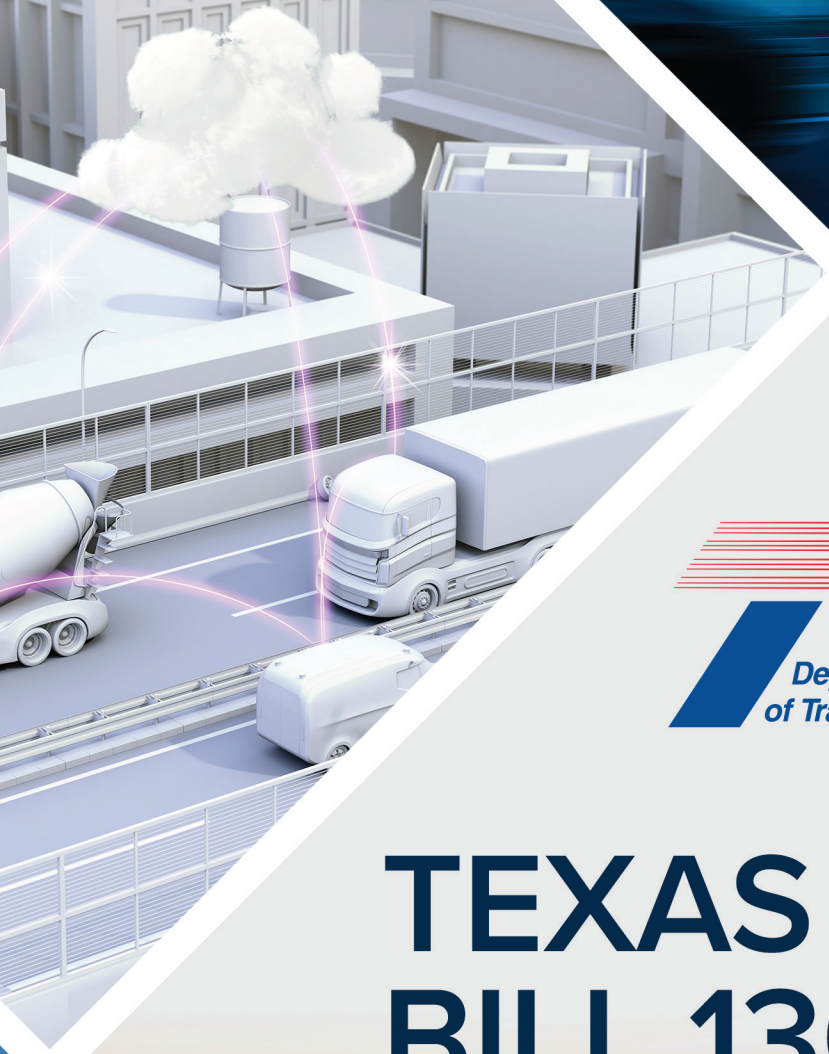

Texas Department of Transportation

TEXAS SENATE BILL 1308 STUDY

DECEMBER 2022

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SENATE BILL 1308 OVERVIEW

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1.0 Senate Bill 1308 Overview

Senate Bill 1308 Study Purpose

Texas' Legislators called for Senate Bill 1308 to study the potential benefits and impacts of Automated Driving Systems (ADS) and Connected Driving Systems (CDS) on key transportation needs.

Texas' success as a transportation and economic leader in North America and beyond is driven by the willingness to explore new solutions to ongoing challenges. In 2021, the Texas Legislature passed **Senate Bill (S.B.) 1308 requiring a study to explore the potential benefits and impacts of ADS and CDS technologies to help mitigate the key challenges** facing the state related to border congestion, public safety, and transportation workforce.

TEXAS SENATE BILL 1308 (S.B. 1308)

S.B. 1308 passed during the 87th (R) Texas Legislative Session (2021) charged the Texas Department of Transportation (TxDOT) and the Texas Department of Public Safety (DPS), in consultation with the Texas A&M Transportation Institute (TTI) and appropriate state and federal agencies, to conduct a joint study on:

- The potential benefits of using ADS, CDS, and other emerging technologies to alleviate motor vehicle traffic congestion at Ports of Entry (POE) between Texas and its four bordering Mexican states.
- The overall impact of using ADS, CDS, and other emerging technologies on the transportation industry workforce and the broader Texas economy, including the effects on driver and public safety.

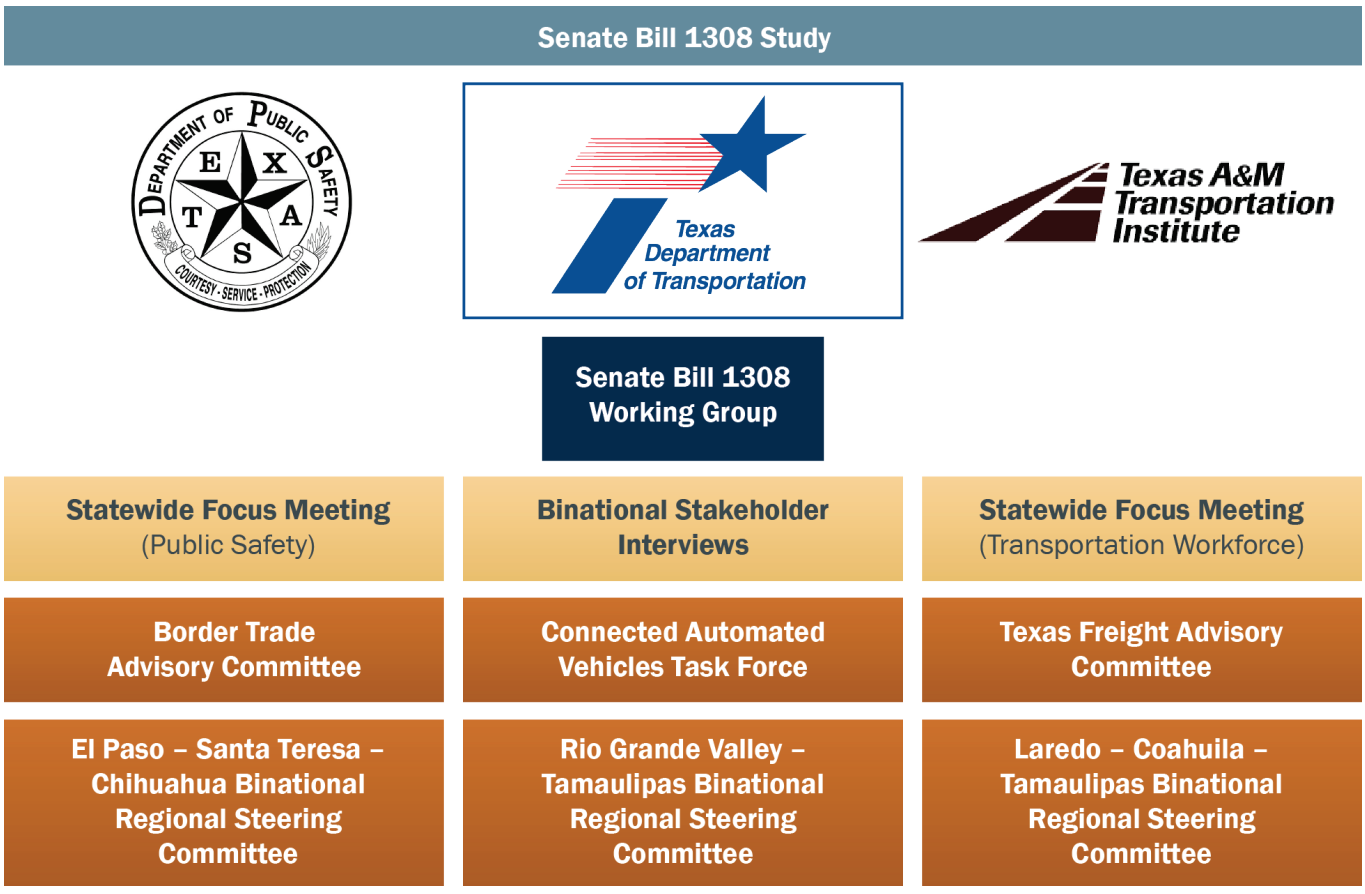
Texas S.B. 1308 requires the results of the study be submitted to the Governor, the Lieutenant Governor, and the Texas legislature not later than January 1, 2023.

Senate Bill 1308 Stakeholder Engagement

The study engaged a diverse group of stakeholders to inform the potential applications and impacts of ADS and CDS.

To ensure this study reflects the latest needs, goals, and innovations related to these rapidly evolving technologies, it was **critical to capture insights and input from a binational and diverse mix of public and private organizations.** The variety and expertise of the stakeholders helped define Texas' needs and opportunities as the state considers the potential benefits and impacts of a future driven by the evolution of ADS and CDS technologies. Figure 1 describes major stakeholder engagement efforts. **The robust stakeholder input helped shape the study's findings.**

Figure 1: Stakeholder Engagement Efforts



S.B. 1308 Working Group

The S.B. 1308 Working Group was formed to guide the study and provide input to TxDOT throughout the analyses on border crossings, safety, and workforce. This Working Group **met regularly throughout the study, providing input at key milestones.** The Working Group was comprised of state and federal agency members with an active role in border operations, public safety, and the transportation workforce, including the following:

- TxDOT: Transportation Planning and Programming (TPP), Strategic Planning (STR), Traffic Safety (TRF), and Information Technology (ITD) divisions and rural, urban, and border districts
- Texas Department of Public Safety (DPS)
- Texas A&M Transportation Institute (TTI)
- Office of the Texas Secretary of State
- Governor's Office of Economic Development and Tourism
- Texas Workforce Commission (TWC)
- Federal Highway Administration (FHWA)
- U.S. Customs and Border Protection (CBP)
- Federal Motor Carrier Safety Administration (FMCSA)
- General Services Administration (GSA)

Existing TxDOT Committees

Additionally, the study sought input from several existing committees **to ensure coordination with other statewide and regional efforts and to gather input from technical experts.** These included the Border Trade Advisory Committee (BTAC), Texas Freight Advisory Committee (TxFAC), the TxDOT-led Connected and Automated Vehicle (CAV) Task Force, and the Binational Regional Steering Committees (BNRSCs) which include representatives from the border regions of El Paso-Santa Teresa-Chihuahua, Laredo-Coahuila-Nuevo León-Tamaulipas, and the Rio Grande Valley-Tamaulipas. These committees provided valuable insight and partnership throughout the study.

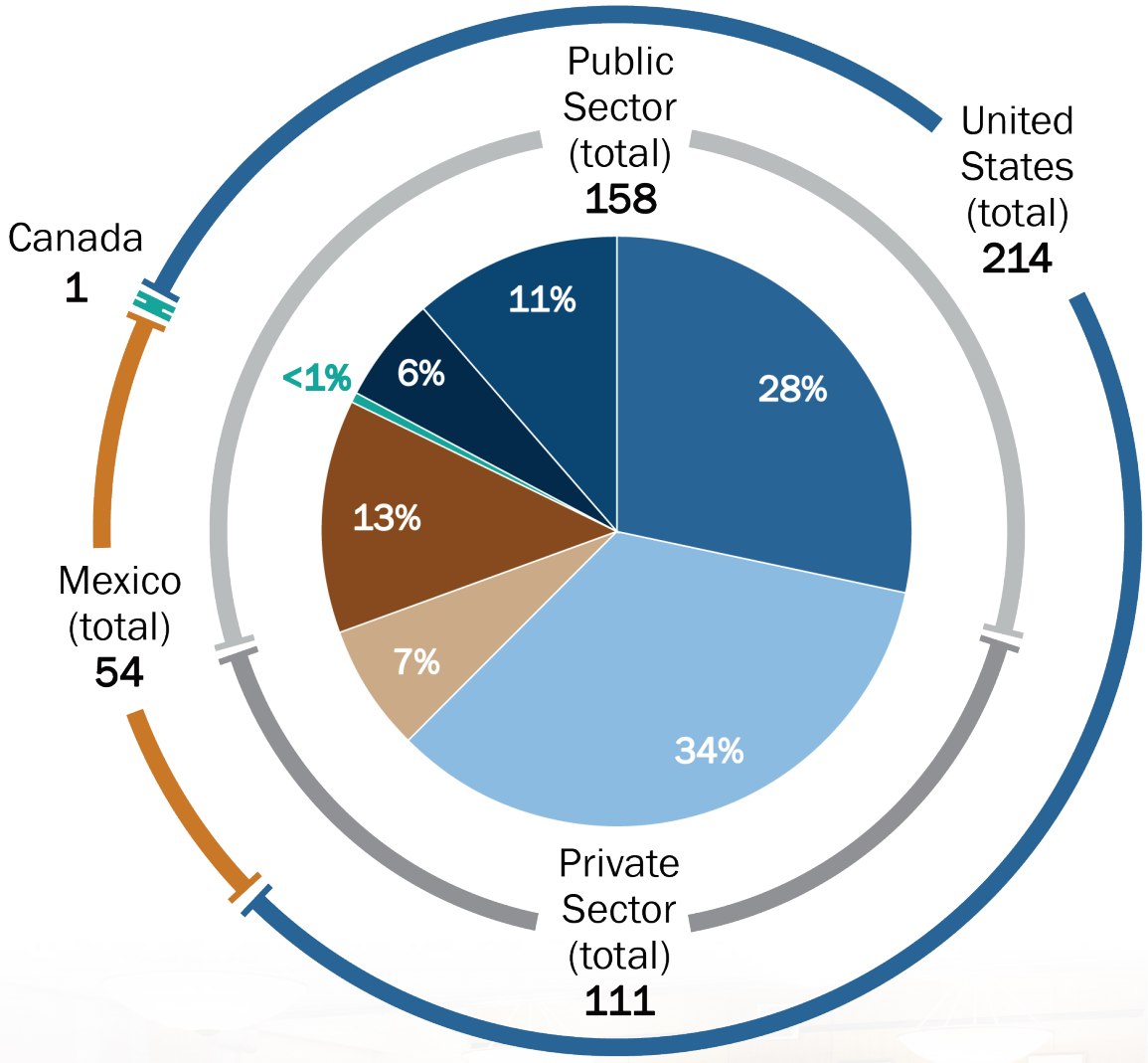
Other Key Stakeholders

The study also held multiple statewide focus groups **to assemble Texas stakeholders to discuss the potential impacts of ADS/CDS technology** on the state's driver and public safety and transportation workforce and to get a range of perspectives from industry experts. Finally, a series of 34 stakeholder **interviews were conducted with binational public and private organizations to provide the opportunity for more in-depth discussion** on emerging technologies and issues. Of the 34 interviews, 13 interviews were with stakeholders from Mexico to gather additional input and perspective on border crossing operations and the potential impacts of ADS/CDS in Mexico.

