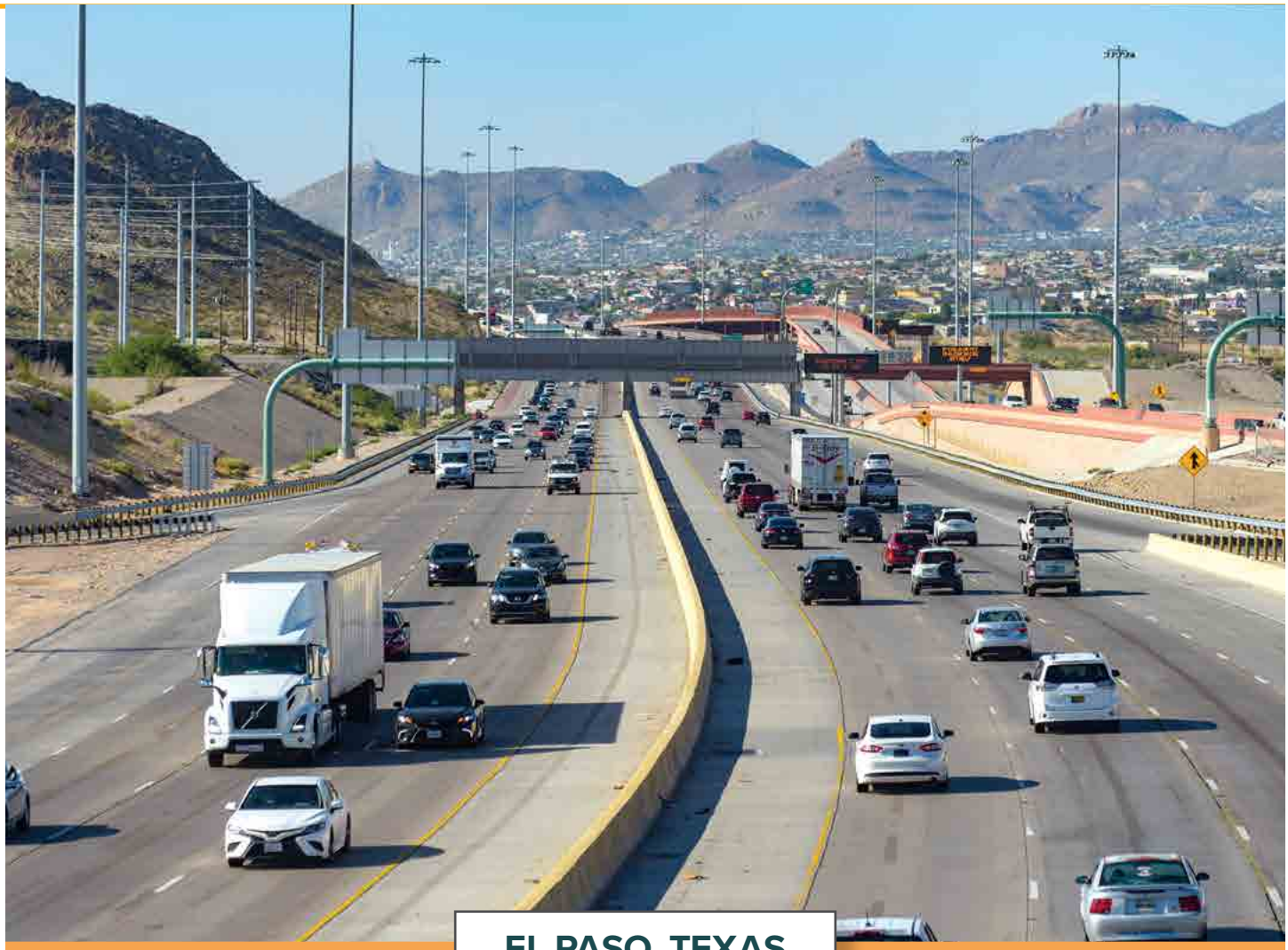
Texas A&M Transportation Institute | Center for International Intelligent Transportation Research

FY 21–22 Biannual Report



EL PASO, TEXAS

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Applying Advanced Technology to Solve Old Problems in New Ways

The more traditional, discipline-driven focus of transportation engineering is moving to a more holistic focus on mobility: the efficient movement, with optimal safety and security, of people, goods and data.

By 2070, the population of the El Paso region—which includes El Paso and its sister city of Cuidad Juárez, Chihuahua—is expected to top 1.5 million people. Assisted by Texas A&M Transportation Institute's (TTI's) Center for International Intelligent Transportation Research (CIITR), the City of El Paso has made significant investment recently to enhance its transportation infrastructure to improve regional mobility for travelers and shippers alike.

The rapid acceleration of transportation technology in the past decade or so has been nothing short of revolutionary. Most of us are familiar with the headlines about self-driving cars and electric vehicles, but even the way we've traditionally counted cars, planned roadway networks and safeguarded the supply chain is changing. And from a traffic management standpoint, the historically distinct areas of tourism and goods movement are merging as traffic engineers shift from a more traditional, discipline-driven focus (e.g., infrastructure development, traffic management) to a more holistic focus on mobility—defined essentially as the efficient movement, with optimal safety and security, of people, goods and data.

Transportation research is moving away from more traditional areas—for example, cross-border freight movement versus tourism travel—to more holistic approaches, like improving mobility for all road users.

Established by the Texas Legislature in 2006, CIITR conducts applied research for local, state and federal sponsors to evaluate and implement advanced technology to improve our shared transportation system. Over the 2021–2022 biennial period, for example, center researchers have pioneered the use of artificial intelligence, crowdsourced data (e.g., cellphone travel information), and high-resolution satellite imaging. These enhanced data-gathering techniques provide more reliable information, which in turn enables traffic management agencies to create more realistic, reliable models to reduce corridor congestion and ensure roadways are safer for all travelers.

