossing time for each lane type and POE from the average total crossing time for each corresponding lane type and POE. The resulting average delays at the border for passenger vehicles are shown in the table below.

Table 32. Average Border-Crossing Delay for Passenger Vehicles (In Minutes)

Lane Type	San Ysidro	Otay Mesa	Tecate	Calexico East	Calexico West	Andrade
NB General Purpose	76.7	75.6	40.0	72.0	74.5	41.0
NB Ready Lane	38.6	40.3		34.4		
NB SENTRI	7.3	2.9		7.4	6.5	
Southbound	4.9	5.8	0.7	3.3	3.2	0.2

Note: Average border-crossing delay was derived from total border-crossing times collected on the days mentioned in this section between the hours of 7 am and 7 pm.

As in the case of average total border-crossing times, average delays for northbound trips across the POEs in Imperial and San Diego Counties that handle the largest number of crossings (Calexico East, Calexico West, San Ysidro and Otay Mesa) are relatively similar, while delays for northbound trips on POEs that handle lesser volumes (Tecate and Andrade) are also similar. Again, the exception is SENTRI crossers through Otay Mesa, who experience lower average delays compared to the other POEs in the region.

The average delays for commercial vehicles are shown in the table below, expressed as number of minutes per trip.

Table 33. Average Border-Crossing Delay for Commercial Vehicles (In Minutes)

Lane Type	Otay Mesa	Tecate	Calexico East
NB General Purpose	60.4	29.0	51.4
NB FAST	32.2		23.7
Southbound	23.4	28.2	27.8

Note: Average border-crossing delay was derived from total border-crossing times collected on the days mentioned in this section between the hours of 8 am and 6 pm.

Even though Otay Mesa still shows higher delays compared to the other POEs that handle commercial traffic, the difference between this POE and Calexico East (the larger of the other two POEs with commercial crossings) is smaller compared to the case when the average total crossing times are compared.

Summary Statistics for Willingness to Pay Questions from Previous Surveys

In May and August of 2014, Crossborder Group (a member of the HDR team for the Impacts of Border Delays at the California-Baja California Land Ports of Entry study) undertook proprietary surveys at the Calexico West POEs to assess a range of economic and policy issues. The questionnaire (which was applied randomly to 784 northbound vehicles in both Regular and SENTRI lanes) included two specific questions that relate to the issue of potential demand for a tolled border crossing between Mexicali and Calexico.

Those questions were:

- "If a toll-based express lane existed with a wait of fifteen minutes or less, would you use it and how much would you be willing to pay?"; and
- "If this express toll lane existed, in a normal month how many times would you use it?"

This survey was applied to a total of 784 individual drivers of passenger vehicles at the Calexico/Mexicali I POE (Calexico West). Of those, 537 responses are from the Regular lanes and the remaining 247 responses are from the SENTRI lanes. Below are the summary results to those two questions, and other key questions, from that Crossborder Group survey.[40]

Slightly more than half (51.3 percent) of Calexico West POV drivers reported being "frequent border crossers" – crossing at least 2 or more times per week, as shown in the table below.

Table 34. Frequency of Crossing for Willingness-to-Pay Respondents

Which answer best describes how frequently you cross the border northbound?	Number of Responses	%
5+ times / week	180	23.0%
2-4 times / week	222	28.3%
1 time / week	162	20.7%
1-2 times / month	157	20.0%
Less than once / month	58	7.4%
First time crossing	5	0.6%
TOTAL	**784**	**100.0%**

During the survey time period (which included holiday travelers), nearly 80 percent reported their primary residence as either Mexicali or Imperial County, as shown in the table below. Given potential tourist respondents during the survey dates, it is possible that local border crossers may have been undercounted.

[40] All data presented here is owned by Crossborder Group, and is considered proprietary in nature. It is being provided under a limited license to HDR for its use in this study. It may not be released to the general public.

Table 35. Place of Residence for Willingness-to-Pay Respondents

In what area do you have your primary residence or do you live?	Number of Responses	%
Mexicali	420	53.6%
Imperial County	203	25.9%
Tecate	1	0.1%
Tijuana	2	0.3%
San Diego County	16	2.0%
Ensenada	4	0.5%
Rosarito	99	12.6%
Other Areas of US	34	4.3%
Other Areas of Mexico	4	0.5%
Other	1	0.1%
TOTAL	**784**	**100.0%**

To test for perceived time spent at the border, and possible demand for a tolled “express lane”, participants were asked the two questions presented in the next two tables. Notably, approximately 40 percent indicated that they spent 2:00-4:59 hours in border queues in a typical week, with just over 9 percent estimating 5+ hours (see table below).

Table 36. Perceived Wait Time per Week by Respondents

In a typical week, approximately how many hours do you estimate that you spend in your vehicle waiting in line at the border?	Number of Responses	%
0:01-0:59	254	32.4%
1:00-1:59	137	17.5%
2:00-2:59	207	26.4%
3:00-3:59	72	9.2%
4:00-4:59	39	5.0%
5:00-5:59	18	2.3%
6:00-6:59	15	1.9%
7:00-7:59	9	1.1%
8:00-8:59	2	0.3%
9:00-9:59	3	0.4%
10:00-10:59	18	2.3%
11:00-11:59	0	0.0%
12:00-12:59	3	0.4%
14:00-14:59	1	0.1%
15:00+	6	0.8%
TOTAL	**784**	**100.0%**

In terms of the tolled express lane, over 44 percent (largely SENTRI users) indicated that they wouldn't use it or be willing to pay anything, however another 40 percent stated they would be willing to pay US$2.00 or more (see table below).

If a toll-based express lane existed with a wait of fifteen minutes or less, would you use it and how much would you be willing to pay?	Number of Responses	%
Would not use or would not pay	347	44.3%
1-99 Cents	37	4.7%
$1.00-1.99	87	11.1%
$2.00-2.99	52	6.6%
$3.00-3.99	28	3.6%
$4.00-4.99	38	4.8%
$5.00-5.99	92	11.7%
$6.00-6.99	7	0.9%
$7.00-7.99	8	1.0%
$8.00-8.99	4	0.5%
$9.00-9.99	28	3.6%
$10.00+ or more	56	7.1%

Of the 437 respondents that stated they would use the tolled express lane, the majority would use it somewhat infrequently (1-5 times/month); however, nearly 28 percent indicated that they would use it more than 10 times/month (and within this, there is a subset of over 9 percent that stated they would use it more than 20 times/month). The shares of the responses for the potential use for the tolled express lanes are presented in the table below.

If this express toll lane existed, in a normal month, how many times would you use it?	Number of Responses	%
1 - 5 times /month	224	51.3%
6 - 10 times /month	91	20.8%
11 - 15 times /month	41	9.4%
16 - 20 times /month	39	8.9%
21 - 25 times /month	12	2.7%
26 - 30 times /month	30	6.9%

When the previous responses are broken down by lane type, it is clear that the tolled express lanes are more appealing to border crossers that use the Regular lanes, as the following table demonstrates.

Table 37. Breakdown of Willingness-to-Pay Responses by Lane Type

	If a toll-based express lane existed with a wait of fifteen minutes or less, would you use it and how much would you be willing to pay?												Total
	Wouldn't Use	1-99 Cents	$1.00-1.99	$2.00-2.99	$3.00-3.99	$4.00-4.99	$5.00-5.99	$6.00-6.99	$7.00-7.99	$8.00-8.99	$9.00-9.99	$10.00+ OR MORE	
Calexico West – Regular	21.4%	5.6%	15.6%	9.3%	5.2%	7.1%	16.9%	1.3%	1.5%	0.7%	5.2%	10.1%	100.0%
Calexico West – SENTRI	93.9%	2.8%	1.2%	0.8%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.8%	100.0%
Total	**44.3%**	**4.7%**	**11.1%**	**6.6%**	**3.6%**	**4.8%**	**11.7%**	**0.9%**	**1.0%**	**0.5%**	**3.6%**	**7.1%**	**100.0%**

Appendix 1: Weighting Methodology

The weighted averages of the variables relevant to the study (including averages of expenditures and wages) were generated by using the sample sizes collected in the field and scaling them up to represent actual population sizes, so that when grouped together, the values from the surveyed samples would statistically represent the actual underlying population in terms of proportions of travel modes/lane types and POE crossing volumes. Below is a description of the steps followed to generate these weighted averages:

1. The first step is to obtain averages of the relevant variable from the survey sample for each subpopulation that needs to be weighted. Each subpopulation consists of a combination of a travel mode/lane type (SENTRI, Ready Lane, General Purpose, and pedestrians) and each one of the six POEs. Additionally, for expenditures, residents of Mexico and residents of the US were kept separate because their spending patterns are expected to be different, thus adding this additional variable to the definition of a subpopulation. For the wage variable, that separation was not made, because it appeared that wages of people crossing the border for work were similar enough regardless of which direction they were crossing.

The expenditure variable will be used as the example below to outline the steps followed in the weighting process. In step 1 above, the expenditure averages for each of the relevant subpopulations were compiled (a data processing software was used but this can be done with Excel filters too). The result was a set of 38 averages because not all POEs have all lane types.

2. Vehicles are separated from the pedestrians, US residents are separated from Mexico residents, and Imperial County averages are separated from San Diego County averages (there are six groups of averages, but there are many options for formatting these groups in a spreadsheet).
3. The averages are scaled up by combining them across the subpopulations for each table using the right proportions (i.e., weights). The weighting steps can be done in any order of categories, but it is recommended to scale up using the lane types first, then scale up using the POEs. Vehicles in San Diego County crossing from Mexico are used as an example below.
    a. For each POE, there are between one and three lane types, each with a corresponding annual total border crossing volume for the most recent year (see Appendix B in the RAP workbook). The sum-product of the average expenditure by each lane type for each POE and the most recent annual volume for that same lane type and POE is calculated and then divided by the total annual border crossing volume across all lane types for that POE (i.e., the average expenditure and the border crossing volume for each lane type are multiplied, then these quantities are added; the resulting amount is then divided by the total border crossing volume for the POE, which is the sum of the border crossing volumes for all lane types).
    b. What results is the average expenditure for vehicles for each POE in San Diego, and the same scaling up process is repeated again, but at the POE level. The sum-product of the average expenditures and the border crossing volumes for each POE is calculated, then divided by the total border crossing volumes for all POEs in San Diego.

4. The result of the previous steps is one value, the average expenditure for Mexico residents crossing in vehicles in San Diego County. The same procedure is done for each group described above:
    a. San Diego vehicles for US residents
    b. San Diego Mexico resident pedestrians
    c. San Diego US resident pedestrians
    d. Imperial vehicles for Mexico residents
    e. Imperial vehicles for US residents
    f. Imperial Mexico resident pedestrians
    g. Imperial US resident pedestrians
5. Note that for vehicles, there are two levels of weighting (lane type to POE and POE to county), for pedestrians there is only one (POE to county, since all pedestrians are recorded as a single lane type). Also, for POEs with only one or two lane-types, this procedure still works, because averages and border crossing values are zero for the absent lane types (i.e. the same excel functions can be used)

For wages, one level of computational complexity is swapped for another, because there is no separation between US and Mexico residents, but the annual border crossing volumes have to be altered to only those who are crossing the border for work purposes.

1. Border crossing volumes are adjusted by multiplying the annual border crossing volumes by lane type and POE used in the scaling up of expenditures by the percent of crossers who crossed for work purposes. Worker percentages are gathered from the primary trip purpose question, by travel mode and POE (see Appendix C and D in the RAP Workbook for these percentages). At the end, there should be 19 adjusted volumes (6 for pedestrians and 13 for vehicles).
2. Wage averages calculated from the survey sample by county and by travel mode (pedestrian vs. vehicle) are separated.
3. The scaling up process continues as described in step 3 above, beginning with 19 average wage values and 19 worker border crossing volumes that have been adjusted as described in step 1 for this variable.

A sum product formula looks like this:

$$\frac{(A_1 * X_1 + A_2 * X_2 + A_3 * X_3)}{(X_1 + X_2 + X_3)}$$

Where averages for lane types or POEs are A_i and border crossing volumes for lane types or POEs are X_i. In excel, this function looks like this:

=sumproduct(A1:A3,B1:B3)/sum(B1:B3)

Where the cells A1:A3 are the averages for your subpopulation, and cells B1:B3 are the border crossing volumes.

Table 38. Border Crossing Volumes Used For Scaling The Survey Responses – Pedestrians

Northbound Border Crossings, Pedestrian Volumes (2016)	Volume
Andrade, Imperial County	833,296
Calexico East, Imperial County	253,992
Calexico West, Imperial County	4,270,911
Otay Mesa, San Diego County	3,504,800
San Ysidro, San Diego County	7,382,363
Tecate, San Diego County	673,605

Source: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics

Table 39. Border Crossing Volumes Used For Scaling The Survey Responses – Passenger Vehicles

Northbound Border Crossings, Vehicle Volumes (2016)	Volume
Andrade, Imperial County	
General purpose lane	506,230
Calexico East, Imperial County	
SENTRI lane	604,147
Ready Lane	2,222,282
General purpose lane	1,003,055
Calexico West, Imperial County	
SENTRI lane	1,810,340
General purpose lane	2,516,694
Otay Mesa, San Diego County	
SENTRI lane	1,831,119
Ready Lane	4,097,403
General purpose lane	1,793,742
San Ysidro, San Diego County	
SENTRI lane	4,664,964
Ready Lane	4,349,713
General purpose lane	4,687,290
Tecate, San Diego County	
General purpose lane	971,193

Source: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics

Appendix 2: Median Statistics for Key Variables

In order to provide a better understanding of the statistical distribution of the key variables used in the Economic Impact model, the study also estimated their median values based on the data collected under the SANDAG Border Survey.

Median Border-Crossing Trip Spending

In general, the survey data indicates that median spending per trip ranges from $50 to $87, across travel modes, border counties, and north and southbound trips. The median crosser[41] living in Mexico spends less per trip than the median crosser living in the U.S. for trips that take place in San Diego County, but the opposite is true for trips that take place in Imperial County. In general, people crossing in Imperial County spend less per trip than people crossing in San Diego County and pedestrians spend less than people driving across the border. The weighted median expenditure per trip is displayed in the table below.

Table 40. Median Spending per Border Crossing Trip

Median Spending per Border Crossing Trip, Dollars	Imperial County	San Diego County
Pedestrians		
Crossers Living in Mexico	$58	$69
Crossers Living in the U.S.	$50	$84
Vehicles		
Crossers Living in Mexico	$72	$82
Crossers Living in the U.S.	$69	$87

Median Expenditures of Border-Crossing Travelers by Expenditure Category

The SANDAG Border Survey asked border-crossing travelers to break down their trip-related expenditures by broad expenditure categories. The categories considered included entertainment, gas, groceries, hotel, public transportation, restaurants, shopping and a category called “other” to capture expenditures not listed in the survey.

The data collected was analyzed using the place where the respondent reported to live, the county where the POE used to cross is located and the mode for crossing (i.e., pedestrian or vehicles). An analysis of the survey data shows that the median crosser living in Mexico has different expenditure patterns compared to the median crosser living in the U.S. regardless of the mode and the POE used to cross.[42] The median crosser living in Mexico has a high propensity to concentrate expenditures on shopping, while the median crosser living in the U.S. diversifies expenditures across categories such as entertainment, groceries, restaurants and shopping regardless of the mode used to cross the border.

[41] The median crosser is identified as the crosser that would have the same number of crossers in front of him/her and behind him/her if the total number of crossers were sorted (from higher to lower) by the amount of money they spend on a crossborder trip.
[42] The median was identified to be the relevant statistic for this variable since it represents a breakdown of the border-crossing trip expenditure variable, whose relevant statistic is the median (as described above).

The median pedestrian living in Mexico has similar expenditure patterns regardless if the crossing takes place through San Diego or Imperial County POEs. In other words, the share of expenditures by category of the median pedestrian crosser living in Mexico that uses a POE in Imperial County is relatively similar to that of the median pedestrian crosser living in Mexico that uses San Diego POEs, even though crossers in San Diego County spend approximately $11 more per trip. Pedestrian crossers living in the U.S. also have similar expenditure patterns for most categories, even though few categories (like entertainment, hotel, and public transportation) differ significantly across the San Diego and Imperial County regions. The median (weighted) expenditures by pedestrians during border-crossing trips is presented in the table below.

Table 41. Pedestrian Median Expenditures by Category

	Imperial County	San Diego County
Crossers living in Mexico	**$**	**$**
Entertainment	$3	$3
Gas	$2	$2
Groceries	$10	$10
Hotel	$0	$3
Other	$1	$2
Public Transportation	<$1	$3
Restaurants	$5	$7
Shopping	$37	$40
Total, all categories	***$58***	***$69***
Crossers living in the U.S.		
Entertainment	$1	$10
Gas	$1	$3
Groceries	$16	$16
Hotel	$0	$7
Other	$4	$7
Public Transportation	<$1	$6
Restaurants	$13	$16
Shopping	$15	$17
Total, all categories	***$50***	***$84***

As in the case of pedestrians, the median vehicle crosser living in Mexico has similar expenditure patterns regardless of the location of the crossing used to enter the U.S. even though crossers in San Diego County spend approximately $10 more per trip. The percentages on the individual categories, however, show slightly more variation than those of pedestrians living in Mexico, but still concentrate heavily on shopping. Median crossers living in the U.S. diversify their expenditures more compared to median crossers living in Mexico, but the shares of expenditures for categories such as gas, groceries and shopping are very similar regardless of the county used to cross. The median (weighted) expenditures by vehicle users during border-crossing trips is presented in the table below.

Table 42. Vehicle Users Median Expenditures by Category

	Imperial County	San Diego County
Crossers living in Mexico	**$**	**$**
Entertainment	$5	$3
Gas	$7	$8
Groceries	$14	$11
Hotel	$0	$2
Other	$2	$2
Public Transportation	$0	$0
Restaurants	$7	$6
Shopping	$36	$50
Total, all categories	***$72***	***$82***
Crossers living in the U.S.		
Entertainment	$9	$5
Gas	$6	$8
Groceries	$11	$15
Hotel	$2	$5
Other	$10	$11
Public Transportation	$0	<$1
Restaurants	$10	$19
Shopping	$20	$24
Total, all categories	***$69***	***$87***

Alternate Median Spending in Home Country

The median expenditure ranges from $43 for pedestrians living in the U.S. and crossing through Imperial County POEs to $81 for vehicle occupants living in Mexico and crossing through POEs in Imperial County.[43] In general, the median crosser living in Mexico has higher average expenditures in their home country than the median crosser living in the U.S. across modes when a border crossing trip is not taken. The exception is the median pedestrian crosser using San Diego POEs, since the median crosser living in the U.S. averages $62 of home expenditure when a border trip is not taken compared to $58 for the median crosser living in Mexico. A possible explanation for this is that the expenditure categories include groceries, shopping and restaurants, which are more expensive in the U.S.

[43] It is worth noting that the behavior of home consumption differs by mode and POE location of the forgone crossing.

The median spending at home if a border trip is not taken is reported in Table 43.

Table 43. Median Spending at Home if Border Crossing Trip is Not Taken

Median Spending at Home if Border Trip is not taken, per Trip, Dollars	Imperial County	San Diego County
Pedestrians		
Crossers Living in Mexico	$70	$58
Crossers Living in the U.S.	$43	$62
Vehicles		
Crossers Living in Mexico	$81	$72
Crossers Living in the U.S.	$53	$49

Notice that in the majority of the cases the median expenditure at home if a border trip is not taken is smaller than the average spending for border crossing trips made. The exceptions are pedestrian crossers that live in Mexico and cross through Imperial County POEs and vehicle crossers that live in Mexico and cross through Imperial County, whose at-home median spending if a trip is not taken are higher than their median spending while on a crossborder trip. There could be several explanations to this result, including price differences between goods and services between the two sides of the border that belong to expenditures categories that are less likely to be deferred by this group of border-crossers when a border trip is not taken.

Median Expenditures by Expenditure Category If Trip is Not Taken

An analysis of the survey data shows that, in general, the median pedestrian crosser that decides not to take a border-crossing trip has a tendency to spend at home primarily on groceries and shopping, regardless of where the crosser lives or the county of crossing.[44] For crossers living in the U.S. and crossing through San Diego County, a category of home expenditure that is also significant is restaurants. The median (weighted) expenditures at home by pedestrians in case a border-crossing trip is not taken are presented in Table 44.

[44] As in the case of expenditures of border-crossing trips by category, the relevant statistic for this variable is the median since it consists of the breakdown of another key variable identified by its median (i.e., alternate spending in home country).

Table 44. Median Expenditures at Home by Pedestrians if Border Crossing Trip is Not Taken

	Imperial County	San Diego County
Crossers living in Mexico		
Entertainment	$3	$1
Gas	$3	$1
Groceries	$11	$15
Hotel	$0	$4
Other	$2	$8
Public Transportation	$0	$6
Restaurants	$4	$6
Shopping	$48	$18
Total, all categories	***$70***	***$58***
Crossers living in the U.S.		
Entertainment	$0	$7
Gas	$0	$3
Groceries	$15	$18
Hotel	$0	$0
Other	$3	$0
Public Transportation	$0	$1
Restaurants	$3	$22
Shopping	$21	$11
Total, all categories	***$43***	***$62***

As in the case of the median pedestrian, the median vehicle crosser that decides not to take a border-crossing trip has a tendency to spend at home primarily on groceries and shopping, regardless of where the crosser lives or the county of crossing. However, other categories that also represent significant home expenditure regardless of where the crosser lives or the POE used are gas and restaurants. The median (weighted) expenditures at home by vehicle crossers in case a border-crossing trip is not taken are presented in Table 45.

Table 45. Median Expenditures at Home by Vehicle Users if Border Crossing Trip is Not Taken

	Imperial County	San Diego County
Crossers living in Mexico		
Entertainment	$11	$3
Gas	$9	$9
Groceries	$18	$11
Hotel	$1	$1
Other	$3	$0
Public Transportation	$0	$0
Restaurants	$10	$9
Shopping	$30	$39
Total, all categories	***$81***	***$72***
Crossers living in the U.S.		
Entertainment	$2	$3
Gas	$4	$7
Groceries	$9	$13
Hotel	$0	$1
Other	$10	$1
Public Transportation	$0	$0
Restaurants	$9	$11
Shopping	$18	$14
Total, all categories	***$53***	***$49***

Median Wages

The median monthly wage for a pedestrian crossing the border for work is $758 in San Diego County and $604 in Imperial County. For people driving across the border, the weighted median for Imperial County is around $1,700 while the weighted median for San Diego County is $1,126.

Table 46. Median Monthly Wage by Mode and County of Crossing

Weighted Median Monthly Wage/Salary, Dollars	Imperial County POEs	San Diego County POEs
Pedestrians crossing for work	$604	$758
People crossing in vehicles for work	$1,693	$1,126

Appendix 3: Origins and Destinations of Crossborder Trips

The data collected on origin or destination of border crossing trip is presented in this appendix with corresponding maps and graphs. As stated earlier in the report, the results are presented by country where the trip began or ended (i.e., U.S. or Mexico) and by component of the trip (i.e., origin or destination). The survey data for this variable are reflective of respondents crossing via privately-owned vehicle (POV) only.

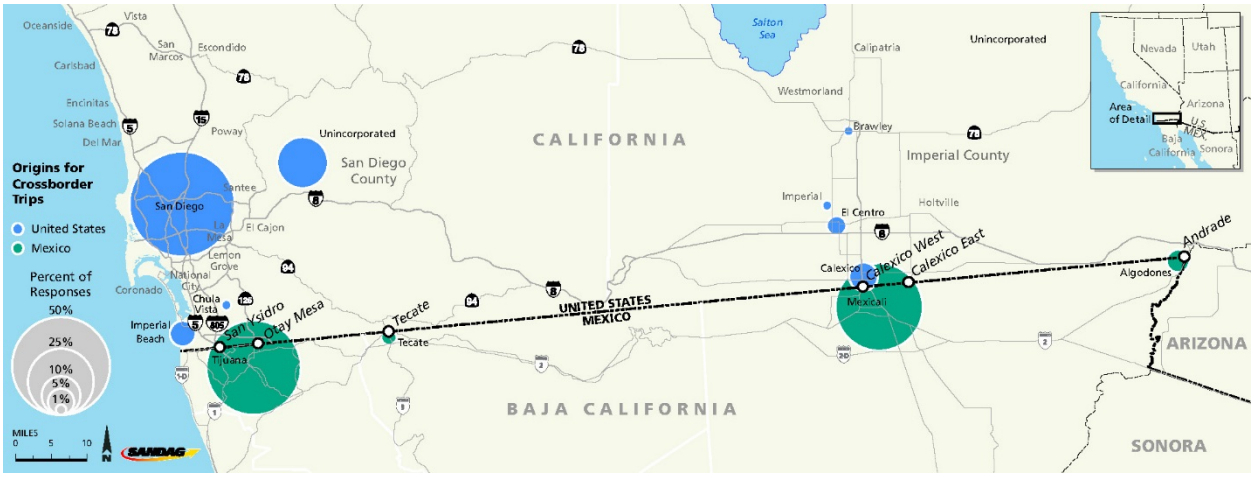
Symbols shown in the maps below are meant to show the overall proportion of trip origins or destinations by jurisdiction and are not a precise representation of actual origin or destination locations.

Relevant zones not shown in the graphs below were either not identified as origins or destinations by survey respondents or had proportionate responses of less than 1 percent of the data set. Excluded from the graphs presented below are the following zones and cities in the U.S. for:

1) Origins: Calipatria, Carlsbad, Coronado, Del Mar, Escondido, Holtville, La Mesa, Lemon Grove, National City, Oceanside, Poway, Santee, Solana Beach, Unincorporated Imperial County, Vista, Westmorland, and the “external zone” that captures other areas in the U.S. outside of these cities.
2) Destinations: Calipatria, Carlsbad, Coronado, Del Mar, Escondido, Holtville, Imperial Beach, La Mesa, Oceanside, Poway, Santee, Vista, Westmorland and the “external zone” that captures other areas in the U.S. outside of these cities.

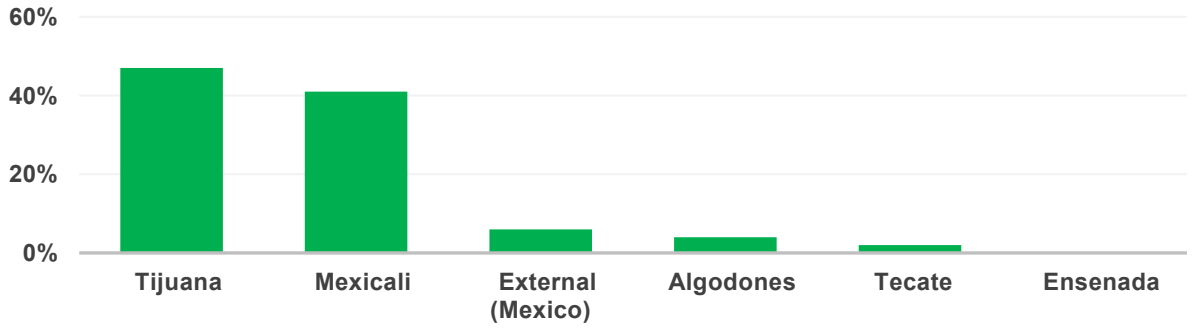
Crossborder Trip Origins

Figure 12. Crossborder Trip Origins, POV Crossers



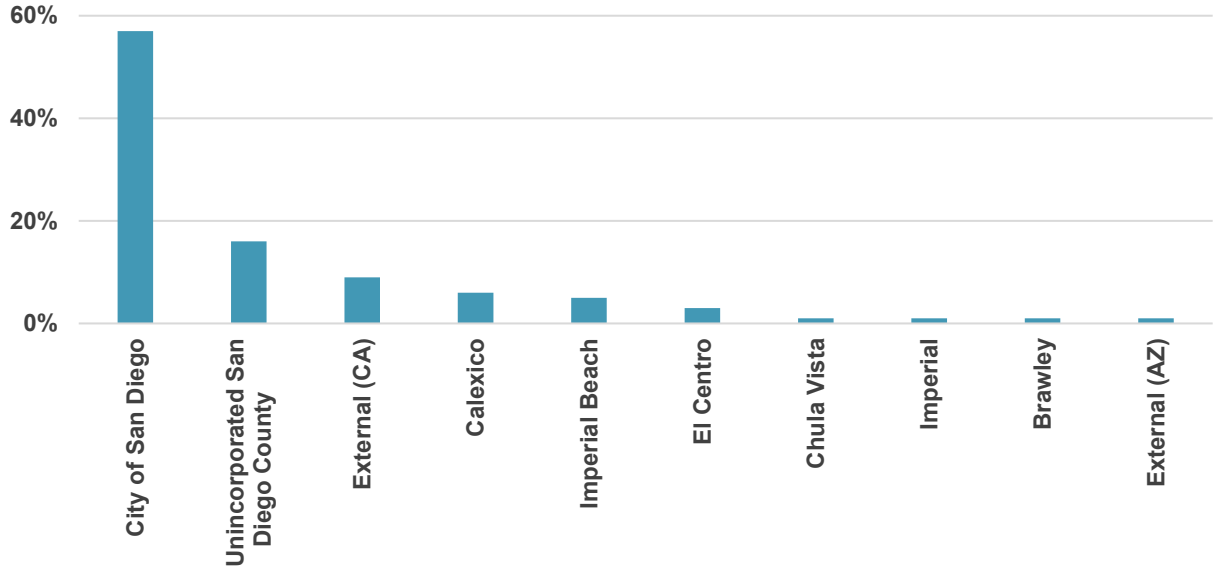
Source: SANDAG Border Survey, 2016

Figure 13. Share of Origins in Mexico, POV Crossers



Source: SANDAG Border Survey, 2016

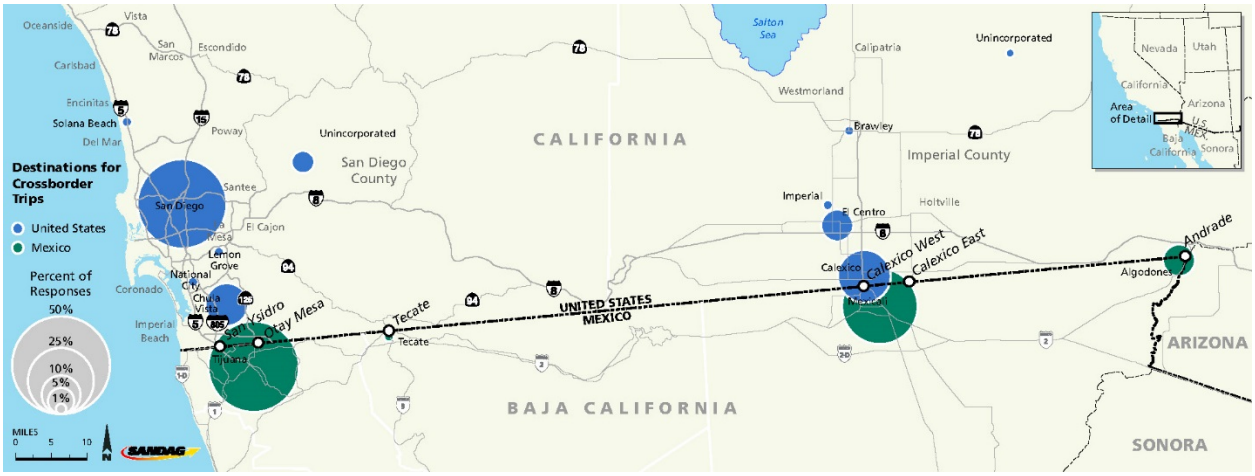
Figure 14. Share of Origins in the U.S., POV Crossers