Overall, the study engaged **622 unique participants representing 269 agencies or private sector companies** for a total of **1,267 total stakeholder interactions.**[1] Figure 2 identifies the stakeholder types by category based on the 269 unique agencies or companies.

[1] Interactions are defined as unique touch points such as a meeting and/or interview.

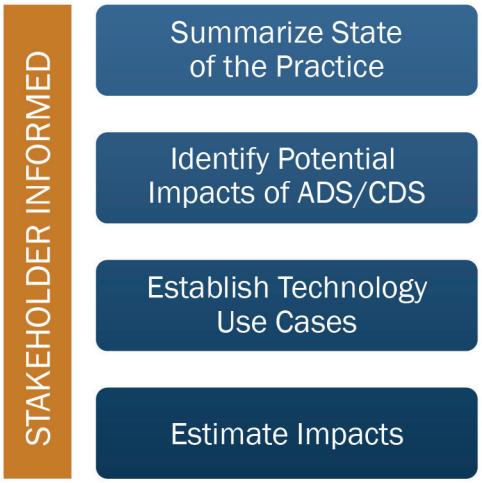
Figure 2: Stakeholder Types Involved by Category



Senate Bill 1308 Study Technical Approach

S.B. 1308 study used a robust technical approach centered around detailed analysis and stakeholder engagement and input.

The technical approach for this study **incorporated the current state of the practice of ADS and CDS in Texas, United States, and throughout the world**, which allowed for the **identification of potential impacts on border crossing congestion, public safety, and transportation industry workforce.** These potential impacts informed the development of use cases, which defined the possible future operating environments for a mix of vehicle technology applications. These future "what if" scenarios looked at three possible futures for each of the questions posed by S.B. 1308 based on **three critical factors – technology capabilities, infrastructure readiness, and level of adoption by users.** Benefits and impacts of ADS and CDS were estimated for 2035 and 2050 based on a mix of use cases and a range of market penetration. As noted above, **this approach was stakeholder-informed** including being led by a study-specific Working Group.



A review of the state of the practice and existing efforts to develop, test, and deploy ADS and CDS helped identify potential impacts and define "what if" scenarios.

Existing research and demonstrations provide insight into the types of potential ADS/CDS applications that could provide benefits, as well as the conditions that would be necessary for success.

- The analysis of the **potential benefits of ADS and CDS for alleviating congestion at POEs** found that, while there are not many examples of ADS usage at borders in practice, there are opportunities for cross-border applications. Notably, ADS-equipped vehicles (both Commercial Motor Vehicles (CMVs) and Personally Owned Vehicles (POV)) can potentially operate with greater safety and efficiency even at lower levels of automation. At higher levels of automation, the potential for CMVs not requiring a human driver creates a potentially substantial leap for efficiency by streamlining border regulation and security responsibilities.
- The review of **ADS and CDS impacts on public safety** found that ADS, CDS, and other emerging technologies have the potential to enhance the overall safety of the Texas transportation system. The technologies present an opportunity to continue along the path toward eliminating traffic fatalities and serious injuries on Texas roadways.
- Finally, the review of **ADS and CDS impacts on the transportation industry workforce** showcased that the transportation industry represents a major component of the Texas economy. The impacts of ADS- and CDS-equipped vehicles along with other emerging technologies present an opportunity for new jobs, but care must be taken to ensure that these opportunities are made available to workers across the state.

ADS and CDS can have many potential transportation uses.

To identify the impacts of ADS/CDS technologies, the S.B. 1308 Working Group **considered different use cases to evaluate the most relevant Society of Automotive Engineers (SAE) level 4 and 5 ADS/CDS technology applications** (Table 1). Based on a review of potential ADS and CDS applications and stakeholder engagement, these use cases include CMV and POV moving both goods and passengers, respectively.

Table 1: Statewide ADS and CDS Use Cases

USE CASE	DESCRIPTION
CMV ADS Operation for Long-Haul in Mixed Traffic	Trucks carrying long-haul freight use ADS, operating in mixed traffic. May or may not have supervisory operator in place.
CMV Platooning Supported by ADS/CDS Operation	Trucks are grouped in clusters of two or three vehicles, with a single driver in the lead vehicle and automated systems controlling the following vehicles.
CMV ADS Operation for Long-Haul in Autonomous Vehicle (AV)-Only Lanes	Trucks carrying long-haul freight use ADS, operating in dedicated lanes. May or may not have supervisory operator in place.
CMV ADS Operation for Short-Haul Delivery	CMVs operate using ADS in mixed traffic to make short-haul and delivery trips.
POV ADS Operation	POVs are regularly engaged for full self-driving capabilities during regular travel; this can include limited Zero Occupancy Vehicle (ZOV) movements that result when a self-driving vehicle makes a trip to pick up a passenger that is not linked to another passenger trip. This is likely more common with POVs.
Taxi/Rideshare with ADS (Driverless)	Taxi and rideshare trips are made using dedicated ADS-equipped vehicles for full self-driving capabilities (ZOV movements not considered here because trips are likely to be planned to include passengers, maximize revenues).
ADS-equipped Transit on Dedicated Right-of-Way	Public transportation vehicles operate using ADS on designated facilities.
ADS-equipped Transit in Mixed Traffic	Public transportation vehicles are regularly engaged for full self-driving capabilities in mixed traffic.
Enhanced Data-Sharing for CDS-Equipped Vehicles	CDS-equipped vehicles (CMV and POV) have greater data sharing direct to vehicles including safety messages and advanced delay notifications.

The **border crossing environment requires consideration of additional use cases**. Border crossing use cases considered a variety of ADS and CDS applications for POV, CMV, and transit at the border, factoring in the existing trusted traveler programs and expedited processing facility types that currently are utilized. These applications also distinguish lane type between standard lane operation, expedited processing lanes (such as Free and Secure Trade for Commercial Vehicles (FAST) lanes or Secure Electronic Network for Travelers Rapid Inspection (SENTRI) lanes), and introduced the concept of dedicated, AV-only lanes.

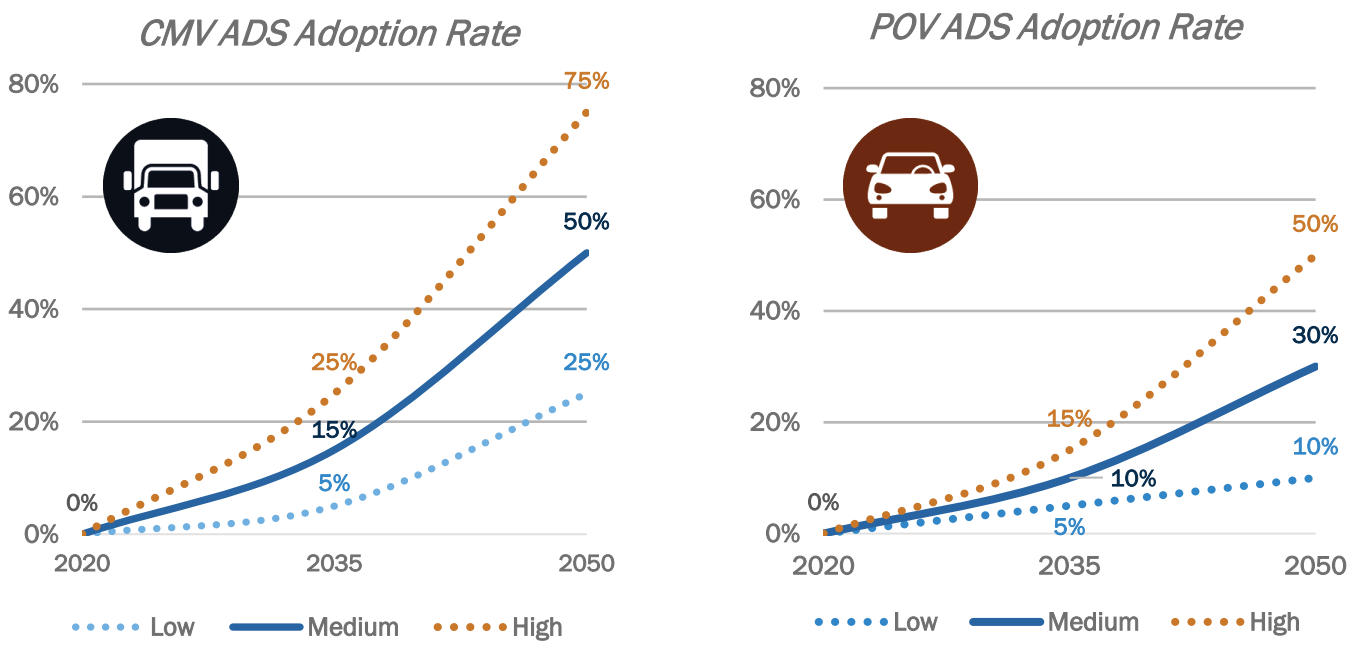
The range of future ADS and CDS adoption rates is a major factor in predicting impacts and potential benefits.

The S.B. 1308 Working Group **used potential "what if" scenarios to consider how Texas can prepare for the future**. These scenarios can help Texas evaluate how the benefits and impacts of technology may take shape in the future years of 2035 and 2050, given that ADS and CDS technologies have a high degree of uncertainty related to functionality, user acceptance, and adoption timeline.

The Working Group utilized three tiers for scenarios: **Low (Conservative)**, **Medium**, and **High (Optimistic)**. Each tier was evaluated to capture the range of possible operational outcomes that occur when considering the impacts of ADS and CDS being widely utilized in Texas. Within these scenarios, **adoption, or usage of ADS/CDS in Texas is the most critical driver of change.** Adoption refers to the percentages of vehicles equipped with and using the technologies.

Figure 3 shows the ADS adoption rate assumptions used for the scenario analyses. This study also includes consideration of CDS and fully driverless trucks.[2]

Figure 3: ADS Adoption Scenarios



Note: All technology adoption rates were based on a synthesis of available research into projected ADS and CDS adoption by the years 2035 and 2050 as well as stakeholder feedback. The range was selected to provide reasonable bounds for an uncertain future.

[2] For CDS usage, the assumptions are 75%, 80%, and 90% in 2035 for the Low, Medium, and High scenarios respectively. By 2050, these assumptions are 80%, 90%, and 99%, reflecting close to universal penetration.

The assumptions used for driverless trucks at border crossings in 2035 are 2.5%, 5%, and 10% across the Low, Medium, and High Scenarios respectively. In 2050, the assumptions are 8%, 17%, and 33%. These assumptions were based on existing research, stakeholder feedback, and consideration of existing trusted traveler program engagement, which is a leading indicator of technology interest/adoption.

Organization of the Report

This report summarizes the findings for all three key S.B. 1308 questions.

The remainder of this report summarizes the findings of the S.B. 1308 study organized as follows:

- Section 2 – Introduction.
- Section 3 – Potential Benefits of Using ADS/CDS to Alleviate Motor Vehicle Congestion at Ports of Entry.
- Section 4 – Potential Impacts of ADS/CDS on Driver and Public Safety.
- Section 5 – Potential Impacts of ADS/CDS on Transportation Industry Workforce and Texas Economy.
- Section 6 – Summary and Considerations.

In the following section, the study introduces border delay, driver and public safety, transportation industry workforce, and key technology definitions

2

INTRODUCTION

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2.0 Introduction

Trade and Border Crossings

Trade across the U.S.-Mexico border has strengthened the competitiveness of both the U.S. and Mexico.

Mexico has been the U.S.'s top trading partner since 1994, representing 14.8 percent of total imports and exports in 2019. The amount of trade between the U.S. and Mexico has **more than tripled between 1994 and 2019, increasing from $173 billion to $615 billion.**[3] This trade is a consistent and growing contributor to the economies of the U.S., Mexico, and Canada. Trade with Mexico, which includes both parts and finished products, such as automobiles, vegetables, furniture, and clothing, supports more than 5 million U.S. jobs. Texas ranks first among U.S. states trading with Mexico, with 33 percent of the total truck and rail trade. In 2019, the value of Texas-Mexico trade grew to $213 billion.

The current border transportation system makes these connections possible—allowing companies from both sides of the border to flourish and for people to access work, school, shopping, and social opportunities. In fact, the U.S. and Mexico share 49 vehicle and pedestrian border crossings, 28 of which are located between Texas and Mexico. **Texas' border infrastructure is an asset to both the U.S. and Mexican economies** – particularly as trade continues to grow.

NEARSHORING HAS THE POTENTIAL TO DRIVE GROWTH IN TRADE

Nearshoring opportunities in Mexico are increasing as international companies look for ways to mitigate supply chain disruptions – this in combination with the United States-Mexico-Canada Agreement (USMCA) has the potential to dramatically grow trade crossing the U.S.-Mexico border.

[3] Texas Department of Transportation. Texas-Mexico Border Transportation Master Plan 2021, March 2021. Accessed at: https://www.txdot.gov/Government/partnerships/trade-border/btmp.html.

The Texas-Mexico border is a vital economic gateway between the thriving economies of Texas and Mexico.

The **Texas-Mexico border comprises 64% of the shared border (approximately 1,254 miles) between the United States and Mexico.** It follows along the Rio Grande from El Paso to the Gulf of Mexico, and **28 border crossings** accommodate the movement of people and goods between Texas and Mexico. Texas' and Mexico's international bridges and border crossings serve as major gateways for all modes of transportation, facilitating the movement of goods and people.

The more than 7 million residents and businesses of the vibrant, complex, and growing border region rely on the Texas-Mexico border for the success and health of both the U.S. and Mexican economies.

Cross-border trade is critical to the Texas economy. $100.2B or 5.3% of Texas GDP is tied to trade crossing the Texas-Mexico border.

The **Texas-Mexico border is North America's busiest trade gateway.** Mexico is the largest trading partner of Texas and **68 percent of trade** between the U.S. and Mexico passes through the Texas-Mexico border. Trade through the Texas-Mexico border reaches businesses and homes throughout the U.S., Mexico, and Canada. **In fact, trade crossing the Texas-Mexico border quadrupled from $111B to $451B between 1994 and 2019.** It is forecasted to continue to grow significantly through 2050, **reaching $1.5T**.[4]

Recognizing the vital nature of the Texas-Mexico border, TxDOT developed the **Texas-Mexico Border Transportation Master Plan** (Texas-Mexico BTMP) in 2021.