CIITR has a tradition of working with sponsors on both sides of the U.S.-Mexico border to leverage technology to its utmost. TTI developed a Border Crossing Information System for federal and state agencies to measure and share real-time (and historic) data at commercial and passenger land ports of entry to reduce crossing times for travelers and shippers alike. CIITR researchers have built on this system by developing new technologies and applications to enhance its value to transportation and security agencies and the traveling public. Sometimes there's a disconnect across national lines, the result of differing policies and data-gathering protocols. This disconnect can stymie shipping efficiency. The urban freight regulatory plan we developed in partnership with local authorities and private-sector stakeholders in Ciudad Juárez will help improve freight flow in El Paso's sister city, a benefit that will propagate up the line as goods travel north.

As extreme weather events become more frequent, their impact on transportation infrastructure is more significant. Through simulation using real-world data, CIITR studied the impact of major interstate and international bridge closures to measure first-order direct costs of supply-chain slowdowns and the subsequent, longer-term effects on the transportation network. And in a related initiative, we're researching how artificial intelligence can efficiently analyze high-resolution satellite images to extrapolate assumptions about traffic patterns in extreme border queuing situations. In addition to helping avoid supply-chain bottlenecks during future crises, this cutting-edge application can help shippers move goods more cost-effectively on a daily basis, which could translate to lower prices on store shelves for consumers. It can even help authorities better plan for mass evacuation events like hurricanes, earthquakes and hazardous spills, and that translates to lives saved.

As the El Paso region evolves both in population and economic opportunity, CIITR researchers continue to pioneer applications of advanced technology to ensure that growth is as smooth—and safe—as possible. And these solutions, created locally, can benefit communities far beyond our own.

Rafael Aldrete, Ph.D.
TTI Senior Research Scientist
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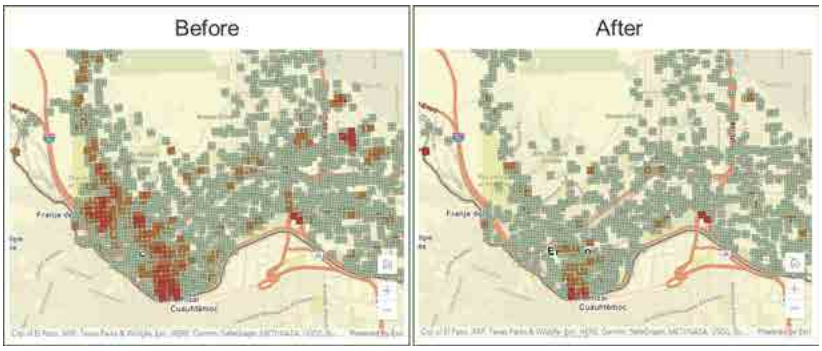
Safety and Mobility

El Paso is growing, and with that growth comes a need for improved mobility and congestion mitigation. Construction alone isn't the answer. CIITR's regional research focuses on more efficiently using the system we have, combined with smarter planning for growth and building out the local transportation network in a way that prioritizes safety.

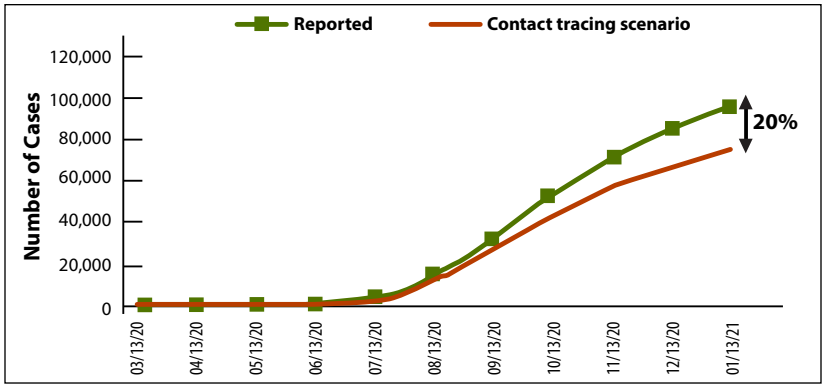
Cross-Border Cooperation, Contact Tracing Key to Reducing Pandemic Infections

One unintended consequence of a seamless, connected worldwide transportation network is to provide a disease vector for the spread of global pandemics like COVID-19. Border points of entry between countries can prove particularly challenging in mitigating international infection rates because of different national priorities and protocols. During COVID-19, most countries implemented severe travel restrictions, many allowing only essential travel (e.g., vital to trade) and significantly impacting economies. At the U.S.-Mexico border, trips reduced by 63 percent.

Contact tracing—documenting person-to-person interaction as a way of determining exposure—is vital in reducing infection rates. Modern technology like mobile phones facilitate contact tracing when end-users opt in to reporting their whereabouts via smartphone apps. During COVID-19, CIITR researchers developed the Border Crossing Epidemiological Model to analyze various what-if scenarios related to contact tracing. Leveraging technology like smartphones to facilitate contact tracing is key to stopping the cross-border spread of pandemics. The model also showed that relying solely on tracing cross-border interactions does not significantly reduce the spread of the disease. Better results occur when both countries coordinate contact tracing conducted within their own borders.



Leveraging technology like smartphones to facilitate contact tracing is key to stopping the cross-border spread of pandemics.



A model developed by TTI demonstrated that contact tracing, when properly coordinated cross-border and across agencies, could reduce the number of COVID-19 cases (and deaths) by 20 percent.