Source: SANDAG Border Survey, 2016

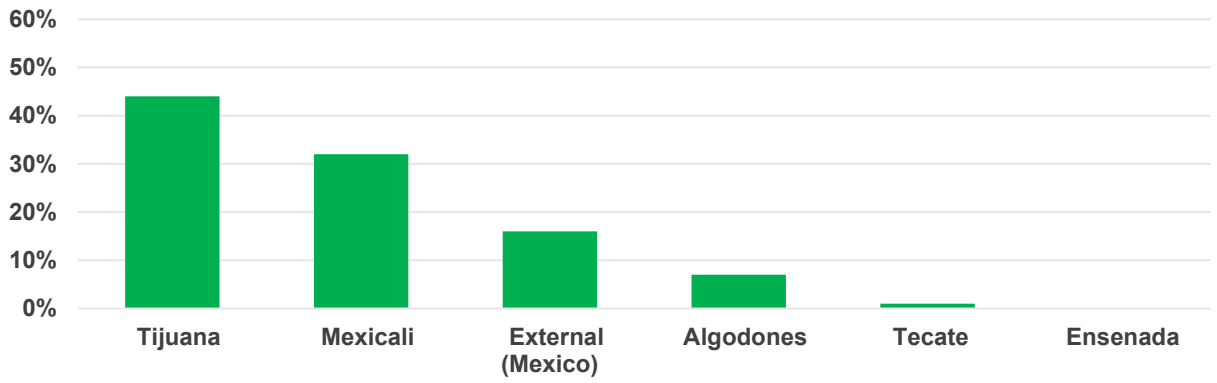
Crossborder Trip Destinations

Figure 15. Crossborder Trip Destinations, POV Crossers



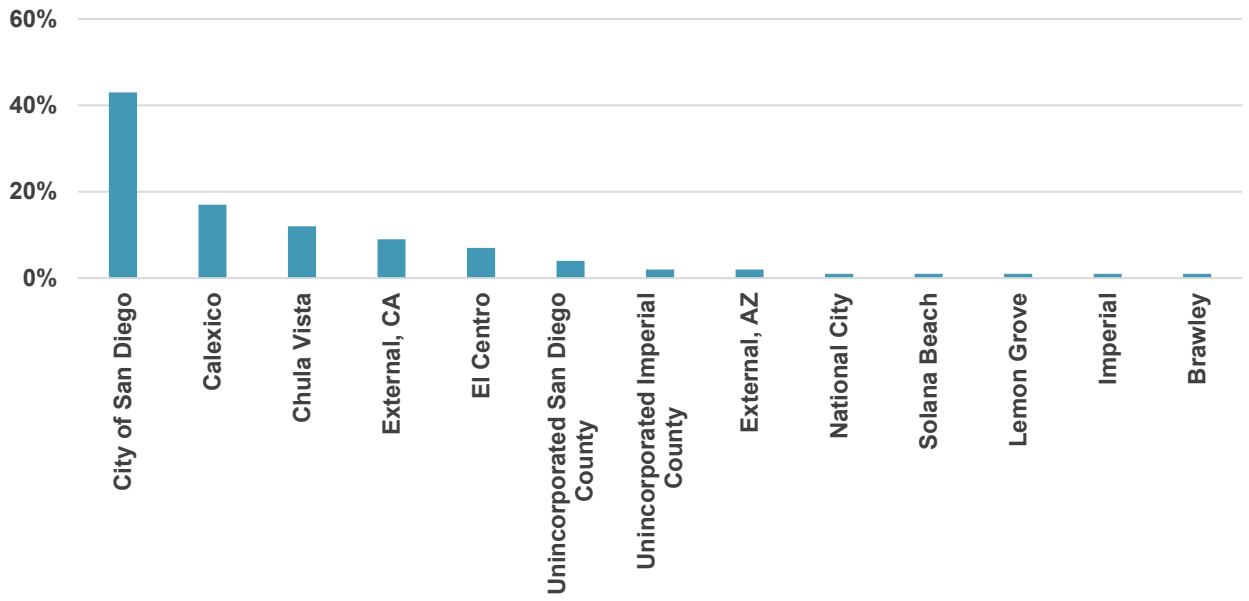
Source: SANDAG Border Survey, 2016

Figure 16. Share of Destinations in Mexico, POV Crossers



Source: SANDAG Border Survey, 2016

Figure 17. Share of Destinations in the U.S., POV Crossers



Source: SANDAG Border Survey, 2016

Appendix 4: Graphs of Total Border Crossing Times Collected in the Field

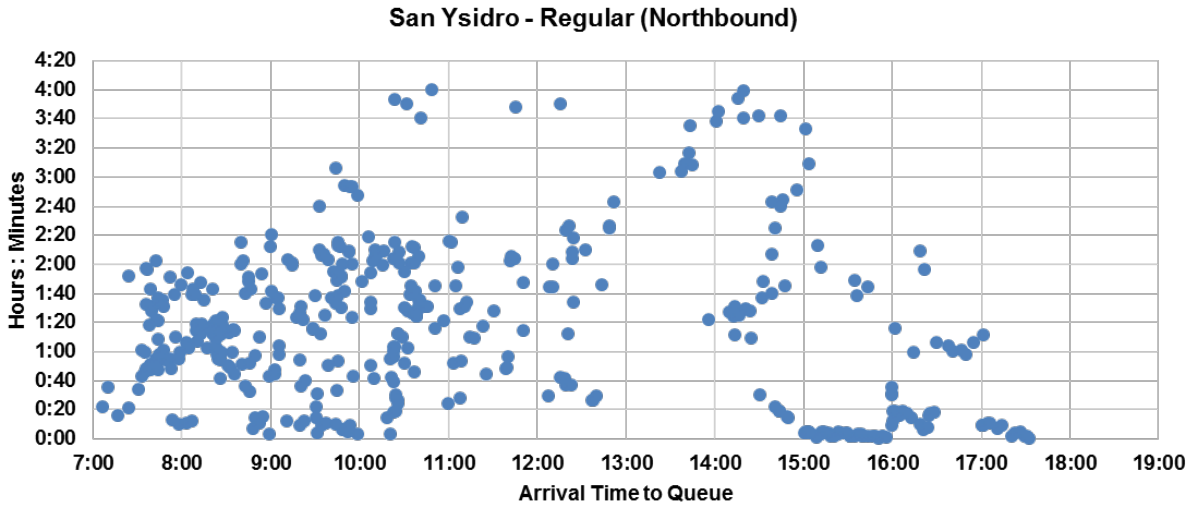
The data collected on total border crossing times is presented in this appendix by vehicle type, POE and lane type. Based on discussions with CBP personnel, the data to produce the summary wait times excludes those observations above 4 hours of total border crossing time. The graphs presented below exclude these "outliers."

Notice that in the graphs the blue dots represent actual observations and that the graphs aggregate the data from all days when border-crossing times where collected. As a result, a particular time of arrival to the queue may be associated with multiple observations for border-crossing time (each one of them representing a different date of collection). Since the dates when data was collected include different seasons of the year, this aggregation also explains potential variances observed in border-crossing times for a particular time of arrival to the queue.

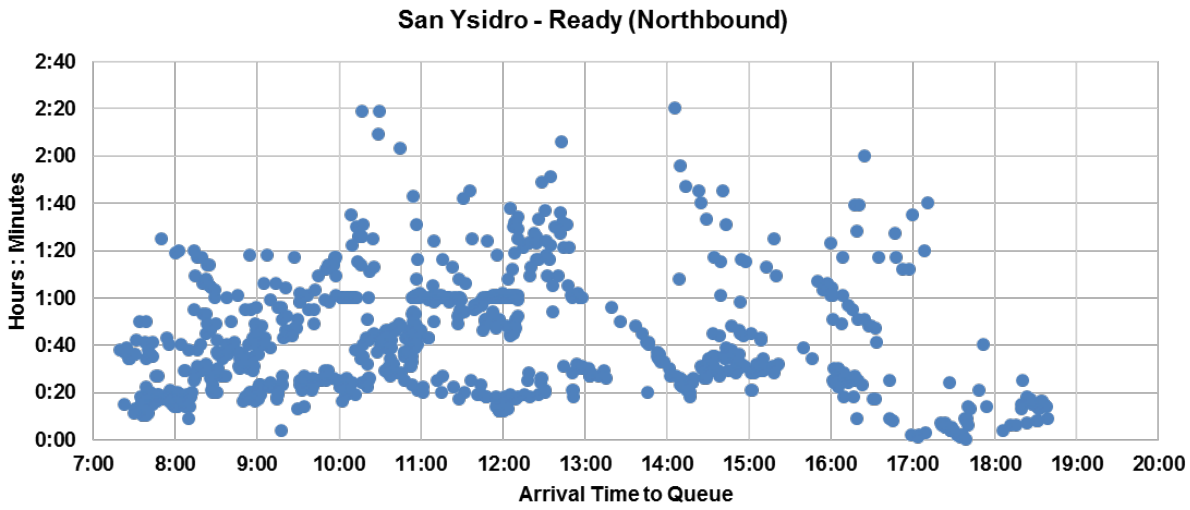
Passenger Vehicles

The graphs for the total border crossing times of passenger vehicles are presented by lane type (southbound flows are treated as a lane type) for each POE in the following order: San Ysidro, Otay Mesa, Tecate, Calexico West, Calexico East and Andrade.

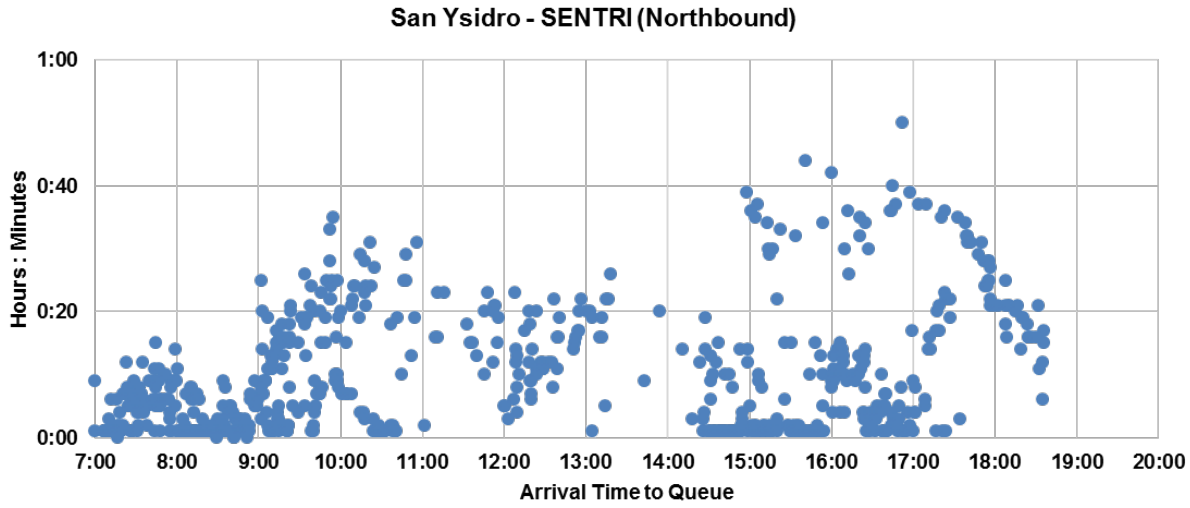
SAN YSIDRO POE



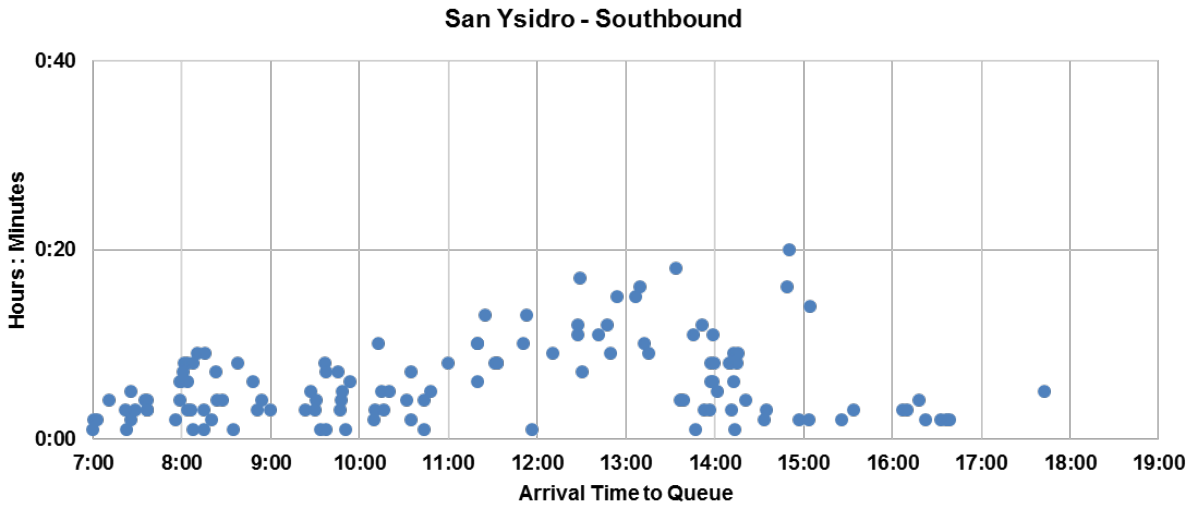
Note: Data collected on July 1, 4, 5 and October 16 and 17, 2016



Note: Data collected on July 1, 4, 5 and October 16 and 17, 2016

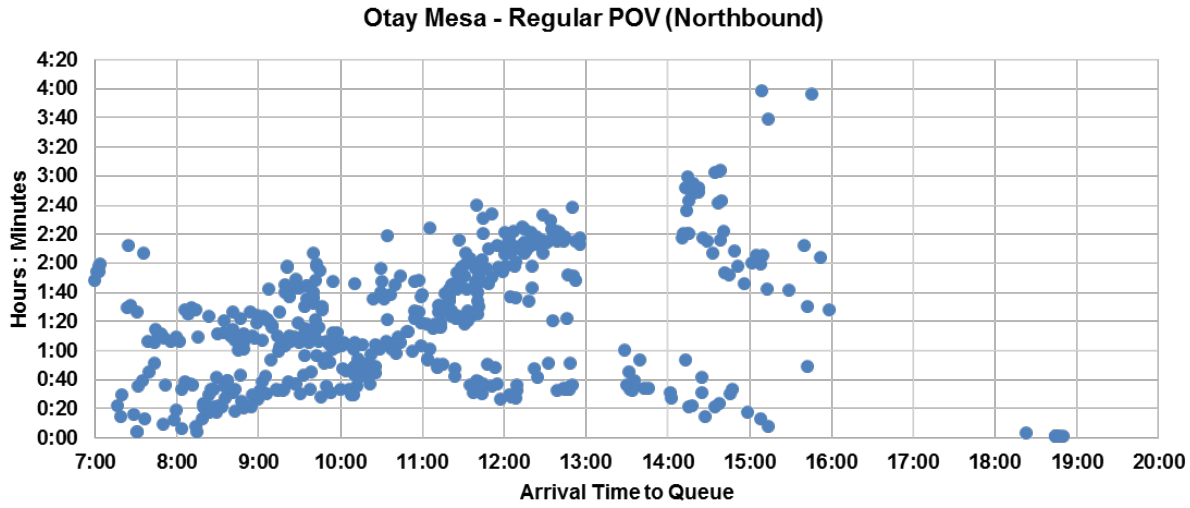


Note: Data collected on July 1, 4, 5 and October 16 and 17, 2016

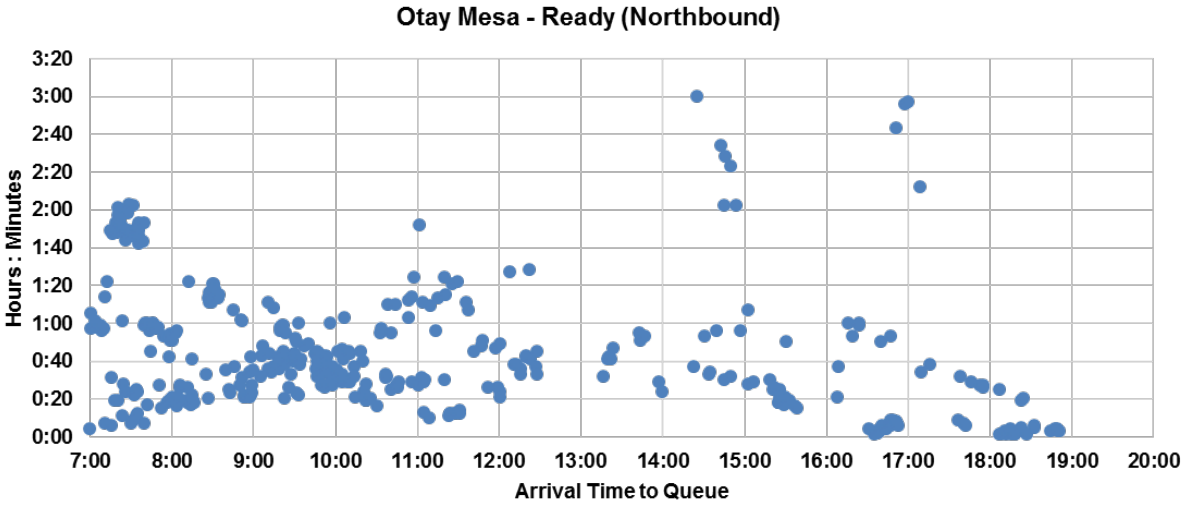


Note: Data collected on July 4, 5 and October 16 and 17, 2016

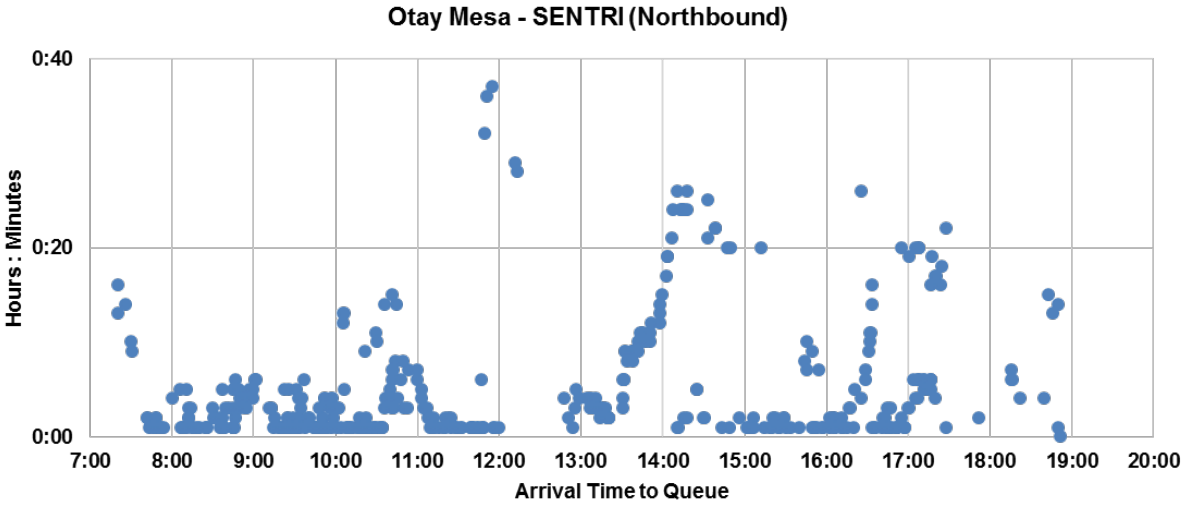
OTAY MESA POE



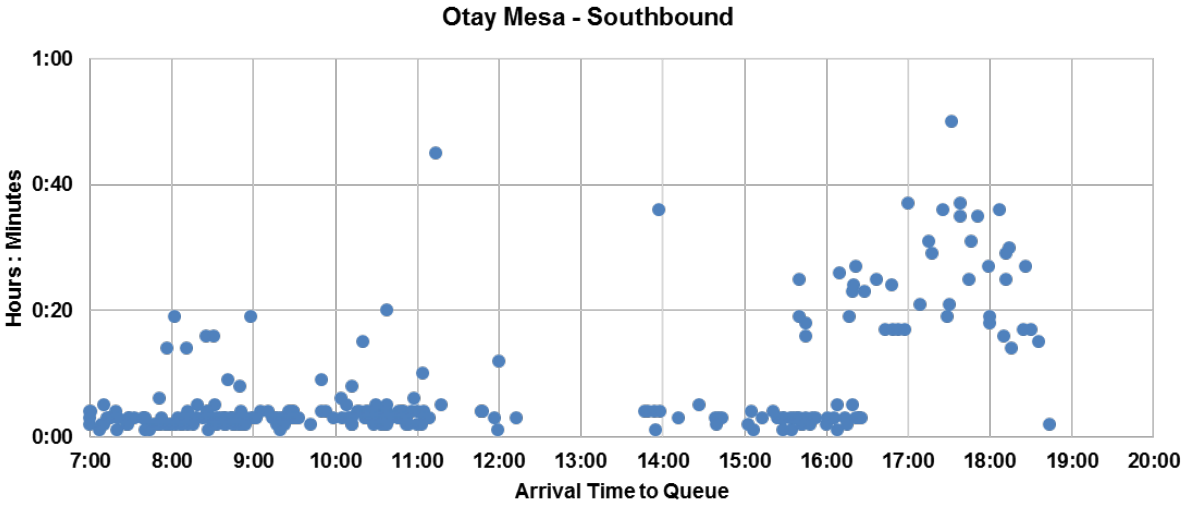
Note: Data collected on July 1, 4, 5 and October 16 and 17, 2016