The Texas-Mexico BTMP looked at the significant contributions of cross-border trade as well as the readiness of the border infrastructure to accommodate significantly larger volumes of people and goods in the future.

For greater detail on the opportunities and challenges associated with the Texas-Mexico border, readers should consult the Texas-Mexico BTMP (available in English and Spanish) at https://www.txdot.gov/projects/planning/international-trade-border-planning/btmp.html .

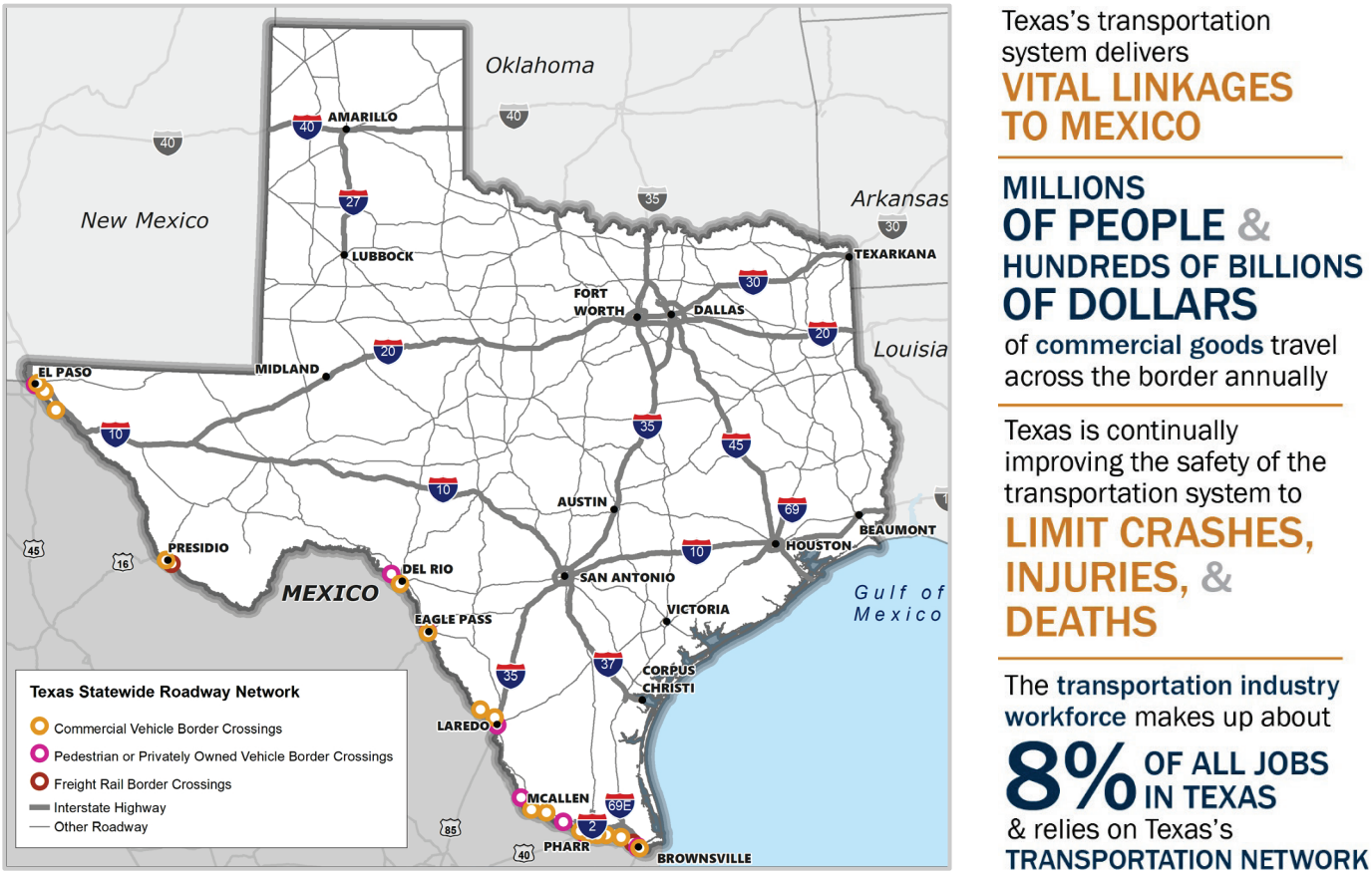
Maintaining timely and efficient border crossings is essential to economic growth. The volume of current and projected traffic creates a significant need. Based on the increase in border crossing traffic, the Texas-Mexico BTMP forecasted a **dramatic increase in border crossing times by 2050 if no operational efficiency and system capacity improvements are made**. In fact, without improvements, the Texas-Mexico BTMP projected that northbound **border crossing times could grow between 1 and 22 times**. Border capacity, along with supporting highway and roadway system capacity, is not keeping pace with the growing demand.

This projected increase in border crossing delays has the potential for serious impacts on the economies of the Texas-Mexico border region, Texas, the Mexican border states, and the U.S. and Mexico overall. As a result, the Texas-Mexico BTMP included **investments and partnerships that lead to upgrades and modernization for the border crossing environment** as a program recommendation.

[4] Texas-Mexico BTMP, 2021.

Transportation is critical to the ongoing growth and success of population and industry in Texas. As noted in the Texas Transportation Plan 2050,[5] **providing a safe, reliable, and integrated transportation system ensures the state's citizens enjoy a high quality of life and enables businesses to prosper.** Texas has more than **314,000 centerline miles of public roads** and **more than 55,000 bridges**. The state supports more than **540 million vehicle miles traveled** (VMT) on state roads annually including some **highways that carry as many as 300,000 vehicles a day**.[6] Figure 4 provides an overview of the Texas highway network and the Texas-Mexico border crossings.

Figure 4: Texas Statewide Transportation and Highway Network and Border Crossings



Source: Texas Department of Transportation.

Given the importance of the transportation system, there is a **fundamental need to move goods and people safely and efficiently across Texas' multimodal transportation system and across the Texas-Mexico border.**

5 Texas Department of Transportation, Texas Transportation Plan 2050. Accessed at https://ftp.txdot.gov/pub/txdot/tpp/2050/ttp-2050.pdf

6 Analysis of TxDOT Open Data Portal, 2020 data.

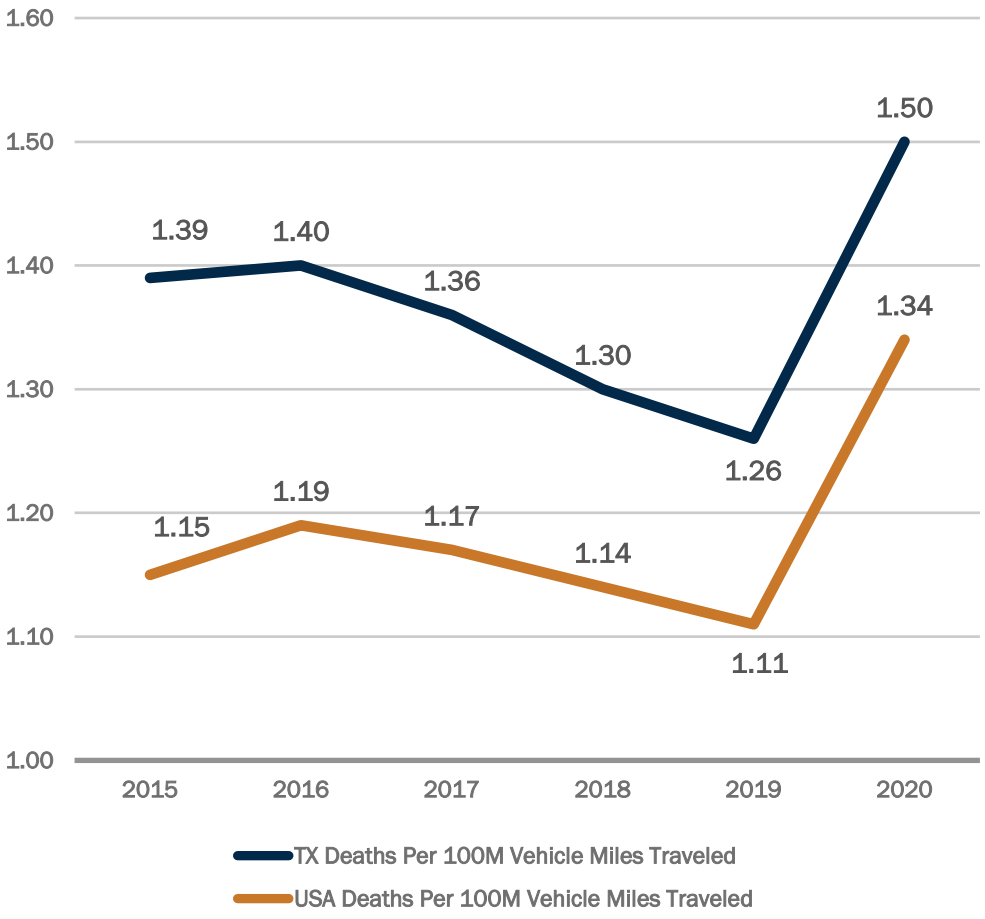
Driver and Public Safety

Driver and public safety are essential to the Texas transportation system.

The Texas transportation system supports the movement of people and goods by providing connections for commerce, convenience, and daily life. **Driver and public safety are essential to the Texas transportation system for all roadway users including personal vehicles, CMVs, pedestrians, and bicyclists.** Motor vehicle crashes, injuries, and fatalities result in the loss of life, injuries, property damage, income loss, and time lost in congestion caused by crashes.

As measured by the number of deaths per mile people are driving, the rate at which people lose their life in traffic crashes in Texas is above the national average. In 2020 1.5 deaths per 100 million VMT occurred on Texas roadways versus 1.34 deaths per 100 million VMT nationwide (Figure 5). This means, even after accounting for the number of miles of Texas roadways, **the number of people per mile who lose their life in traffic crashes in Texas is higher than the number of deaths per mile for fatalities nationwide**.

Figure 5: Texas and USA Motor Vehicle Fatality Rates



Source: Fatality Analysis Reporting System (FARS).

Source: 2021 Texas Motor Vehicle Traffic Crash Facts.

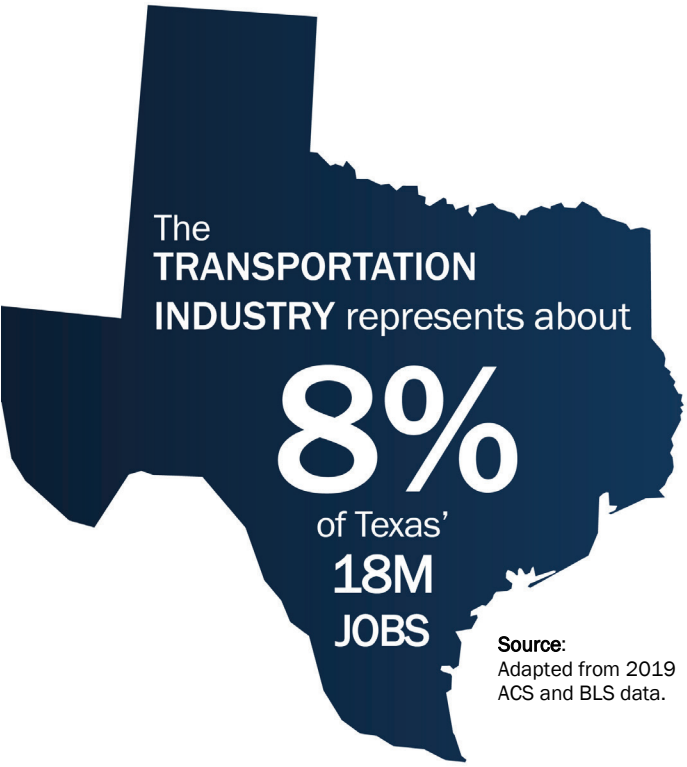
TxDOT already focuses on safety with engineering, education, and enforcement efforts. The Texas Strategic Highway Safety Plan (SHSP) 2022-2027 and the Texas Transportation Commission's 2019 Road to Zero Minute Order represent a strategic approach to reduce fatalities and serious injuries on Texas roadways. The SHSP focuses on selected traffic safety improvements with the greatest promise of success in the least amount of time. The Road to Zero initiative is a two-part goal to **reduce the number of deaths on Texas roadways by half by the year 2035 and eliminate road deaths by 2050.** The goal builds on an increased emphasis on safety during project prioritization, selection, and design as well as continuing driver safety awareness programs and working to implement the SHSP.

Despite the focus on addressing traffic safety in Texas, **crashes, injuries, and fatalities are significant and forecasted to grow**. Motor vehicle crashes on Texas' on-system highways have been on the rise as population and VMT increase. These crashes result in lives lost, severe injuries, and property loss and damage. At the same time, **technology advancements have the potential to address key public safety needs** as Texas continues to make a concerted effort to reduce the fatalities and serious injuries that occur on its roadways.

The TX SHSP is a roadmap of the strategies and countermeasures to reduce fatalities and serious injuries in Texas on all public roadways, focused on the most severe crash types.

Transportation Industry Workforce

A growing economy requires a growing workforce.



The Texas economy is supported by an engaged and growing transportation industry workforce that represents about **8% of all jobs in Texas**. There are significant **opportunities for continued economic growth and development associated with the exciting transportation innovations** that are already shaping Texas as a leader.

To support this dynamic economic sector, **a strong, capable, and well-trained workforce will be required**. Today, many subsectors of the transportation workforce—notably, vehicle operators with Commercial Driver's Licenses (CDLs)—face a **serious shortage of qualified workers**.

While new technologies may shift the roles and responsibilities of the transportation workforce, it is unlikely that they will result in a reduced need for workers across the industry. Rather, these industries may reduce the need for a few specific roles—such as crewed long-haul vehicles or taxi/ride hailing operators—while **introducing new roles in logistics, operations, and technology**.