Trips reduced 63% at the U.S.- Mexico border

Contact tracing could reduce the number of fatalities by 20%

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Crowdsourced Cross-Border Travel Analysis Supports Economic Development Far Beyond the Border

Researchers studied eight locations in the U.S.-Mexico border region. **Of the Mexico-domiciled visitors traveling to places in Texas:**

44% of total Mexican visitors in **retail trade industry**

27% of total Mexican visitors in **accommodation and food services industry**

Travel along and through the U.S.-Mexico border has economic impacts well beyond the region itself. Better understanding how that traffic moves—and what the travelers' ultimate destination and purpose for traveling are—can help transportation agencies better plan, maintain, and manage their local transportation networks. Local transportation agencies—particularly those along the border—often lack the funding to gather large-scale data sets that can help them justify transportation improvements to support local economic development. The ubiquitous nature of smartphones and variety of applications provide a new crowdsourced data source—location-based services (LBS)—that agencies can use to bridge that gap.

Between Jan. 2018 and Dec. 2021—before and after COVID-19 travel restrictions—CIITR researchers used point-of-interest LBS data to analyze visitation patterns of Mexico-domiciled travelers in eight locations: four border regions (Brownsville, McAllen, Laredo, and Paso del Norte) and four inland urban areas (Austin, DFW, Houston, and San Antonio). Potential applications and data limitations were also identified. Transportation agencies can use the study's methods and findings to study similar travel patterns in their own communities. By applying the results, agencies can improve their local transportation networks to serve travelers more effectively, not only improving safety and efficiency, but also fostering local economic development.

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Improving the TCQSM for Border Region Transit Agencies and Their Customers

Border transit agencies account for and manage a significant influx of transit passengers due to their location at international border crossings. The current Transit Capacity and Quality of Service Manual (TCQSM)—the guidance standard on transit capacity and quality-of-service (QoS) issues, as well as techniques measuring operational effectiveness—has not accounted for border-specific transit applications.

CIITR researchers documented how the TCQSM can better serve border regions, specifically in estimating transit-supportive areas based on zonal demographic and economic data to assess QoS for fixed-route transit services. Researchers surveyed border transit leaders and planning staff and documented their feedback on the pros and cons of the manual. If the team's recommended changes are made in future editions, the TCQSM can benefit agencies in assessing not only QoS and transit capacity, but also in improving overall regional mobility. Additionally, decision-makers could use the methods therein to assess—with greater accuracy and reliability and before ever beginning the project—the impacts of a proposed transit plan. The ability to pre-determine effectiveness will help agencies optimize resources and funding while better serving their consumers in the long run.

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The ability to pre-determine effectiveness will help agencies optimize resources and funding while better serving their consumers in the long run.

Increasing Vaccination Rates, Limiting Travel Saves Lives During Pandemics

For every month from July to November 2020, the model demonstrated that extending restrictions resulted in a decrease from nine cases to less than one case per day.

Building on CIITR's earlier research during the COVID-19 pandemic into the effectiveness of contact tracing in mitigating cross-border infections, CIITR researchers studied when imposing travel restrictions no longer significantly impacts infection rates. Such restrictions can drastically affect economies, and stakeholders in the El Paso Region were interested in when they could be lifted without severely impacting public health.

Researchers updated the Border Crossing Epidemiological Model developed in the previous study and ran multiple what-if scenarios to answer specific stakeholder questions. The results were then shared with multiple groups comprised of approximately 170 participants. Generally speaking, researchers found that extending travel restrictions resulted in fewer COVID-19 cases. For every month from July to November 2020, the model demonstrated that extending restrictions resulted in a decrease from nine cases to less than one case per day. Results also indicated that, had the El Paso community achieved a vaccination rate of 95 percent during the period, 87 lives could have been saved.

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Successful Demonstration of e-Inspections at Texas Weigh Stations

Traditional inspections, which typically take 30 minutes, can cause downtime, backed-up truck queues, and add to a shipper's operational costs, which almost always pass on to consumers.

Moving goods through U.S.-Mexico ports of entry requires balancing security, to ensure only legitimate goods enter, expediency, to get timely shipments to market, and safety. Downtime resulting from backed-up truck queues can add to the bottom line of shipments and, ultimately, consumer prices. E-inspections leverage technology to provide on-the-fly inspections and can reduce a 30-minute process to only a few minutes. The process can mean time savings (and associated cost savings), while enabling safer, pre-screened vehicles to keep moving and law enforcement to focus resources on problematic equipment and drivers.

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CIITR researchers worked with the Texas Department of Public Safety and the Federal Motor Carrier Safety Administration to demonstrate the efficacy of using DriveWyze to conduct e-inspections under real-world conditions. While the software was successfully demonstrated using three trucks and drivers in New Waverly, Texas—and while the regulatory culture has become open to using e-inspections in lieu of more traditional methods—widespread adoption of the technology and process is expected to take longer at the border due to fewer trucks using electronic logging devices. The research team documented responses via video and produced a report describing the successful tests.

Using DriveWyze, TTI Senior Research Engineer Dan Middleton demonstrated the efficacy of conducting e-inspects for trucks.