Note: Data collected on July 1, 4, 5 and October 16 and 17, 2016

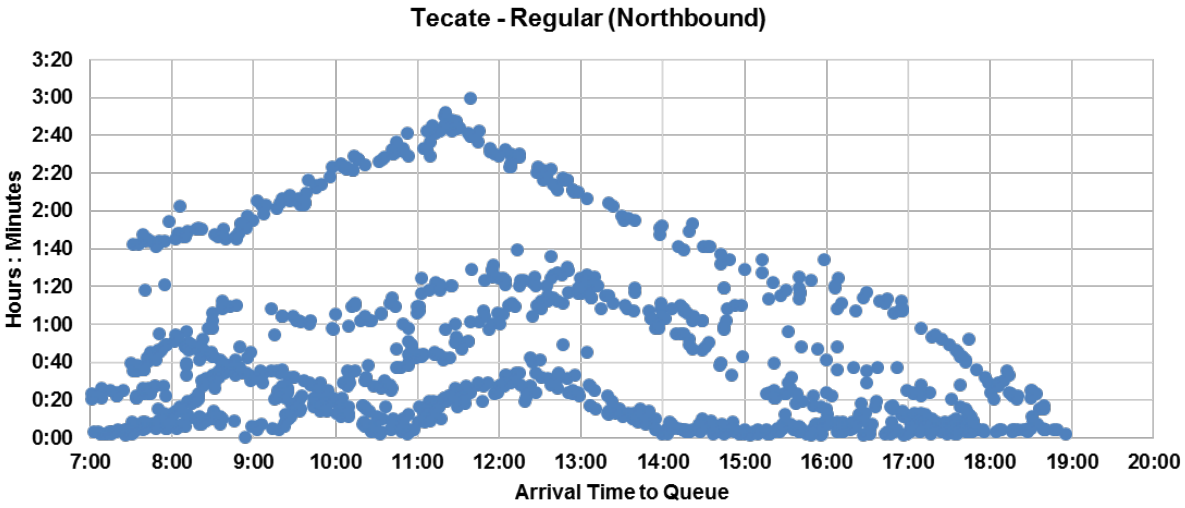


Note: Data collected on July 1, 4, 5 and October 16 and 17, 2016

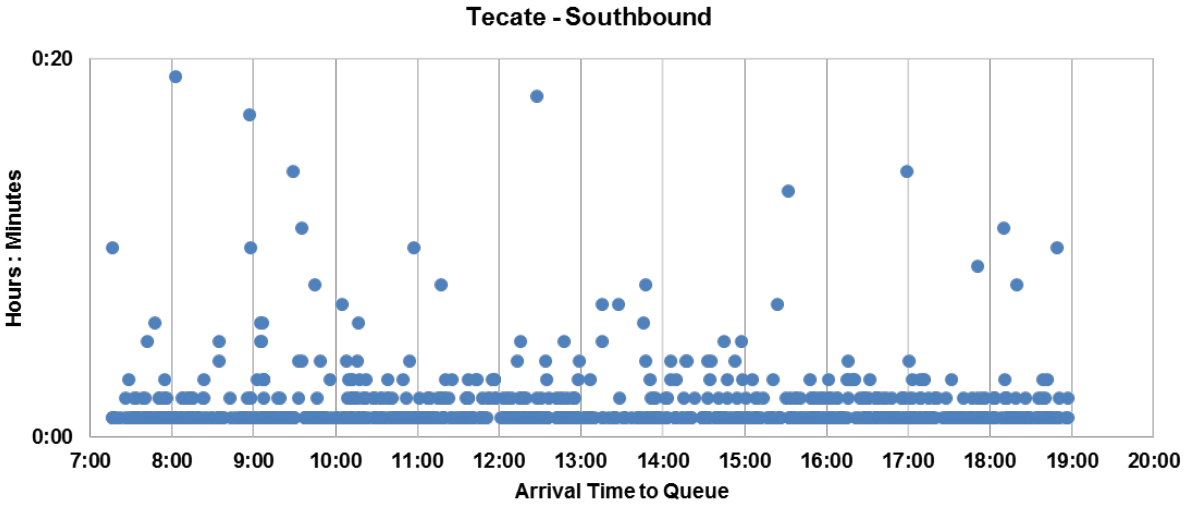


Note: Data collected on July 1, 4, 5 and October 16 and 17, 2016

TECATE POE

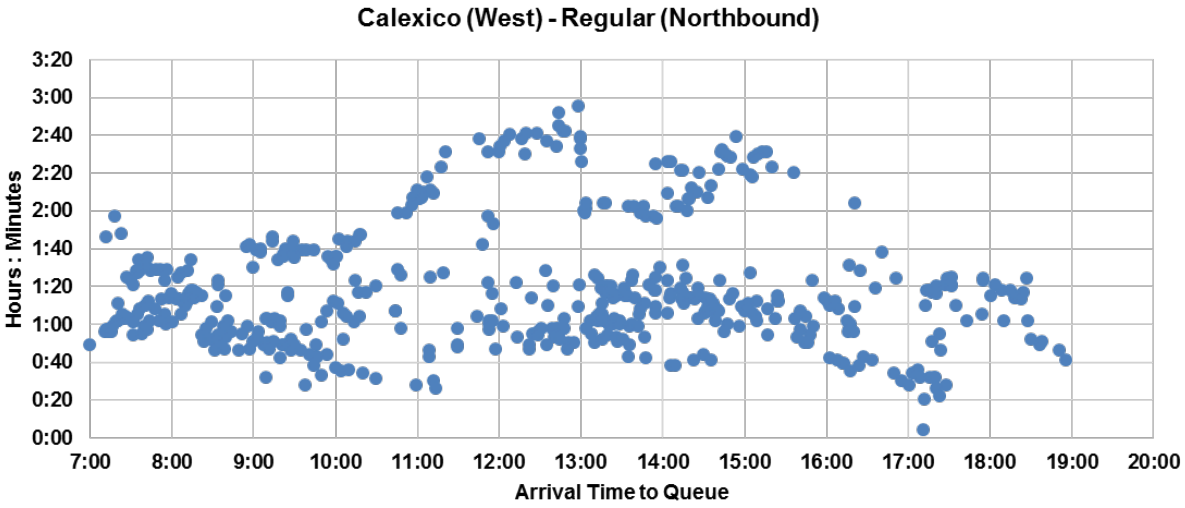


Note: Data collected on July 1, 4, 5 and October 16 and 17, 2016

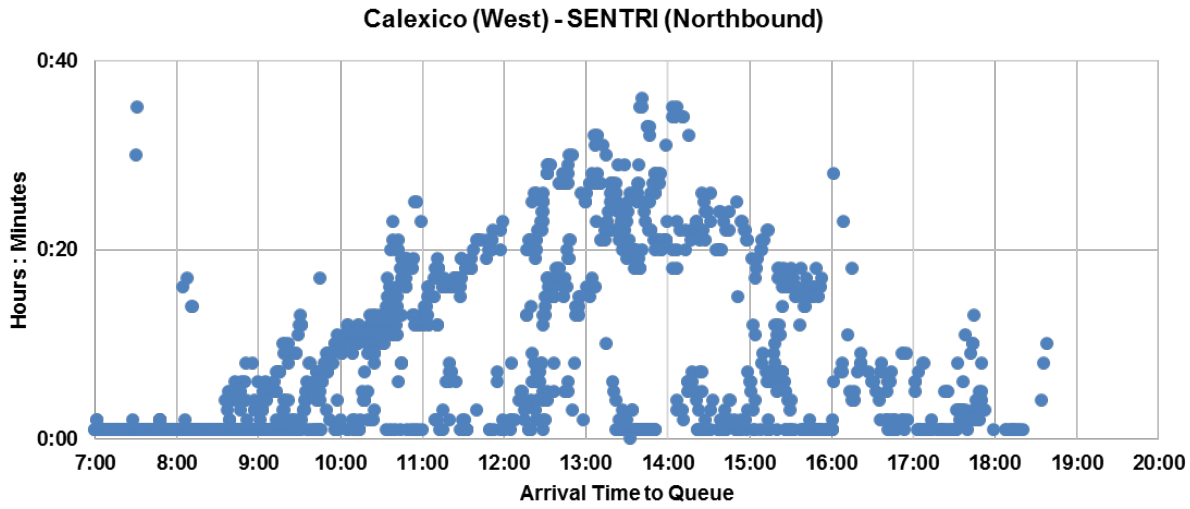


Note: Data collected on July 1, 4, 5 and October 16 and 17, 2016

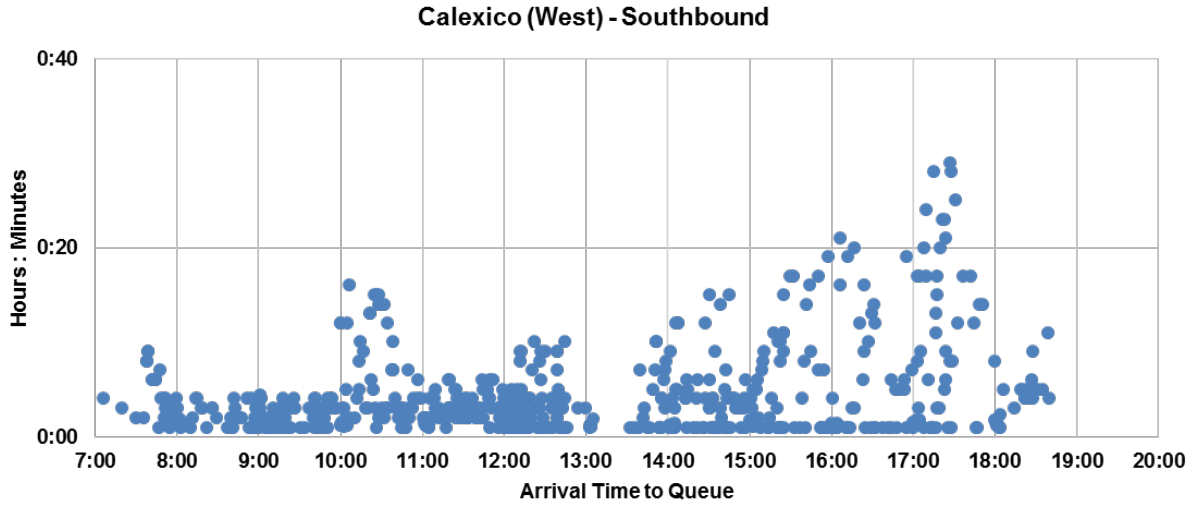
CALEXICO WEST POE



Note: Data collected on July 1, 4, 5 and October 16 and 17, 2016

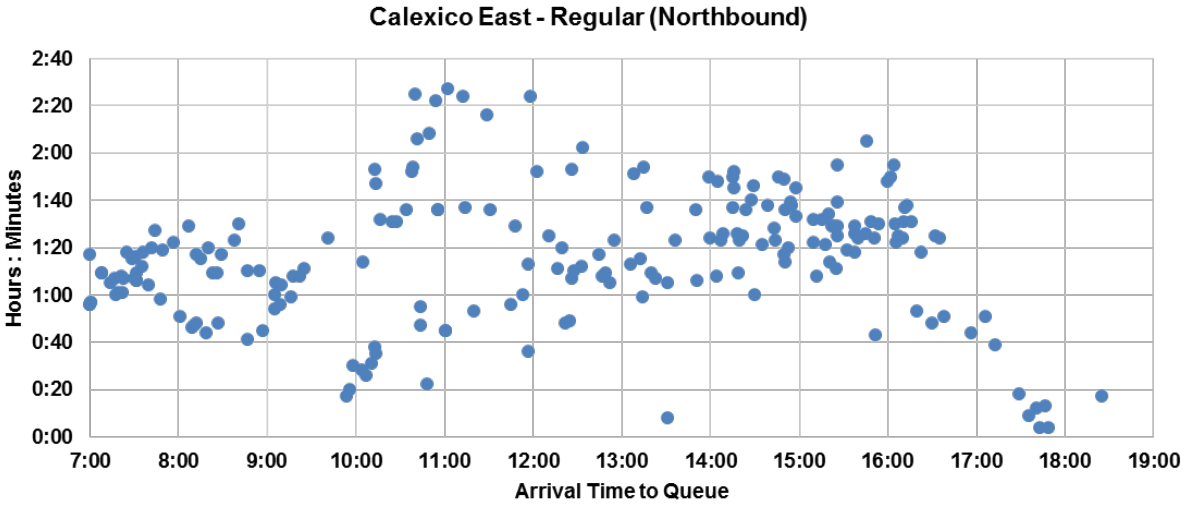


Note: Data collected on July 1, 4, 5 and October 16 and 17, 2016

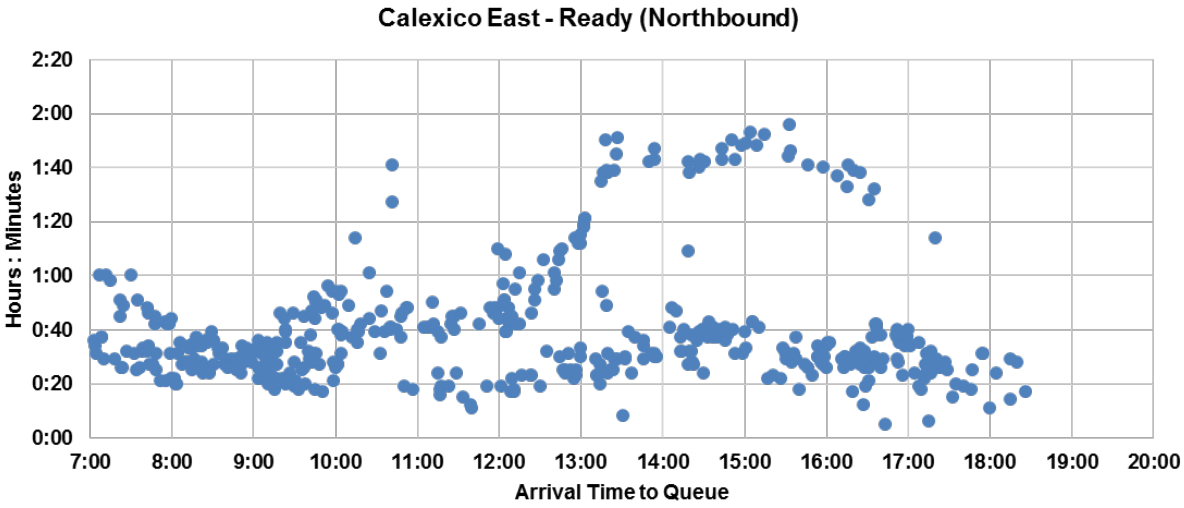


Note: Data collected on July 1, 4, 5 and October 16 and 17, 2016

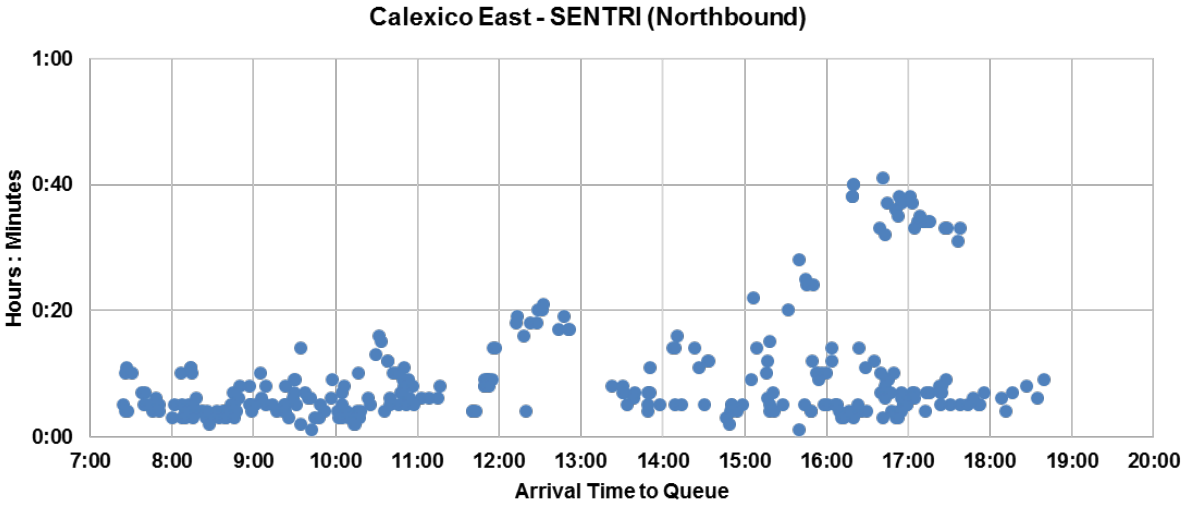
CALEXICO EAST POE



Note: Data collected on July 1, 4, 5 and October 16 and 17, 2016



Note: Data collected on July 1, 4, 5 and October 16 and 17, 2016



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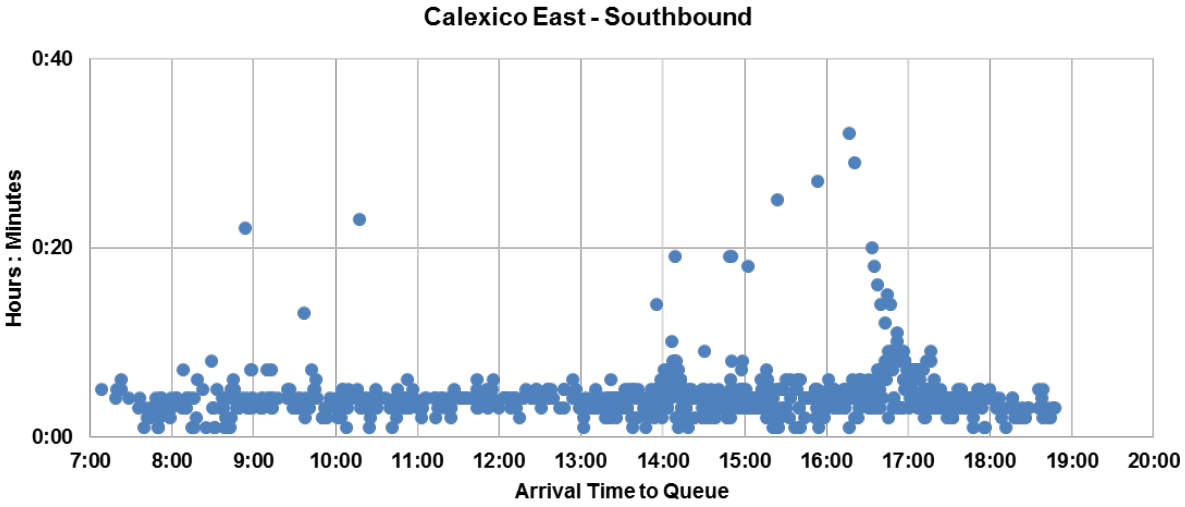
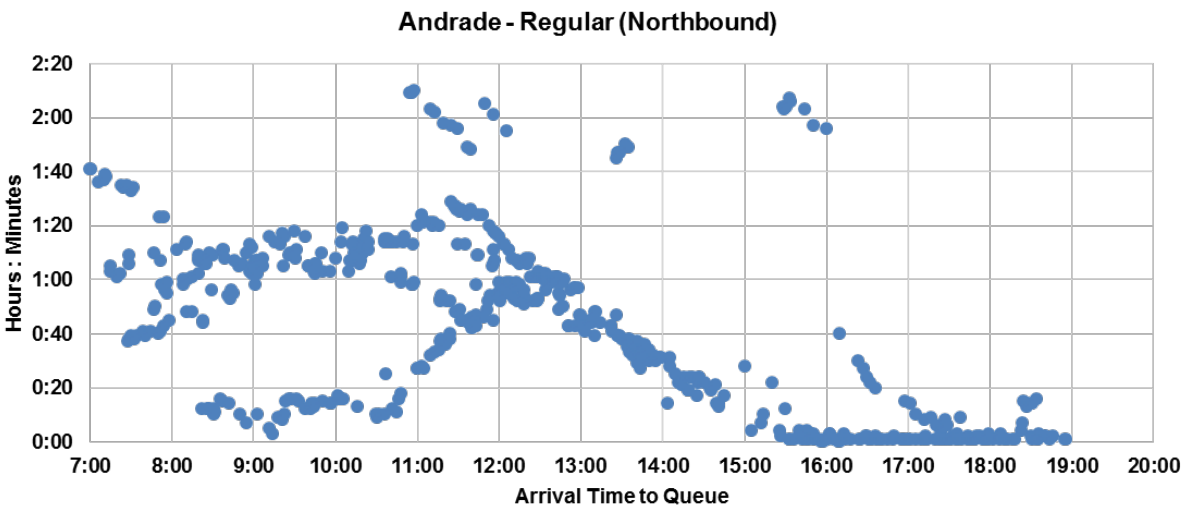
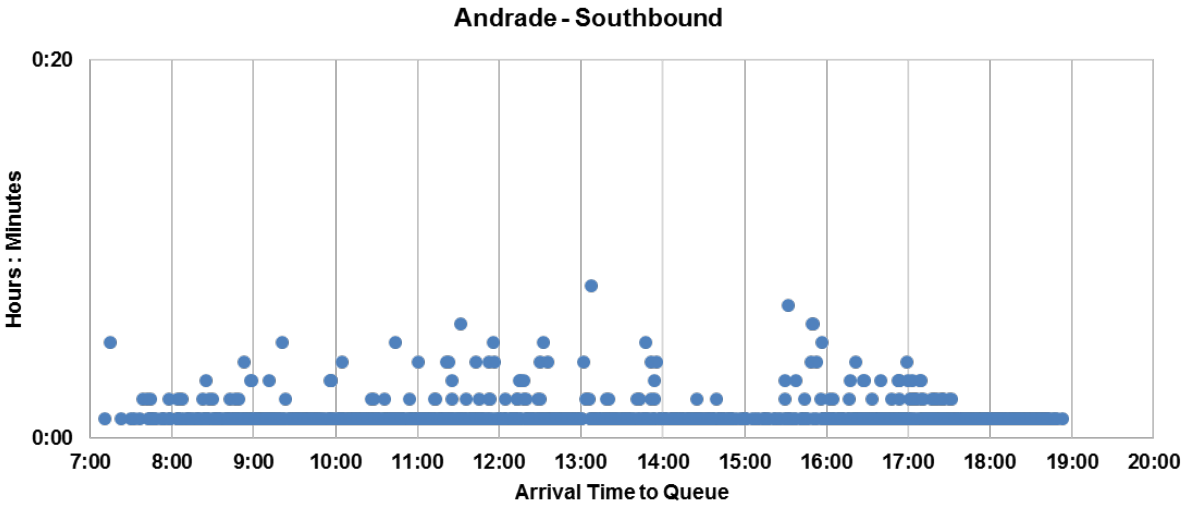


Note: Data collected on July 1, 4, 5 and October 16 and 17, 2016

ANDRADE POE



Note: Data collected on July 1, 4, 5 and October 16 and 17, 2016

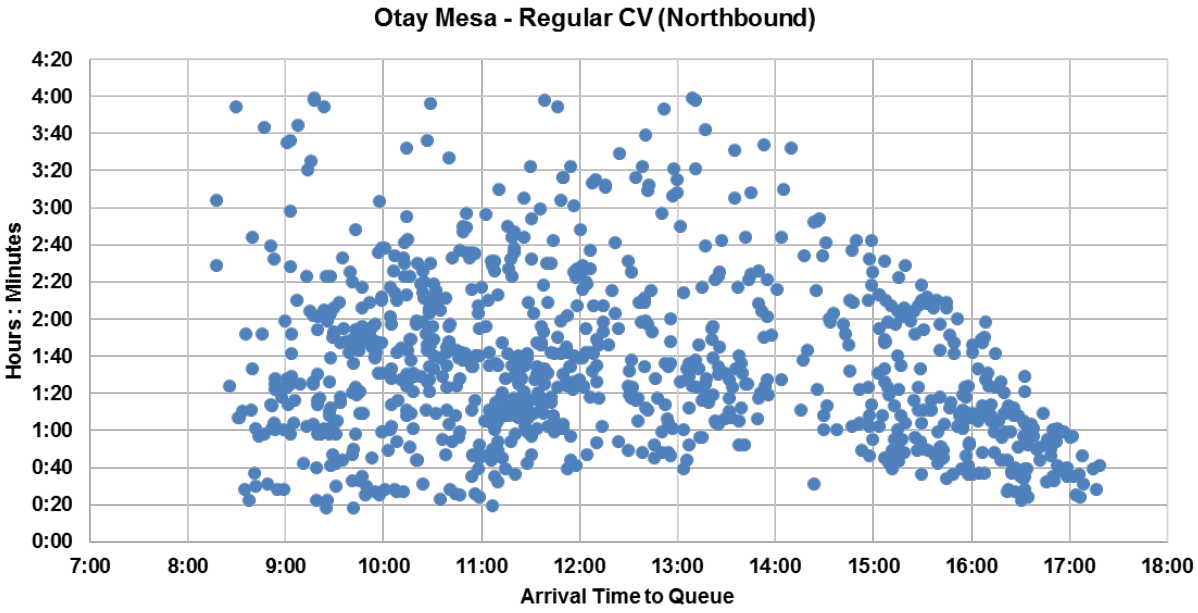


Note: Data collected on July 1, 4, 5 and October 16 and 17, 2016

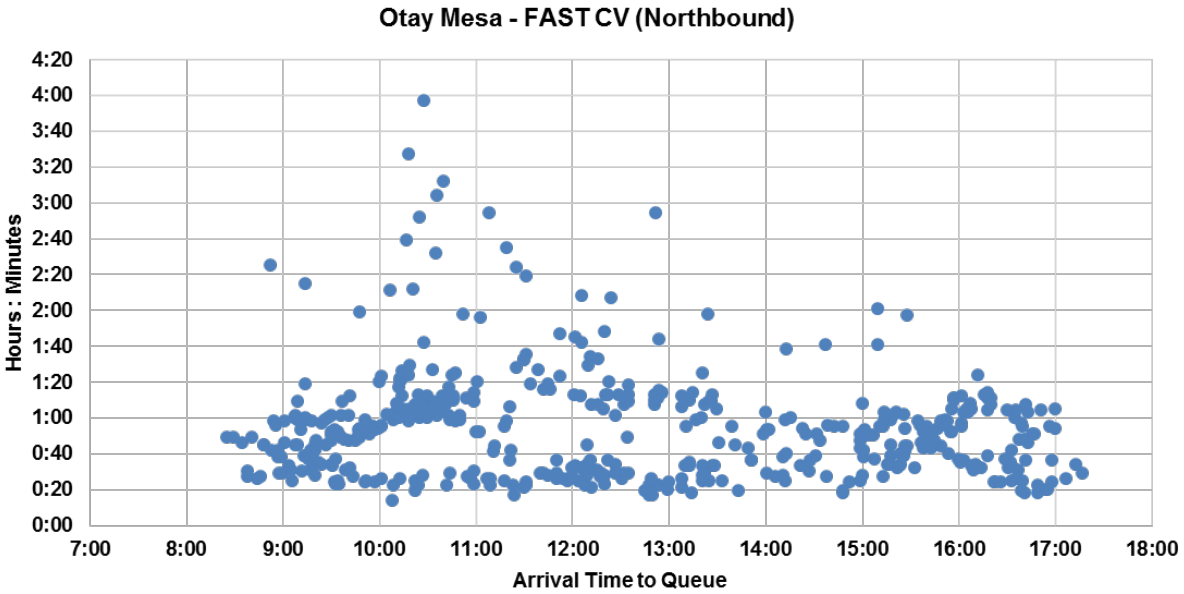
Commercial Vehicles

The graphs for the total border crossing times of commercial vehicles are presented by lane type (southbound flows are treated as a lane type) for each POE in the following order: Otay Mesa, Tecate, Calexico East and Andrade.

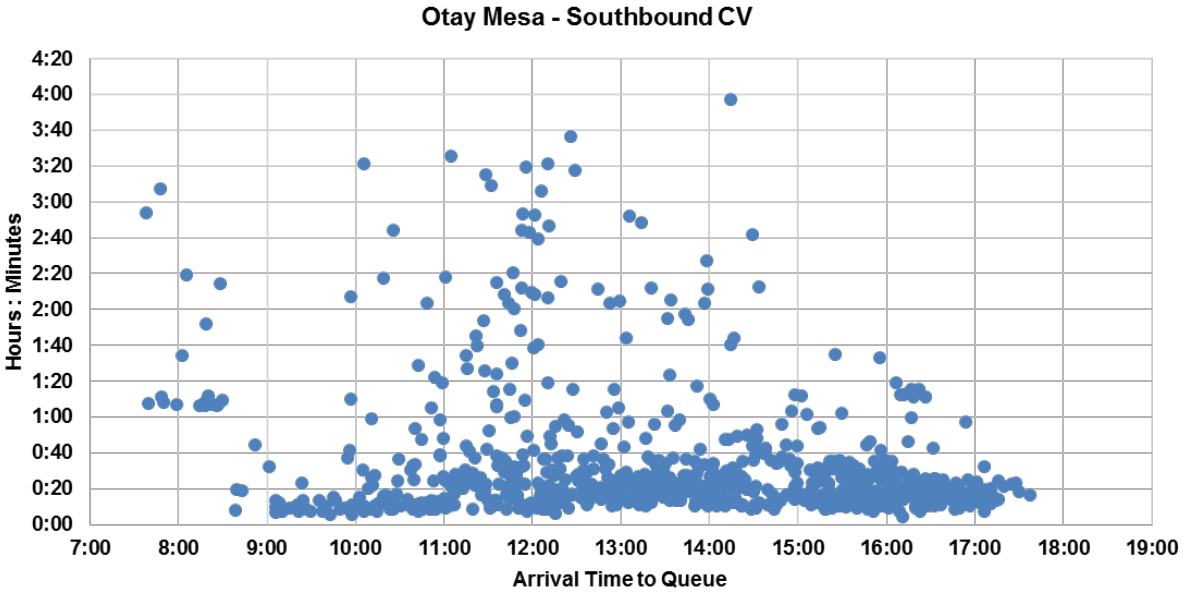
OTAY MESA POE



Note: Data collected on February 10, 13, 14 and March 8 and 9, 2017

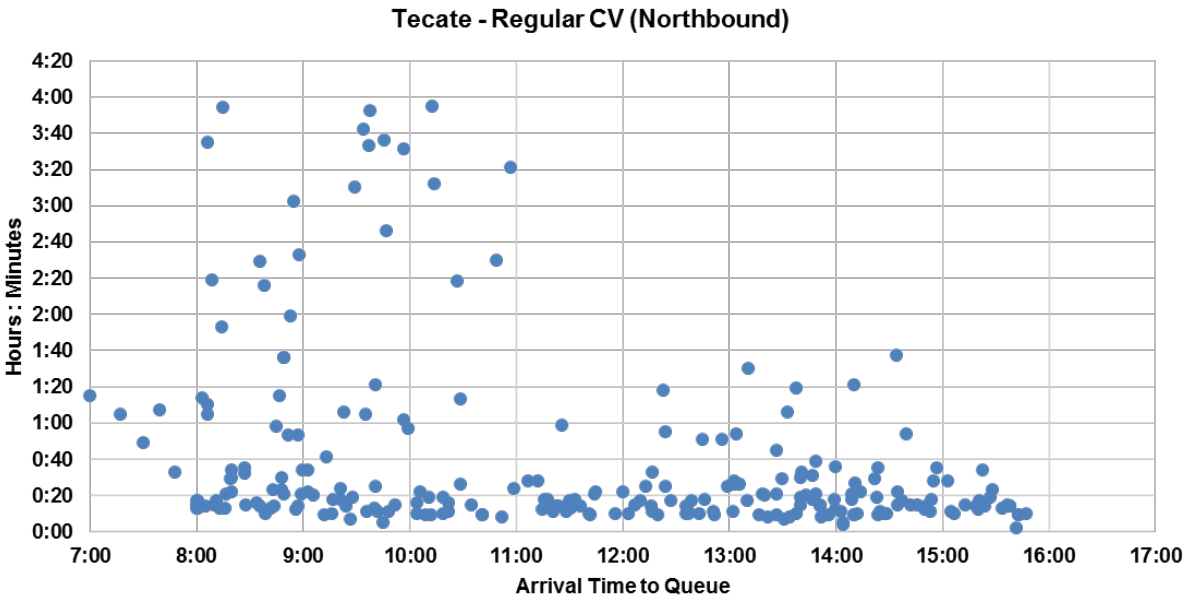


Note: Data collected on February 10, 13, 14 and March 8 and 9, 2017

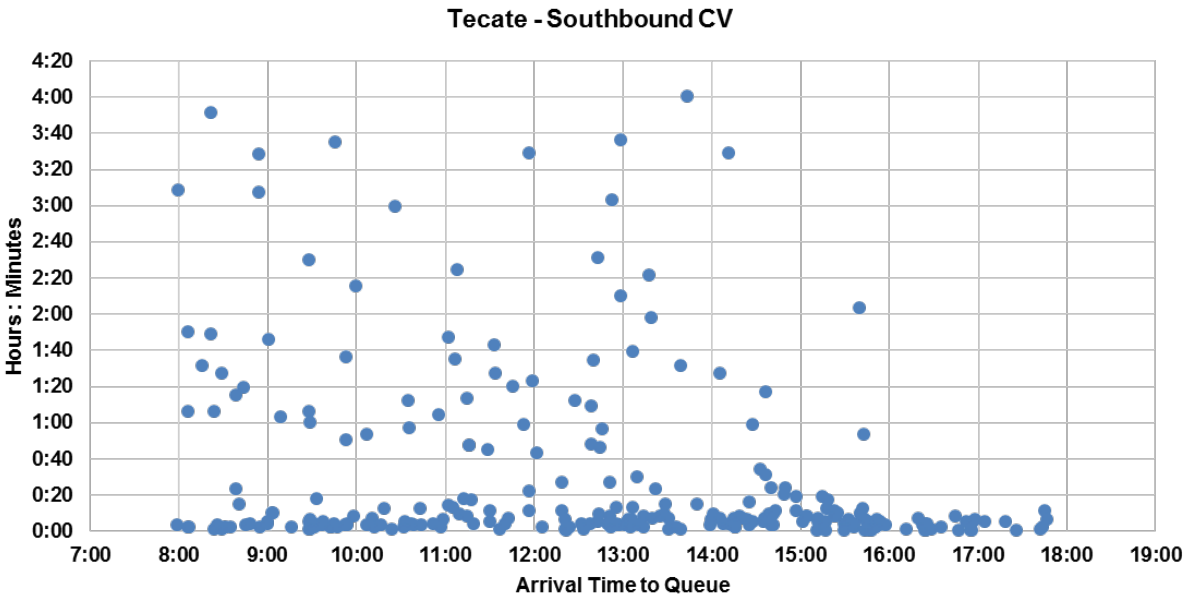


Note: Data collected on February 10, 13, 14 and March 8 and 9, 2017

TECATE POE

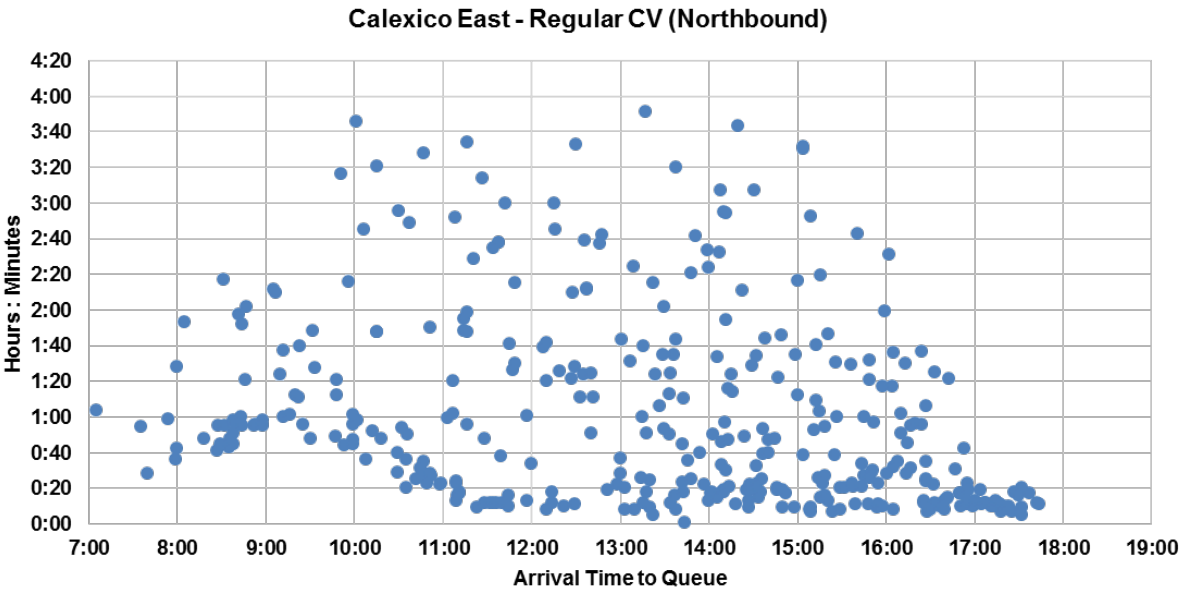


Note: Data collected on October 12, 13 and 14, 2016 and March 1 and 2, 2017

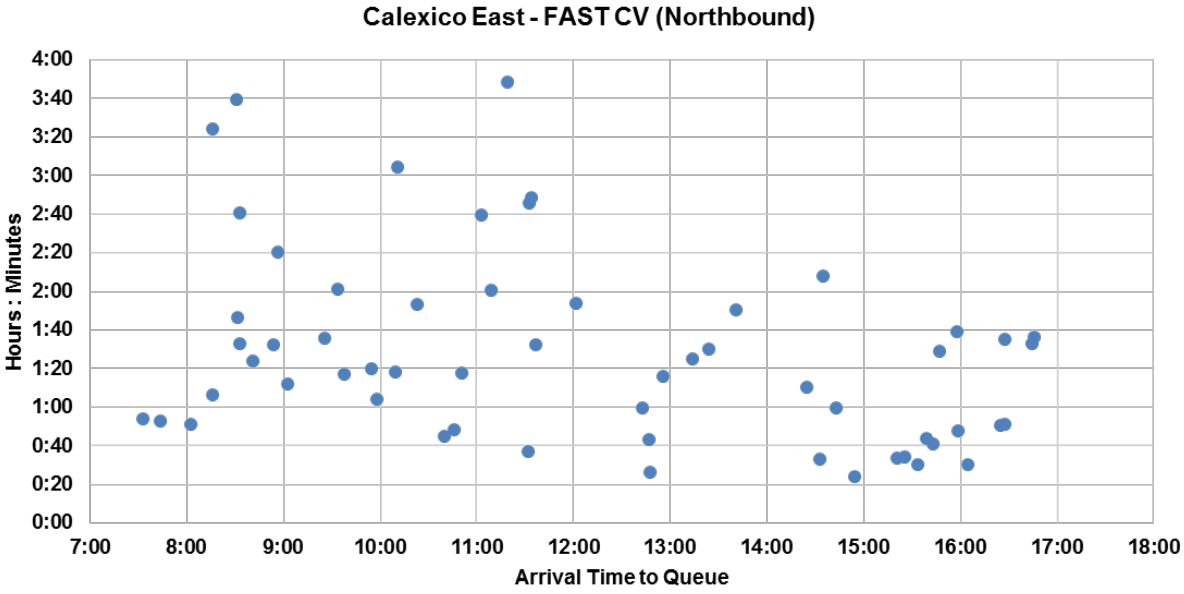


Note: Data collected on October 12, 13 and 14, 2016 and March 1 and 2, 2017

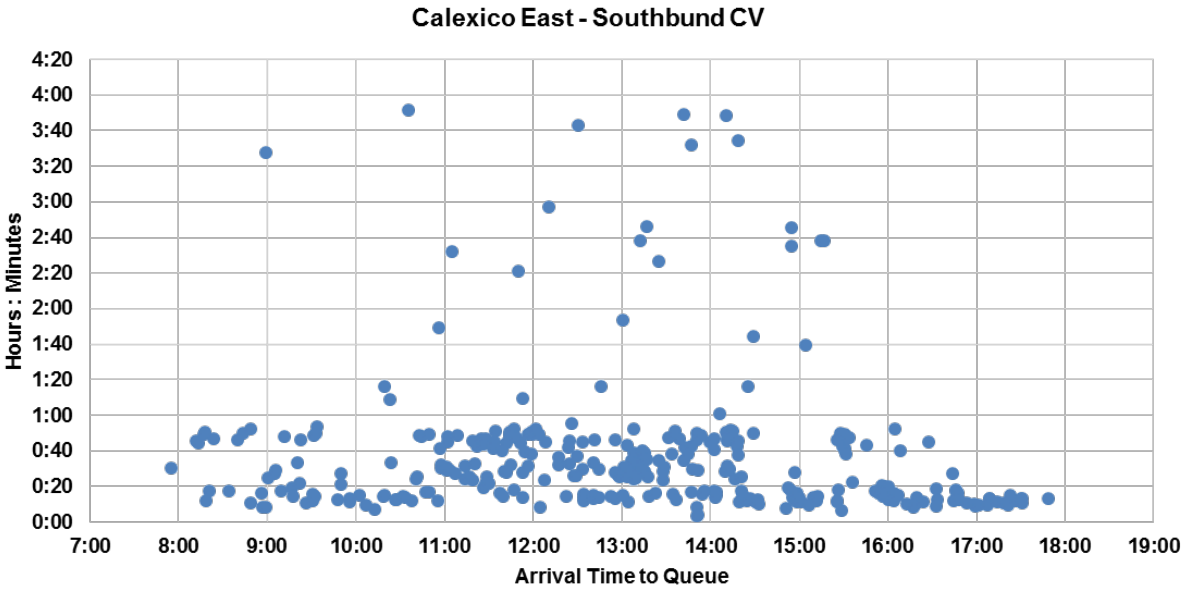
CALEXICO EAST POE



Note: Data collected on October 19, 20 and 21, 2016 and March 1 and 2, 2017



Note: Data collected on March 1 and 2, 2017



Note: Data collected on October 19, 20 and 21, 2016 and March 1 and 2, 2017

Appendix D: Border Wait Time Technologies and Information Systems White Paper

Border Wait Time Technologies and Information Systems White Paper

Economic and Air Quality Impacts of Delays at the Border

San Diego, CA
October 31, 2017

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Contents

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Introduction

The California – Baja California border region is one of the most important and dynamic economic zones in North America due to its geographic location, comparative advantages, and the infrastructure in both countries. However, demand is posed to outstrip supply at the region's border crossings. While the crossings have become a critical element of the binational region's economic integration and competitiveness, growing demand has led to increased congestion at border crossings and generated delay and unreliable crossing times for cars, trucks, and pedestrians at California-Baja California land ports of entry (LPOEs). These delays and unreliability at the border have the potential to reduce the region's economic competitiveness and attractiveness to business, which can translate into lower levels of economic activity and growth.