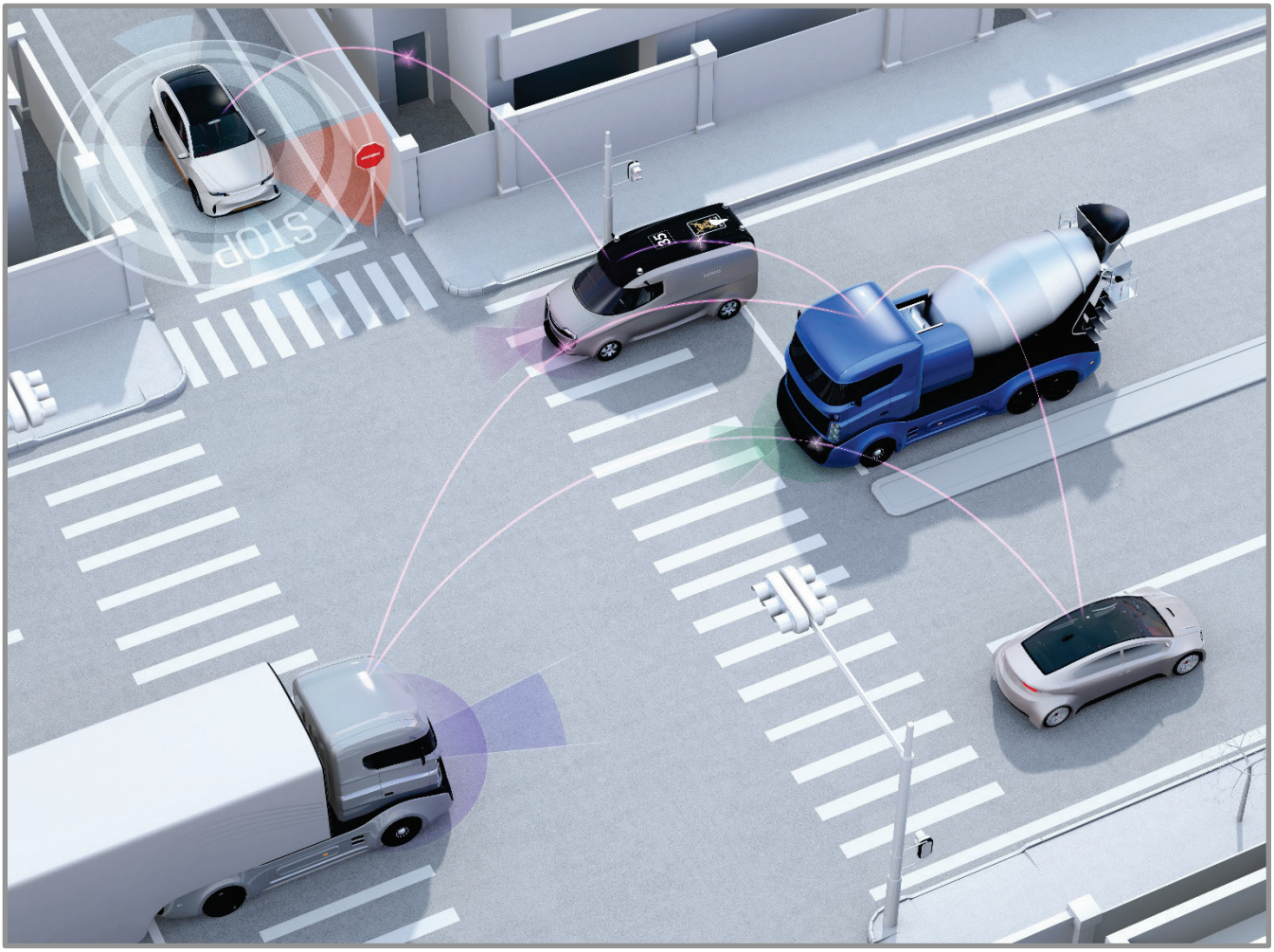
As vehicles become more technologically advanced, **manufacturing and maintenance facilities will play a significant role in the Texas economy**. Texas has already had great success attracting development, manufacturing, and assembly operations to the state; emerging technologies should support this trend.

Emerging Vehicle Technologies and Key Definitions

Emerging technologies can help Texas meet its most critical needs.

Over the last two decades, **automated and connected vehicle technologies have made significant advancements on the transportation systems in Texas,** the United States, and throughout the world. These types of emerging technologies in vehicles have the potential to increase fuel efficiency, reduce traffic congestion, improve mobility, access, and public safety, in large part by reducing driver error while delivering advanced information exchange, improved connectivity, and integration within and between vehicular operating systems.

As technology advancements continue, State Departments of Transportation (DOT) and other planning agencies face the new challenge of integrating and accommodating a variety of system users and finding ways to maximize the opportunities provided by these new capabilities. **ADS and CDS are two of the most potentially transformative technologies being developed, tested, and deployed today.**



ADS are already having transformational impacts on transportation.

AUTOMATED DRIVING SYSTEMS (ADS)

As defined in Texas transportation code § 545.451, hardware and software that, when installed on a motor vehicle and engaged are collectively capable of performing without any intervention or supervision by a human operator.

Sources (clockwise from upper left): Ford Argo, Cruise Origin, Lyft/Motional Las Vegas, TuSimple

ADS includes vehicles capable of performing a part, or all, of the real-time operational and tactical functions required for a vehicle to function in on-road traffic (e.g., steering, throttle, or braking) without direct human input. Vehicles with ADS may use vehicle sensors or may be connected, using CDS technology, to communicate with vehicles and transportation infrastructure. TxDOT's definition aligns closely with the U. S. Department of Transportation (USDOT) definition for ADS which defines it as systems capable of performing the entire driving task on a sustained basis, regardless of whether it is limited to a specific operational design domain.[7,8] Based on the definition for ADS in Texas and text of S.B. 1308, this study is focused on impacts and benefits of advanced automation (SAE levels 4 and 5, see next page).

There are a growing number of demonstrations and deployments under way in Texas today that are transforming the way we look at transportation options. Multiple leading companies are currently testing ADS systems for heavy-duty trucking use on Texas roads. Section 5 provides more information on ADS and CDS deployments underway in Texas.

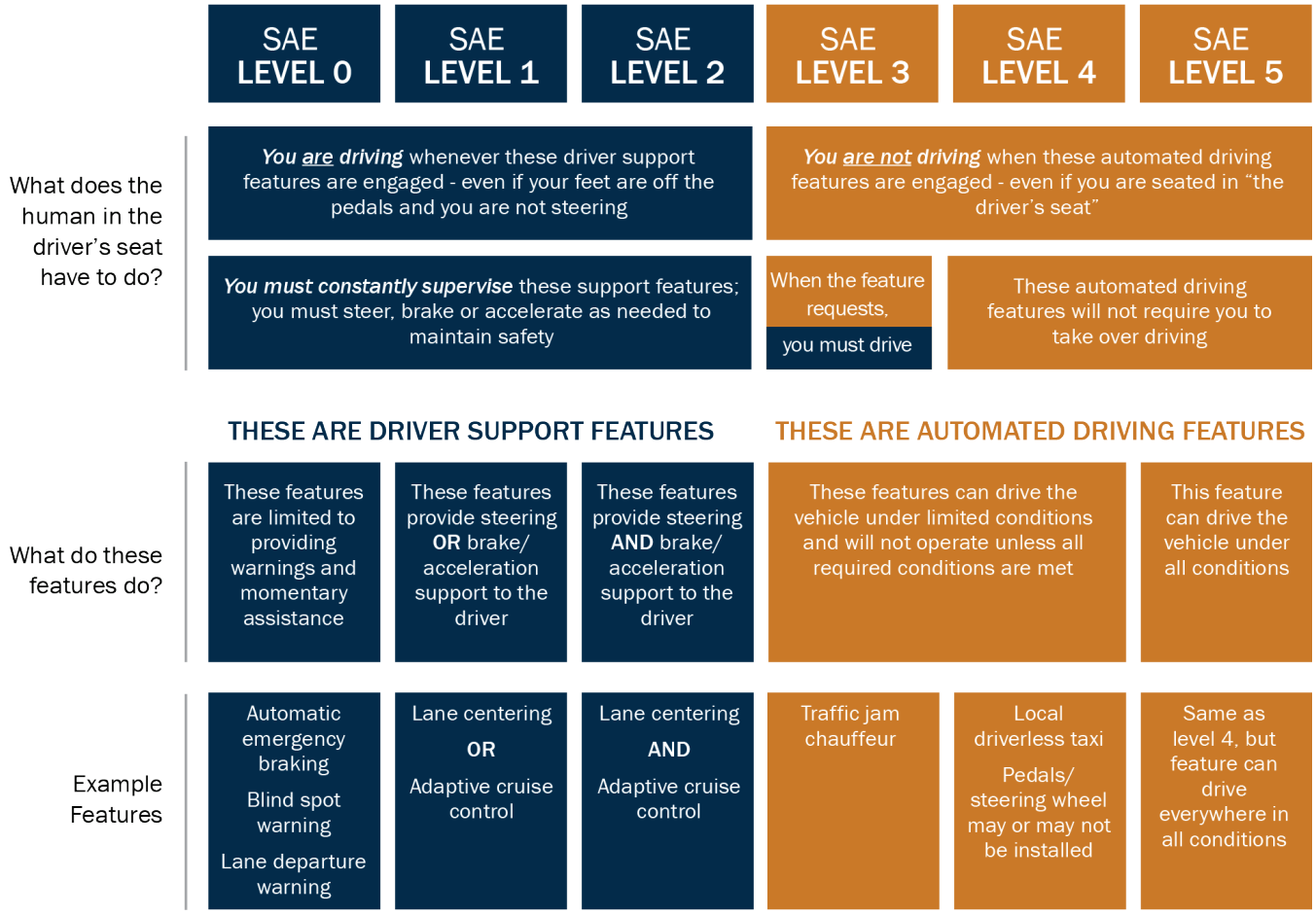
7 U.S. Department of Transportation. Automated Vehicles Strategic Plan. Accessed at https://www.transportation.gov/sites/dot.gov/files/2021-01/U.S. DOT_AVCP.pdf.

8 ADS is also associated with the term Automated or Autonomous Vehicles (AV), as well as Connected and Automated Vehicles (CAV), which carries the additional criteria of using some element of CDS. TxDOT and other agencies use an additional term, Cooperative Automated Transportation (CAT), a cooperative ecosystem of physical and digital infrastructure and emerging vehicle technologies to enable the safe, reliable, and efficient movement of people and goods in a multimodal transportation network.

ADS describes a range of levels of automation that reflect an evolving industry.

It is critical to understand that **ADS can serve as an umbrella term that includes systems that perform at different levels of automation.** When defining levels of vehicle automation, the most-cited source in the industry is the SAE document SAE J3016 Levels of Driving Automation. SAE J3016 outlines six levels, ranging from 0 to 5. Traditional vehicles fall within levels 0 through 2. These levels include a range of Advanced Driver Assistance Systems (ADAS) features. For instance, ADAS can range from blind spot warning to lane centering and adaptive cruise control. Vehicles with level 3 automation and above are referred to as ADS and can fully operate in roadway environments, although some environments, such as those with low visibility and complex geometries, may prompt driver operation (SAE Level 3). Figure 6 shows the SAE levels of driving automation.[9] [10]

Figure 6: Levels of Driving Automation



Source: 2021 SAE International.

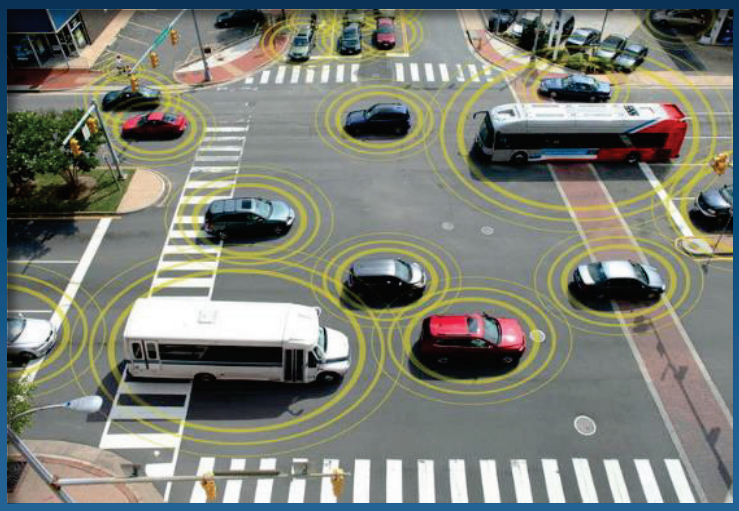
9 SAE International. Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles. Accessed at https://www.sae.org/standards/content/j3016_202104/.

10 As noted on the prior page, the S.B. 1308 Study looks at the potential benefits and impacts of ADS in SAE levels 4 and 5.

CDS continue to evolve and advance as vehicle capabilities expand.

CONNECTED DRIVING SYSTEMS (CDS)

Hardware and software that, when installed on a motor vehicle, enables vehicles to receive and share mobility and safety information between vehicles, people, other roadway users, and transportation management systems.



Source: United States Department of Transportation (USDOT)

CDS vehicle technologies allow DOTs to deploy roadside communications units for a wide variety of beneficial applications. With the appropriate communication network in place, **vehicles with onboard communications can exchange messages**, such as vehicle information, location, and speed, with roadside units (RSU).[11] CDS also enables a **full range of communication options between vehicles and other roadway users.**

Although autonomy can happen without connectivity, connected systems can greatly enhance safety and efficiency benefits by allowing vehicles and other objects to readily transmit and receive data. This connectivity will help vehicles to not only communicate with their own complex vehicle systems but also with an external environment. This includes vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-pedestrian (V2P) communication, which are collectively known as vehicle-to-everything (V2X). V2V communication enables vehicles to wirelessly exchange information about their speed, location, and heading to create 360-degree awareness of other vehicles in their proximity.

NHTSA. V2V Fact Sheet. Vehicle-to-Vehicle Communication

[11] A RSU (Roadside Unit) is communication equipment that supports two-way communications between onboard units and roadside equipment. This exchange of data is a fundamental feature of CDS.

Other emerging technologies will complement ADS and CDS.

Advances in ADS and CDS are not occurring in a vacuum. Other emerging technologies that are maturing simultaneously also have the power to disrupt personal mobility and how public agencies provide mobility and solve transportation challenges. **Other emerging technologies are defined as transportation-related applications that will potentially have direct interaction with ADS/CDS and the ability to shape ADS/CDS impacts.**

The potential impacts of **Electric Vehicles (EV)**, a significant emerging technology, need to be considered in relation to ADS/CDS. The TxDOT Cooperative Automated Transportation (CAT) Strategic Plan defines EVs as vehicles fueled by electricity and can be charged from an off-board electric power source. Because EVs are often more digitally connected than conventional vehicles, they are often discussed in conjunction with ADS and CDS. This is a timely topic given greater emphasis by transportation agencies such as TxDOT on National Electric Vehicle Infrastructure (NEVI).