Using Crowdsourced Data to Understand Cross-Border Travel

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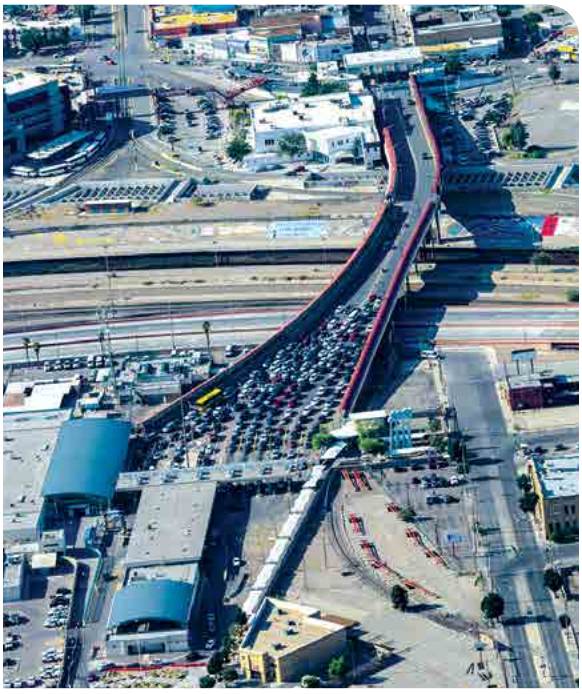
The El Paso and Ciudad Juárez regions have long functioned as one metropolitan center, divided by a border but united by international land ports of entry (LPOEs). The area, in fact, serves as the second busiest U.S.–Mexico border region. Better understanding travel demand and trip patterns of travelers crossing the border can help managing agencies solve transportation problems involving congestion, air quality, and traffic safety. Acquiring rich, accurate, and continuous travel information necessary to do that is often a challenge, however, due to lack of resources and international differences in data availability, policy, etc. Crowdsourced data—sourced from mobile devices, road sensors and GPS-equipped vehicles, for example—can provide easily acquired data to agencies in both countries.

CIITR researchers explored how crowdsourced data can be used to better understand cross-border trips and travel patterns. Conducted using data from January to April 2021 and focused on four LPOEs connecting El Paso and Juárez, the study examined the frequency and trip patterns before and after the declaration of travel restrictions related to COVID-19. Findings identified limitations agencies should consider related to both the data gathered and their acquisition. Transportation officials can use these results to develop robust, data-driven policies regarding cross-border trips that, in turn, should make for more efficient, safe, and secure travel.



Using crowdsourced data, regulatory agencies can better understand cross-border trips and travel patterns.

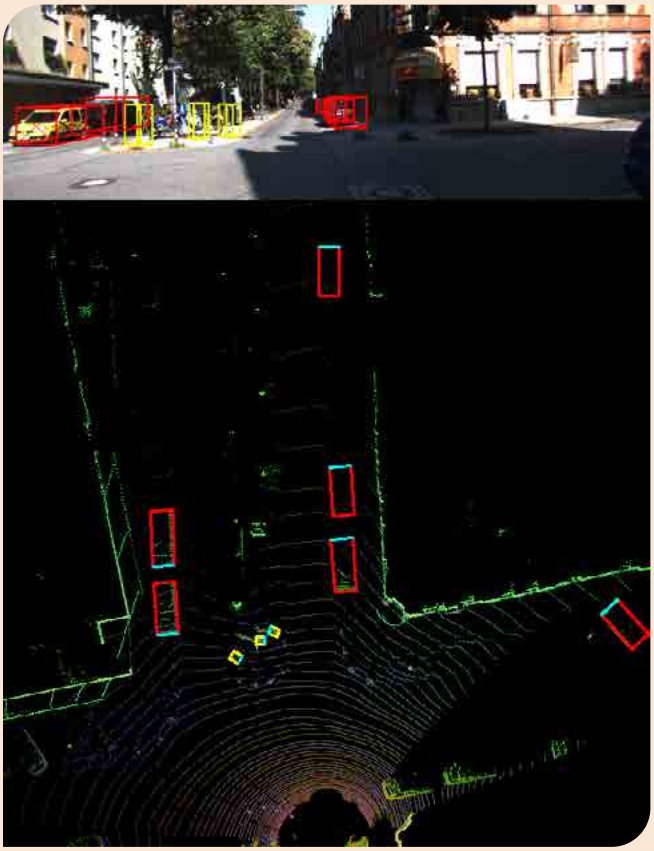
Different sources of crowdsourced data used in the study, such as mobile devices, road sensors, and GPS-equipped vehicles, help illustrate the different ways that data were collected.

From October–November 2019 and January–April 2022, this study explored cross-border trip characteristics using crowdsourced data at the U.S.–Mexico border (specifically in El Paso, Texas, and Ciudad Juárez, Mexico).

Northbound (NB) trips	Southbound (SB) trips
94,336 Total number of trips	**153,435** Total number of trips
49% of NB passenger vehicles with a 10-mile or less trip	**36%** of SB passenger vehicles with a 10-mile or less trip
Shopping, Residential Most common cross-border trip purposes for NB trips	**Medical, Shopping** Most common cross-border trip purposes for SB trip

Traffic Operations

Advanced, intelligent transportation technologies hold the potential to vastly improve the efficiency and safety of our transportation network. Properly implementing those technologies in the coming decades will depend on accurately gathering and analyzing large amounts of traffic data from disparate sources. CIITR researchers are at the forefront of this research in the region.



Predicting Cross-Border Land Use Development Using Machine Learning, Satellite Imagery

Accurately predicting how land development is trending in a community is vital to effectively designing the supporting transportation infrastructure. Competing agricultural, commercial, industrial and residential interests, among others, play a vital role in shaping how that development unfolds from "vacant lot" to "developed parcel." When examining a region that crosses national borders, accurate predictions can become even more challenging due to disparate levels of available data.