In 2006, SANDAG and Caltrans conducted studies that showed and quantified how border delays cause significant reductions in economic output and employment. These studies highlighted the need for improving border crossings and infrastructure and helped make the case for developing a third crossing between San Diego and Tijuana (the future Otay Mesa East-Mesa de Otay II border crossing). Similarly, in 2007, the former Imperial Valley Association of Governments and Caltrans conducted an economic delay study for Imperial County border crossings. Much has changed since these earlier studies – the local economy has rebounded from the 2008 recession and there are new emerging industry clusters that depend on crossborder trade.

As a result, SANDAG has commissioned the HDR team (led by HDR Inc., and supported by T. Kear Transportation Planning and Management, Inc., Crossborder Group and Sutra Research) to support the development of the study on Impacts of Border Delays at the California-Baja California Land Ports of Entry.

This document was developed by **Sutra Research** and it is part of the subject study, providing a description of the available technologies to estimate and disseminate information about border-crossing wait times at the different LPOEs along the U.S.-Mexico border.

Purpose

This white paper addresses the following Task for the Economic and Air Quality Impacts of Delays at the Border study:

> ***Task 2.1.2 (as written in the Study Scope of Work)***
> *Finally, the Consultant will develop recommendations for the monitoring of wait times at the border and dissemination of this information to users of LPOEs in the study area. To do this, the Consultant will generate a list of the strengths and weaknesses of each method analyzed that will include considerations such as cost, maintenance requirements, ease of operation, quality of data collected and ease of dissemination.*

Monitoring and reporting northbound and southbound wait times at the border has been conducted through a variety of methods over time, from simple manual observations to more complex systems of technologies that automate the collection, transmission, processing, storage, and dissemination of this information to end-users. The value of this information varies with its intended use and the perspective of the end-user. End-users and their information needs may include:

- Commuters desiring total crossing times and trends;
- Commercial vehicles and businesses desiring total crossing times and trends,
- Leisure travelers and one-time crossers desiring current total crossing times;
- Government agencies desiring wait times to specific points in the queue to assist with operations management;
- Government agencies desiring wait times or crossing times to understand trends for planning purposes;
- Private sector businesses desiring to understand how border crossing environments and end-user behaviors may affect how they develop or deploy services or technologies to support these clients or customers.

Given this, the automation of wait time or crossing time data collection and dissemination must support a variety of needs and objectives for each type of user. This white paper examines the purposes of using technology for monitoring and information dissemination, a brief discussion of previous studies, the individual characteristics and environment of the San Diego County and Imperial County border crossings (relative to and in the context of technology deployments), the most common technologies in use or considered for use in the border environment, and recommendations.

Purpose of using Technologies for Information & Monitoring

The primary purpose of using technologies for border crossing wait time data collection is to provide a continuous, reliable data source that can be used for monitoring and information to support operations, security, management, and planning decisions at the border facilities, in the local community, in the region, and at the U.S. and Mexico national levels. To date, technology deployments have largely been temporary, but some permanent installations now exist along the northern and southern U.S. borders.

The temporary use of technologies in border wait time studies and pilot tests have provided an opportunity to understand how well the tested technologies and methods operate in the border environment. Short term and temporary deployments support border crossing studies with snapshots of data and information.

Permanent, high-resolution, reliable, and technologically flexible deployments of a wait-time data collection systems at border crossings assist in providing the continuous stream of information required to identify trends, behaviors, and operational challenges at the border. To understand current conditions, improve processes, model predictive operations, and prepare for the future in border crossing performance requirements, an automated wait-time data collection system must be deployed that allows a baseline of wait-time information to be established. This baseline must encompass all days of the week, months of the year, seasons, and conditions to be truly useful and comprehensive.

Finally, and ultimately, technology deployments must produce data that is or can be normalized and combined into larger data sets to provide a bigger picture of how border operations occur and perform under various conditions, and in comparison, to one another. To begin this process, the terminology used to define aspects of the border crossing process and technologies must be agreed upon and standardized. The following section discusses some basic definitions used in this document.

Definition of Wait and Crossing Times

To provide consistency in the discussion of technologies that support the monitoring and collection of wait time data in the border crossing environment, there are a few terms that must be defined. These definitions have been used in previous studies and will allow continuity of discussion in this document. A 2012 SANDAG study prepared by IBI Group indicates that wait and crossing times can be defined as follows:

> ***Wait time*** *is defined as "the time it takes for a vehicle to reach the CBP's Primary Inspection booth after arriving at the end of the queue"[46] for U.S. bound vehicles. In the case of Mexico bound vehicles (or southbound traffic), the CBP Primary Inspection booth would be replaced with the Mexican Customs' (Aduana) Inspection booth.*

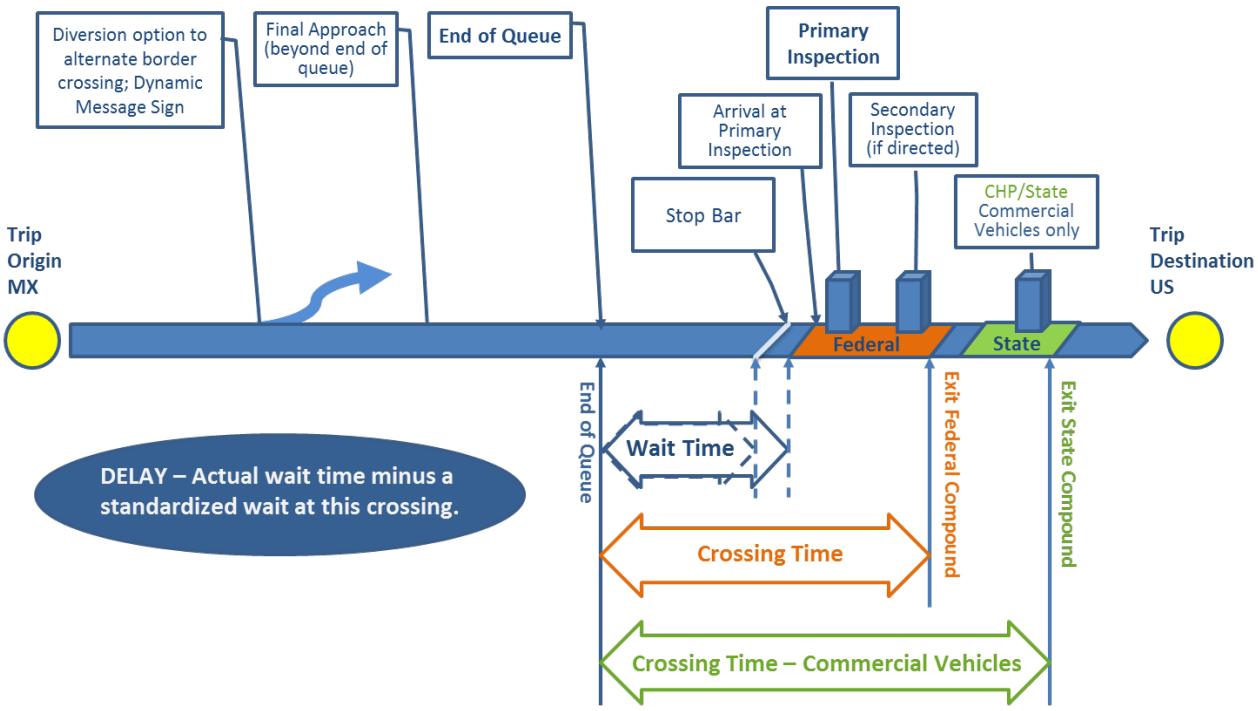
[46] Implementing a System to Measure and Disseminate Wait and Crossing Times at California Border Crossings, SANDAG, IBI Group/Texas Transportation Institute, October 2012.

> ***Crossing time*** *has the same beginning point in the flow as wait time, but its terminus is the departure point from the last compound that a vehicle transits in the border crossing process. For U.S. bound commercial vehicles, that last point is the California Highway Patrol (CHP) vehicle safety facility. For Mexico bound commercial vehicles, it is the inspection facility of Aduana. For U.S.- bound POVs, there would not be much difference between wait and crossing times since agencies do not inspect them, other than CBP.*

As a metric, wait time is of greater significance to CBP and Aduana operations, whereas crossing time is of greater interest to carriers, Secretaría de Comunicaciones y Transportes (SCT), and Federal Highway Administration (FHWA). For SANDAG, ICTC, and Caltrans purposes, wait times may be of higher value than crossing times when it comes to providing traveler information to the general public and determining variable toll pricing.

Furthermore, border crossing time is of significant interest to travelers in passenger vehicles. Processing time within the government compounds are variable and dependent upon many factors. Therefore, while this metric is of interest to the border-crossing public, it is more difficult to establish a baseline case; trends are the most probable indicator for this highly variable datum. **Figure 1** depicts the definitions suggested by the 2012 IBI Group study; it is a Mexico to U.S. northbound crossing.

Figure 18 - Definition of Wait Time, Crossing Time, and Delay



For the purposes of the discussion in this document, wait time will be distinguished from crossing time based on the above definitions. Additionally, wait time will be considered to end upon arrival at the primary inspection booth.

Users of Border Crossing Wait Time Data and Information

The value of different types of border crossing wait time data and information varies with its intended use and the perspective of the end-user. End-users and their information needs may include:

- **Commuters** desiring total crossing times and trends to make daily decisions about when and where they cross the border, and to arrange or plan for continued transportation or inform others of estimated arrival times or exceptional delays;
- **Commercial vehicles** and businesses desiring total crossing times and trends to understand their costs and plan for appropriate equipment and labor resources to accommodate their continuous border crossing needs, and to inform others of estimated arrival times or exceptional delays;
- **Leisure travelers** and irregular or one-time crossers desiring current total crossing times to arrange or plan for continued transportation and to estimate arrival to destination;
- **Government agencies desiring wait times to specific points in the queue** to assist with operations management and plan for appropriate human resources;
- **Government agencies desiring wait times or crossing times to understand trends** for regional transportation, infrastructure, or economic planning, budgetary, capital improvement, and performance measurement purposes;
- **Businesses** desiring to understand border crossing environments and end-user behaviors, wait times, or crossing times such that they may develop or deploy services or technologies to support client's or customer's needs for transportation, information, or other services.

Measurement Methodologies

Additionally, technology "systems" may be classified by the methodology that is used to measure the travel time for the desired roadway segment or points in the wait time queue. Three approaches to measuring wait times, as defined by FHWA in a 2008 study*, Inventory of Current Programs for Measuring Wait Times at Land Border Crossings,* include:

- **Queue Length Measurement**: Uses humans or technology to measure arrival and departure rates of vehicles and estimate the number of vehicles in the queue. This estimate is usually based on a measure of the length of the queue and an estimated average of the density of vehicles within it. The data is fed into an algorithm that estimates the time that it takes the next vehicle arriving at the end of the queue to move through the queue and reach the Primary Inspection booth. This method is ideal for providing real-time information for traveler information purposes. As soon as the data is recorded, it becomes archived data that can also be used for performance monitoring and other analyses.
    - Human involved methods include visual observations, cameras, driver surveys, and time stamp card/toll receipts;
    - Automated methods include inductive loop detectors, ranging radar detectors, video image processing.

- **Fixed Point Vehicle Re-identification**: Variations of this approach are also referred to as Point Vehicle Time Detection (PVTD), Anonymous Re-identification (ARID), and simply re-identification in various documents reviewed for this study. This approach can use a variety of technologies to identify individual vehicles at a fixed point upstream of the queue, and then again at the Primary Inspection booth, or at interim points along the queue and/or at some point beyond the inspection facilities. Methods currently used for Fixed Point Vehicle Re-identification (further discussed in the Technologies and Systems for Data Collection and Monitoring section of this document) include:
    - Timestamped cards, toll receipts, human observations;
    - Automated methods include Radio Frequency Identification (RFID), Automated License Plate Recognition (ALPR);
    - Current automated methods generally include some combination of technologies, such as ARID Wi-Fi or Bluetooth readers supported by wired or wireless communications.

Suggested Improvement

Logged data can be made available more quickly by installing readers in the border region or along the queue that can download the data as soon as a vehicle completes the crossing.

The time difference between two timestamps provides the travel time between the two points. The wait time attributed to the queue alone can be calculated by subtracting out the average (baseline) time required to travel that distance when there is no queue (i.e. under optimal conditions). This approach is well-suited to the calculation of wait time data for archival purposes. In terms of real-time measures, the data is already out of date by the time the vehicle reaches Primary Inspection. In other words, if it took the vehicle one hour to get through the queue, then the system accurately provides the wait time for a vehicle that reached the queue one hour ago. The “current” wait time may have radically changed within that hour. The next-arriving driver may experience a very different wait time, which can lead to issues of trust in the data.

The lag time is then reduced to the time it takes for a vehicle to travel between readers. In addition, it is possible to include predictive components to the algorithm that allow the provision of a forecast delay. Additionally, the vehicle re-identification approach provides some flexibility in terms of what segments are measured because readers can be placed at any point in the crossing process. ARID is a type of Fixed Point Vehicle Re-identification that ensures that the unique identifier provided by the vehicle or technology that is on or in the vehicle, does not readily correlate to a specific vehicle when the data is analyzed; thus, the data source becomes “anonymous”.

Suggested Improvement

A more current estimate of the wait time can be achieved by increasing the number of readers along the length of the queue and using trip segment information from multiple vehicles that are in the measurement zone at the same time.

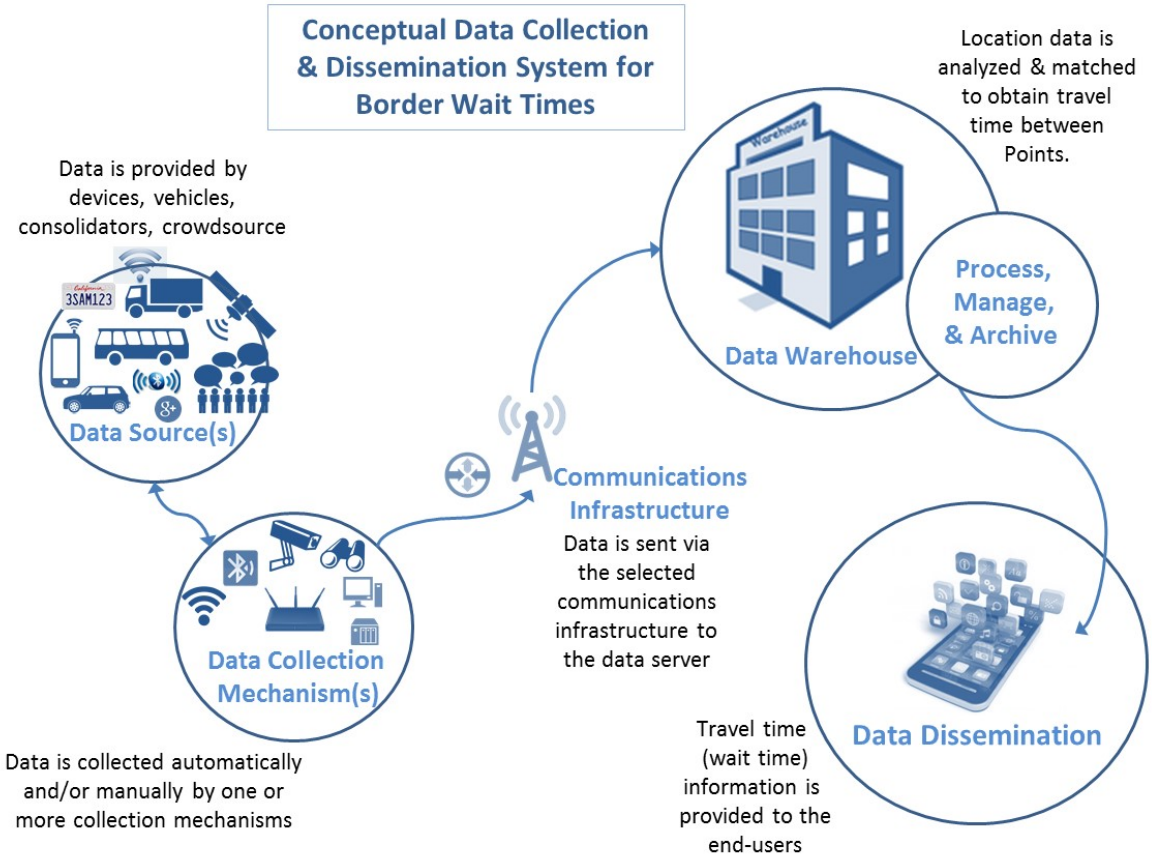
- **Dynamic Vehicle Tracking**: Uses some form of wireless signal to determine the location of a vehicle dynamically, at various or multiple times, along its route. The archived data can then be analyzed to determine how far the vehicle traveled between time intervals on the approach to the border. If a segmented approach is used, the segments in the border zone are summed to produce a wait time. This approach is well-suited to the collection of archived data for performance monitoring purposes. Data is either transmitted on a continuous basis, or logged continuously on board the vehicle or device for later download.
  This method may still be subject to the same lag as the vehicle re-identification method—that is, the data may already out of date by the time the vehicle reaches Primary Inspection. As with the vehicle re-identification method, it is possible to include predictive components to the data analysis algorithm that allow the provision of a forecast delay. Additional flexibility to measure wait times along individual segments of the crossing process can be achieved by "geofencing" (defining virtual geographic zones) specific regions at each crossing.

A simplified example of a fixed-point vehicle re-identification approach could be as follows:

> At a point along a roadway, unique identifying data is made available by a mobile phone (data source) inside the vehicle to Wi-Fi reader on the roadside (data collection mechanism) that transmits the data through a cellular phone network (communications infrastructure) to a server sitting on the cloud (data warehouse). These steps are then repeated at one or more additional points along the roadway. When the same unique identifier on the mobile phone is read at one or more points down the road, a travel time can then be calculated for the distance between two points. This travel time data is then analyzed, processed, repackaged into useful information, and made available via an app or website (data dissemination) to the user.

Figure 2 depicts a conceptual data collection and dissemination system that could include the use of technologies and infrastructure such as described in the previous example.

Figure 19 - Conceptual Data Collection & Dissemination System



Systems and Technologies Currently Used

Technologies and Systems for Data Collection and Monitoring
Technologies used for collecting, transmitting, storing, and disseminating data that depicts border crossing delay are often used in combination to achieve the desired travel time measure. Therefore, when we talk about using a technology, such as Bluetooth, Wi-Fi, Cellular, or RFID, for border wait time data collection, we are really talking about a data collection system that may be interdependent on a few technologies, working together, to collect, store, analyze, and disseminate that data.

In a border crossing environment, a variety of factors will dictate which technologies are best suited to each leg of the data flow. Border crossings have some common characteristics and many unique physical, environmental, infrastructure, security, and suitability characteristics and considerations. So, technology approaches considered may need to be flexible to accommodate:

- The unique characteristics of the crossing,
- Continual changes and advances in technologies,
- Needs of the various stakeholders that desire and require the border crossing information.

The following sections more specifically address each of the potential technologies that can be used independently or in combination with others for the collection/detection, communication, and analysis of border wait times. Technologies addressed in this document include:

- Cellular Networks and Data
- Bluetooth
- Wi-Fi
- GPS
- Radio Frequency Identification (RFID) & Dedicated Short-Range Communications (DSRC)
- Automatic License Plate Recognition
- Connected Vehicles
- Inductive Loop Detectors
- Radar, Microwave, and Laser Technologies
- Crowdsourced/Aggregated Data
- Other Emerging Technologies

CELLULAR NETWORKS AND DATA

Cellular technologies can support all types of measurement methodologies. Cellular technologies can be used in a border wait time system for the generation of location data and/or the transmission of data from mobile devices or other data sources where a wireless communication method would be beneficial, such as when a wired communications infrastructure is unavailable. Cell phones and other mobile devices on a cellular network continually generate location data that is used by the cellular carriers for providing continuous service and for providing or monitoring roaming and other location dependent services used.

Cellular networks are also used for transmitting data to or from other devices and are often the wireless mechanism of choice for data transmissions that exceed the range of other wireless technologies, such as Wi-Fi.

Mobile Devices

A 2008 study by Florida Department of Transportation, *Travel Time Estimation Using Cell Phones (TTECP) for Highways and Roadways* verified cell phones and other mobile devices and their respective location data as viable sources for travel time; and the reliability, accuracy, and resolution of this data continues to improve as smartphone manufacturers refine or adopt more capable components. The reason location data exists for cellular based mobile devices is due to the way cellular signals are transmitted and carried on the cellular network. Specifically, cellular carriers periodically probe mobile devices on their networks, which may or may not be in use, to obtain the device identification and location. This probing is possible because the area serviced by the network is divided into many sectors, called cells, and each cell is serviced by a base station. To communicate with a specific mobile device and select the proper base station, the network must know the area the cell phone is in. So, when a mobile device moves from one sector to another, the cell must be handed off to the appropriate base station. In this way, the network is continually identifying and tracking mobile devices and performing the handoffs. There are many complexities to the operation of cellular networks along with the complexities of territories, ownership, and rights to base stations; each of these complexities impacts the way cellular devices are used when users must cross the US-Mexico border.

Travel Time Calculation

Generally, cell phone location is determined by signal tower triangulation using a variety of statistical methods and algorithms with varying degrees of accuracy. Depending on the method used, cell phone location accuracy can vary widely with the best providing location accuracy within 90 to 120 feet. Older methods may only be accurate to within 1500 feet or greater. For travel time, cell phone location data has been used with GPS as a complementary technology to improve accuracy. In rural settings, cell phone location accuracy may be suitable, but for urban settings accuracy is insufficient.

Suitability for Travel Time Measurement in a Border Environment

In the border environment, the use of cellular mobile devices to calculate wait time or crossing time is dependent upon continuity of location data from a mobile device that is traveling among a myriad of cellular service providers with closely spaced base stations and overlapping service areas. For cell phone customers, this may result in additional costly service charges for “roaming” into the territory of another carrier, data charges and service fees for international service. Given this, border crossers often switch back and forth between mobile devices – having a device specifically for use in Mexico with a Mexican carrier, and another device specifically for use in the U.S. with a U.S. carrier. Depending on which country they are entering, the traveler turns off the device from the country they are leaving, some time prior to crossing the border – thereby eliminating the generation of some location data for that device. Increasingly, there are binational plans with some carriers; as prices for these plans become

more affordable, there will likely be less phone switching at the border, and more continuous location data available.

Cellular Technology as a Communications Infrastructure

As a communications infrastructure, cellular networks provide an essential transmission mechanism, using devices like cellular modems, for data collected or generated by other technologies or devices. A 2015 Arizona border travel time study conducted by Crossborder Group and Lee Engineering, evaluated the penetration rate or the sampling rate of Bluetooth or Wi-Fi anonymous re-identification (ARID) technology at the six Arizona-Mexico POEs. In this study, a cellular modem was used and cellular communication allowed for monitoring and processing the ARID device data in real- time and alerted data collection staff to tampering, theft, or malfunction. If cellular service was not available at a deployment location, the data was stored within the device for upload to a computer and post-processing.

Data

Cellular location data collected via the cellular network must be made available by the cellular network owner/service provider (the carrier) or by a third-party data application or processing entity; this may be at a cost. The location accuracy of mobile devices on cellular networks continues to improve by way of new technologies for base stations, antenna arrays, and the use of differential and assisted-GPS.

BLUETOOTH

Bluetooth wireless technology is a short-range communications technology originally intended to replace the cables connecting portable and/or fixed communications devices while maintaining high levels of security. Bluetooth technology is included commonly on devices such as smartphones, hands-free kits in cars, tablet computers, wireless headsets, and other devices. The key features of Bluetooth technology are robustness, low power, and low cost. Bluetooth is a mature technology that has been in use for about 20 years.[47] The Bluetooth specification defines a uniform structure for a wide range of devices to connect and communicate with each other. A feature of Bluetooth technology is that it has achieved global acceptance so that any Bluetooth-enabled device, almost anywhere in the world, can connect to other Bluetooth-enabled devices in proximity. While not all vehicles contain mobile phones emitting Bluetooth or Wi-Fi signals the proportion that do is now dense enough that meaningful travel time data can be obtained by tracking signals from these devices.[48]

[47]Bluetooth, Our History, https://www.bluetooth.com/about-us/our-history
[48] ITS International, Bluetooth and Wi-Fi offer new options for travel time measurements, http://www.itsinternational.com/categories/detection-monitoring-machine-vision/features/bluetooth-and-wi-fi-offer-new-options-for-travel-time-measurements, 2013.

Bluetooth-enabled devices can communicate with other Bluetooth-enabled devices from a range of 1 meter to about 100 meters, depending on the class of radios attached to the device.

Bluetooth systems are best suited for vehicle/device re-identification detection methodologies and have been tested extensively in recent years to determine viability for travel time applications. The Bluetooth protocol uses a unique electronic identifier in each device called a media access control (MAC) address. Bluetooth readers can search for nearby devices using a refresh rate defined by the software running inside the reader and can obtain the MAC addresses of Bluetooth-enabled devices along with a timestamp. Because each MAC address is unique, traditional matching algorithms like those used for license plate, cellular, or toll tag tracking can be used to estimate travel time between two locations on a roadway. MAC addresses are not directly associated with any of the users' personal information, thus minimizing privacy concerns. Bluetooth signals used in the previously mentioned methodologies are discoverable signals – meaning that the device emitting the signal has not been paired or is open to pairing with multiple devices. Other Bluetooth methodologies combine discoverable and non-discoverable segments of Bluetooth signals and may increase the number of detections resulting in higher detection density and additional data[49].

Data sources for Bluetooth signals include devices such as:

- Cellular phones and other Bluetooth-equipped mobile devices
- Vehicles equipped with Bluetooth
- Headsets, speakers, and other Bluetooth accessories

Roadside data collection hardware, Bluetooth readers, must be installed along the queue to support Bluetooth data collection methodologies. As mentioned in the previous section, the Crossborder Group and Lee Engineering Study in Arizona evaluated Bluetooth as an anonymous re-identification technology to collect travel times. Bluetooth, was compared with Wi-Fi in this study by deploying it on opposite sides of the road at the same location. In this study, the penetration rate (similar to sampling rate), was essentially the number of unique devices detected by the ARID technology divided by the traffic volume for the same time window; Bluetooth had a lower penetration rate than Wi-Fi by 4 to 5 times. In other words, the Wi-Fi readers detected more mobile devices than Bluetooth readers. Bluetooth readers for the CBG/Lee study detected discoverable Bluetooth signals only.

Suggested Improvement

A solution to intermittent cellular service is to create a virtual private network as a back-up option when cellular service is not functioning. Another solution (used by the Peace Bridge border wait time system) is to hardwire data/internet connections to the Bluetooth readers, as this is much more reliable but can have large upfront costs

[49] Bluetooth readers that detect non-discoverable Bluetooth signals may be configured to detect only 6 of the usual 12 characters of the MAC address to provide another layer of privacy protection when using this methodology.

When depending on cellular data service for communication to a data warehouse, test studies and pilot deployments have shown that cellular service may be intermittent.

WI-FI

Like Bluetooth technology, and in the context of border wait time systems, Wi-Fi is another short-range communications technology intended to provide communications among devices while maintaining high levels of privacy. Wi-Fi technology is most often included commonly on modern devices such as smartphones, hands-free kits in cars, tablet computers, other media streaming devices. The Wi-Fi signal emitted from these devices has made Wi-Fi another highly viable candidate technology for capturing the travel time of vehicles when drivers or passengers carry these devices, or vehicles with OEM or third-party Wi-Fi capabilities.