There are border crossing-specific technologies to be considered for their potential impacts on ADS/CDS. For example, DPS operates border safety inspection facilities (BSIF) at 8 border crossings along the Texas-Mexico border as part of an effort to improve safety by verifying that CMVs entering the United States are compliant with applicable state safety standards. ADS and CDS technologies also have the capacity to work collaboratively with trusted traveler programs (such as the current FAST)/SENTRI programs) and non-intrusive inspections that reduce crossing times. It is important to consider where existing and future technologies can assist and advance these processes.

In the following section, the study discusses the potential benefits of using ADS and CDS to alleviate motor vehicle congestion at the border.

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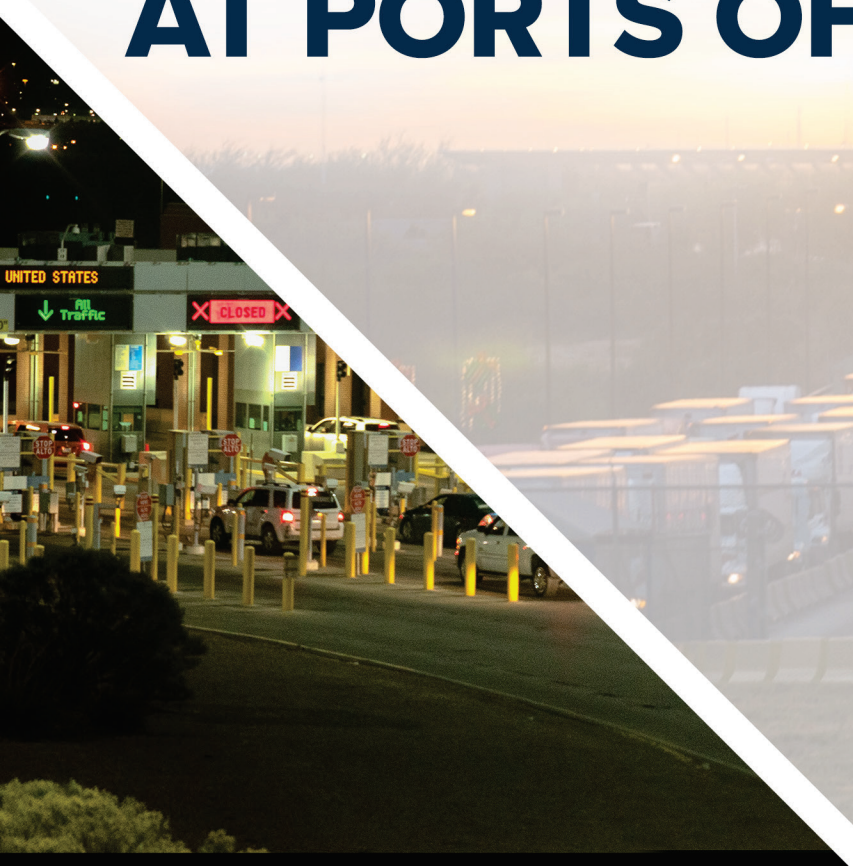
POTENTIAL BENEFITS OF USING ADS/CDS TO ALLEVIATE MOTOR VEHICLE CONGESTION AT PORTS OF ENTRY



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3.0 Potential Benefits of Using ADS/CDS to Alleviate Motor Vehicle Congestion at Ports of Entry

Background on Texas-Mexico Border

The Texas-Mexico border is a vital economic gateway.

The U.S. and Mexico share a 1,954 common border, **64% or 1,254 miles of which is shared between Texas and Mexico**. The Texas-Mexico border follows along the Rio Grande from El Paso to the Gulf of Mexico, and its **28 border crossings accommodate the movement of people and goods between the two nations** (Figure 7).[12] As noted in the recent Texas-Mexico Border Transportation Master Plan (Texas-Mexico BTMP), the more than 7 million residents and businesses of the vibrant, complex, and growing border region rely on the Texas-Mexico border for the success and health of both the U.S. and Mexican economies.

[12] TxDOT. Texas-Mexico Border Transportation Master Plan 2021. March 2021. Accessed at: https://www.txdot.gov/Government/partnerships/trade-border/btmp.html.

Figure 7: Texas-Mexico Border Crossing and Supporting Infrastructure

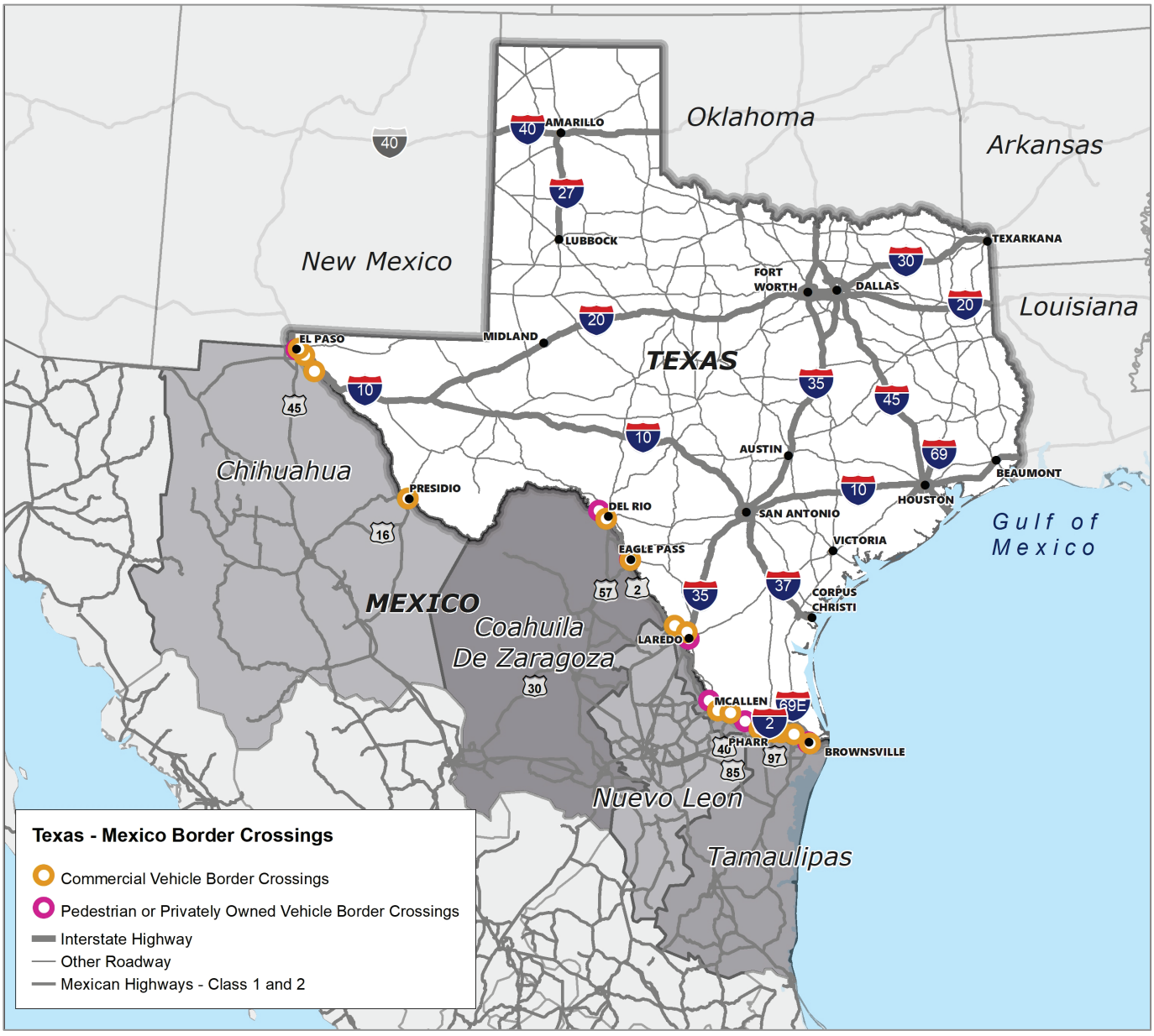
28 Border Crossings along the **Texas-Mexico border**

12 Vehicular Crossings serve both **CMV & POV**

1 Exclusively Serves **Commercial Vehicles**

24 Border Crossings allow **Pedestrians & Bicycles**

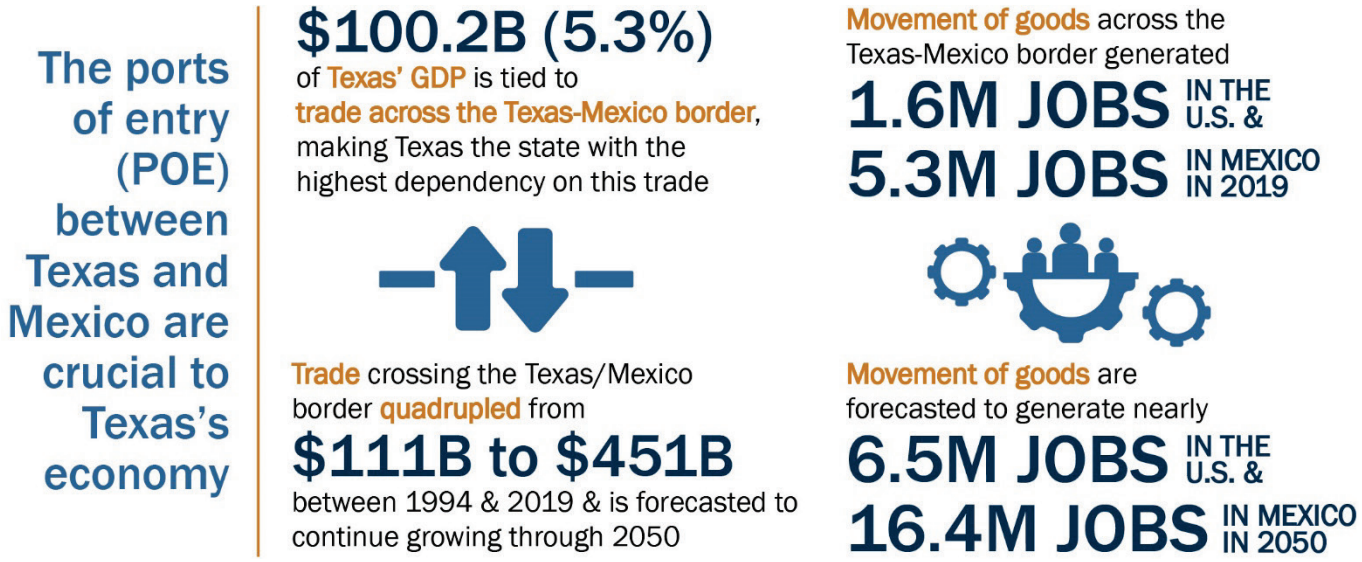
10 Border Crossings process **Buses**



Source: TxDOT and Texas-Mexico BTMP, 2021.

Texas' strong economy and strategic location make it a leader in trade with Mexico, as well as **providing a gateway for international trade for the nation.** As a result, the Texas-Mexico border and its POEs are crucial to Texas' economy. Some relevant statistics include: $100.2B or 5.3% of Texas' Gross Domestic Product (GDP) is tied to trade across the Texas-Mexico border, making Texas the state with the highest dependency on this trade; trade crossing the Texas-Mexico border quadrupled from $111B to $451B between 1994 and 2019 and is forecasted to continue growing through 2050; the movement of goods across the border generated 1.6M jobs in the U.S. and 5.3M jobs in Mexico in 2019; and the movement of goods are forecasted to generate nearly 6.5M jobs in the U.S. and 16.4M jobs in Mexico in 2050.[13] As shown in Figure 8, the Texas-Mexico border is crucial to the state's and the U.S.' GDP due to the value of the crossings and jobs that depend on the trade relationship. Texas ranks first among U.S. states trading with Mexico, with 33 percent of the total truck and rail trade. In 2019, the value of Texas-Mexico trade grew to $213 billion.[14]

Figure 8: Economic Impacts of the Texas-Mexico Border



The 1994 North American Free Trade Agreement (NAFTA) stabilized trade and helped catalyze trade growth between the United States, Mexico, and Canada, significantly strengthening economic ties between the three countries. Several decades later, the 2020 USMCA was established to further bolster growth and enhance the relationship between the United State, Mexico, and Canada. Today, the bilateral relationship between Texas and Mexico goes beyond trade and includes close commercial, cultural, and educational ties. This enduring relationship between the United States and Mexico has a direct impact on the lives and livelihoods of millions of people.

[13] Texas-Mexico BTMP, 2021.

[14] Ibid.

Motor vehicle congestion at Texas-Mexico ports of entry is significant and forecasted to grow.

Millions of people and hundreds of billions of dollars of commercial goods travel across the 28 border crossings in the Texas-Mexico border annually, and 13 of the border crossings serve as major gateways for the export and import of commercial goods via CMVs. Demand for cross-border travel is expected to continue to increase due to several factors.

Northbound crossing times for CMVs in 2019 ranged from 8-60 minutes on average. Between 2019 and 2050, these border crossing times are forecast to grow between 1 and 22 times by the Texas-Mexico BTMP.

Trade crossing the Texas-Mexico border quadrupled from $111B to $451B between 1994 and 2019 and is forecasted to continue to grow significantly through 2050, reaching $1.5T.[15] This places significant demand on the existing POEs that service CMVs.