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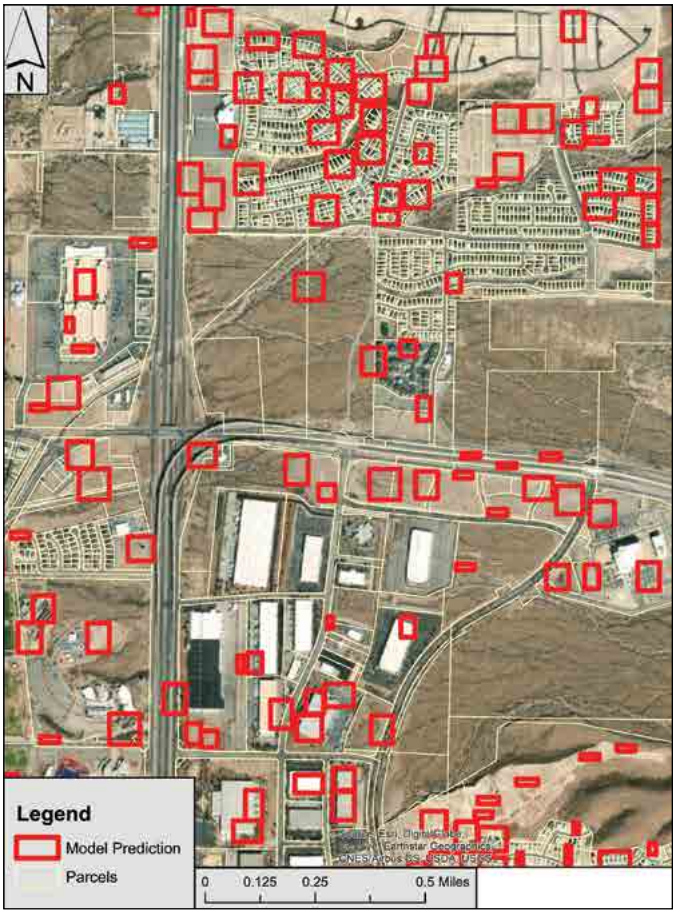
CIITR researchers studied the use of machine learning and satellite imagery to predict land development patterns in U.S.–Mexico cross-border transportation corridors. Using the ArcGIS image analyst tool to process satellite images proved 60 percent accurate (testing 1,000 locations in the City of El Paso) and 80 percent accurate (testing 800 locations in Ciudad Juárez)—the model proved more accurate in predicting development in rural regions. Using 10 years of El Paso parcel-level data, researchers studied a second method using Microsoft Azure and, employing the multiclass-decision forest model, achieved 98 percent accuracy in predicting the type of land use (e.g., residential, commercial, industrial, agricultural) after a lot is developed (using 500-foot buffer configuration).

Competing agricultural, commercial, industrial and residential interests, among others, play a vital role in shaping how that development unfolds from "vacant lot" to "developed parcel." When examining a region that crosses national borders, accurate predictions can become even more challenging due to disparate levels of available data.



Using machine learning and analysis of satellite imagery can help identify which land parcels in a given area are likely to be developed in the future.

Reducing Error, Increasing Reliability for Border Traffic Sensor Deployment

Historically, traffic sensors are developed separately from back-office systems used to receive and disseminate the data they collect, as well as monitor sensor operability. Because these two components are not better integrated from the get-go, configuring the sensors in the field is necessary. Additional steps require installing the back-office systems and integrating the deployed sensors with them. This disjointed process is time consuming and error prone due, in part, to the need for hands-on, human control of the process.

Thanks to cloud computing, better coordinating data sharing between traffic sensor components is possible, which in turn can improve operational efficiencies, increase reliability of information, and reduce error associated with traditionally disjointed systems.

The widespread availability of cloud computing has facilitated the development of Internet-of-Things (IoT) devices. The center's research team applied IoT concepts—specifically, the idea of interrelating typically disparate components and non-reliance on human interactions—to implementing laser imaging, detection, and ranging (LiDAR)–based traffic counters developed by CIITR researchers. This approach not only facilitates remote deployment of sensors, but also automated data collection and using cloud resources to monitor sensor health. These improvements can offer traffic management agencies both time and money savings in deploying, monitoring, and troubleshooting such field devices.

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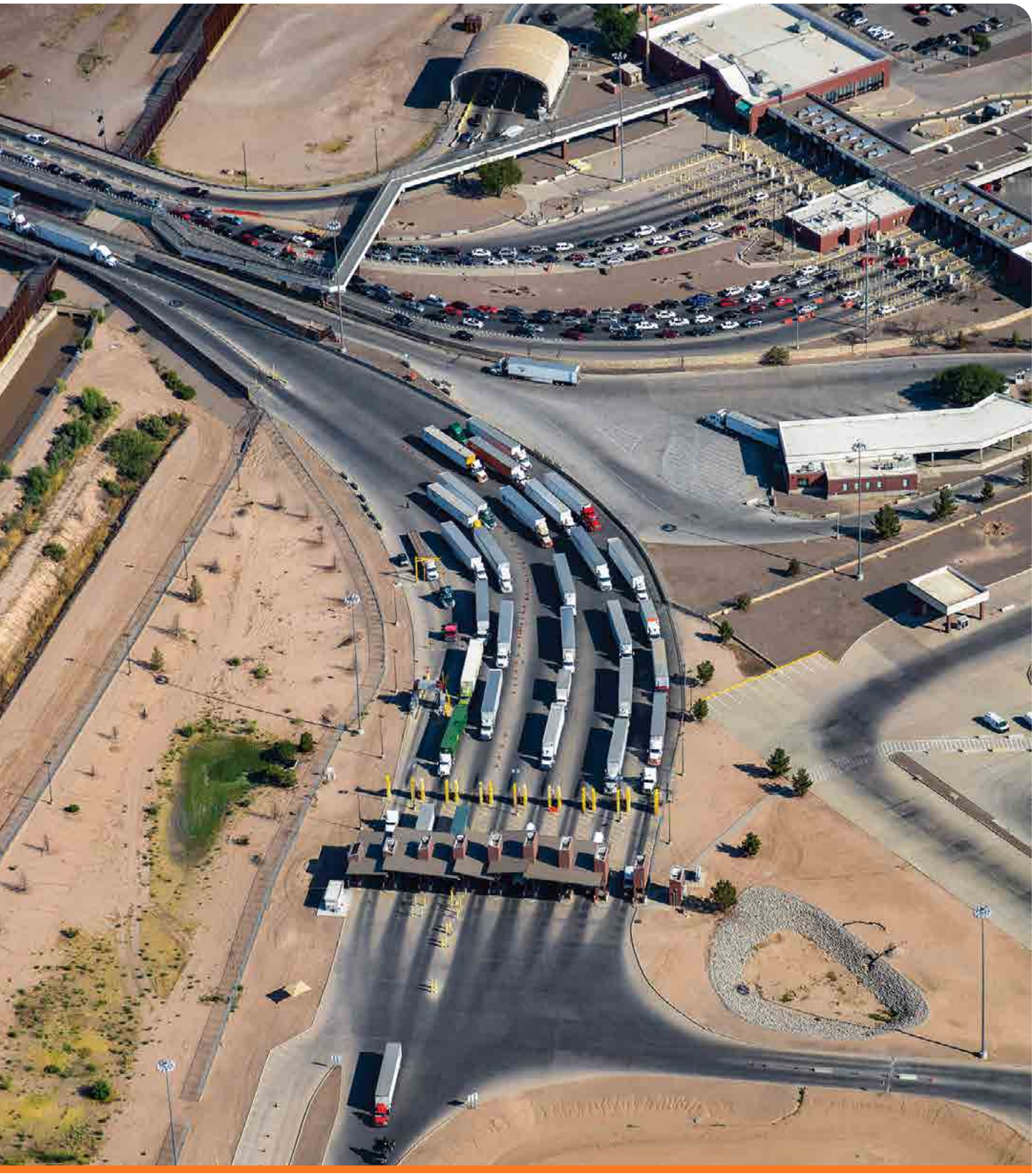
Border-Crossing Efficiency