In a series of 2013 Danish travel time trials, in Aalborg, Denmark using Bluetooth, Wi-Fi, and a combination of the two respectively, data from the combined technologies trial indicated that 20% more vehicles were identified by Wi-Fi than Bluetooth[50].

Wi-Fi is the subject of current and recent tests in the San Diego regional border environment and is considered well-suited for Vehicle Re-identification (VRID), Anonymous Re-Identification (ARID) or Point Vehicle/Time Detection (PVTD) data (detection) collection methodologies. Wi-Fi is currently widely available in mobile devices and for roadside reader applications. A device must have Bluetooth or Wi-Fi enabled to be visible to the network and available for detection and be within range of the PVTD device (in this case approximately 500 ft.). Previous surveys indicate that mobile device users often leave Wi-Fi enabled on their devices, vs Bluetooth which is often disabled when not in use. Given this user behavior, Wi-Fi provides a higher probability data point for roadside readers. Currently, an application of Wi-Fi is being tested to collect border crossing travel times at the southbound San Ysidro US-Mexico border crossing. The San Ysidro Southbound Border Wait Time Pilot program is currently using the region's solar powered freeway call boxes by retrofitting them to house the sensors/readers and equipment required to gather anonymous data (a portion of the MAC address of the device) as vehicles drive by the equipped call boxes. The device is identified and then reidentified at multiple points (call boxes) along the route and then the time points are used to calculate travel time along the route into Mexico.

The use of Wi-Fi in the current Border Wait Time Detection pilot required the following modifications to the call boxes:

- Replacing the existing single antenna with a 3-function antenna that includes:
  - A data communication antenna (Cellular)
  - A voice communication antenna (Call Box system)
  - A PVTD antenna
- Adding a PVTD device board into the existing call box enclosure
- Adding an underground box containing a 12V battery for the PVTD detector

[50] Bluetooth and Wi-Fi Offer New Options for Travel Time Measurements, ITS International, Blip Systems, October 2013, http://www.itsinternational.com/categories/detection-monitoring-machine-vision/features/bluetooth-and-wi-fi-offer-new-options-for-travel-time-measurements/.

- Replacing the existing solar panel with one that will furnish enough energy to both call box and PVTD systems.

Note that cellular communication (with a cellular modem) is being used for this pilot, eliminating the need for a physical communication connection (see also the previous discussion of cellular communications).

Maintenance of these installations is expected to be minimal and device functions can be tested remotely with the system web interface, if or when a communications link is available.

Another advantage of Bluetooth and Wi-Fi over Automatic Number Plate Recognition (ANPR)/Automatic License Plate Recognition (ALPR) systems is that, in bumper to bumper traffic, these technologies can detect and track device in vehicles at locations where the license plate is not visible an ALPR/ANPR camera. Additionally, the Wi-Fi and Bluetooth readers can detect Wi-Fi and Bluetooth devices in vehicles traveling at high speeds (200 km/h (124mph)). Further these technologies are bi-directional and can measure vehicles passing in both directions, if they are within range. Additionally, a single sensor is generally required, where ALPR requires cameras for each lane of the installation. These technologies can be combined for more complex solutions requiring more than travel time data. (ALPR and ANPR are discussed in more detail in the Automatic License Plate Recognition (ALPR) section of this document).

GPS

As a location data source, Global Position System (GPS) transceivers are currently used with smartphones and other mobile devices, navigation systems, data loggers, and in-vehicle units (IVUs - often for transit and commercial vehicles).

One primary strength of GPS over other technologies is that it does not necessarily require a roadside reader to retrieve or transmit the raw location data collected by the GPS unit. However, for the location data to be retrieved from a GPS unit, it must be downloaded manually from the unit, or combined with and transmitted using some other communications technology. GPS transceivers can transmit data through the cell phone network (Octel technology, for example), via satellite (e.g., Skybitz or Qualcomm), or through other short-range communications technologies such as Bluetooth, to report location and time information. The location and time stamp information can then be used to calculate crossborder travel time. Additionally, with GPS and cellular enabled mobile devices, such as smartphones, the GPS works together with cellular technology to “calculate” location, and then the cellular technology is the communication mechanism responsible for transmission of the data to a data warehouse. The combination of cellular and GPS technologies results in more accurate position data.

In 2009 FHWA study, Delcan & Cheval Research evaluated GPS alongside Automatic License Plate Recognition (ALPR) for the purposes of determining suitability as a border wait time data collection technology[51]. The following attributes of GPS were noted in the context of requirements for border wait time applications and remain relevant:

- GPS can provide total cross border time measurement, or any segment thereof with proper "geofencing" of segments.
- GPS can provide detailed data regarding movements of vehicles on approach to and within inspection facilities at the border.
- Data collection is dependent on the private sector cooperation and collaboration for the use of data collected by IVUs, data loggers, and some other privately owned or controlled devices.
- There are no known issues with safety and security – particularly when data is made anonymous (via a third party or through other data processing techniques).
- Stakeholders (participating in this FHWA study) generally supported sharing and selling of GPS data.[52]

Data must be normalized for outlying data points that periodically occur with this technology; it is also subject to occasional atmospheric anomalies. GPS requires the installation of equipment in individual vehicles and a center for receiving and processing information. In addition, some telemetry systems may not be able to provide data at sufficiently fine time increments. Overall, GPS is a reliable and essential assistive technology with potentially high resolution (depending on sampling rates) and wide-ranging data collection capabilities.

RFID/DSRC

RFID technologies include a variety of passive and active transponders, toll tags, and other types of tags that serve as vehicle identifiers. The best use of RFID for border wait times is for vehicle re-identification applications. RFID readers detect the ID of automated toll tags using dedicated radio frequencies. RFID is a mature technology that has been used in vehicle identification applications for more than 25 years[53]. Accuracy of this technology decreases with distance but has a directional advantage. Certain border crossers (such as commercial vehicles) warrant the use of RFID to measure travel time due to the higher levels of RFID tag fleet penetration for the various cargo, vehicle, and fleet pre-screening programs or membership with toll service providers, such as FastTrak.

RFID readers are placed along the roadside or above the roadway using existing infrastructure. Readers are most accurate when located near the target vehicle and serving a single travel lane. Distance and obstructions decrease sensor accuracy. Depending on the generation and type of RFID tag and reader system, the range is approximately 12-15 meters.

[51] Measuring Cross-Border Travel Times for Freight: Otay Mesa International Broder Crossing, Technology Evaluation, FHWA, Delcan & Cheval Research, March 2008.
[52] Measuring Cross-Border Travel Times for Freight: Otay Mesa International Broder Crossing, Technology Evaluation, FHWA, Delcan & Cheval Research, March 2008
[53] Department of Transportation, Federal Highway Administration (FHWA), http://www.ops.fhwa.dot.gov/publications/fhwahop13029/ch2.htm

RFID technology is only applicable for crossborder travel time applications on roadways where a sufficient number of vehicles are equipped with tags – such as a toll road, SR125 for instance, or tolled crossing, such as the one planned for the Otay Mesa East facility, or for fixed commercial vehicle routes on the way to the border crossing.

RFID tag privacy is generally protected by truncating the tag IDs before the data are transmitted to the managing agency. This truncation prevents the tag ID from being matched to the tag owner in the managing agency's database of owners. Some emerging connected vehicle (CV) technologies use a very similar detection technology; however, privacy restrictions may make CV technology an unsuitable replacement for segment travel time data collection.[54]

RFID readers are also protocol specific and not all tags and readers are interoperable. This limits the ability for RFID readers to be used with any tag that may enter its sensing field. A Texas A&M study is testing a 3-protocol reader which may prove to overcome this limitation.

Most land POEs already use RFID technologies for other purposes, and many national border agencies have already installed RFID-based systems. The re-use of transponders already in border crosser's vehicles for travel time and border wait time calculations is a possibility.

AUTOMATIC LICENSE PLATE RECOGNITION (ALPR)

ALPR is a mature technology that has been used in the context of the border environment for many years. The 2008 FHWA/Delcan study compared it with GPS for border wait time collection. While ALPR is stable and reliable overall, the roadside equipment indicated a more complex installation subject to higher infrastructure costs with equipment security concerns. Current applications of ALPR technologies are being tested by the Buffalo & Fort Erie Public Bridge Authority in combination with Bluetooth and Wi-Fi to create a more robust data set and with positive preliminary results. Delcan's primary findings, that are largely applicable to today's systems, are summarized as follows:

- The specific location of ALPR camera at beginning of queue must be pre-determined
- Travel times may be estimated based on statistical distributions of trip types within the total sample.
- The total travel time using ALPR can be reported in real-time, but only after a vehicle passes both the first and last reader locations.
- ALPR data for multiple measurement points can be collected using portable ALPR stations at temporary points. This requires additional analysis and estimation for segments not measured.
- The sponsoring agency will own both the infrastructure and the raw data, but will also be responsible for maintenance of the physical assets, which include camera/antenna/power "out station" assemblies, and corresponding "in station" to receive transmitted data.

[54] Department of Transportation, Federal Highway Administration (FHWA), http://www.ops.fhwa.dot.gov/publications/fhwahop13029/ch2.htm

- Safety and security of ALPR infrastructure is primary concern. Life span of equipment is 3- 5 years; more information is needed to assess useful life under rugged border conditions. Potential security risk from theft or damage to fixed infrastructure.
- Historical precedent exists regarding ability of agencies to support long-term maintenance, security, and life-span of equipment. At the time of the study, FHWA identified trends in state-of-practice that suggested, fixed infrastructure for travel time measurements would likely be replaced by probe technologies; the outcome of this prediction is still uncertain, given the variety of infrastructure, environmental, and political conditions that surround each such installation
- Initial cost of infrastructure along with maintenance and security issues were sources of high stakeholder concern. Cameras near border may add additional privacy concerns for carriers.

ANPR/ALPR system requires high quality cameras with fast frame rates to capture an image of the license plate with the proper definition for the system to recognize and interpret the vehicle's plate number. Cameras for these systems are relatively costly to install and maintain.[55]

CONNECTED VEHICLES

Connected vehicles include short range radio communications technologies for vehicle-to-vehicle (V2V), where vehicles on the roadway communicate with one another, and vehicle-to-infrastructure (V2I) applications, where vehicles on the roadway communicate with roadside technologies and devices. Connected vehicle technologies are still in early stages of development, but have been maturing, and have been prototyped and tested for a couple of decades. With currently defined standards, connected vehicles communicate using DSRC technology – a reliable, low-latency radio-frequency communication standard selected for use with U.S. DOT's connected vehicle initiative. DSRC is capable of two-way communication, allowing both vehicle and infrastructure devices to send and receive data, possibly up to distances of 3280 ft. (1 kilometer). DSRC transceivers may be built into vehicles or mobile devices such as smartphones. In V2V communications, vehicles can anonymously exchange information about their position, speed, and heading, allowing each vehicle to be aware of surrounding vehicles enabling cooperative safety features to warn drivers of potential conflicts or collisions. In V2I communications, DSRC technologies may communicate location-specific and roadway condition information such as curve speed warnings, weather, pavement conditions, incidents, and detours. Conversely, vehicles with embedded devices or transponders, can indicate their presence to infrastructure, enabling features such as traffic signal actuation or priority, automatic toll payment, incident detection, credentials verification (for commercial vehicles at CBP inspections stations and with PrePass™ enabled California Highway Patrol (CHP) Inspection stations) and importantly for this study, travel time.

[55] ITS International, Bluetooth and Wi-Fi offer new options for travel time measurements, http://www.itsinternational.com/categories/detection-monitoring-machine-vision/features/bluetooth-and-wi-fi-offer-new-options-for-travel-time-measurements, 2013.

At minimum, DSRC requires a small radio frequency transceiver to be present in the vehicle or host device, and for basic travel time data collection purposes, the vehicle-based transceiver only needs to send its current speed to an infrastructure transceiver.

INDUCTIVE LOOP DETECTORS

Magnetic loops are in-pavement, electrically conductive wire loops that detect the presence of a vehicle. This technology is very simple and mature and widely used for vehicle detection, speed, and classification applications, however it is not well suited for travel time applications. Paired loops can measure spot speeds, and special processors can match vehicle signatures at multiple locations using single loops. The vehicle signature capabilities have not been widely deployed. Vehicle signatures create the possibility of vehicle re-identification, but this also requires special processors that are not widely available.

Loop detectors have a high detection rate and are inexpensive. However, installation and maintenance costs are more expensive due to the requirement to cut or dig up the pavement for retrofit installations, repairs, or replacements.

Loop detectors cannot capture any unique or personal identification information from devices or vehicles, thus there are no security or privacy issues.

Even though loop detectors are widely used for traffic detection, there are currently no federally identified deployments of loop detectors used to measure segment or vehicle travel times. There are companies that continue to actively research the use of loops for future travel time applications.

Some agencies, such as the Canada Border Services Agency, have observed that the accuracy and reliability are not as high as with some other technologies, such as Bluetooth or Wi-Fi.

RADAR, MICROWAVE AND LASER TECHNOLOGIES

Radio wave (Radar), microwave, and laser light wave (or light detection and ranging (LIDAR)) technologies are mature, widely-used, spot speed and distance measurement technologies. These technologies all work on a similar principle in which an active sensor emits a radio wave, microwave, or light (LIDAR) wave that is reflected off a target vehicle, and the return time of the reflection or the frequency shift of the reflected energy is used to determine the vehicle's speed. Microwave and radar emit energy in a wide cone that can monitor a broad section of roadway whereas LIDAR emits a narrow laser beam that can be used in a single lane over a longer range.

These wave technologies, although in use for decades by highway law enforcement and in other industries, have not been widely used for travel time detection. There are a wide variety of wave technology products available with equally variable capabilities and applications. Generally, sensing equipment must directly face arriving or departing vehicles. There are perpendicular (also known as "sidefire") radar technologies that can be used perpendicular to traffic flow.

Wave technologies are used for spot speed measurements but do not have intelligent communications capabilities required for vehicle matching that is essential to accurate travel time applications. Speed can be used to calculate estimates of travel time, but in the border environment where speeds and location dwell times may vary on the border approaches and departures, wave technologies would not be the best choice for a travel time application. Additionally, heavy precipitation can reduce the functionality of radar; although this would not be a frequent problem for San Diego of Imperial County regional border crossings.

Also, because there is no identifying information required to measure spot speeds using these technologies, there are no privacy or security concerns. Finally, due to the viability and lower cost of other probe technologies, these wave detection technologies will continue to diminish in importance as choices for travel time applications.

CROWDSOURCED DATA

Generally, crowdsourcing leverages the combined intelligence, knowledge data, or experience of a group of people (or their devices) to answer a question, solve a problem, or manage a process.[56] For travel time data collection and information dissemination, crowdsourced methods are the most commonly used private sector mechanism today. Mobile devices carried by drivers or their passengers, or installed in their vehicles, can provide information about their location, speed, and possibly additional information to a public or private entity, and that information is used to generate traffic/ travel time information. Essentially, vehicles carrying passengers or a driver with a mobile device that provide location information become “probe vehicles”, meaning its anonymous location is provided providing data points for speed and travel time in the transportation network.

The typical model for crowdsourced data involves location-aware (GPS or cellular network-based) devices running an application that automatically sends information to a central server using cellular transmission. One advantage of location-based crowdsourcing is that vehicles can be individually tracked in near real-time, allowing more precise and timely speed and travel time estimates than can be achieved by other data collection technologies.

For the public sector, obtaining crowdsourced data could be more challenging; however, third-party aggregated crowdsourced data is being obtained by many transportation agencies to avoid the difficulties associated with accessing the data and the complex collection, data cleaning, management, and security tasks, and privacy considerations. Third-party, commercial providers offer access to proprietary data with clearly defined products, services, customer support, and professional expertise.

[56] Michigan Department of Transportation, Center for Automotive Research, “Crowdsourcing Transportation Systems Data”, February 2015.

Third party commercial special, traffic and location data providers include companies such as:

- Inrix, http://www.inrix.com/
- HERE, http://here.com/
- Cellint, http://www.cellint.com/
- Telenav, http://www.telenav.com/
- TrafficCast, http://trafficcast.com/
- TomTom, http://www.tomtom.com/en_gb/licensing/products/traffic/
- Cuebiq, https://www.cuebiq.com

Crowdsourced information dissemination platforms, such as Google Maps, Waze, Apple Maps, MapQuest, generally are used by travelers to receive live traffic information and turn-by-turn navigation directions. Web and mobile Application Programming Interfaces (APIs), such as Google's API for its online map (launched in 2005) can be used by agencies to reference this live traffic data. There are similar APIs from Bing Maps, MapQuest, HERE, TomTom and others that provide similar reference data. Each of these sources vary regarding their policies for access to free (unlimited) data (i.e., the number of queries that are allowed before a paid commercial account is required). Crowdsourcing the internet sources for travel time estimation has been found to be nearly as accurate by traditional sensor networks and less prone to errors and gaps in data provision as long as traffic volumes are not low (such as with rural highways)[57].

Other potential data sources for the public sector can include dedicated platforms and custom-built, dedicated applications, such as San Diego's 511 app. The apps must be frequently used by travelers along the roadway segments of interest to provide the volume and density of data required to derive useful information.

Social media mining and aggregation of social media data has provided some information about the condition of the border and transportation system in general; however, the precision desired in determining border wait times may not be possible using this source. Social media is an effective public engagement tool and is highly effective in disseminating information distilled from data collected through other methods.

Crowdsourced data is often fused with traditional data sources from sensor readings to create a richer data set that provides a higher level of detail and accuracy. This fusion of data and the resulting information is currently and predominantly disseminated by third-party service providers. A part of this fused data is often public agency data, and partnerships have been created to benefit both entities. An example of this type of partnership is the crowdsourced traffic speed and travel time data sets that are pre-aggregated and structured and provided to Michigan DOT by HERE.

[57] Kurkcu, Abdulla; Ender Faruk Morgul; Kaan Ozbay. "Extended Implementation Methodology for Virtual Sensors: Web-based Real Time Transportation Data Collection and Analysis for Incident Management." *2015 Annual Meeting of the Transportation Research Board.* Washington, D.C. Compendium of Papers. 2015.

Challenges specific to the border crossings, when considering cellular geo-positioning data as the collection method for crowdsourced data, may include cell phone service provider incompatibilities and the user's switching of devices or providers at the border (to avoid international roaming, calling, and data charges), which interrupts the continuity of the data stream for one person or vehicle as they cross the border.

Advantages

- No need to procure, install, and maintain equipment in the field; and,
- Less vulnerability to outages related to unforeseen circumstances such as extreme weather, vandalism, power outages, or collisions.
- Variety of API capabilities, data access plans and cost tiers (some free) for multiple types of agency uses and users.

Disadvantages

- Systems will not count all vehicles. The sample size will vary based on technology penetration rate in a region for a given type of vehicle (e.g. commercial versus passenger vehicles) at a given time – and partnership agreements held by the aggregator.
- System may not have the ability to provide distinct information by lane or vehicle type, unless supplemented by other data sources.
- Agencies may need to contract with, possibly pay, a 3rd party vendor for supplemental data, or install supplemental data collection systems, and possibly develop unique applications for data collection, processing, or management.

OTHER EMERGING TECHNOLOGY CONSIDERATIONS

Multi-technology Readers

Many emerging traffic counting and travel time detection systems gather data by using multi-technology readers or other equipment to detect and/or connect with various devices in vehicles. These include the following:

- Radio frequency identification (RFID);
- Bluetooth;
- Wi-Fi; and,
- Global positioning system (GPS).

Common Advantages

These emerging hardware-based technologies share certain advantages:

- Vehicles equipped with the relevant technology can be uniquely identified while preserving privacy;
- Can provide real-time data;
- Can provide distinct geospatial data; and,
- Continuing costs of operation are relatively low.

Common Disadvantages

These emerging hardware-based technologies share certain disadvantages:

- Systems will not count all vehicles. The sample size will vary based on the penetration rate of each technology in each region for a given type of vehicle (e.g. commercial versus passenger vehicles) at a given time.
- Initial costs to create a system can be high.
- Requires the installation of hardware, if not already present.
- Many hardware-based systems may be vulnerable to weather impacts and may require ongoing maintenance.

Agencies have developed a variety of solutions to address these challenges. For example, agencies conduct feasibility studies to estimate the sample sizes for a technology prior to implementing a system. They may also combine technologies to validate data and/or develop estimating algorithms based on ground-truthing. Agencies have addressed potential equipment failure through a variety of strategies, such as:

- Maintain spare equipment;
- Monitor readers automatically to proactively detect and address issues; and,
- Develop software solutions that can adapt to continue providing data when one piece of hardware fails.

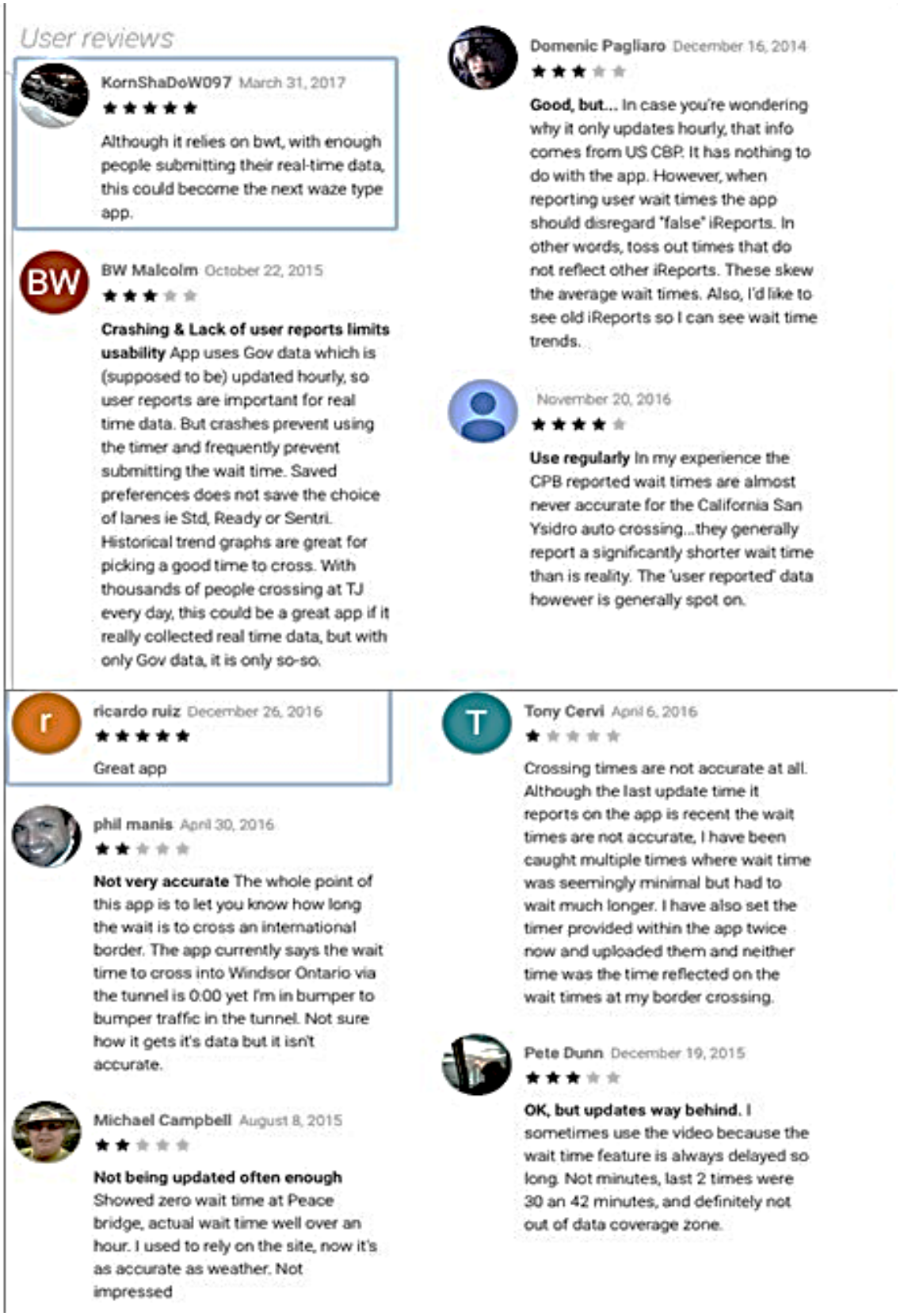
Information Dissemination Systems and Data Management

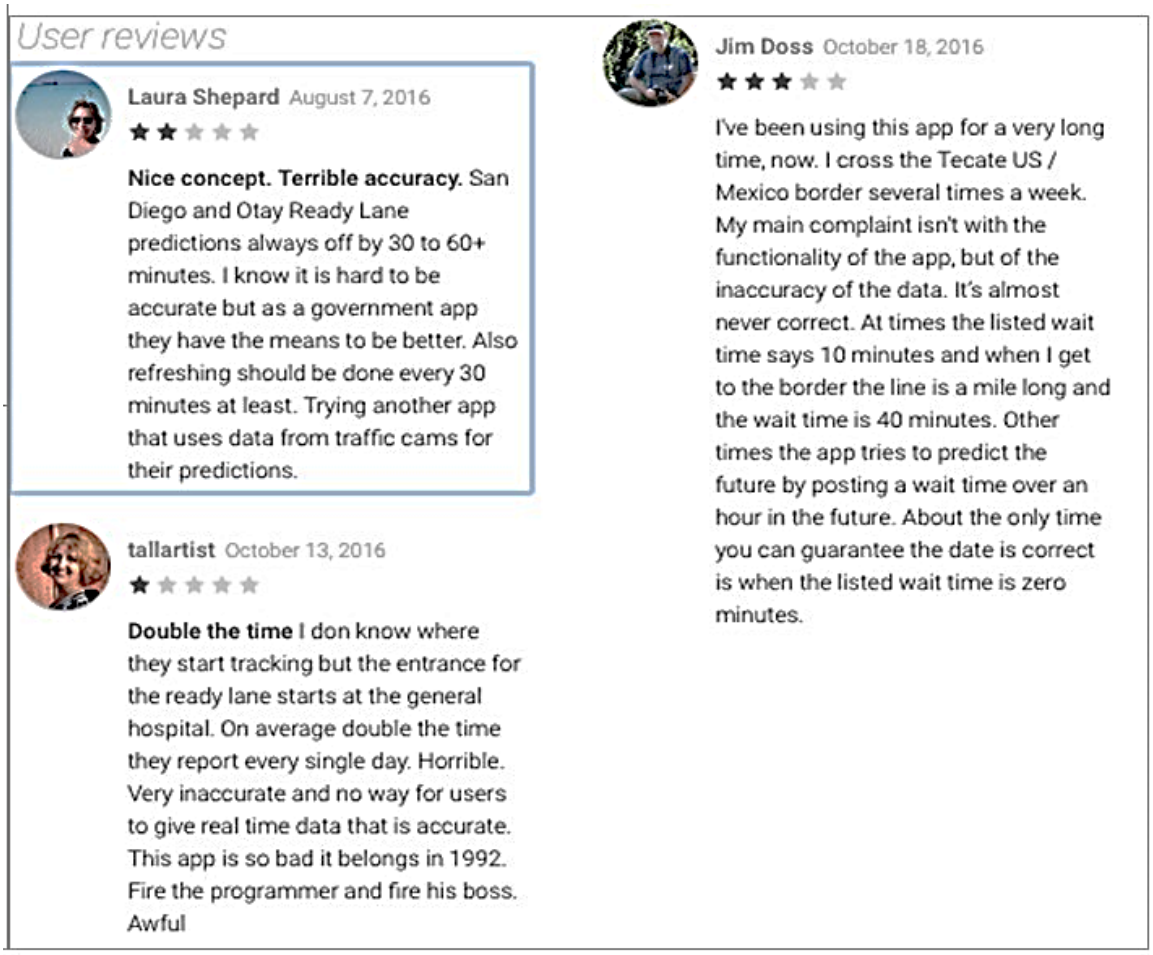
A variety of information dissemination mechanisms now exist that allow border crossers to obtain estimates of wait times. Television, radio, and word of mouth continue to be prominent sources of information with websites, mobile device apps, and social media also prevalent.

Smartphone navigation apps with live traffic information are available and used by border crossers, but the extent of use for the purposes of obtaining border wait time information were not addressed in this report. The type of data and methods used to calculate wait times vary according to the publisher of the information. Most applications rely on CBP's manually observed estimations of wait times and combine this with other data points such as live updates and reports from people crossing the border, analysis of historic wait time data and algorithms developed from live video feeds. While users suggest that these information sources seem more accurate than solely relying on the official CBP information, there is still a need to improve accuracy of the information. Crowd sourced data is becoming more available, and sources of data from academic and pilot programs are used for some applications and websites.

Figure 3 below demonstrates the lack of consensus of users of the various border wait time mobile apps that are currently available. Users expect and demand more accuracy than is currently possible through existing applications.

Figure 20 - Border Crossing Mobile App User Reviews





Apps and other border-focused websites that specifically address border crossing travel time and conditions have been developed by a variety of interested parties and some notable examples are described in the following section. The section titled Other Border Environments and Projects Reviewed in this document includes a more detailed discussion of the use of information dissemination mechanisms, predominantly web sites, by other agencies and organizations at border crossings in Washington, New York, Arizona, and Texas in their respective border environments.

INFORMATION DISSEMINATION

Smart Phone and Tablet Navigation Apps with Live Traffic Information

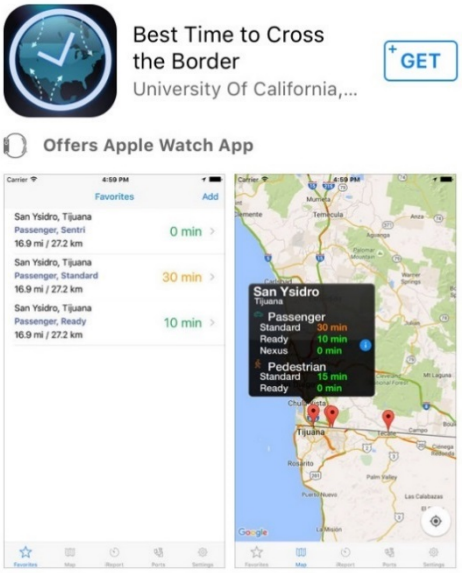
Many drivers use popular smartphone navigation apps to monitor traffic conditions and to obtain navigation information, and some provide basic border traffic and wait time information. The details of border wait time information and border area travel times vary with the app, the number of users at any point in time, and user reporting. A list of these apps is included in this report in the following section. The apps that have been developed, and are available and operational, continually evolve; therefore, this list is representative of what was available at the time this report was written.