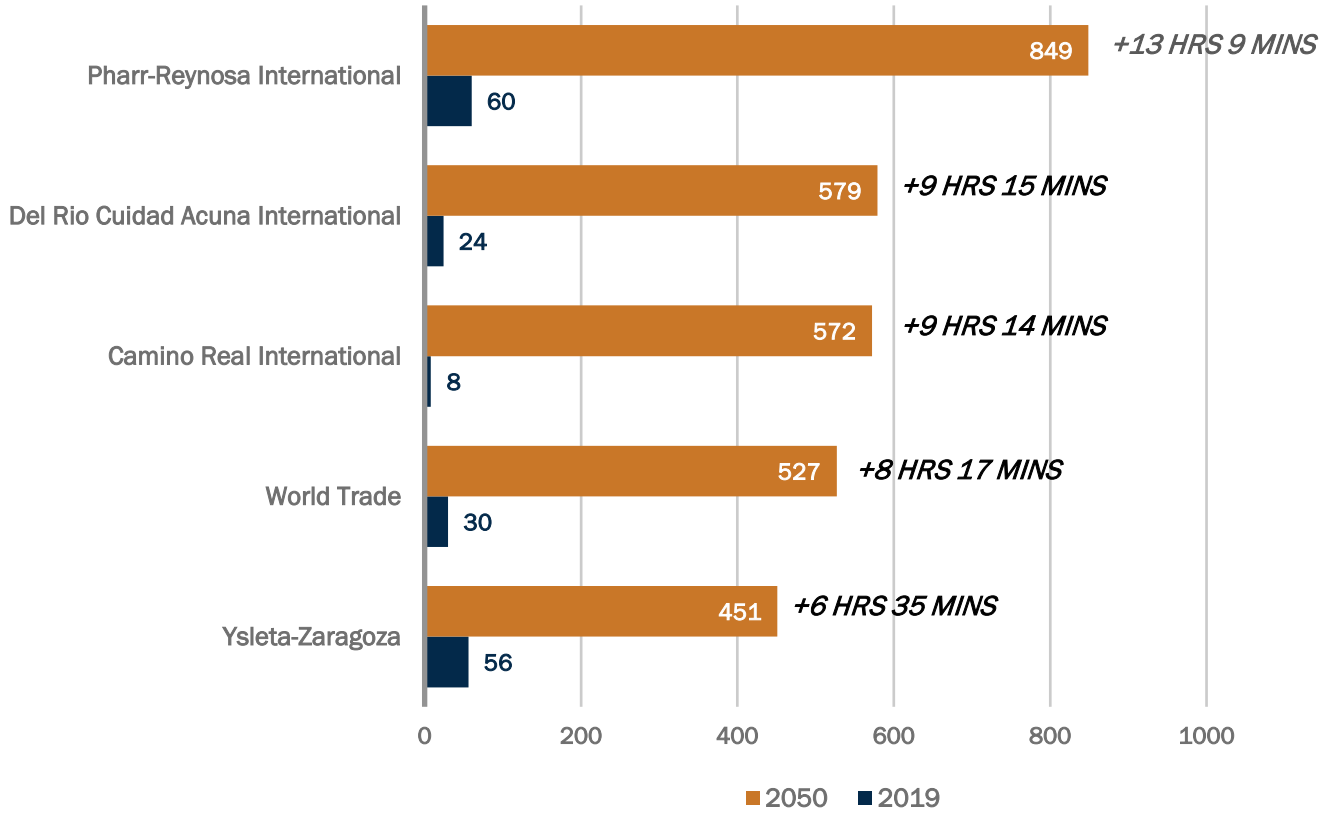
Additionally, the population within the border region is forecast to increase 19 percent from 7.4 million residents in 2019 to 8.8 million residents. By 2050, approximately 112.4 million people are forecast to cross the Texas-Mexico border, an increase of 30 percent from the 86.3 million people that crossed in 2019.[16] This places significant demand on POEs that service POVs as well as the shared approaches and exits to key crossings.

Based on the increase in border crossing traffic, the Texas-Mexico BTMP forecasts a dramatic increase in CMV crossing times by 2050. **At many of the larger crossings, the average crossing time is predicted to be between 3 and 9 hours assuming no future operational or capacity improvements**, representing a significant increase (Figure 9). Border capacity, along with supporting highway and roadway system capacity, is not keeping pace with demand.

[15]Texas-Mexico BTMP, 2021.

[16] Ibid.

Figure 9: Top 5 Increases in Average Annual CMV Border Crossing Times in "Do Nothing" Scenario – Northbound, 2019 and 2050



Source: Texas-Mexico BTMP, 2021.

The Texas-Mexico BTMP identified the following as a need to address the issue of increasing border wait times and delays: coordinated border management, advanced technologies, increased border inspection staff and hours of operation, improved distribution of POV and CMV, and streamlined procedures.

Stakeholders also identified lack of reliable connectivity in the border environment as a critical contributor to existing congestion.

Congestion at border crossings has a direct impact on freight transportation costs and limits economic growth.

Goods and people movements across the border support Texas' growing economy. When these border crossings face significant delays and unreliable crossing times, they have far-reaching impacts. **These impacts hurt the many shippers and carriers that rely on the border for key supply chain linkages.** The time spent at the region's international bridges in queues is a significant component of total travel time for these operations.

DELAYS AT THE BORDER LEAD TO:

- *Lost economic opportunities*
- *Inefficient use of time and resources*
- *Greater fuel consumption*
- *Greater vehicle emissions*
- *Greater costs for transportation and consumer goods*
- *Less trade competitiveness*
- *Travel time unreliability*
- *Slower economic growth*

The Texas-Mexico BTMP estimated that in 2019, **border crossing delays resulted in $68.3M in economic productivity losses**, reducing GDP by $2.3B in both countries. This represents a **GDP loss of more than $5,000 per minute of delay.** If no improvements are made, border delays will result in an economic productivity loss of $4.4B in 2050, reducing GDP by $116B in both countries. **This represents a GDP loss of more than $293,000 every minute.**

According to a 2019 study from the Waco-based Perryman Group, wait times at Texas POEs cost the state more than $32 billion in just over three years.

Potential Benefits of ADS and CDS for Border Crossing

ADS and CDS have key differences from traditional motor vehicle operation and can improve operational efficiency at or around POEs and reduce motor vehicle traffic congestion between Texas and its four bordering Mexican states.

ADS and CDS technologies are in a rapid state of advancement, and future adoption levels are anticipated to grow aggressively. Market forces—namely the need to improve operational efficiencies and transport more volume—are major drivers, and several **trucking companies are conducting ADS demonstration projects in Texas to help show the value** of this equipment.

HOW ADS AND CDS ALLEVIATE CONGESTION AT THE BORDER

CDS has the potential to allow travelers greater access to actionable information about the border environment. This information includes border wait time data, such as that currently generated by the Border Crossing Information System (BCIS), which can help operators make informed departure time and route selection decisions.

ADS and CDS technologies have the capacity to work collaboratively with trusted traveler programs (such as the current FAST/SENTRI programs), non-intrusive inspections (NII), and Unified Cargo Processing (UCP) programs, all of which cut down needed safety and security primary inspection times and allow more vehicles to travel through even congested POEs at a faster pace.

CDS can support efficient electronic data exchanges with safety and security monitoring agencies. This is a critical element to potentially speeding up average CMV screening and inspection times and reducing queues.

ADS at significant penetration rates provides more efficient operations on the approach, at the POE, and on the exit, leading to less congestion. Driver errors are eliminated, which can lead to fewer minor incidents and smoother acceleration and vehicle spacing.

The removal of the driver inspection element for some CMVs will **streamline screening and inspection**.

AV-only lanes—while assumed to be a possible future option at only the largest POEs—can **greatly amplify these delay reductions**.

ADS and CDS also have the potential to **support more efficient transit services at border crossings**. Notably, ADS can lead to lower labor costs and operational efficiencies. At the border, the necessary screening of passengers plays a critical role in determining what may or may not work. Vehicles equipped with ADS could be used to help reduce pedestrian travel times at the border by providing a higher speed alternative across the long distances that must be currently covered on foot. The capacity for and capabilities of transit at the border are unlikely to be driven by ADS, but ADS can and should be considered as part of individual projects and services by the local agencies deploying them.

Advancements in infrastructure, policy/regulation, system integration, and data sharing will be needed for ADS and CDS to be effective in the border environment.

The border crossing environment is complex. The S.B. 1308 bi-national stakeholders identified some of the needs for successful operation of ADS and CDS in that environment as noted below.

CRITICAL NEEDS IDENTIFIED BY STAKEHOLDERS

Robust communications networks in place at POEs that allow for safe and secure information transfer and connectivity.	Regulations and processes that are aligned on both sides of the border.
Well-maintained infrastructure (such as signage and striping) that supports ADS navigation.	Infrastructure to support the electrification of the CMV fleet, which will likely accompany adoption of ADS and CDS.
ADS-equipped vehicles must demonstrate the ability to navigate complex POE configurations and respond to safety and security screening directives.	ADS-equipped vehicles must demonstrate the ability to operate effectively during unexpected events including closures, inclement weather, and through work zones.
Alignment between ADS and CDS operation and existing safety and security screening programs including trusted-traveler programs, such as FAST and SENTRI, UCP, and different methods of NII.	

Mexican Stakeholder Insight into Needs for Successful Technology Deployment

SECURITY AND SAFETY of goods is a primary reason why ADS/CDS could prove valuable as supply chain managers need confirmation of the location of their loads.

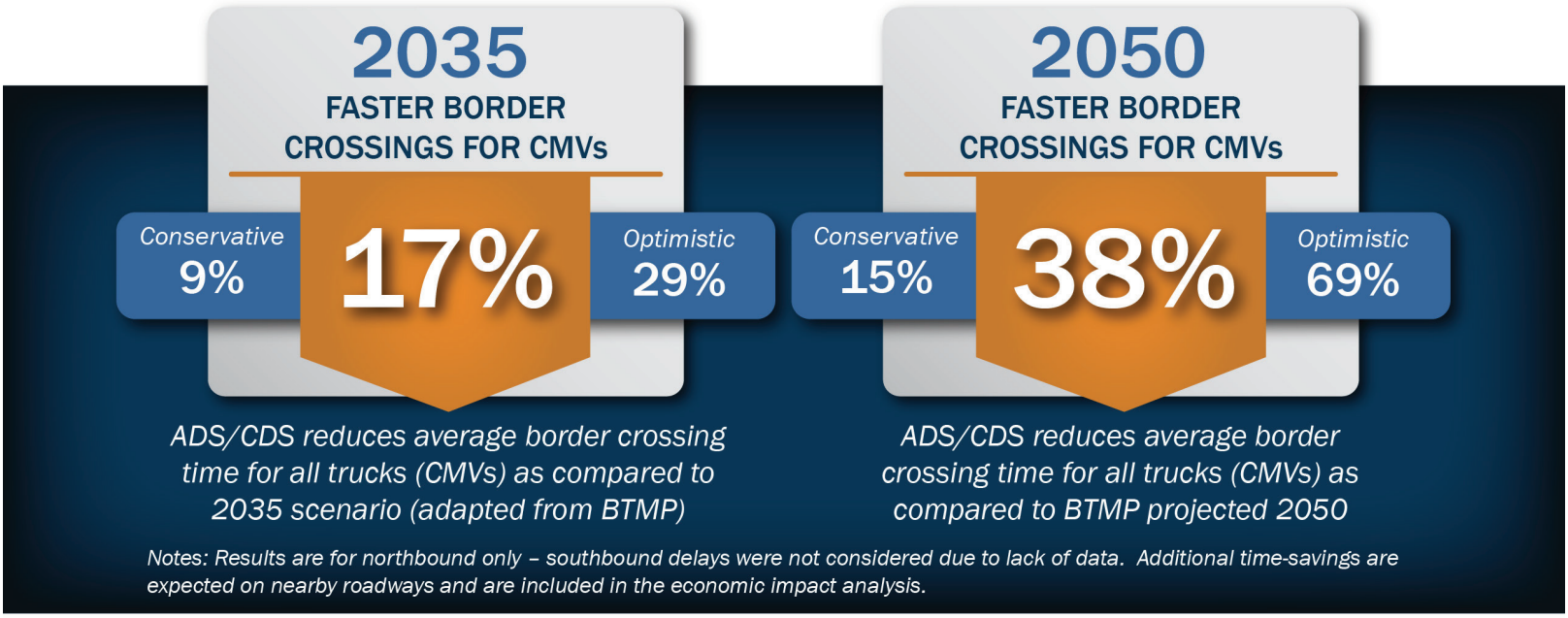
IMPROVEMENTS IN BASIC INFRASTRUCTURE such as pavement conditions, striping, and signage are needed, as are operational improvements such as clearing of incidents and other congestion management.

ENTHUSIASM FOR USING THE DATA from ADS/CDS to support demand management policies, such as pricing and reservation systems.

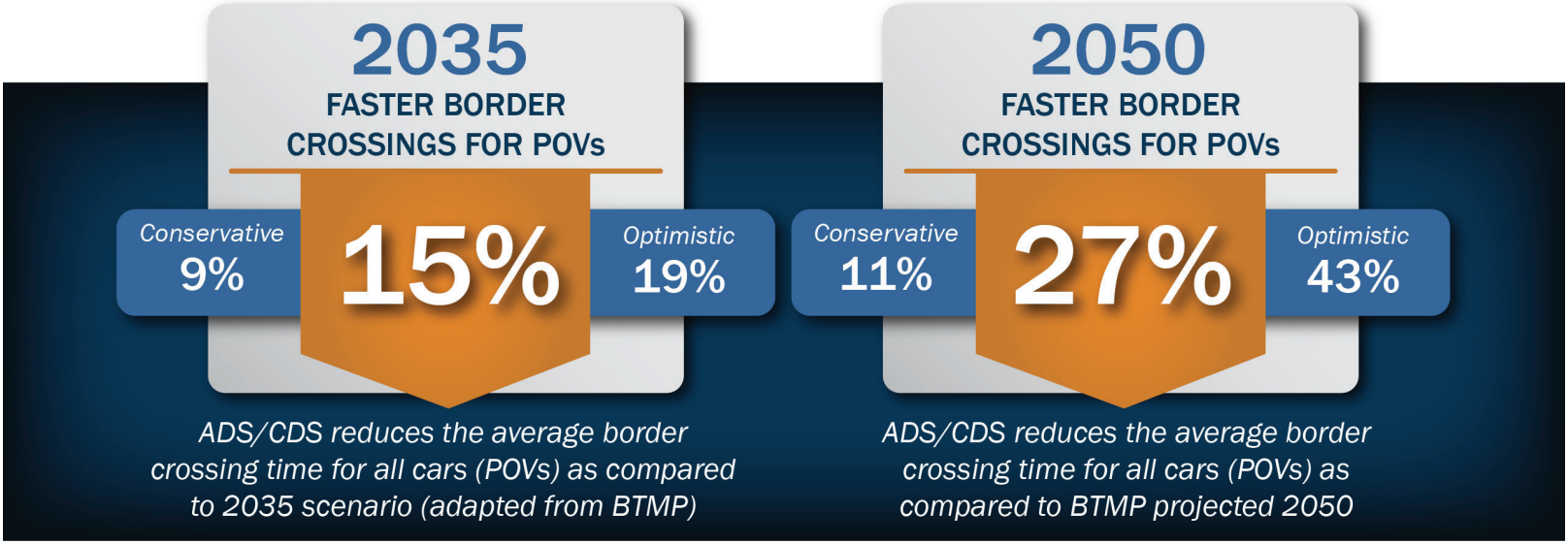
Analysis Results for ADS and CDS Benefits for Border Crossing

ADS and CDS applications at the Texas-Mexico border can reduce congestion.