Trade, tourism, and international security—all depend on the efficient, safe, and thorough monitoring of cross-border traffic. CIITR researchers are evaluating advanced monitoring technologies—as well as facilitating communication among stakeholders from both countries—to ensure the secure, efficient movement of people and goods between the United States and Mexico.



3D LiDAR Technology Applications for Monitoring Border Traffic in Real Time

Better understanding traffic flow through deployment of advanced technologies—especially at major land ports of entry like the Bridge of the Americas pictured here—can facilitate cross-border goods movement.

3D light detection and ranging (LiDAR) sensors allow automated vehicles (AVs) to "see" their surroundings with high frequency/precision. By integrating these sensors into roadside infrastructure, traffic management agencies can gain a clearer understanding of traffic flow, especially at high-volume international border crossings.

In this project, CIITR researchers developed improved, faster simulation models using synthetic datasets to refine improved deep-learning algorithms that enable LiDAR-enhanced infrastructure to detect and track road users in real-time. The team is currently implementing a pilot roadside LiDAR-based traffic monitoring system at various border crossings. Ultimately, researchers will create a real-time roadside LiDAR-based multimodal border crossing traffic monitoring system that researchers will pilot test at selected crossing sites in El Paso/Ciudad Juárez. Such a system would benefit border management agencies by helping them anticipate, troubleshoot, and expedite extended traffic queues at border crossings. In particular, the El Paso/Ciudad Juárez region could benefit from piloting LiDAR at border crossings and, by doing so, position itself as a leader in border traffic data collection and planning.

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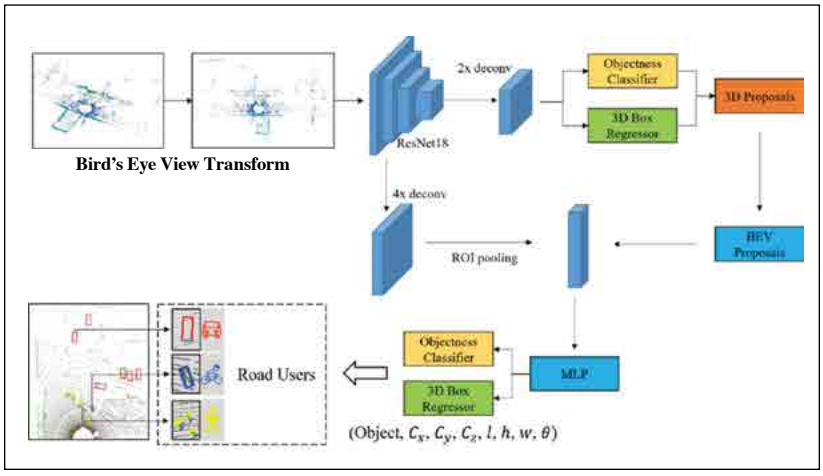
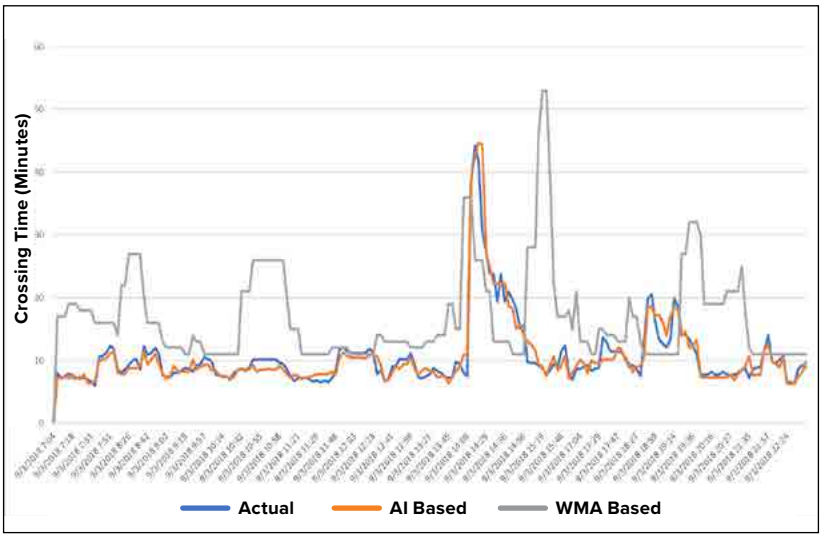


Integration of LiDAR sensors into roadside infrastructure and how they are used to monitor traffic flow at border crossings.