Table 47- Smart Phone and Tablet Navigation Apps with Live Traffic Information

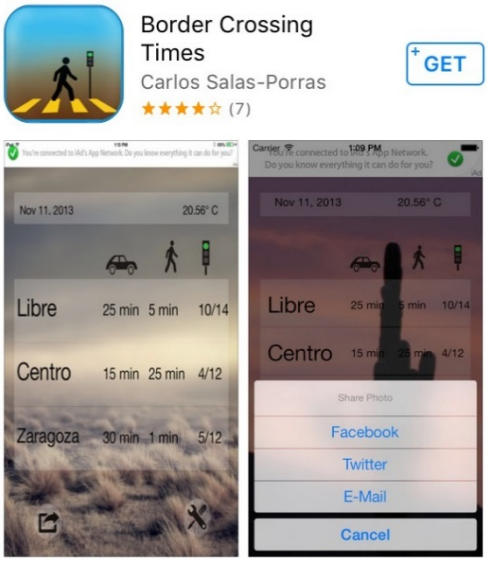
App Name	Cost	Comments
Apple Navigation	Free	Proprietary map and traffic data. iOS only.
Co-Pilot HD	$15+$10/yr	From ALK Technologies, Ltd. Traffic data by Inrix.
Garmin Viago	$2+$20/yr	Unique 3D views and lane choice guidance. Traffic data from HERE.
Google Navigation	Free	Proprietary map and traffic data. The world's most popular smartphone app.
Inrix	$10	Inrix Traffic data. Google Map data.
MapQuest	free	Owned by AOL. Uses OpenStreetMap. Traffic from TomTom/Inrix
MotionX GPS Drive	$10/yr	Traffic data from Trafficast.
NAVIGON	$50+$20/yr	Owned by Garmin, maps and traffic data by HERE.
Scout	Free	By Telenav, Inc. Uses OpenStreetMap. free Allows crowdsourced user reports. Proprietary traffic data
Sygic	$40+ $15/yr	Offline maps only. Traffic data provided by TomTom/Inrix.
TomTom	$39+ $20/yr	Traffic data from Inrix.
Waze	Free	Proprietary map and traffic data. No offline option. Crowdsourced traffic hazard reporting and map editing

Border Wait Time Smart Phone and Tablet Apps

Introduction here…

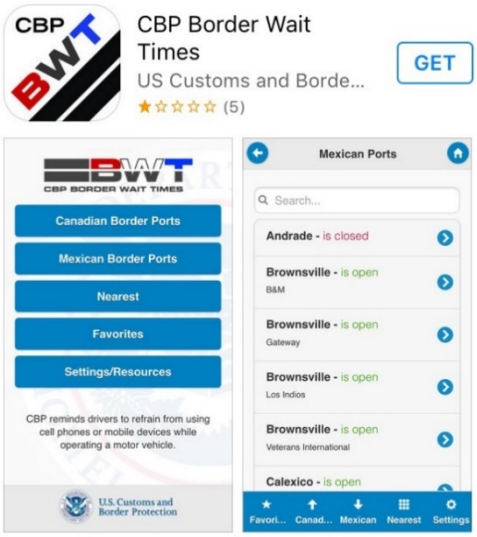


The **UCSD Calit2 app/website Best Time to Cross the Border App and Website** has been developed by students at University of California San Diego (UCSD). The app and website lets commuters report wait times via its *iReport* (crowdsourcing) feature which is fused with the CBP data to improve accuracy. Social media integration via Twitter and historical graphs showing trends allow users to make decisions as to when to cross. http://traffic.calit2.net/border/border-crossing-wait-times-map.php



The **Border Crossings Times** app was developed by a person who lives along and frequently crosses the Ciudad Juarez to El Paso, Texas border. Its popularity is rooted in the limited content for pedestrian and vehicle crossing times only at this border as provided by the U.S Customs and Border Protection

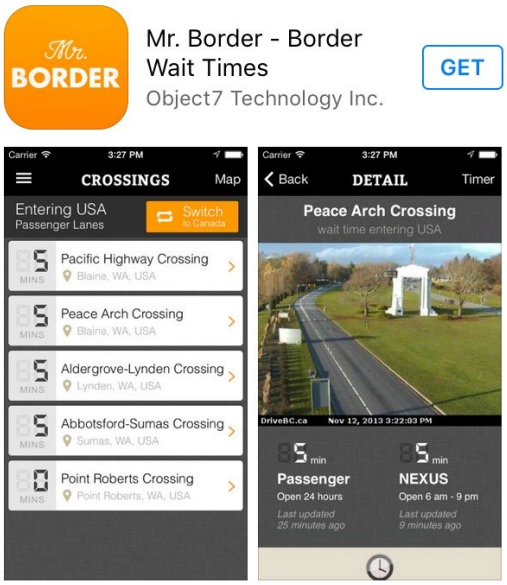
The **CBP BWT** app provides a smart phone app that reflects the same data that is available on the Customs and Border Protection web site. The app was first launched in December 2014. The app covers the US-



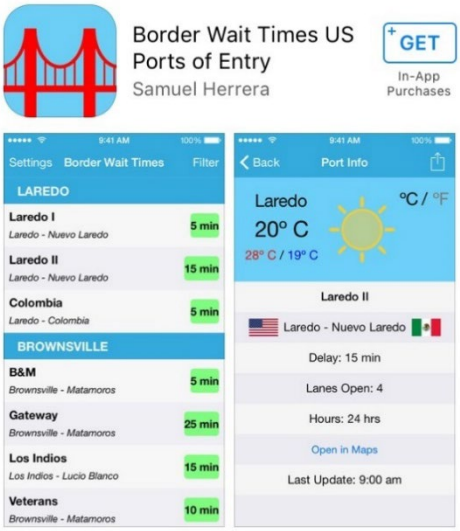
Canadian and US-MX border crossings and reports estimated wait times and open lane status for Standard, SENTRI, FAST, Ready Lane, and Nexus. Users of the app are generally more satisfied* with reported wait times relating to SENTRI and Ready lanes. Data for the app is derived from visual observations and cameras. Users of the app that are inquiring about wait times for standard lanes are dissatisfied with the accuracy of the reported wait times. The app is a free service provided by the Department of Homeland Security/U.S. Customs and Border Protection.

*Google Play and Apple App Store Reviews

Metropia is an app funded by City of El Paso that provides real-time POE wait time estimation and prediction and incentives (points collected and redeemed for gift cards). City of El Paso's goals are to reduce traffic congestion and wait times across the El Paso-Juarez border. This app went live in May 2018. The app incorporates user insights into their predictive models.



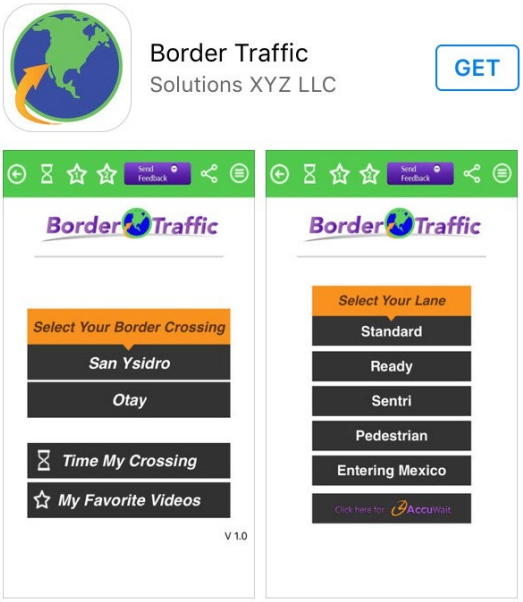
Mr. Border provides wait times for the USA/Canada and USA/Mexico border crossings by combining both official wait times with real-time wait information reported by actual border-crossing travelers (crowd-sourcing). An additional feature that increases usage of the app is the gas prices at the border crossings that are updated by users as they cross.



Border Wait Times US Ports of Entry is a simple app, released in 2016 provides the estimated wait times for US/Mexico border crossings.

Garitas is a simple app developed in 2015 to provide wait time for lanes at a specified US-MX crossing. The app is in Spanish or English. It allows the user to save a favorite crossing/mode for viewing when the app is opened. Color coding of the icons gives a visual indication of the delay expected for the specific lane. User reviews indicate there are some issues with accuracy of the estimated times.

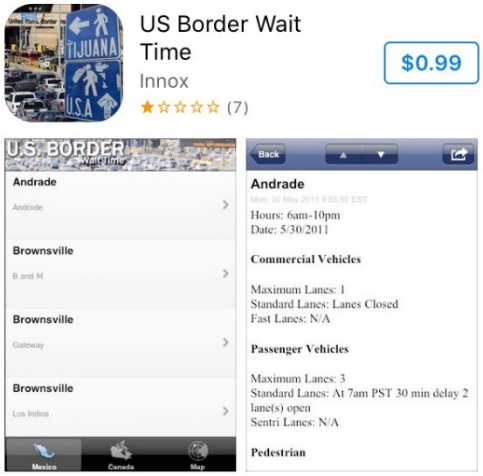
The **Border Traffic** app provides near real time videos of the San Ysidro (San Diego) / Tijuana and the Otay Mesa / Tijuana border crossings, 24 hours a day, 7 days a week (the front of vehicle lanes plus all available pedestrian views). The app feature, AccuWait, generates estimated wait times using analytics of BorderTraffic.com videos. It also provides, My Alerts, which notifies users when wait times meet criteria that they have set. For example, users can create an alert when the wait in the San Ysidro Ready Lane is less than 20 minutes.



Border Buddy Mexico, released in 2012, provides wait times at US/Mexico border crossings. No further information was provided by the developer or users.

The **US** **Border Wait Time** application shows the wait times to cross into the U.S. from Mexico or Canada through the pedestrian border or by car.

The app also includes maps of the border crossings so you can choose another one should there be a long wait time in your border crossing point.



Border Crossing Environment: Information and Monitoring Foundations and Needs

Past Border Wait Time Studies

Past border wait time studies are numerous and are motivated by a variety of data and information needs. Studies include public and private sponsors with varying levels of detail; some used existing and available data and others generated data through manual and/or technology based collection methods.

Studies reviewed included tests and pilot programs of a variety of data collection and monitoring technologies. These technologies and their applications are evolving so quickly that a study completed just a few years ago, may have been overtaken by new information, new tests, new pilots and new versions or generations of the technology involved. Agencies and organizations interested in ways to automate border wait time data collection are continually testing new combinations of technologies that provide more robust and accurate data sets that may be distilled into more accurate and useful border crossing travel time and wait time information for the end users – the people traveling on foot, by car, or operating commercial vehicles.

Lessons learned from some of these studies are timeless, and usually pertains to planning, stakeholder engagement, policy, operation, maintenance, and inter-agency and international coordination, collaboration, and cooperation. These studies are footnoted throughout this document as attributable information is woven into the relevant section or topic.

Below is a list of the relevant studies reviewed for this white paper:

1. Commercial Trade Statistics, Department of Homeland Security, Customs and Border Protection, August 2017.
2. Wireless Technologies for Motor Carrier Efficiency: Update, Draft, Sutra Research & Analytics, January 2017.
3. NOW: Taking it to the Streets: Collecting Travel Time Data, Speed with Bluetooth Technology, Texas Transportation Institute, Texas Transportation Researcher Article, 2016.
4. Assessment of Existing “Gaps” on Border Data (Including Wait Times); Economic and Air Quality Impacts of Delays at the Border, SANDAG, HDR, July 2016.
5. Data Collection and Uses at International Border Crossings – Technology Options, Texas Transportation Institute; Villa, Juan Carlos; July 26, 2016
6. Border Waits Analysis at the Nogales-Mariposa Port of Entry, FHWA, ADOT, January 14, 2016.
7. Border Wait Time Detectors Temporary Installation Procedure, IBI Group, January 14, 2016.
8. Memorandum to SANDAG: Results of Temporary Installation of Bluetooth and Wi-Fi Point Vehicle Time Detection (PVTD) Devices, SANDAG, IBI Group, January 28, 2016.
9. Memorandum to SANDAG: Border Wait Time Detection System Installation and Maintenance, IBI Group, December 1, 2015.
10. Border Corridors and Trade Report, Texas Department of Transportation, December 2015.

11. Analysis of Bluetooth and Wi-Fi Technology to Measure Wait Times of Personal Vehicles at Arizona-Mexico Ports of Entry, Arizona Department of Transportation, Lee Engineering, LLC, October 16, 2015.
12. San Ysidro Southbound Border Wait Time Pilot, IBI Group, September 2015.
13. Border Wait Time Detection Pilot Program, Fact Sheet, SANDAG, March 2015.
14. Crowdsourcing Transportation Systems Data, Michigan Department of Transportation, Center for Automotive Research, February 2015.
15. Technical and Bureaucratic Challenges to National Data Warehouses: Summary of the US-Canada Data Warehouse Project, Whatcom Council of Governments, IBI Group, 2014.
16. Joint Interim Committee to Study the Effects of Border Wait Times, Interim Report 2014: A Report to the House of Representatives 84th Texas Legislature, September 2014.
17. Border Wait Time – Buffalo-Niagara Region, US/Canada Transportation Border Working Group, Niagara Falls Bridge Commission and Buffalo & Fort Erie Public Bridge Authority, Dafoe and Ripa, May 2014.
18. Measuring and Documenting Truck Activity Times at International Border Crossings, USDOT Region V NEXTRANS Project No. 067OY03, Ohio State University, McCord, Mark, April 2, 2014.
19. State of the Practice on Use of Intelligent Transportation Systems at US-Mexico Land Border Crossings, 92nd Annual Meeting of the Transportation Research Board; Texas Transportation Institute, Rajbhanddari, Rajat, January 2013.
20. SR 11/Otay Mesa East Port of Entry ITS Pre-Deployment Strategy, SANDAG, IBI Group, October 2012.
21. Implementing a System to Measure and Disseminate Wait and Crossing Times at California Border Crossings, San Diego Association of Governments (SANDAG), Prepared by IBI Group, October 2012.
22. Commercial Border Crossing and Wait Time Measurement at Laredo World Trade Bridge and Colombia-Solidarity Bridge, Texas Department of Transportation, Texas Transportation Institute, March 31, 2012.
23. SR 11/Otay Mesa East Port of Entry ITS Pre-Deployment Strategy, State of the Practice Scan, Final Technical Memorandum I, Version 3.0, SANDAG, IBI Group, February 2012.
24. Field Experiment to Identify Potentials of Applying Bluetooth Technology to Collect Passenger Vehicle Crossing Times at the U.S. – Mexico Border, Center for International Intelligent Transportation Research, TTI, 2009.
25. Field Experiment to Identify Potentials of Applying Bluetooth Technology to Collect Passenger Vehicle Crossing Times at the U.S.-Mexico Border; Texas Transportation Institute, Rajbhanddari, Rajat, July 2009.
26. Inventory of Current Programs for Measuring Wait Times at Land Border Crossings, Transport Canada, May 2008.
27. Measuring Cross-Border Travel Times for Freight: Otay Mesa International Broder Crossing, Technology Evaluation, FHWA, Delcan & Cheval Research, March 2008.
28. Travel Time Estimation Using Cell Phones (TTECP) for Highways and Roadways, Florida Department of Transportation, Wunnava, Subbarao, et. al., January 29, 2007.

Regional Border Environments

This section is included to provide context for understanding challenges associated with selecting and deploying data collection technologies and systems for border wait or crossing time assessments. The border crossing environments in San Diego and Imperial counties are varied in population, demographics, climate, and usage. Each crossing has unique characteristics that are favorable for certain types of technologies and data collection methodologies. Each crossing is uniquely managed to accommodate the specific characteristics of the local environment, community, infrastructure, facilities, and government agency staffing and capabilities. The following snapshots provide a quick summary of the environments, populations, any notable unique characteristics, and recent Bureau of Transportation Statistics estimates of crossing volumes for personal vehicles, trucks, buses, and pedestrians. This context is important when reading the following section, Other Border Environments and Projects Reviewed, such that reasonable comparison may be made between the crossings and technology deployments.

SAN DIEGO BORDER ENVIRONMENTS

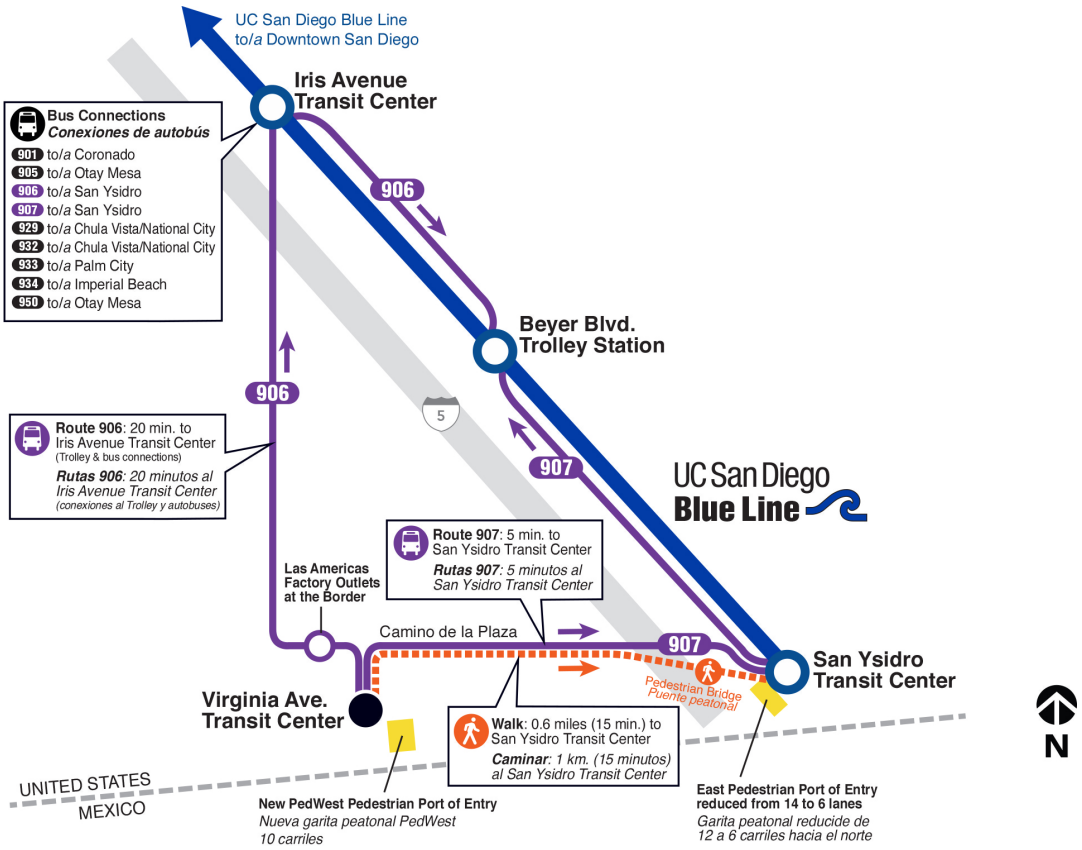
San Diego region includes the crossings at San Ysidro, CA (crossing with Tijuana, BC), Otay Mesa, CA (crossing with Mesa de Otay, BC), and Tecate, CA (crossing with Tecate, BC). In general, the San Diego area crossings are subject to coastal and Mediterranean climates with warmer, dryer environments to the east; this environment is conducive to the use of a variety of technologies. Any technology deployed in an outdoor environment is subject to weather, thus appropriately hardened or protected technologies are among the considerations from an environmental standpoint.

Security of the equipment must be analyzed and considered for deployment of each technology - security has proven to be challenging in some border environments and must be a primary consideration when selecting deployment sites, infrastructure requirements, monitoring capabilities, technology housing, and operations and maintenance requirements and procedures.

San Diego's land ports of entry each have the following described unique characteristics:

San Ysidro straddles the border between metropolitan Tijuana and the community of San Ysidro (12 miles to the south of downtown San Diego). San Ysidro is a crossing for passenger vehicles (privately owned vehicles (POVs) and buses) and pedestrians only. Data collected from this crossing will be limited to passenger vehicles and pedestrians; information disseminated for this crossing will need to be most useful to passenger vehicle and pedestrian crossers along with the government agencies and private businesses that will use the data for their own purposes. Major highways connect vehicles and pedestrians to this crossing. This crossing is also served by two transit centers (San Ysidro and Virginia Avenue) that offer bus connections (MTS, Greyhound, and Mexican providers), trolley connections to the "Blue Line," taxi and jitney services. These services, routes, and transit centers, are depicted in **Figure 4**.

Figure 21 - San Ysidro and Virginia Ave Transit Centers (Blue Line)



The crossing has infrastructure and communications capabilities to support a variety of data collection technologies. Cellular services are plentiful and often conflicting in this busy border environment.

The U.S. Bureau of Transportation Statistics reports that the annual northbound San Ysidro crossing volumes (2016) are as follows[57]:

Personal Vehicles	Trucks	Buses	Pedestrians
13,701,967	NA	NA	7,382,363

San Ysidro is ranked the number one U.S. – Mexico border crossing for volumes of personal vehicles and pedestrians for the period January to December 2016.

Otay Mesa accommodates passenger vehicles, pedestrians, and commercial vehicles (within a specific commercial vehicle only section of the facility). Otay Mesa East, when completed, will accommodate the same mix of passenger and commercial vehicles. Data collected and information disseminated for these crossings will need to be useful to all three types of crossers along with the government agencies and private businesses that will use the data for their own

[57] U.S. Bureau of Transportation Statistics, https://transborder.bts.gov/programs/international/transborder/TBDR_BC/TBDR_BC_QuickSearch.html

purposes. Major highways connect passenger and commercial vehicles and pedestrians to these crossings. Construction is underway at for the new Otay Mesa Transit Center with dedicated access to South Bay Rapid service (anticipated to begin in 2018) and local bus routes operated by MTS. The crossings have infrastructure and communications capabilities to support a variety of data collection technologies. Cellular services are plentiful and often conflicting. The future Otay Mesa East crossing has similar capabilities currently under construction and will include fiber optic communications.

The U.S. Bureau of Transportation Statistics reports that the annual northbound Otay Mesa crossing volumes (2016) are as follows:

Personal Vehicles	Trucks	Buses	Pedestrians
7,722,264	899,336	32,877	3,504,800

Tecate accommodates passenger vehicles, pedestrians, and commercial vehicles (within a commercial vehicle only section of the facility). The Tecate crossing is located in a rural part of San Diego County served by rural State Route 94, a two-lane road with curves that limit some types of commercial vehicles. On the Mexican side of the crossing is the busy city of Tecate. The Tecate crossing has infrastructure and some communications capabilities to support certain data collection technologies. Cellular service in Tecate is improving, but dependent on service provider and often wrought with connection issues and “dead zones”.

The U.S. Bureau of Transportation Statistics reports that the annual northbound Tecate crossing volumes (2016) are as follows:

Personal Vehicles	Trucks	Buses	Pedestrians
971,193	56,269	94	673,605

IMPERIAL COUNTY BORDER ENVIRONMENTS

The border crossings at Andrade, CA (crossing with Los Algodones, BC) and Calexico East and West (crossings with Mexicali, BC) occupy the dry desert climate and terrain of the Imperial Valley with temperatures often exceeding 100 degrees for four to five months of the year. Wind, sand, excessive heat, and periodic monsoon rains create a challenging environment for electronic technologies. As technologies are selected for these crossings, consideration must be given to whether they require cooling, additional protection, or hardened components that can withstand the harsher than average conditions that may be outside of equipment tolerances for temperature, humidity, or contaminants.

Calexico West serves a frequently crossing population that is passenger vehicle dominant with some pedestrians. The only wait time or crossing time data that can be collected for this crossing is from pedestrians and passenger vehicles. Commercial vehicles are not permitted at this port of entry. Therefore, information disseminated for this crossing will need to be most useful to passenger vehicle and pedestrian crossers along with the government agencies and private businesses that will use the data for their own purposes.

The U.S. Bureau of Transportation Statistics reports that the annual northbound Calexico West crossing volumes (2016) are as follows:

Personal Vehicles	Trucks	Buses	Pedestrians
4,327,034	NA	NA	4,270,911

Calexico East serves the city of Calexico on the U.S. side and the city of Mexicali on the Mexican side. Calexico has a population of about 40,000 people and Mexicali has a population of about 690,000 people. The Calexico East/Mexicali crossing accommodates passengers, pedestrians, and commercial vehicles (within a commercial vehicle only facility). Data collected and information disseminated for these crossings will need to be useful to all three types of crossers along with the government agencies and private businesses that will use the data for their own purposes.

The U.S. Bureau of Transportation Statistics reports that the annual northbound Calexico East crossing volumes (2016) are as follows:

Personal Vehicles	Trucks	Buses	Pedestrians
3,829,484	349,727	2,906	253,992

Andrade is a border crossing that sits near the Colorado River along the border of Arizona and shares the border crossing with the Mexican town of Los Algodones. Andrade had a population of 49 people during the last census. Los Algodones is a busy Mexican town with a population of about 5,500 people. Pedestrians and passenger vehicles dominate this crossing. Andrade/Los Algodones border crossing ranks 11th among pedestrian border crossers and is used heavily by tourists and those seeking medical supplies and services. The crossing is served by rural State Route 186 in the US.

The U.S. Bureau of Transportation Statistics reports that the annual northbound Andrade crossing volumes (2016) are as follows:

Personal Vehicles	Trucks	Buses	Pedestrians
506,230	NA	NA	833,296

Other Border Environments and Projects Reviewed

Other border crossing environments that provide relevant and recent experience with technology deployments, pilot tests, or studies that are relevant to San Diego and Imperial County include Nogales, AZ (crossing with Nogales, Sonora, Mexico); Whatcom County, WA (Including I-5 Peace Arch, SR 543 Pacific Highway, SR 539 Lynden/Aldergrove, SR 9 Sumas/Huntingdon crossings); Peace Bridge in Buffalo, NY (crossing with Fort Erie, ON, Canada); and the Texas border crossings (including Brownsville, Pharr, Eagle Pass, Laredo, and El Paso, TX). The following sections provide comparison information about these crossings with descriptions of wait-time technology deployments, pilot programs, or tests conducted the crossing location.

NOGALES, ARIZONA

The environmental conditions of the Nogales area border crossings, situated along the southern border of Arizona and northern border of Sonora, Mexico, are very similar to harsh, arid desert conditions and temperature extremes of the crossings in Imperial County at Calexico and Andrade. Nogales, AZ has a population of about 20,400 people; and Nogales, Sonora, Mexico is a much larger city with a population estimated at 220,292 (in 2010). Arizona shares 9 land ports of entry with Mexico. Three border crossing facilities are located within, or in the vicinity of, the cities of Nogales, AZ and Nogales, Sonora, MX along the southern border of Arizona and northern border of Sonora, Mexico. The three crossings, as they are commonly referred to, are:

- **Nogales-Mariposa** crossing at Nogales, AZ/Nogales, Sonora, Mexico at Mariposa Rd. serves trucks and cars along SR189 in AZ and Fed. 15 in Mexico; this is the only crossing for trucks in the Nogales area.
- **Nogales-Grand Avenue** crossing (also sometime referred to as the Nogales – DeConcini crossing) serves cars only (no trucks) along Interstate 19 in AZ and Boulevard Adolfo Lopez Mateos in Nogales, Sonora, Mexico.
- **Nogales-Morley Gate** crossing at Morley Avenue serves pedestrians only.

The U.S. Bureau of Transportation Statistics reports that the approximate combined annual northbound Nogales ports crossing volumes are as follows:

Personal Vehicles	Trucks	Buses	Pedestrians
3,477,415	312,010	9,423	3,420,708

Arizona currently uses the CBP estimated crossing volumes for all their ports of entry. Wait times have also been historically compiled through manual observation of the end of the queue by CBP personnel and traveler surveys. New Wi-Fi readers are being installed at the Nogales-Mariposa and Nogales-Grand Avenue crossings as part of a larger installation of readers that began in 2016 and is pending completion in 2017. The intent of the installation is to make wait time data available to motorists via the CBP website once testing for reliability has been completed.

A recent comparison study by Arizona Department of Transportation (ADOT) and Lee Engineering of border crossing installations of Bluetooth and Wi-Fi equipment included co-located detectors along the highway to detect Bluetooth and Wi-Fi enabled devices in passenger vehicles traveling to and from the port of Entry. The study installed test devices along primary access roads to six U.S. – Mexico ports in Arizona; the Nogales-Mariposa and Nogales-Grand Avenue (DeConcini) crossings were among the six.

Some notable findings from this study include:

- Anonymous Re-identification travel time data collection using Wi-Fi technology resulted in higher penetration rates for this Port of Entry study application than using Bluetooth technology.
- Travel time data collection using Wi-Fi technology resulted in higher penetration rates for this Port of Entry study application than other Arizona deployments on freeways and urban arterial roadways within the past year.
- ARID (Wi-Fi) technology collects enough valid data to estimate border crossing times with 95% confidence, except for the Mariposa POE in the northbound direction. This is due to low penetration rates at the Mariposa POE, which may have been related to deployment location or technology interference.
- Due to security concerns, the equipment at each location was taken down each day by 10:00 PM to ensure the security of the devices. Data was collected between the hours of 4:00 AM and 10:00 PM at this POE.

At the Nogales – Mariposa crossing, another ADOT study is underway to measure commercial vehicle wait times that uses existing RFID equipment installed in trucks already enrolled in the FAST program and used by ADOT at state inspection facilities. For this study, no new in-vehicle equipment installation is required and continuing costs of operation are expected to be low. Agreements must be made among the U.S. and Mexican agencies to install RFID readers at appropriate locations on both sides of the border. The first reader is located at the Aduana (Mexican Customs) facility, 8 miles from the border. The second reader is located near the anticipated end of the queue, about 0.5 miles south of the U.S. CBP primary inspection booths. A third reader is located at the CBP primary inspection booths, and the last reader is located at the exit of the ADOT rapid inspection lanes. The RFID-generated data is processed and reported as wait time using Texas A&M Transportation Institute (TTI) Border Crossing Information System (BCIS) website as shown in **Figure 5**. A more detailed mapped view of the wait time for specific segments along the route through the Nogales – Mariposa crossing is shown in **Figure 6**. Additionally, ADOT intends to disseminate this date using dynamic message signs, the Arizona 511 (AZ511) system, and smart phone apps.

Figure 22 - Border Crossing Information System - Nogales - Mariposa

BORDER CROSSING INFORMATION SYSTEM
COMMERCIAL VEHICLES
REAL-TIME INFORMATION

Real-time Information
Query Archived Data
View Dashboard
Subscribe Data
View Project Reports
About Team and Sponsors
Help and Glossary
Contact Us

Nogales-Mariposa Port of Entry, Nogales, AZ

Wait time for Nogales-Mariposa Port of Entry, Nogales, AZ is estimated based on the travel time between the RFID station located approximately half a mile south of the border line and the RFID station at U.S. CBP Primary.

Crossing time for Nogales-Mariposa Port of Entry, Nogales, AZ is estimated based on the travel time between the RFID station at exit of Mexian Aduana and the RFID station at Exit of ADOT.