Using assumptions carefully vetted by stakeholders, analysis indicates that there is a potential for significant benefits. By 2035, CMVs may see delay reductions of 9% to 29% of what is forecasted in the Texas-Mexico BTMP "Do Nothing" scenario, with the S.B. 1308 Medium scenario suggesting average crossing time savings of 17%. This benefit is anticipated to grow by 2050 with the Medium scenario showing reductions of 38% versus the anticipated average crossing time. These reductions vary by POE, but at all POEs, the analysis shows a reduction in average crossing time for all vehicles due to the presence of ADS and CDS, including benefits to vehicles without ADS or CDS capabilities. Values are also provided for POVs.



Notes: Results are for northbound only – southbound delays were not considered due to lack of data. Additional time-savings are expected on nearby roadways and are included in the economic impact analysis.



Note that benefits to POVs may skew closer to the conservative estimates unless advancements in safety and security screening at the border allow for greater traveler processing speeds.

The hours saved by faster and more reliable border crossings in the future will have positive economic impacts.

Economic impacts in the year 2035 would include a positive impact on the GDP of Texas ranging from $105 million to $500 million. The Medium scenario identified likely GDP impacts of $207 to $305 million. Economic impacts in the year 2050 would include a positive impact on the GDP of Texas ranging from $487 million up to $3.4 billion. The Medium scenario identifies likely GDP impacts in the range of $1.2 to $1.9 billion. These economic impacts are accompanied by benefits in job creation, labor income, and taxes. [17] The separate benefits from POV travel time savings are also shown below.

[17] When cars and truck travel times savings are considered together, economic impacts in the year 2035 would include a positive impact on the GDP of Texas ranging from $224 million to over $1 billion. The Medium estimate identified likely GDP impacts of $419 to $735 million. Economic impacts in the year 2050 would include a positive impact on the GDP of Texas ranging from $720 million up to $5.2 billion. The Medium estimate identifies likely GDP impacts in the range of $1.8 to $3 billion.

Summary of ADS and CDS Benefits for Border Crossing

Texas has an opportunity to be a frontrunner in ADS/CDS border crossing applications.

SIGNIFICANT OPPORTUNITIES EXIST FOR TEXAS TO LEAD THE INTERNATIONAL COMMUNITY IN THIS AREA

- *Texas currently has an in-state presence of several key ADS developers with a focus on CMV.*
- *There are a wide variety of existing ADS/CDS demonstrations occurring in Texas for other relevant applications.*
- *Collaborative working relationships that already exist with critical border-focused partners (such as members of the Border Trade Advisory Committee, the Binational Regional Steering Committees, and many more collaborative efforts).*
- *There is ongoing work by critical partners including CBP, GSA, DPS, and TTI to define "border crossings of the future" with improved operations that incorporate new technologies.*
- *Most significantly, economic forces are in place that will drive growth and increase demand for cross-border goods movement along the Texas-Mexico border. Solutions to the motor vehicle congestion that will accompany additional traffic are needed.*

Stakeholders in the border region support a "call to action" for a border-focused demonstration of ADS/CDS and emerging technologies.

In the following section, the study discusses the potential impacts of ADS and CDS on driver and public safety.

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POTENTIAL IMPACTS OF ADS/CDS ON DRIVER AND PUBLIC SAFETY

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4.0 Potential Impacts of ADS/CDS on Driver and Public Safety

Background on Driver and Public Safety

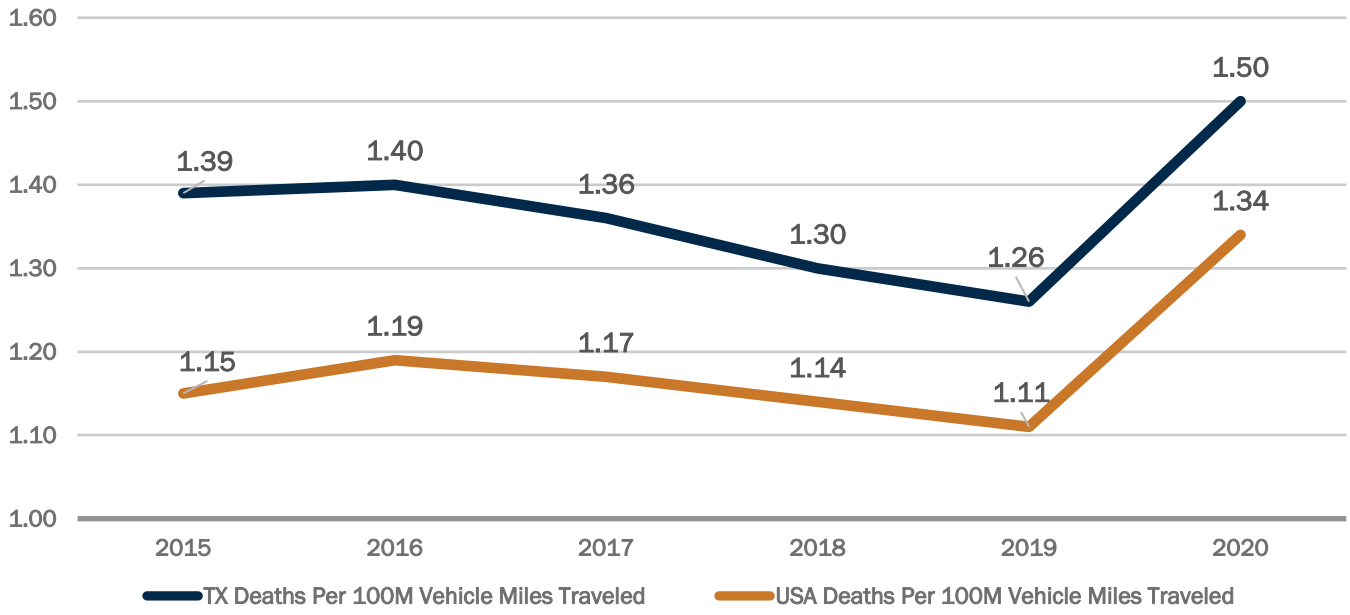
Driver and public safety are essential to the Texas transportation system and its ability to support economic vitality and an improved quality of life.

The Texas transportation system supports the movement of people and goods by providing important connections for commerce, convenience, and daily life. **Driver and public safety are essential to the Texas transportation system for all roadway users including personal vehicles, CMVs, pedestrians, and bicyclists.** Motor vehicle crashes, injuries, and fatalities result in the loss of life, injuries, property damage, income loss, and time lost in congestion caused by crashes.

> *In 2020, nearly 4,000 deaths from crashes on public roadways in Texas resulted in over $44 billion in total costs – including medical costs and cost estimates for lost quality of life and lives lost.*
>
> Texas Motor Vehicle Crash Statistics 2020

As measured by the number of deaths per mile people are driving, **the rate at which people lose their lives in traffic crashes in Texas is above the national average** (Figure 10). This means, even after accounting for the number of miles of Texas roadways, the number of people per mile who lose their lives in traffic crashes in Texas is higher than the number of deaths per mile for fatalities nationwide.

Figure 10: Texas and USA Motor Vehicle Fatality Rates



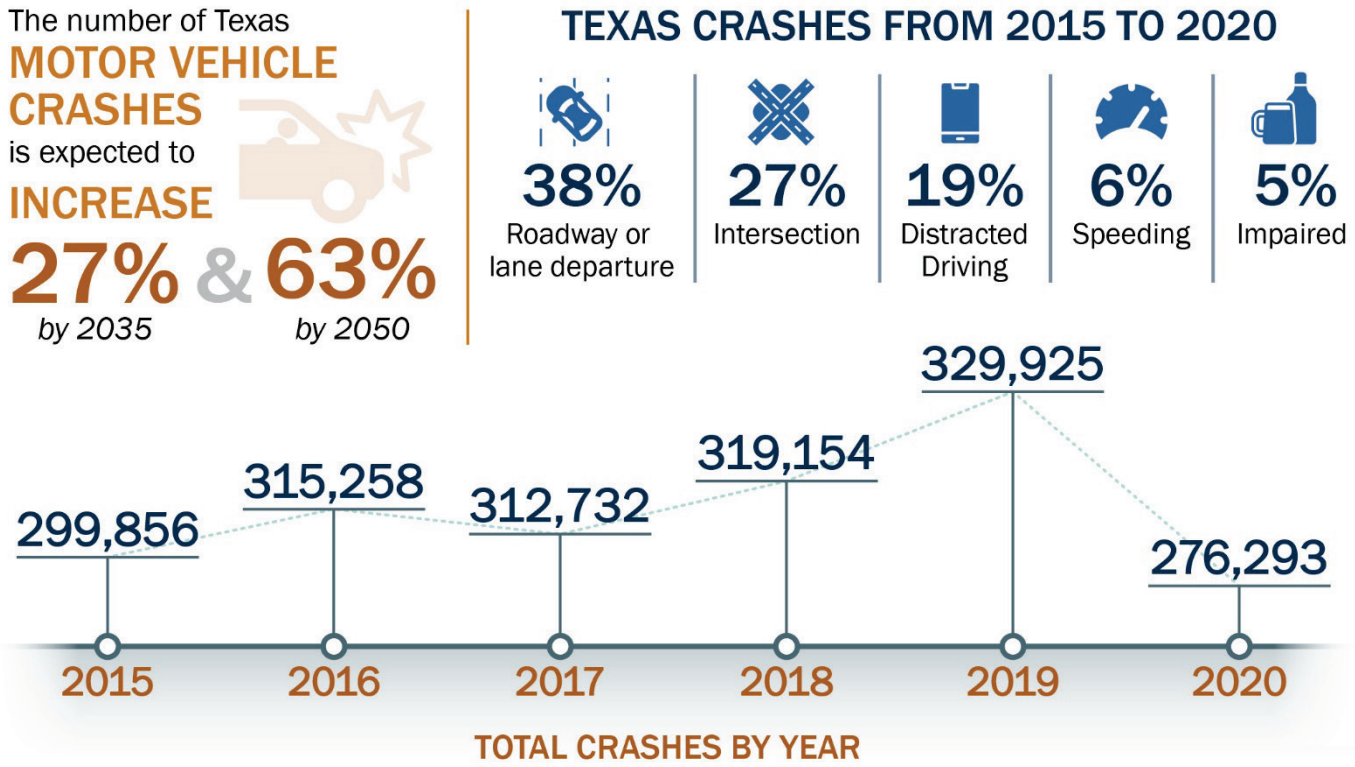
Source: Fatality Analysis Reporting System (FARS).

TxDOT is working toward a future with zero traffic fatalities and serious injuries, and **safety is the department's top priority** in terms of both planning and investment. Given the vast size of the Texas roadway network, and the significant resources committed to traffic safety improvements, **additional solutions are needed to ensure the safety of the traveling public**.

TxDOT is working toward The Road to Zero initiative, a two-part goal to reduce the number of deaths on Texas roadways by half by the year 2035 and eliminate road deaths by 2050.

Motor vehicle crashes on Texas' on-system highways have been on the rise as population and VMT increase. These **crashes result in lives lost, severe injuries, and property loss and damage**. The overwhelming majority of crashes are preventable. Roadway or lane departure and intersection crashes, coupled with human errors and behavior such as distracted driving, aggressive driving, impaired driving, and speeding, are the primary cause of 95% of crashes.[18] Figure 11 presents the five-year trend in total crashes and expected future increases, and identifies primary causes.

Figure 11: Texas On-System Motor Vehicle Crashes, 2015-2020

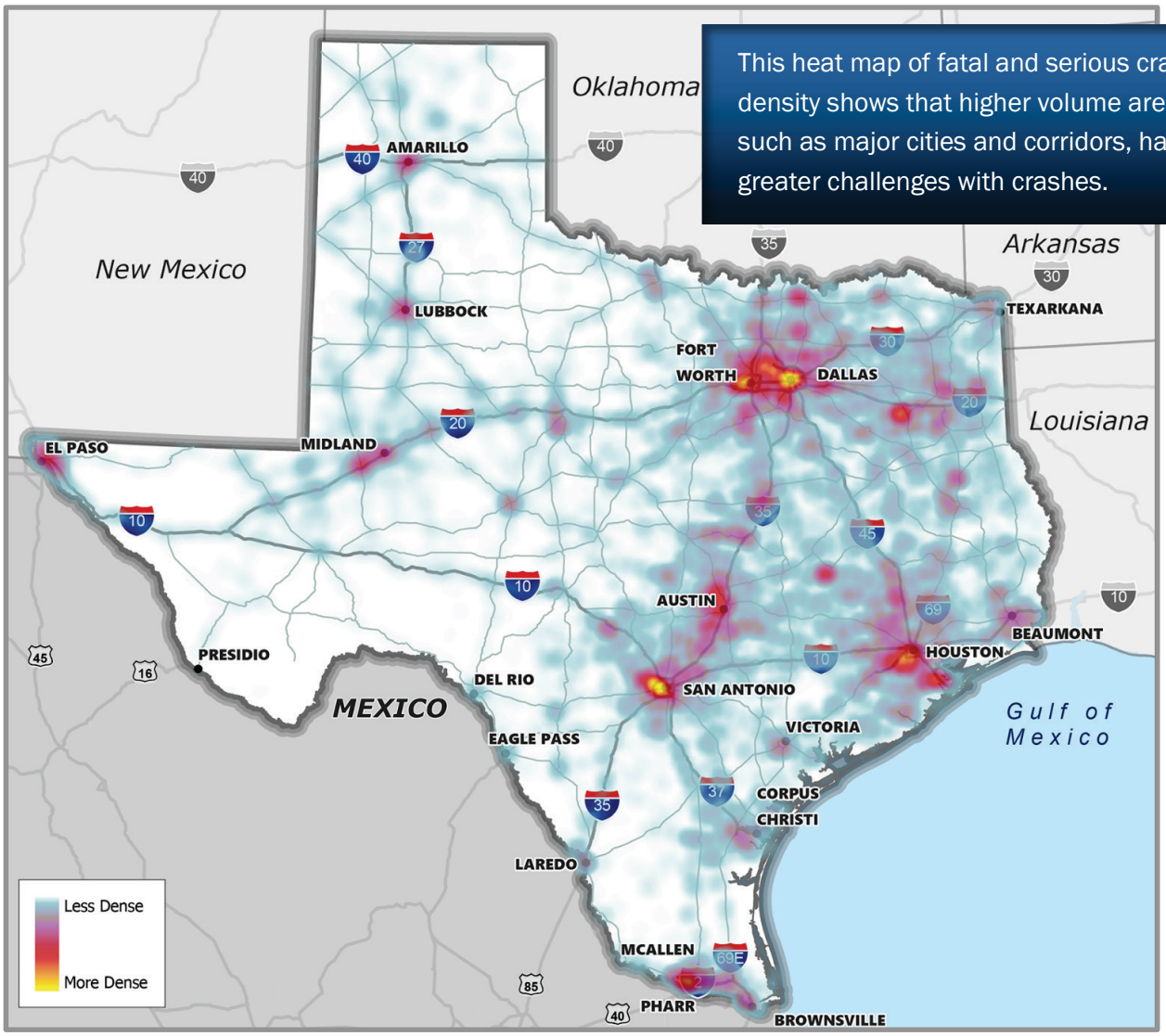


[18] National Highway Traffic Safety Administration (NHTSA) (2008) National Motor Vehicle Crash Causation Survey. U.S. Department of Transportation, Report DOT HS 811 059. Retrieved from: http://www-nrd.nhtsa.dot.gov/Pubs/811059.PDF (October 15, 2014).