Applying Machine Learning to Improve Border Wait Time Prediction

Reidentification-based travel-time measurement methodologies can report travel time only after the same vehicle is identified twice (by sensors upstream and downstream of the travel path). This approach to estimating border crossing times works effectively when the travel period between points A and B is relatively low. However, in a scenario where travel time is long, this method can result in 1) delays in reporting current travel times and 2) the inability to accurately predict the delay drivers reaching the end of the wait queue might expect.

CIITR researchers created a wait time prediction system that uses data from laser imaging, detection, and ranging (LiDAR)–based traffic counters deployed at the Ysleta-Zaragoza commercial crossing in El Paso.



Use of Artificial Intelligence/Machine Learning to predict short-term border wait time. This approach augments the data from field sensors with historic trends and current queuing conditions to predict the border wait times for vehicles joining the end of queue.

The system fuses counter data with information available at the U.S. Customs and Border Patrol's website, then employs a machine-learning model to compute expected wait times for vehicles. The estimates produced were validated against actual wait times drivers experienced. Traffic management, security agencies, and private shippers can use these more reliable estimates to better plan for troubleshooting peak-period travel times, making freight movement through checkpoints more efficient and, potentially, lowering the costs associated with shipping delays ultimately passed along to consumers on store shelves.

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Traffic management, security agencies, and private shippers can use these more reliable estimates to better plan for troubleshooting peak-period travel times, making freight movement through checkpoints more efficient and, potentially, lowering the costs associated with shipping delays ultimately passed along to consumers on store shelves.

Assessing the Potential Benefits of Co-locating Texas-Mexico Border Safety Inspections

Researchers found that one agency rarely inspects the same trucks inspected by the other, so co-locating inspections would not save significant time for the process.

Time is money, so making inspections for trucks crossing the U.S.–Mexico border as efficient as possible is a priority for shipping companies.

Commercial motor vehicles (CMVs) crossing at U.S.–Mexico land ports of entry (LPOEs) in Texas can undergo five different inspections by state and federal agencies. Two of these inspections are focused on safety, one performed by the Federal Motor Carrier Safety Administration and one performed by the Texas Department of Public Safety. Delays at any of these potential inspections can add to bottom-line shipping costs, and the perception exists that redundancy exists across the two existing safety inspection types.

CIITR researchers analyzed the feasibility of co-locating the federal and state safety inspections at Texas LPOEs to assess the potential for improving crossing efficiency. Researchers assessed also to what extent, if any, such inspections unnecessarily duplicate each other, as well as how influential inspections are in causing CMV border crossing delays. The research team interacted extensively with state and federal officials and conducted field visits, in-depth process analysis, data gathering, data analysis, and objectively and subjectively quantified the potential benefits of conflating processes. Researchers concluded that not only do safety inspections not duplicate one another but, rather, they complement one another by focusing on different things. Also, researchers found that one agency rarely inspects the same trucks inspected by the other, so co-locating inspections would not save significant time for the process. Further, inspections have minimal impact on delay since most trucks crossing through the LPOE are visually inspected without having to stop, with only 2–7 percent pulled over for comprehensive safety assessment.

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Estimating Border Crossing Times Using Drones, Satellites, and Artificial Intelligence

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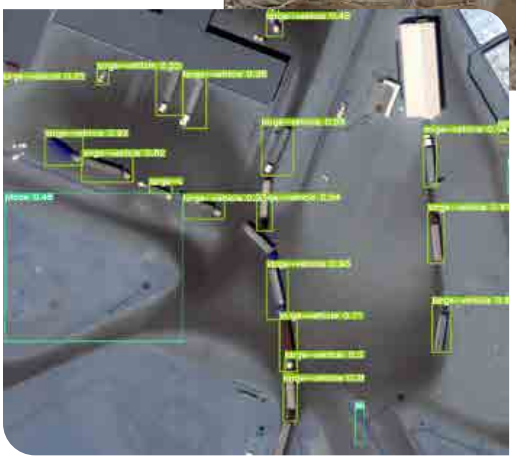
Increased trade across the U.S.–Mexico border and enhanced security requirements have increasingly resulted in protracted traffic delays at the border and non-recurrent extreme traffic queuing events have increased in frequency and magnitude. Because traditional, infrastructure-based travel-time monitoring systems are limited in their coverage, developing accurate wait-time estimates can be challenging when extreme queues of semi-trucks occur. And without reliable estimates, agencies cannot effectively manage traffic before, at, or beyond the border.

CIITR researchers previously demonstrated that Unmanned Aerial Systems (or drones)—combined with the "big picture" view afforded by high-resolution commercial satellite images—can significantly supplement traditional counting systems. As technology continues to advance, obtaining high-resolution images of extensive queues in real time (and less expensively) from commercial providers is likely to be commonplace soon. In 2021, researchers successfully demonstrated the efficacy of AI algorithms to analyze thousands of satellite images in a fraction of the time it would take a human, making the combination of satellite imaging and AI analysis a powerful new tool for agencies to use in mitigating traffic congestion. In 2022, the CIITR team proved that using AI algorithms to enhance high-resolution satellite imagery can make those images even more useful. Researchers also identified other traffic operations applications (e.g., optimizing traffic flow during extreme weather events) that would benefit from applying these technologies to traffic management scenarios.