EXPECTED WAIT TIME		UPDATED AT
EXPECTED CROSSING TIME	FAST	
	Non FAST	

FAST	Non FAST

Veteran's Memorial Bridge, Brownsville, TX

No Delay	37 Minute(s)	24 Minute(s)	53 Minute(s)	Apr 25 2017 5:20PM CST

Pharr-Reynosa International Bridge, Pharr, TX

No Delay	49 Minute(s)	50 Minute(s)	104 Minute(s)	Apr 25 2017 5:20PM CST

World Trade Bridge, Laredo, TX

29 Minute(s)	32 Minute(s)	108 Minute(s)	108 Minute(s)	Apr 25 2017 5:20PM CST

Colombia Bridge, Laredo, TX

No Delay	No Delay	16 Minute(s)	40 Minute(s)	Apr 25 2017 5:20PM CST

Camino Real International Bridge, Eagle Pass, TX

N / A [1]	No Delay	N / A [1]	21 Minute(s)	Apr 25 2017 5:20PM CST

Ysleta Bridge, El Paso, TX

No Delay	24 Minute(s)	30 Minute(s)	36 Minute(s)	Apr 25 2017 4:20PM MST

Bridge of the Americas, El Paso, TX

No Delay	No Delay	27 Minute(s)	45 Minute(s)	Apr 25 2017 4:20PM MDT

Nogales-Mariposa Port of Entry, Nogales, AZ

N / A [2]	No Delay	N / A [2]	37 Minute(s)	Apr 25 2017 3:20PM MST

N / A[1] = Not available as there are no FAST lanes at this crossing
N / A[2] = Not available at the moment as FAST crossing and wait times are not being measured

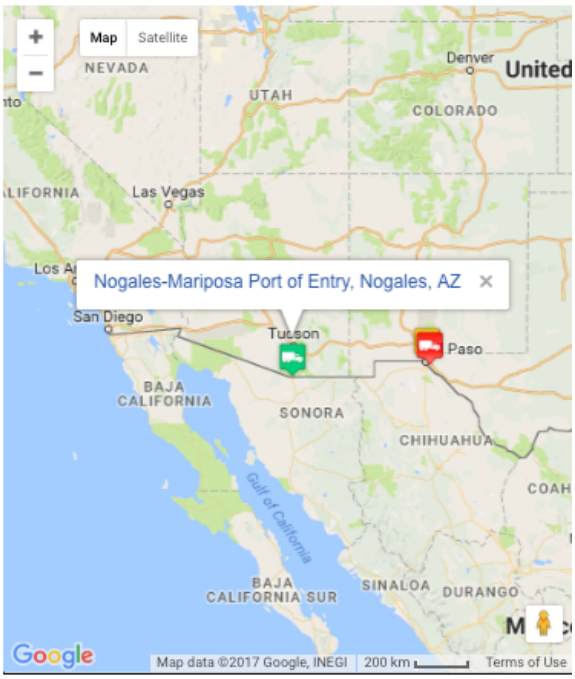
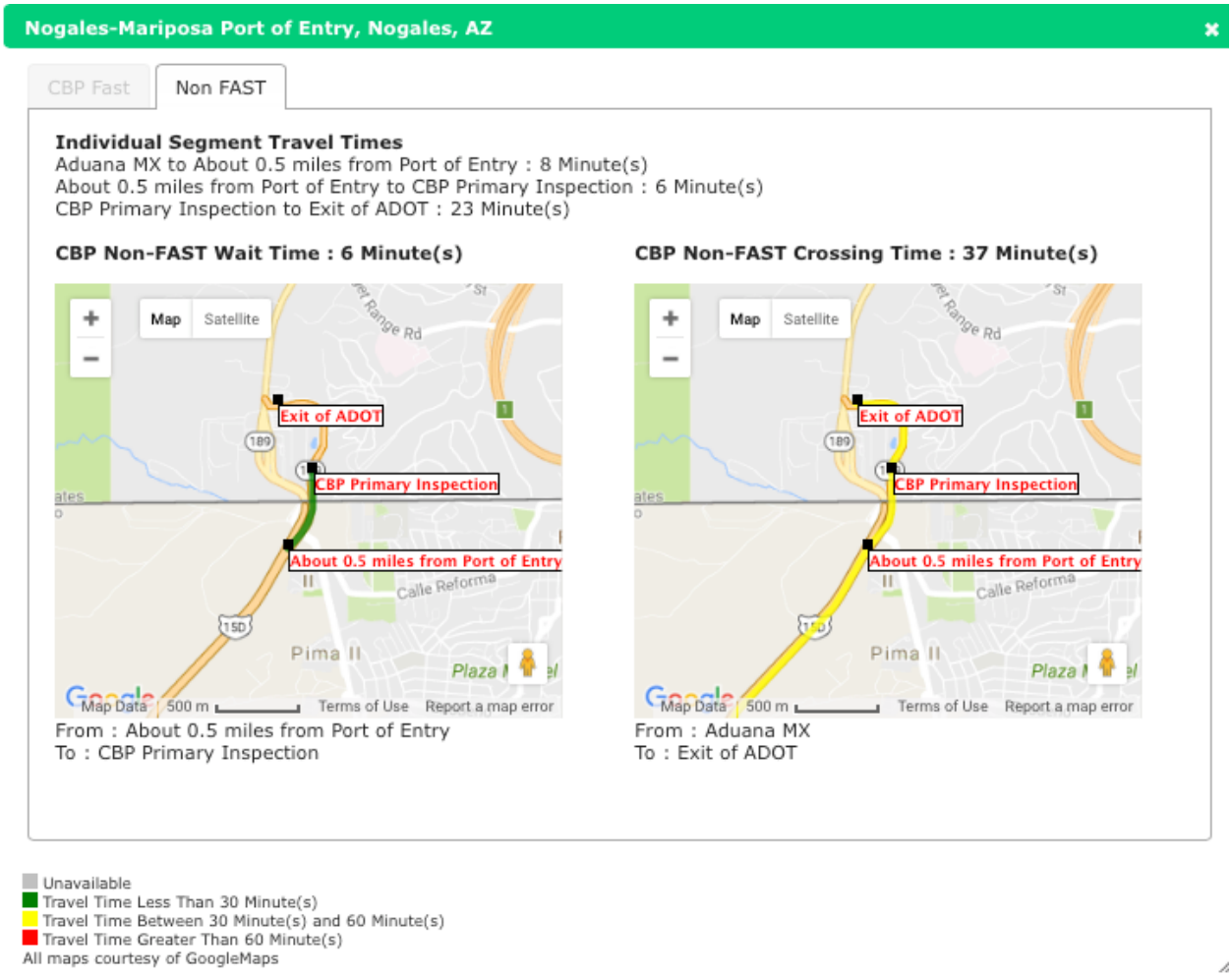


Figure 23 - BCIS Detailed Segment Travel Time maps



WASHINGTON STATE AND WHATCOM COUNTY

The U.S. – Canadian border crossings in Whatcom County in Washington State are situated along a stretch of the northern U.S. and Canada border that begins at the Pacific coast and continues into the Cascade Mountains, sharing this border with British Columbia, Canada. **Figure 7** depicts the relative locations of these crossings. The environment is four seasons with frequent rain throughout the year and snow in the winter. Populations along the northern border crossing in Washington State are relatively sparse. The border crossings in Whatcom County include 2 crossings at Blaine, WA (Peace Arch and Pacific), Aldergrove at Lynden, WA, and Sumas at Sumas, WA:

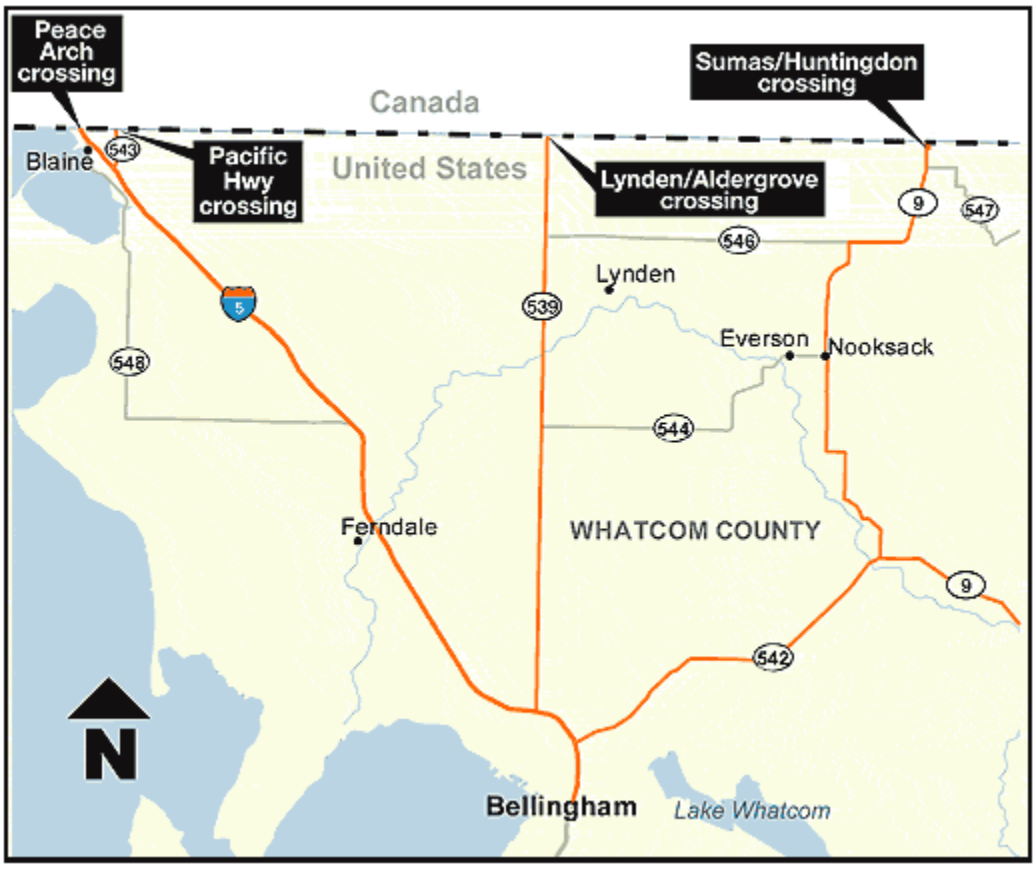
- **Peace Arch, Blaine** – is located at Blaine, WA and serves cars (personal vehicles) only and includes a Nexus lane (I-5). This crossing operates 24 hours a day;
- **Pacific Highway, Blaine** – is located at Blaine, WA just east of the Peace Arch crossing and serves cars and trucks. This crossing includes Nexus and FAST lanes (Hwy 543). This crossing operates 24 hours per day;

- **Aldergrove, Lynden** – is located at Lynden, WA and serves cars and trucks. (Hwy 539). This crossing has no Nexus lanes and operates 8:00AM to midnight daily.
- **Sumas** – is located at Sumas, WA (Hwy 9). This crossing operates 24 hours per day. Sumas has the highest volume of northern border pedestrian crossings on the west coast and is rated #2, with Buffalo-Niagara Falls at #1.

The U.S. Bureau of Transportation Statistics reports that the annual southbound Whatcom County-based crossing volumes are as follows:

Crossing	Personal Vehicles	Trucks	Buses	Pedestrians
Blaine (combined)	3,900,537	365,489	14,961	NA
Aldergrove (Lynden)	512,823	46,221	29	1,236
Sumas	841,997	158,257	531	33,531

Figure 24 - Whatcom County (Washington State) Border Crossings Map



Washington State Department of Transportation (WSDOT) uses different types of data collection devices, predominantly inductive loops embedded in the roadway, to monitor traffic flow and travel times. Data is sent from roadside equipment to WSDOT TMCs to monitor operations and provide traffic conditions to websites, variable message signs, and the WSDOT 511 traffic information hot line. WSDOT operates seven regional Traffic Management Centers that gather real-time traffic information around the clock.

The Cascade Gateway Border Traveler Information System collects wait time data at the following U.S.-Canadian border crossings: Blaine-Peace Arch passenger vehicle crossing including Nexus lane (I-5), Blaine-Pacific Highway passenger and commercial vehicle crossing, including Nexus and FAST lanes (Hwy 543), Lynden-Aldergrove (Hwy 539), and Sumas (Hwy 9).

Loop detectors near border inspection booths and further up the highways were installed initially in 2001, with additional installations in 2003 at the Peace Arch and Pacific Highway crossings. Loop detector systems are also in place at the Lynden-Aldergrove and Sumas border crossings. An additional smaller wait time measurement system that uses loop detectors and license plate readers is in place at the Oroville border crossing site. All loop detectors and license plate readers are located on DOT owned and operated roads.

The system uses an algorithm that calculates wait times by the estimated number of vehicles in the queue by the service rate. Loop detectors prior to the inspection booths determine service rate by counting the vehicles per minute and loop detectors further upstream determine the number of vehicles in the queue. WSDOT also has a set of 16 traffic cameras that allow monitoring of traffic conditions at the four U.S. Canada border crossings.

The SR 539 border crossing was a study site in 2011 for Bluetooth MAC address detection devices and methodologies. The distance between the Bluetooth sensors for this study was about 2.64 miles. Delay for this study was measured as follows*: Delay = Travel Time – Free Flow Travel Time*. Although this study is now a few years old, it provided important early information about Bluetooth reader and data processing capabilities compared with ALPR and loop detectors, and validated it as a viable, low-cost, minimal infrastructure alternative method for collecting travel time data using MAC address detection.[58]

Canada-bound border traffic is reported on the WSDOT website, https://www.wsdot.wa.gov/traffic/border/, and displayed as shown in **Figure 8**.

U.S.-bound border traffic is reported on the B.C. Ministry of Transportation and Infrastructure, B.C./U.S. Border Traveler Information website, http://www.th.gov.bc.ca/ATIS/atis.htm, and displayed as shown in **Figure 9**.

[58] Wang, *Error Modeling and Analysis for Travel Time Data Obtained from Bluetooth MAC Address Matching*, WSDOT, Washington State Transportation Center, December 2011.

Figure 25 - WSDOT Canadian Border Traffic Website (Canada-bound Traffic)

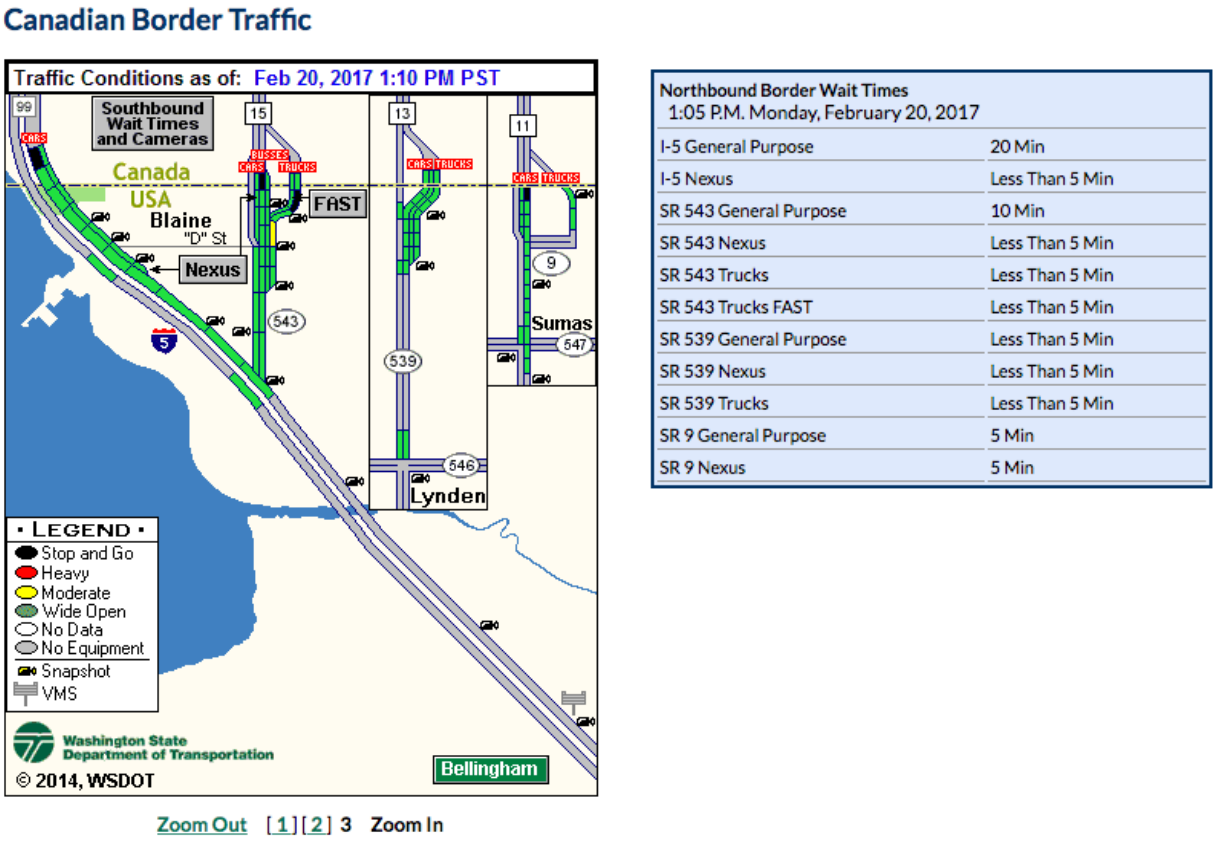
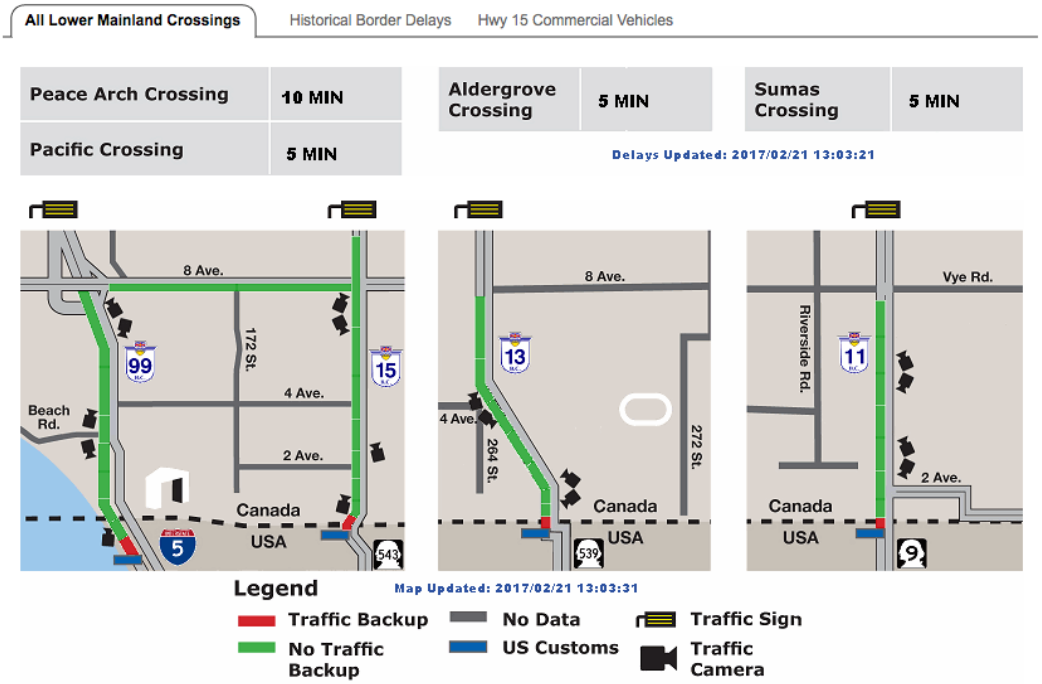


Figure 26 - BC MTI B.C/U.S. Border Traveler Information Website (U.S. Bound Traffic)



In the International Mobility and Trade Corridor (IMTC) Program: Dynamic Border Management studies, led by the Whatcom Council of Governments (WCOG), identified three initiatives that contain priorities for border wait time system management, accuracy, and validation. These projects include[59]:

1. **Border facility simulation modeling** to enable detailed comparisons of investment alternatives and other operations and policy changes to border transportation and inspection systems.
2. **Cascade Gateway RFID pilot** to complete data collection, modeling, and a business case for a proposed pilot project to distribute vicinity readable RFID border crossing documents to frequent crossers already in possession of valid passports.
3. **Integrated border wait time validation and calibration methodology** will develop, implement, and document a standardized method of validating regional border wait time systems.

The integrated border wait time validation and calibration methodology project is particularly important for any agency or consultants planning the operation and maintenance of a technology system to assist with measurement and monitoring of border wait times, or any other similar system. For this project, WCOG provided the following summary of the need for regular periodic validation and calibration in the operation and maintenance of their technology-based system:

> *Since B.C. Ministry of Transportation and WA State Department of Transportation installed border wait time measurement systems, typical incremental changes to facilities (roadway and inspection) have resulted in often unexpected impacts to border wait time system accuracy. Other sources of periodic error have included failed hardware (loops, controllers, etc.) or operational changes (changed location of dedicated commuter lanes, etc.).*
>
> *Border wait time measurement systems are a relatively new and geographically limited feature of the transportation network. They were installed without a program of periodic validation and, if needed, calibration (refinement of the estimation algorithm or other software or hardware fixes). Over the years, it has become clear that the regional border wait time measurement systems should be validated on a scheduled basis and supported by sufficient resources for ongoing adjustments and maintenance.*

The IMTC documents reviewed indicate that Bluetooth would be the proposed technology of choice for the wait time validation system. However, in conversation with WCOG staff, they indicated that the interest in installing a Bluetooth-based system has been indefinitely delayed due to lack of required funding. Canada Border Services Agency primarily advanced the concept to help measure times for standard (non-Nexus lane) traffic. The system currently in place is based on data collection through the inductive loops installed along the route to the

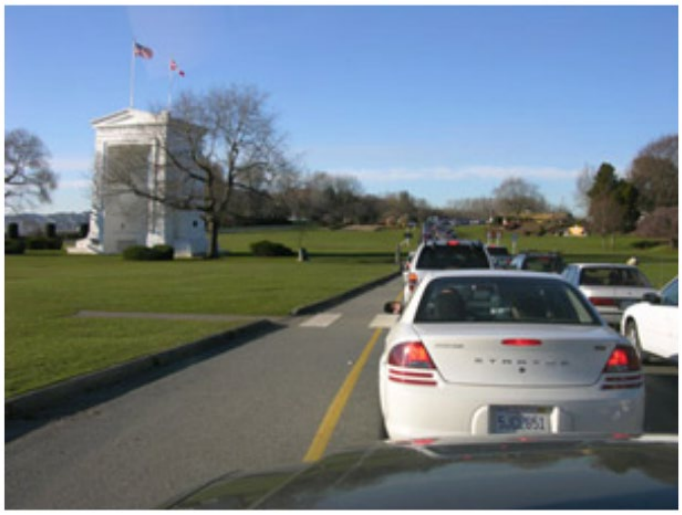
[59] Whatcom Council of Governments, International Mobility and Trade Corridor Program, Dynamic Border Management website, http://theimtc.com/dbm/

inspection facilities. Overall, WCOG staff indicate that this system is good at estimating wait time of next arriving vehicle; but not actual wait times.[60]

More specifically, the Bluetooth system would have required the addition of new power and IT connections at an unacceptable cost. Further, the agencies are also now concurrently looking at Wi-Fi as the underlying technology for any future supplementary or validating systems due to perceived better coverage and reliability.

In the interim, WCOG addressed the validation issues with updates to the underlying algorithm. Additional validation measures were conducted with ALPR in a temporary installation of mobile license plate readers. The agencies jointly analyzed data and figured out where errors where originating. Systems were brought into integrity by working with DOT and inspection agencies to adjust the system's algorithm accordingly. The system wait times have been corrected and now take into consideration and integrate newly available data – based on the CBSA's new dynamic booth management. Dynamic booth management allows the agency to re-purpose lanes as demand changes. To do this the agency installed corresponding LED signage – to be able to move Nexus booth to open additional lanes during peak traffic.

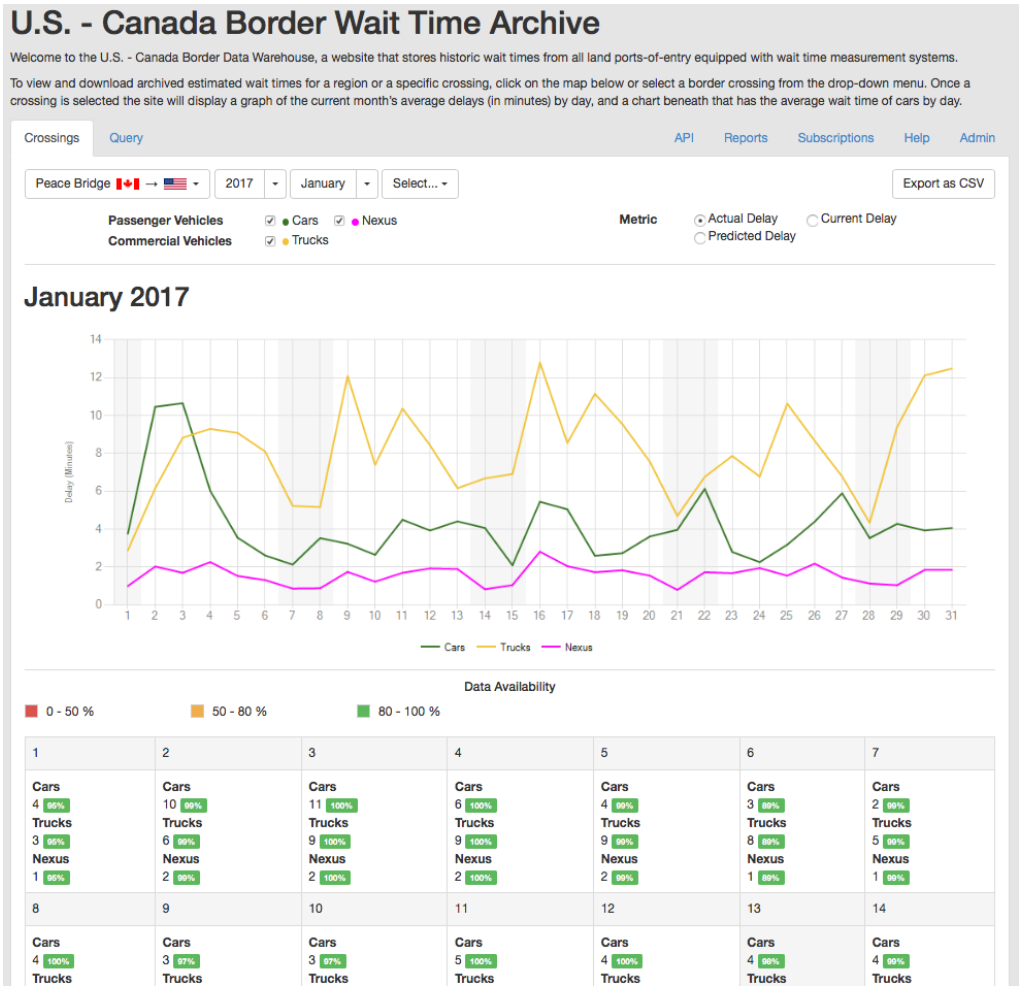
Figure 27 - Peace Arch Border Crossing, near Blaine, WA (WSDOT)



Border Wait-time data collected is consolidated, archived, and disseminated from the US-Canada Border Data Warehouse, a dynamic database accessible online. The objective of the database and online access site are to provide a single source for high resolution border wait time data that is comparable to all connected crossings. The database and website are scalable to allow for new wait time systems to be added as they are installed. The wait times provided are historic and depicted in **Figure 11**. The site is located at the following URL: www.borderdatawarehouse.com .[61]

[60] Phone conversation with WCOG IMTC Program staff, Hugh Conroy, Director of Planning, February 6, 2017.
[61] Beyond the Border: Border Wait Time Measurement, Regional Round Table Discussions, http://www.thetbwg.org/downloads/8.19.15%20-%20Pacific%20Region-%20IrvineJulien.pdf, 2015

Figure 28 - U.S. - Canada Border Data Warehouse Crossing Archive Report



1	2	3	4	5	6	7
Cars 4 95% Trucks 3 96% Nexus 1 95%	Cars 10 99% Trucks 6 99% Nexus 2 99%	Cars 11 100% Trucks 9 100% Nexus 2 100%	Cars 6 100% Trucks 9 100% Nexus 2 100%	Cars 4 99% Trucks 9 99% Nexus 2 99%	Cars 3 89% Trucks 8 89% Nexus 1 89%	Cars 2 99% Trucks 5 99% Nexus 1 99%
8	9	10	11	12	13	14
Cars 4 100% Trucks	Cars 3 97% Trucks	Cars 3 97% Trucks	Cars 5 100% Trucks	Cars 4 100% Trucks	Cars 4 98% Trucks	Cars 4 99% Trucks

BUFFALO, NEW YORK AND FORT ERIE, ONTARIO REGION

There are four bridges in the Buffalo / Niagara Falls area. The Peace Bridge, the most heavily used bridge in the area, is operated by Buffalo and Fort Erie Public Bridge Authority. Pedestrians, bike, passenger, and commercial vehicles can all cross here. The Rainbow (no trucks), Whirlpool (only NEXUS) and Lewiston/Queenston Bridges (no pedestrians) are operated by the Niagara Falls Bridge Commission which handles customs and immigrations on both sides of the border. The lower left side of the map in **Figure 12** shows the approximate locations of Commission's four facilities near Niagara Falls.

The city of Niagara Falls is home to just 50,000 people, yet nearly 10 million people per year visit the area. It is located just 15 miles from Buffalo, which is the second most populous city in New York with over 260,000 residents.

Figure 29 - Niagara - Fort Erie Border Crossings Map

In 2011, the U.S. and Canada agreed to implement border wait-time systems at the top 20 high-priority US-Canada land border crossings. Among these crossings, is the Peace Bridge at Buffalo, NY (I-190) and Fort Erie, ON (QEW).

The U.S. Bureau of Transportation Statistics reports that the annual southbound crossing volumes for the Buffalo-Niagara Falls crossings are as follows:

Crossing	Personal Vehicles	Trucks	Buses	Pedestrians
Buffalo – Niagara Falls (2 crossings)	4,791,851	956,491	18,100	340,674

The Peace Bridge crossing is capturing automated border wait time data on commercial and personal travel lanes using a Bluetooth data collection system. During the time, this border wait time system has been in operation, valuable lessons have been learned.

The following is a summary of these as presented by the Buffalo & Fort Erie Public Bridge Authority in problem and solution format:

Problem: **Improper placement of readers**.
Solution: Hands-on investigation by all parties to track down issues and to tune and relocate readers. Testing to insure proper separation of vehicle types (auto, truck, NEXUS)

Problem: Improper configuration of readers and links.
Solution: Live system monitoring by agencies working together with software developer receiving the data

Problem: **Separating distinct vehicle types**.
Solution: **Directional antennas** to detect certain areas of traffic separately from others (ex. NEXUS lanes). **"Tagging" of vehicles** – record an ID and classify it as car or truck for future visits. Currently a 34.7% repeat use rate. **Queue mode** versus cumulative mode wait times

Problem: **Wait time lag (slow to show changes in delay)**.
Solution: Shorter distances between links; Queue mode helps.