Using advanced technologies like photos taken from satellites and artificial intelligence (which can rapidly analyze thousands of such images), agencies can better estimate wait times and, thereby, mitigate traffic congestion at crossings like the Zaragosa Bridge.

Estimating the USMCA's Impact on Cross-Border Energy Sector Transportation

Mexico and the United States enjoy a close trade relationship. Regarding energy, Mexico is the third-largest provider of U.S. oil imports, and the United States is Mexico's largest gasoline and natural gas supplier. Adopted in 2020, the U.S.–Mexico–Canada Agreement (USMCA), the framework for North American trade, could affect the transportation logistics surrounding U.S.-Mexican energy exchange.

CIITR researchers studied the potential logistical impacts involving transporting energy resources, particularly at border crossings. The team conducted expert interviews to develop six potential scenarios (in 2030 and 2050) that accounted for changes in trade policy, production levels, and other economic indicators in both countries. Simulation analysis studied possible changes in transportation logistics via pipeline, truck, and ships. Assuming a stable USMCA, the findings show expected increased U.S.–Mexico energy trade over the next two decades. At the state and local levels, the agreement's stability will provide confidence in prioritizing transportation infrastructure investments that support trade over the long term. At the national level, stability supports economic growth through predictable, reliable goods movement across the border. The conflict in Ukraine, for example, points to how vital such stability is in encouraging U.S.–Mexican economic growth while maintaining the health and well-being of populations in both countries.

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Evaluating CV Data for Determining Border Wait Times

The advent of connected vehicles and availability of crowdsourced (e.g., smartphone) data provide the possibility of alternative data sources to leverage for measuring delay.

Although passenger vehicles passing through border land ports of entry (LPOEs) must necessarily be monitored and inspected for safety and security, this process can often be onerous for travelers. Long lines mean idling vehicles polluting the environment, and delays can dampen both tourism and international business. To regulate traffic at LPOEs, agencies have traditionally relied on infrastructure-based sensor networks that are costly to implement and maintain. The advent of connected vehicles (CVs) and availability of crowdsourced (e.g., smartphone) data provide the possibility of alternative data sources to leverage for measuring delay.

CIITR researchers explored using these new data sources to estimate crossing times for passenger vehicles at LPOEs. Using Bluetooth® and CV data to estimate crossing times, the team developed testing models, determining that CV data have future potential to produce similar estimates of crossing times compared to Bluetooth data. This makes CV data a promising alternative data source, particularly compared to more expensive, less thorough infrastructure-based sensor systems. In the not too distant future, agencies will likely be able to use CV data to obtain more accurate, comprehensive assessments of traffic congestion and, thereby, improve planning and increase mobility at LPOEs.

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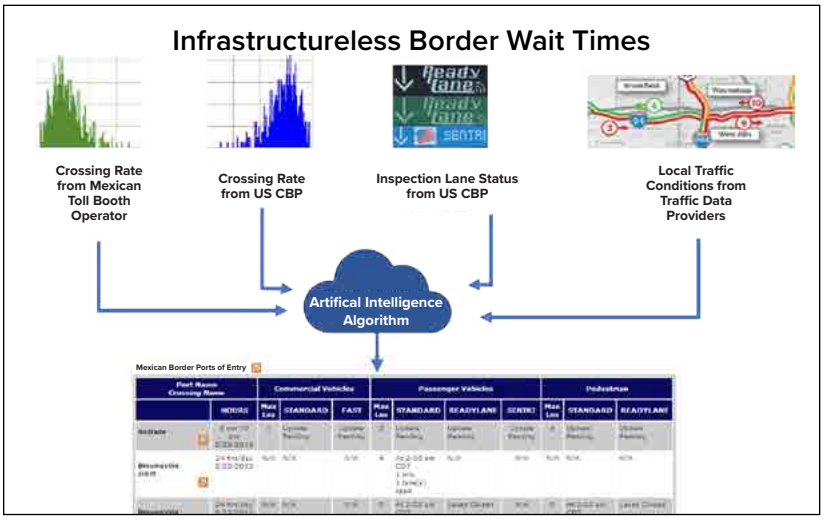
Infrastructureless Wait/Crossing Times at the U.S.–Mexico Border

For more than a decade—working with the Texas, New Mexico, and Arizona departments of transportation—TTI/CIITR researchers have deployed and maintained infrastructure assets along the U.S.–Mexico border. These assets are used to estimate wait and crossing times for trucks, which often wait for hours for checkpoint inspections. Deploying and maintaining field infrastructure components has, up to now, been a labor-intensive, expensive undertaking. Moreover, recent bottlenecks at border crossings, which result in longer lines times, have exceeded the existing built-out infrastructure's range for estimating queue lengths and wait times.

CIITR researchers created a framework and methodology to calculate wait and crossing times without the need for traditional infrastructure components. This first-of-its-kind solution uses artificial intelligence and machine learning to parse data from public- and private-sector sources to predict—in real time—wait and crossing times. Trade traffic is expected to increase in coming decades. This approach is more scalable (e.g., not limited by a component's range) and is significantly less expensive over time compared to in-place counting and estimating technology. These benefits will allow traffic and security agencies to reallocate funds and personnel to other priority projects and tasks without compromising the integrity of either counting reliability.



The objective of this project is to compute accurate real-time border wait times without any field infrastructure. The approach fuses data from various sources such as U.S. Customs and Border Protection, Mexican tool booth operators and traffic data providers (Google/INRIX) to estimate the border wait times in real time. This approach would not be susceptible to equipment downtime, would not need any field hardware maintenance and would eliminate the cost of expensive field side equipment.

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