Problem: **Cellular internet communication issues near the border**.
Solution: Hardwiring readers into existing networks where possible. Switching to a private cellular network versus the public network.

In a 2015 report to FHWA Border Working Group, the authority also presented the following regarding flexibility to changing border inspection facility operations. The Authority indicated that this Bluetooth installation will accommodate changes if:

- There is a physical separation between cars and trucks at some point upon approaching the crossing. Peace Bridge and Queenston/Lewiston bridge have this on the U.S. bound side.
- The lane designations (e.g., general purpose, Nexus, etc.) are not constantly changing from one type to another without some early upstream vehicle type classification.

The system would require notification of these changes and various methods could then be implemented to allow for operational changes on the fly.

Next steps indicated by the Authority for this border wait time system are included below and followed by an update from the Authority representative as of February 2017. These updates also include some important insights regarding the installation, operation, and performance of the selected technologies for the border wait time system[62]:

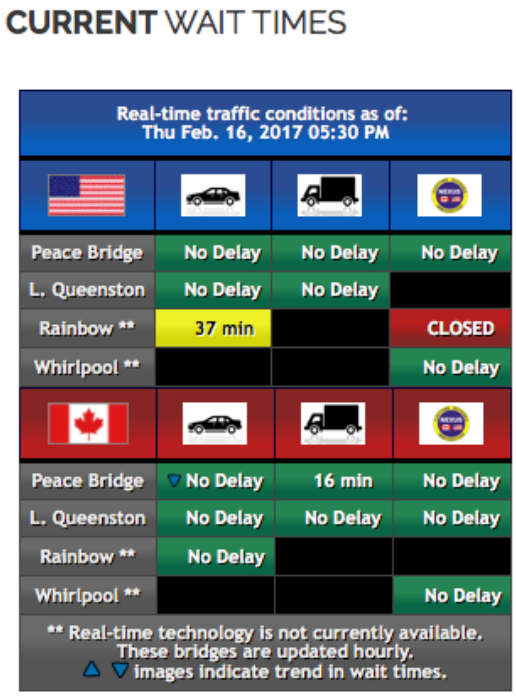
- **Hardwire power and data to all readers where possible;**
  UPDATE: Installations have been completed at Peace Bridge. All onsite readers are wired for power and data communications; cellular communications services have been discontinued thereby also eliminating the associated monthly fees. The original Bluetooth (Trafax) readers (detectors only) have been replaced with dual-reader technologies that track Bluetooth and Wi-Fi signals. The Authority is also currently experimenting with automatic license plate readers (ALPRs), (cameras with wide-angle lenses and infrared capabilities produced by Genetec) that have all software built-in to the unit to capture the license plate numbers and process the images – no server is required. In other words, this data collection device becomes just another node on the network. After testing, the Authority may add this as another technology to enhance and enrich the current data set. The ALPR's are somewhat more expensive to implement, but provide lane specific capabilities and fill gaps in Bluetooth/Wi-Fi penetration. More cameras are needed to be more lane specific, to capture Nexus, FAST, and other specific lanes. The company (Fast Lane Software) that created the Authority's border wait time software just sold the software to Genetec; thus, better integration of technology is now possible.
    - **ALPR Test Configuration** – two (2) cameras are being used in the current test configuration. The first camera is set up on US side catching all Canada-bound traffic. The second camera is set up just after truck inspection on Canadian side towards toll booths. This set up provides ALPR wait times for all trucks crossing into Canada on the Peace Bridge. The Authority is working with CBSA to participate in the acquisition and implementation of additional cameras to accommodate the newly opened FAST truck lane and to assist them with their operational performance monitoring. The ALPR and Bluetooth/Wi-Fi technologies' data are now mixed together for a richer data set.
- **Outfit Rainbow Bridge with Bluetooth readers;**
  UPDATE: Rainbow Bridge has been outfitted with a border wait time system. Niagara Falls Bridge Commission finalized a contract with Fast Lane to outfit the bridge with dual-readers as a first step. Only auto traffic is using Rainbow Bridge at this time. The expected date for completion is unknown at this time.
- **More users of the data (Ontario Ministry of Transportation (MTO)/Ontario 511 service);**

[62] All Peace Bridge and Rainbow Bridge border wait time systems and technology updates are courtesy of the Buffalo & Fort Erie Public Bridge Authority staff member, Roger Ripa, Senior Systems Analyst, via phone conversation February 2017 and update August 2017.

UPDATE: Have given out data feeds for free to anyone that wants one. MTO has not progressed on this yet. When Rainbow Bridge is also on line, then there may be more movement to use the available data. Niagara International Transportation Technology Coalition (NITTEC) is the grant holder and lead on the Rainbow Bluetooth/Wi-Fi reader project.

- **Live data feeds to highway signs in Canada and USA (NITTEC/MTO);**
  UPDATE: NITTEC is ready to install the data collection equipment on the Rainbow Bridge project; they are now waiting for MTO prioritization of the installation and integration of the equipment and data.
- **Monitor the volume of Bluetooth data available to the system;**
  UPDATE: The authority is currently conducting a comparison of the volume of detections vs. volume of traffic over time. They are specifically looking for reductions or increases in volumes. More data is better for supporting statistical analysis.
- **Possible integration/addition of Wi-Fi, E-Z Pass or license plate data feeds into the existing software solution;**
  UPDATE: The Authority indicates that since they are using ALPR they won't need EZ Pass [data and systems to be integrated]. Now have 30% of cars, 80% of trucks, and 60% of buses. In 2018 the Authority is looking to budget for additional ALPR cameras. Having the redundant technologies is proving to create a more robust system with better overall volumes and accuracy. Bluetooth and Wi-Fi dual-readers are producing a penetration rate of 30% all trucks, 14% all autos, 25% of Nexus only traffic. With the ALPRs, the rate increases to 80% of all vehicles.

Figure 30 - Buffalo- Fort Erie Bridge Authority border wait time website



On the current Peace Bridge website home page, operated by the Buffalo and Fort Erie Public Bridge Authority, www.peacebridge.com , a display of current wait times or wait time trends that are updated hourly are provided. A footnote (**) indicates that certain crossing times for certain locations as shown, are not supported by real-time technology yet. **Figure 13** is a screen shot of this border wait time display provided by the Authority.

TEXAS BORDER CROSSINGS

Texas and Mexico share 1,254 miles of common border and are joined by 28 international bridges and border crossings. Twenty-five of these crossings allow some combination of commercial, personal vehicle and/or pedestrian traffic. The other three crossings include two (2) dams and a ferry.[63] The Texas border is shared with the states of Tamaulipas, Nuevo Leon, Coahuila, and Chihuahua.

Border wait times for commercial vehicles are being monitored at seven (7) Texas Border Crossings using a point to point estimation method with DSRC technology by Texas A&M Transportation Institute (TTI). For the DSRC methodology, RFID tags (that are used for CBP programs and toll tags) are read by 2 DSRC readers installed on the Mexican side of the border and two readers installed on the U.S. side of the border[64]. DSRC readers were installed in locations that captured the average end of the queue at peak crossing times. Enough trucks were equipped with RFID tags at these crossing that penetration rates were sufficient to allow accurate wait time reporting without deploying additional tags. Additionally, in 2014-15, TTI conducted a study to analyze the penetration rate of Blue-tooth enabled devices for passenger vehicles at five Texas U.S. – Mexico border crossings, indicated with a *. The crossings currently using the DSRC/RFID methodology for trucks indicated below and five of the crossings were included in the Bluetooth study. Currently, only El Paso's Zaragoza/Ysleta crossings are using Bluetooth readers (northbound and southbound to estimate wait times for POV'. The following list includes brief information about what technologies are used at leach location with brief descriptions of each crossing/bridge:

- **Veterans Memorial Bridge, Brownsville*** - is a 4-lane bridge that connects U.S. Highway 77 in Brownsville, Texas to Matamoros, Mexico using Boulevard Luis Donaldo Colossio which extends to Ciudad Victoria and Reynosa. This border crossing has FAST lanes in both directions and a dedicated commuter lane using SENTRI. DSRC technologies for wait time data collection for trucks are being used at this crossing.
- **Pharr-Reynosa International Bridge, Pharr** - is a 4-lane bridge with 3 lanes in the northbound direction and 1 lane in the southbound direction. It connects Highway 281 in Pharr, Texas to Mexico's Highway 2 and the City of Reynosa, Tamaulipas. FAST lanes are available at this border crossing. DSRC technologies for wait time data collection for trucks are being used at this crossing.
- **World Trade Bridge, Laredo*** - is a commercial bridge over the Rio Grande River between the cities of Laredo, Texas and Nuevo Laredo, Tamaulipas in Mexico. It is owned and operated by the City of Laredo and Mexico's federal Secretariat of Communication and Transportation. The World Trade Bridge is accessed via I-35 in Laredo and Highway 2 in Mexico. DSRC technologies for wait time data collection for trucks are being used at this crossing.

[63] Texas Department of Transportation (TXDOT), http://www.txdot.gov/inside-txdot/projects/studies/statewide/border-crossing.html
[64] DSRC/RFID system information provided by Juan Carlos Villa, Texas Transportation Institute, October 2017.

- **Colombia-Solidarity Bridge, Laredo** – is an 8-lane bridge with pedestrian walkways that connects Laredo, Texas over the Rio Grande river with Colombia in Anáhuac, Nuevo León in Mexico. This bridge is a tolled crossing owned and operated by the City of Laredo and the Secretaría de Comunicaciones y Transportes. The crossing is open to personal and commercial vehicles (except on Sunday for commercial vehicles). The bridge connects to Texas State Highway 255 (a toll road) that bypasses downtown Laredo and connects downstream to Interstate 35. On the Mexico side, the bridge connects to the Nuevo Leon State Highway 1 Spur which connects downstream to Highway 1 proper. FAST lanes are available. DSRC technologies for wait time data collection for trucks are being used at this crossing.
- **Camino Real International Bridge, Eagle Pass*** – is a 6-lane bridge with 3 lanes in each direction, 2 pedestrian walkways, and connects Highway 480 in Eagle Pass, Texas over the Rio Grande to Piedras Negras, Coahuila and Mexico's super highway that extends to Mexico City. The bridge is open to personal and commercial vehicles. DSRC technologies for wait time data collection for trucks are being used at this crossing.
- **Zaragoza (Ysleta) Bridge, El Paso** - connects El Paso, Texas with Ciudad Juarez, Chihuahua in México. The border crossing consists of 2 bridges, one for passenger vehicles and pedestrians and the other for commercial vehicles. The bridge used for passenger vehicles consists of 2 northbound lanes, 2 southbound lanes, and 1 lane dedicated for commuter traffic. The commercial bridge consists of 2 southbound lanes and 2 northbound lanes, one of which is a designated FAST lane. Plans are underway to expand the commercial bridge throughput without adding additional width to the bridge by creating 2 southbound lanes and 2 northbound lanes in addition to a northbound FAST lane. DSRC technologies for wait time data collection for trucks are being used at this crossing. For passenger vehicles, Bluetooth readers have been installed Northbound and Southbound to estimate wait times.
- **Bridge of the Americas, El Paso*** - crossing between El Paso, Texas and Ciudad Juarez, Mexico consists of a northbound structure and a southbound structure and is used by passenger vehicles using Boulevard Ing. Bernardo Norzagaray and Avenida Abraham Lincoln in Mexico and I-110, Highway 54, I-10, and Loop 375 in Texas while commercial vehicles access the crossing from Cuatro Siglos Street and Highway 45 in Mexico and Gateway Boulevard, East Paisano Drive, and Highway 54 in Texas. FAST lanes are available. DSRC technologies for wait time data collection for trucks are being used at this crossing.

The map in **Figure 14** shows the approximate locations of the Texas border crossings currently equipped with wait-time measurement systems.

Figure 31 - Texas Border Crossings with Wait-Time Measurement Systems Map[65]

Texas border crossings have some of the highest volumes of crossings along the southern border with Mexico.

The U.S. Bureau of Transportation Statistics reports that the annual northbound crossing volumes for selected Texas crossings are as follows:

Crossing	Personal Vehicles	Trucks	Buses	Pedestrians
Brownsville	4,635,919	217,331	10,217	2,550,833
Eagle Pass	2,729,400	159,538	1,035	824,560
El Paso (2 crossings)	12,525,548	763,868	15,050	7,032,715
Laredo (2 crossings)	5,092,204	2,083,964	41,856	3,573,992
Pharr-Reynosa (Hidalgo)	4,721,387	568,235	25,045	2,414,852

Note: this data collection project is also reporting RFID-based wait times for the Nogales-Mariposa Port of Entry at Nogales, AZ/Nogales, MX (see section titled Other Border Environments and Projects Reviewed for more information on this crossing and Nogales border crossing technologies).

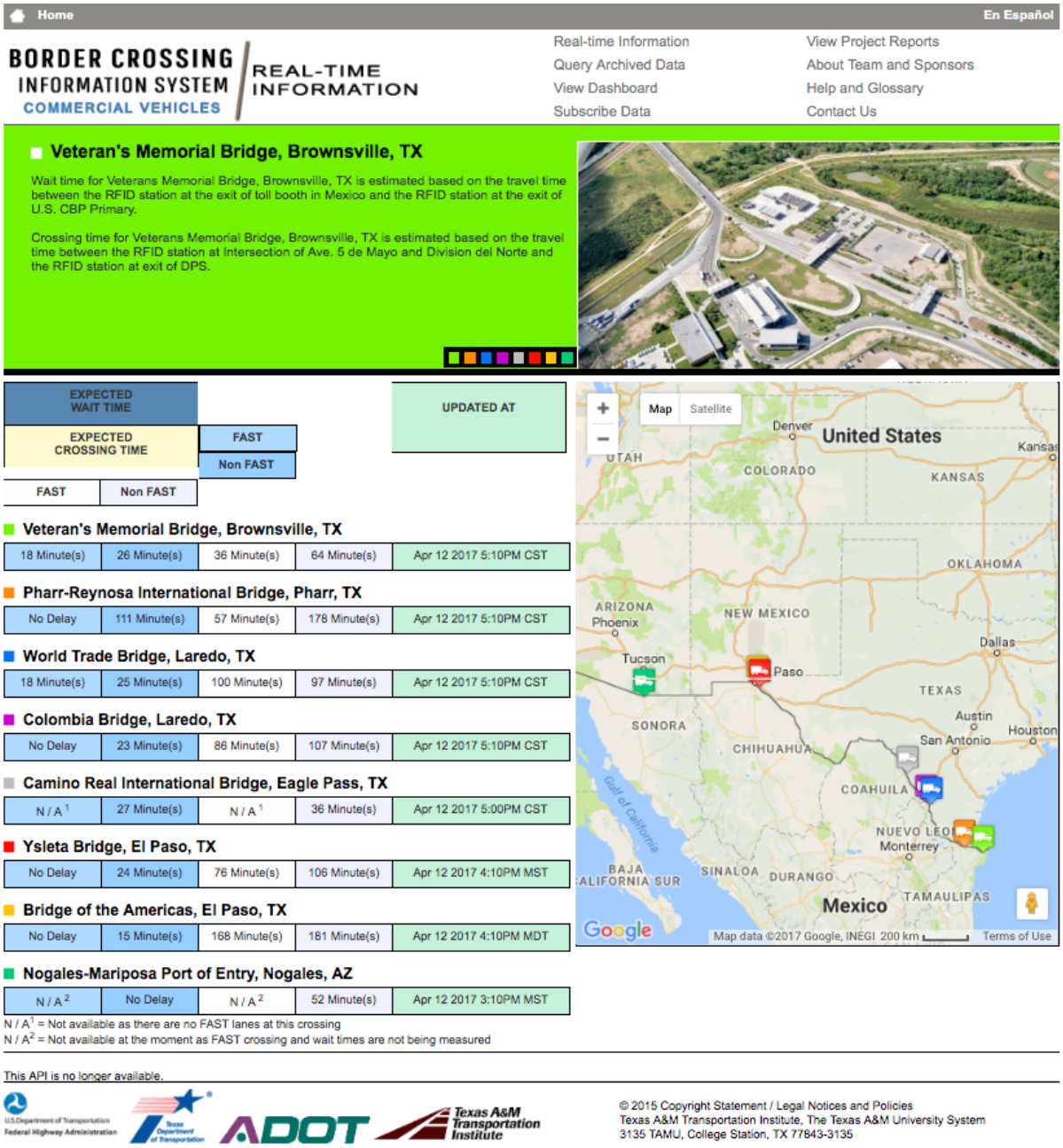
[65] Texas A&M Transportation Institute (TTI), Using RFID Readers to Measure Wait Times at the U.S.-Mexico Border (2013), https://tti.tamu.edu/2013/03/01/using-rfid-readers-to-measure-wait-times-at-the-u-s-mexico-border/

The wait time for selected crossings for commercial vehicles is estimated based on the travel time between the RFID station at the exit of the toll booth in Mexico and the RFID station at the exit of the U.S. CBP primary booth at each of the crossings.

The crossings have been equipped with the various technologies and are collecting data from trucks and cars as follows:

Texas A&M Transportation Institute provides this information on their Border Crossing Information System (BCIS) website as shown in **Figure 15**.

Figure 32 - Texas Border Crossing Information System (BCIS) for Commercial Vehicles



An online tool, a dashboard, to communicate border delays and the economic impacts of those delays was developed by Texas Transportation Institute specifically focused on commercial vehicles. Two sets of metrics were discussed in a report that described this project and the outcomes – delay measures and economic costs of the delay. The data source for the delay measures included an RFID-based system to collect raw crossing times. These systems provide a continuous stream of crossing time data from northbound trucks equipped with transponders issued by various agencies, such as U.S. Customs and tolling agencies. Data from the RFID systems are archived in a centralized data warehouse where crossing times of trucks are aggregated into different temporal granularities and converted into various performance measures for purposes of the project. The data collected were not able to provide lane-by-lane assessments or breakdowns by FAST and non-FAST status at the time of this study[66].

Finally, during a 2015 study conducted by TTI to analyze the penetration rates of Bluetooth devices in passenger vehicles crossing the border at five ports of entry, it became clear that Bluetooth is subject to a variety of limitations based on the behaviors and preferences of the users of the mobile devices that are crossing the border along with the physical configuration of the crossing facility. The TTI conclusion for this study indicates that based on the penetration rates observed during the study, out of five ports, only the Gateway to the Americas Bridge in Laredo has consistently higher than 10 percent penetration rates and hence is appropriate for deploying Bluetooth technology to measure wait times of passenger vehicles[67].

[66] Rajbhandari, Saman, Valadi, and Kang, Dashboard Tool to Communicate Delays and Economic Cost of Delays at International Border Crossings, 2012.
[67] Analysis of Bluetooth Technology to Measure Wait Times of Passenger Vehicles at International Border Crossings, Final Report, Texas Department of Transportation, Texas A&M Transportation Institute, June 10, 2015.

Summary Analysis of Current Systems and Technologies

The following table summarizes the advantages and disadvantages of selected available technologies and systems discussed in this report for border travel time data collection.

Table 48 - Summary of Current Systems and Technologies

(Table begins on the following page.)

Technology	Use	Initial Deployment Cost	Advantages/ Disadvantages	Operation/ Maintenance Cost	Ease of Operation	Quality of Data	Suitability for Border Wait Time Systems
Cellular Networks & Data	Source, Collection, Communication, Dissemination	On-going monthly costs, depending on use; may need to be combined with other technology systems	**Advantages** • Mature technology, widely available; • Easy implementation; • Variable cost depending on application as source, collection, communication, or dissemination technology; • Privacy concerns are filtered through cellular service provider; • Large, mature data sets collected via cellular user's devices provides opportunity for predictive capabilities. **Disadvantages** • Cellular services can be intermittent and service coverage is not always reliable; • Service providers at the border vary by country, and cellular device users may switch devices mid-crossing (to avoid international use fees) causing probable interruption in crossing time data; • Complex algorithms are required for location triangulation and are dependent on cellular service provider; • Subscriptions, periodic service charges are charged by owning service provider; • Cellular data must be purchased from cellular service provider; or, • Cellular data must be collected via custom developed applications for mobile devices that are to provide the data; • Triangulation of cellular data does not always produce the vehicle location accuracy required for wait time applications.	Depends on use; None is required for data collection or dissemination on established cell service provider networks. Modems and other cellular communications devices are required for data collection infrastructure using cellular as a communications mechanism.	Easy; highly available.	Medium (combine with other methods for accuracy and reliability)	Low - Medium

Technology	Use	Initial Deployment Cost	Advantages/ Disadvantages	Operation/ Maintenance Cost	Ease of Operation	Quality of Data	Suitability for Border Wait Time Systems
Bluetooth	Collection, Communication, Dissemination	Low installation, requires longer range communication and power	**Advantages** • Mature technology (about 20 years on the market[68]); • Easy implementation; • Low cost; • Allows anonymous device detection addressing privacy concerns. **Disadvantages** • Complex algorithms are required for data processing and reduction; • Low penetration and match rate; • Tests show overestimation of travel time (via low sample rate and multiple detections); • Performs best when combined with other technologies (such as Wi-Fi).	Low	Moderate	High (if enough volume)	High
Wi-Fi	Collection, Communication, Dissemination	Low installation, requires longer range communication and power	**Advantages** • Mature technology; • Easy implementation; • Low cost; • Allows anonymous device detection addressing privacy concerns. **Disadvantages** • Complex algorithms are required for data processing.	Low	Moderate	High (if enough volume)	High

[68] Bluetooth, Our History, https://www.bluetooth.com/about-us/our-history

Technology	Use	Initial Deployment Cost	Advantages/ Disadvantages	Operation/ Maintenance Cost	Ease of Operation	Quality of Data	Suitability for Border Wait Time Systems
GPS	Source, Communication	Low- Medium initially installation, depending on use. Requires receiver, longer range communication, and power	**Advantages** • Satellite-based location system with wide geographical coverage; • Low operations cost; • High data availability; • Medium to high accuracy; • Combines effectively with other technologies. **Disadvantages** • Insufficient number of GPS-equipped vehicles; • Signals periodically subject to (obscured by) urban canyons or natural topographical conditions; • Privacy concerns; • Data collection dependent on cooperation of owner or carrier of GPS equipment or device; • Low penetration rate.	Medium	Easy	Medium	High

Technology	Use	Initial Deployment Cost	Advantages/ Disadvantages	Operation/ Maintenance Cost	Ease of Operation	Quality of Data	Suitability for Border Wait Time Systems
RFID/DSRC	Source, Collection	Varies with component: *Low* – transponders; if used for commercial vehicle wait time applications *High* – readers require communication and power; *Medium* - Initial cost for DSRC use in connected vehicles; *Medium* – subsequent data collection cost due to private sector ownership of the data.	**Advantages** • Mature technology (40 years on the market); • Easy implementation; • Low operating cost; • Precise data collected; • Performs well for commercial vehicle wait times due to wide-spread deployment of transponders for other programs. **Disadvantages** • Roadside equipment and hardware required (high cost); • Requires careful tuning/re-tuning to prevent data loss and multiple detection; • Low penetration rate for POVs due to fewer transponders deployed; • Insufficient deployment for POV wait-time measurement.	Medium	Moderate	High	High, for commercial vehicle wait time/crossing time measurement
ALPR/ANPR	Collection	High, requires power, ancillary equipment, and communications	**Advantages** • Mature technology; • Good identification rates; • No onboard equipment required; • Easy implementation; • Low operating cost; **Disadvantages** • Cameras are negatively affected by slow-moving, or turning vehicles, and heavy traffic. • Cameras affected by weather, dirt, or other conditions that would occlude the camera lenses; • Readers required at many locations along border approach to be able to accurately estimate border crossing travel time.	Low	Moderate	Medium – High (availability depends on weather, other obscuring conditions)	Medium

Technology	Use	Initial Deployment Cost	Advantages/ Disadvantages	Operation/ Maintenance Cost	Ease of Operation	Quality of Data	Suitability for Border Wait Time Systems
Inductive Loops	Collection	Low device cost, Medium cost for initial installation (when considering required controller, software, communications, and power) or replacement	**Advantages** • Installation is inexpensive and easy when coordinated with new roadway construction (otherwise installation has disadvantages); • Mature, proven technology (50 years on the market)[69]; • Flexible design to meet a wide variety of applications; • Good presence detection; • High frequency models can provide data classification; • No onboard equipment required; • Candidate technology to be combined with other technologies with better spatial coverage (i.e., Bluetooth, Wi-Fi, GPS, RFID). **Disadvantages** • Initial installation on existing roadways is intrusive and requires road closure and pavement removal/replacement; • Repair and maintenance requires lane closure; • High errors possible depending on placement (traffic conditions are not captured between detectors); • Low reliability of detectors (25% of installed detectors fail every year)[70]; • May require manual tuning; • May be damaged by heavy vehicles; • High rate of failure.	Low (unless there is a failure)	Easy	High (when working properly), None when failed	Medium, requires controller and controller software, communications, and power

[69] Villa, Juan. Texas A&M Transportation Institute, Enterprise Technology Options, July 2016.
[70] IBID.

Technology	Use	Initial Deployment Cost	Advantages/ Disadvantages	Operation/ Maintenance Cost	Ease of Operation	Quality of Data	Suitability for Border Wait Time Systems
Radar, Microwave, Laser	Collection	High	**Advantages** • Low cost; • Can be installed to detect laterally in multiple lanes with a single detector; • Directly measures speed when installed overhead; • Operation not affected by vibration. **Disadvantages** • Calculates average speed only when in lateral mode; • Lower accuracy in distant lanes; and, • Overhead installation requires an appropriate mounting structure.	Low	Moderate	High (depending on weather, placement, and other obscuring conditions)	Medium
Crowdsourced & Aggregator Data	Collection	No device cost (devices serving as data sources are usually owned by private sector); On-going monthly or other periodic cost for data or 3rd party data aggregator/ provider service	**Advantages** • No procurement, installation, or maintenance of hardware/equipment in the field; • Not subject to weather, vandalism, power outages or collisions; • Growing data sets and contextual information provide continually improving opportunities for predictive capabilities and insights. **Disadvantages** • Sample sizes vary based on technology penetration rate on the corridor or at the border crossing; • Must be combined with other data sources to provide lane usage, vehicle type, or other distinguishing information.	Low	Easy	High (if enough volume)	High

Technology	Use	Initial Deployment Cost	Advantages/ Disadvantages	Operation/ Maintenance Cost	Ease of Operation	Quality of Data	Suitability for Border Wait Time Systems
Connected Vehicles	Source, Collection, Communication, Dissemination	No device cost, possible on-going monthly cost for data or 3rd party data provider service	• Advantages and disadvantages are being proven and disproven through pilot programs and testing of connected vehicles in a variety of contexts. • The primary estimated advantage is the opportunity is downline queue and wait time estimates to other connected vehicles; this provides drivers/passengers with the opportunity to make routing and travel decisions in real-time. • Technologies used for vehicle to vehicle and vehicle to infrastructure are still evolving. • DSRC is the current standard; however, 5G applications are being tested and expected to be available in the next year.	Low	Easy		Predicted to be High; not enough data yet to determine

Key Institutional and Technological Findings and Recommendations

The literature review and the analysis of current practices on the use of technologies and information systems to collect border wait time resulted in the following findings and recommendations:

- Coordination between agencies on opposite sides of the border may vary when implementing a data collection solution. Budget constraints, priorities, political climate, changes in agency leadership, all contribute to the ability of an agency to carry out plans cooperatively.
- Privacy considerations, policies, and laws protecting border-crossers may differ among agencies and jurisdictions. Collected data that may be acceptable in one jurisdiction may not be permitted in another. San Diego and Imperial regional governments and policy-makers will need to coordinate with private companies and other public agencies to find the best fit for the data providers and users.
- Border crossing agencies, such as CBP, continue to use unaided visual observation or cameras to determine wait times, with varying levels of accuracy based on recent evaluations by the General Services Administration (GSA). Collaboration with CBP is needed to assist in providing the more accurate data feeds to CBP from other agency and private sector deployments.
- Newer applications of technologies are being compared with clear performance differences resulting, such as Wi-Fi edging out Bluetooth in ADOTS's 2015 study of ARID technologies and in a 2016 SANDAG study at the San Ysidro border crossing. Systems will need to remain modular and highly-flexible to accommodate changing technologies and performance enhancements.
- Tests of various combinations of technologies, such as RFID, ALPR, Video, Loop Detectors, Radar, Bluetooth, and Wi-Fi have been pilot tested or deployed to monitor wait times – with an increasing knowledge base developing on which technologies work well under specific conditions. However, because no two crossings or deployments are alike, each deployment needs to be tailored and cannot be replicated on a larger scale.
- Continuing education of deployment sponsors is helpful in conveying the fact that multiple technologies are required to achieve the desired end-to-end data collection, data communication, warehousing, processing, and dissemination of the data that produces border travel time, crossing time, and wait time information.
- Ports of entry (POEs) with adequate capacity and free flow traffic will have less travel time variability than other POEs with constricted traffic and "stop and go" delays. Consideration of required sample size (the number of vehicles needed during a specified period to accurately represent the travel time of passenger vehicles) must be determined in tests of MAC address detection and other re-identification technology methods.
- Systems and technologies for border wait time must be customized to each unique deployment location. Therefore, the overarching trend in systems deployed is to combine technologies that serve the traffic patterns, border crosser characteristics, terrain, and infrastructure of the crossing.

- Technologies continue to rapidly evolve. Therefore, periodic evaluations of previously deployed systems and technologies for monitoring, data collection and information dissemination must be conducted to compare them with the capabilities of new or evolving systems and technologies.
- Data collected from mature and evolving sources, like cellular location data, connected vehicle, and crowdsourced data, provide enormous numbers of data points to assist with predictive analytics and estimates. Care must be exercised to elicit the most valuable insights from this "big data" and ensure that the appropriate context for these insights is applied or considered. Context is the biggest current challenge for data-driven and machine assisted automation, intelligence, and predictive applications. Contextualization is crucial in transforming mountains of senseless data into real information – information that can be used as actionable insights that enable intelligent decision-making.

  For the purposes of this discussion, context includes a variety of tangible and intangible factors that affect or are affected by the body of travel time and travel behavior knowledge and information attained through the acquisition, analysis, and incorporation of large amounts of data. These factors include, but are certainly not limited to, physical infrastructure, communications infrastructure, system interfaces, human-machine interfaces, human behaviors and quality of life, outcomes of behavior changes, environmental impacts, and the consequential policy and regulatory decisions surrounding these factors. Additionally, further contextualization occurs when these localized factors are compared with and integrated into similar factors from other installations, communities, and regions. It is then that we have a more sensible and holistic understanding of the data collected.