Reducing the most severe crashes on Texas roadways will save lives and prevent injuries.

TxDOT's safety program is **focused on reducing the most severe crashes on Texas roadways to save lives and keep travelers safe.** This important work focuses on key problem areas based on crash density across Texas (Figure 12).

Figure 12: Fatal and Serious Injury Crash Density in Texas, 2015-2020

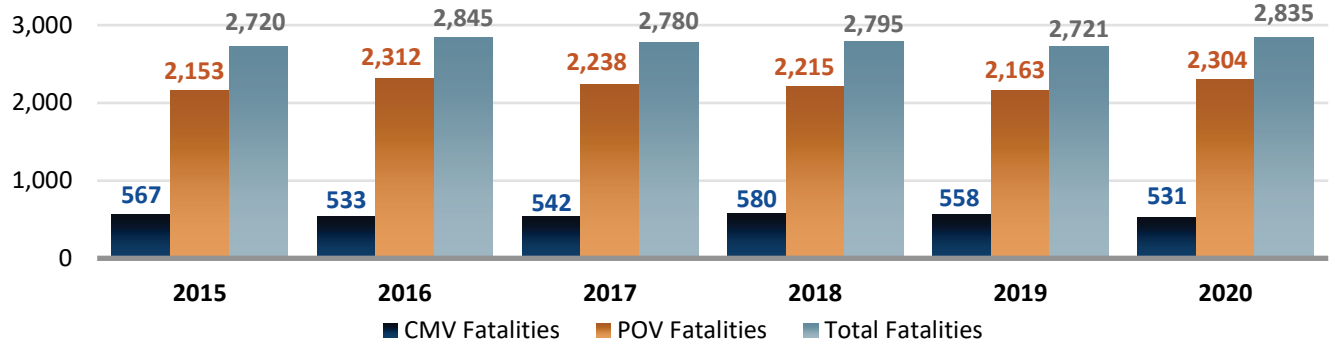


Source: TxDOT Crash Record Information System (CRIS) Data.

Note that while this study focused on **statewide safety issues**, it is vital to recognize the importance of driver and public safety at and approaching/exiting border POEs. The Texas-Mexico BTMP identified safety challenges in the border region due to conflicts between people and goods movement and the enhanced capacity of hazardous materials and other specialized cargo. The mixed modes of transport in the region contribute to first and last mile roads with hot spot crash locations, highway rail conflicts due to at-grade crossings, and frequent and severe bicycle and pedestrian crashes.

Figure 13 shows Texas on-system motor vehicle fatalities. **An average of 2,783 people lost their lives in motor vehicle crashes annually from 2015 to 2020**. While CMV-related fatalities have remained relatively flat, POV fatalities increased from 2019 to 2020 by 6.5% after being on the decline since 2016.

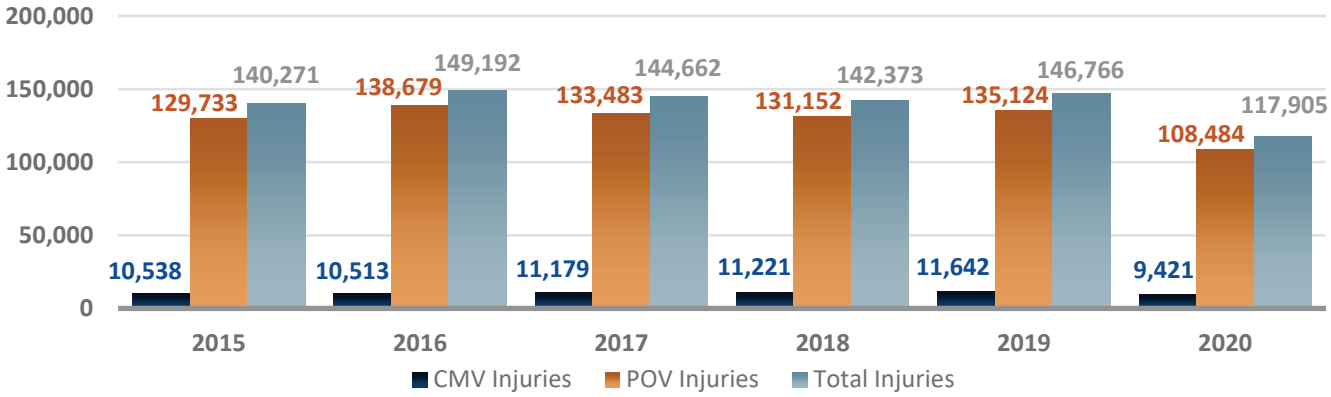
Figure 13: Texas On-System Motor Vehicle Fatalities, 2015 to 2020



Source: TxDOT CRIS Crash Data.

Figure 14 shows on-system motor vehicle injuries. **An average of 140,195 people were injured in motor vehicle crashes annually from 2015 to 2020.** Injuries are defined as incapacitating, non-incapacitating, and possible injury categories. Approximately 8% of injuries involved a CMV. POV injuries declined 16.4% from 2015 to 2020, while CMV-related injuries declined by 10.6%.

Figure 14: Texas On-System Motor Vehicle Injuries, 2015 to 2020



Source: TxDOT CRIS Crash Data.

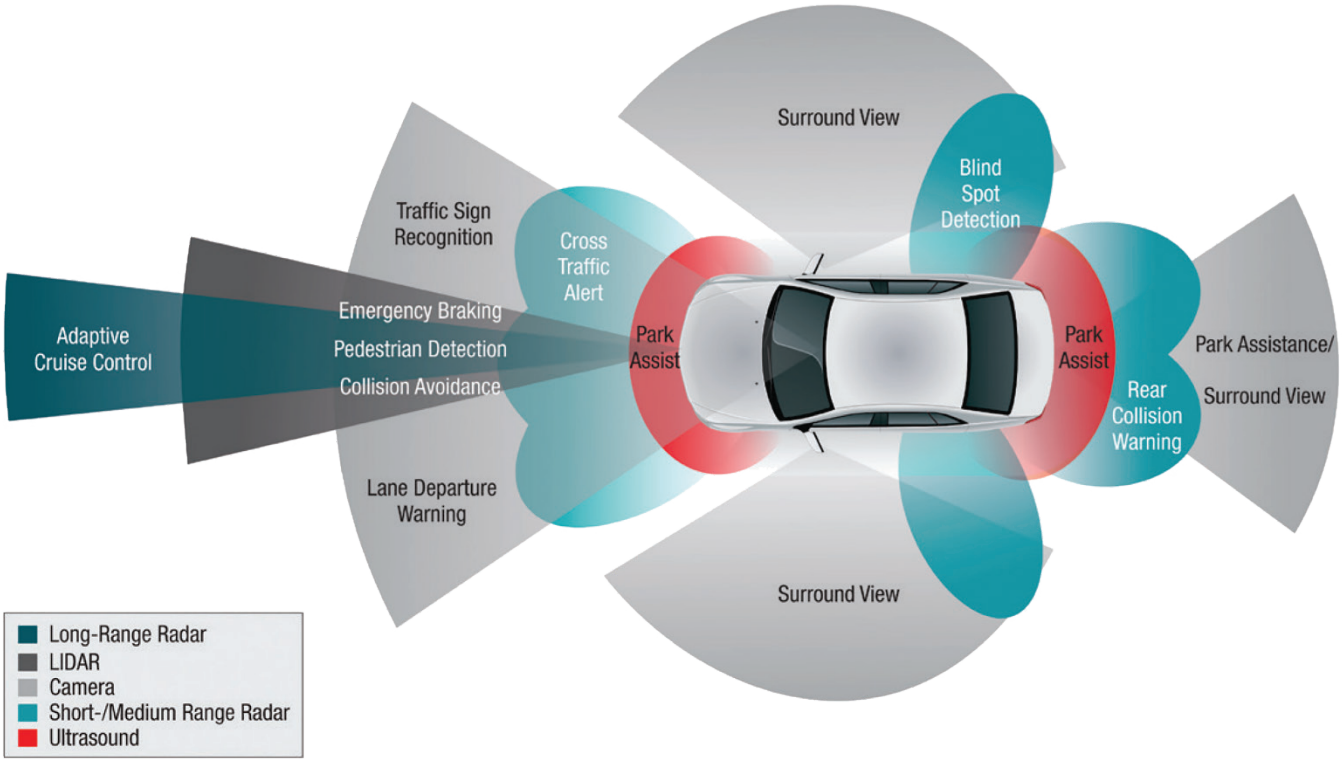
Investments in ADS and CDS technologies may lead to greater potential safety impacts.

Vehicle manufacturers have introduced ADAS features as standard equipment in newer model vehicles by adding sensors, radars, and cameras. These technologies assist operators with driving tasks and provide warnings upon detecting pedestrians or approaching vehicles. **Lower levels of automation such as ADAS already are available in passenger vehicles,** and they include: braking, steering, warning, and monitoring.[19] Figure 15 provides an illustration of

[19] Fleet Owner. "Trucking's ADAS technologies still have many barriers to overcome." Retrieved from https://www.fleetowner.com/safety/adas/article/21177550/adas-technologies-in-trucking-still-have-many-barriers-to-overcome.

ADAS technology applications. In an effort to improve safety impacts, **the trucking industry is expected to adopt some ADAS features**. ADAS falls within the automation levels of zero to two so are not a focus of this S.B. 1308 Study, though they provide insight into the future of ADS.

Figure 15: Vehicle with ADAS Technology



Source: Texas Instruments (2015). Advanced Driver Assistance Solutions Guide.

Currently, most vehicle manufacturers and hardware/software companies in the ADS industry are in the research and development phase, exploring a range of vehicle types, capabilities, and business models. To achieve the end goal of fully self-driving vehicles that can operate autonomously under all driving conditions, **the industry is likely to take incremental steps starting with partially automated vehicles**, such as those that provide driver assistance with some automated functions (e.g., automated braking and lane centering). Building on those assistive technologies, **the industry is expected to then migrate to highly automated vehicles that do not require a driver**, such as unmanned aerial vehicles delivering passengers and packages, automated on-demand transit vehicles of varying sizes and speeds, and shared connected e-bikes and fleets of robo-taxis, among others. The introduction of partly automated vehicles and driverless vehicles operating in closed environments (i.e., transit loops) will eventually pave the way for ADS that are SAE Level 5 certified to operate in any roadway environment without a human driver present. The S.B. 1308 study looks at the ability of ADS and CDS technologies to reduce crashes, save lives, and prevent injuries.

Potential Impacts of ADS and CDS for Driver and Public Safety

ADS and CDS applications in Texas can directly impact driver and public safety and help Texas reach its vision of zero deaths and injuries by 2050.

The TX SHSP is a roadmap of the strategies and countermeasures to reduce fatalities and serious injuries in Texas on all public roadways, focused on the most severe crash types.

TxDOT already focuses on safety with engineering, education, and enforcement efforts. The Texas Strategic Highway Safety Plan (SHSP) 2022-2027 and the Texas Transportation Commission's 2019 Road to Zero Minute Order represent a strategic approach to reduce fatalities and serious injuries on Texas roadways. The SHSP focuses on selected traffic safety improvements with the greatest promise of success in the least amount of time. The **Road to Zero initiative is a two-part goal to reduce the number of deaths on Texas roadways by half by the year 2035 and eliminate road deaths by 2050.** The goal builds on an increased emphasis on safety during project prioritization, selection, and design as well as continuing driver safety awareness programs and working to implement the SHSP.

The vision of zero deaths and injuries on Texas roadways is shared by many and founded on the belief that **everyone should be able to arrive at their destination safely.** This vision will require extensive collaboration across modes, disciplines, and agencies responsible for public safety. The mission of TxDOT's SHSP is to help improve safety on Texas roadways by reducing the most severe crashes and eventually eliminating traffic fatalities and serious injuries on all public roadways.[20] This complements the intent of the S.B. 1308 study, which measures the impacts of ADS, CDS, and other emerging technology on driver and public safety.

ADS and CDS technologies have the potential to reduce the number of crashes on Texas roadways involving distracted and impaired drivers, intersection-related crashes caused by driver errors, speeding and aggressive driving, pedestrians struck by vehicles, and vehicles leaving the travel lane. ADS systems could improve safety for CMVs by improving reaction time when nearby drivers are operating unsafely (like sudden lane changes). Automated trucking applications could help with hours-of-service requirements for truckers.

WHAT WE LEARNED FROM STAKEHOLDERS

ADS can serve key vulnerable groups including young, old, disabled, and impaired by increasing mobility and saving lives.

[20] TxDOT. Texas Strategic Highway Safety Plan. Accessed at https://www.texasshsp.com/.

ADS and CDS applications will have significant safety impacts on the driving environment.

REDUCE OR ELIMINATE DRIVER ERRORS

- *Reduce intersection and roadway departure crashes.*
- *Improve detection of bicyclists and pedestrians.*
- *Prevent drowsy/fatigue driving.*
- *Eliminate many older and younger driver crashes.*

PREVENT RISKY DRIVER BEHAVIOR

- *Reduce crashes caused by motor vehicles being operated under the influence of alcohol or other drugs.*
- *Eliminate aggressive driving by reducing speeds and eliminating driving behaviors such as following too closely.*
- *Reduce crashes due to driver distractions.*

INCREASE COMPLIANCE WITH DRIVING LAWS

- *Increase use of in vehicle safety devices such as safety belts and child safety seats.*
- *Ensure safe operating speeds in various driving environments such as school zones.*
- *Reduce the number of crashes caused by failure to comply with traffic control devices such as stop and yield signs, traffic signals, and yielding for non-motorists.*
- *Increase compliance with work zone and highway rail grade crossing safety mechanisms.*

ENHANCE COMMUNICATIONS

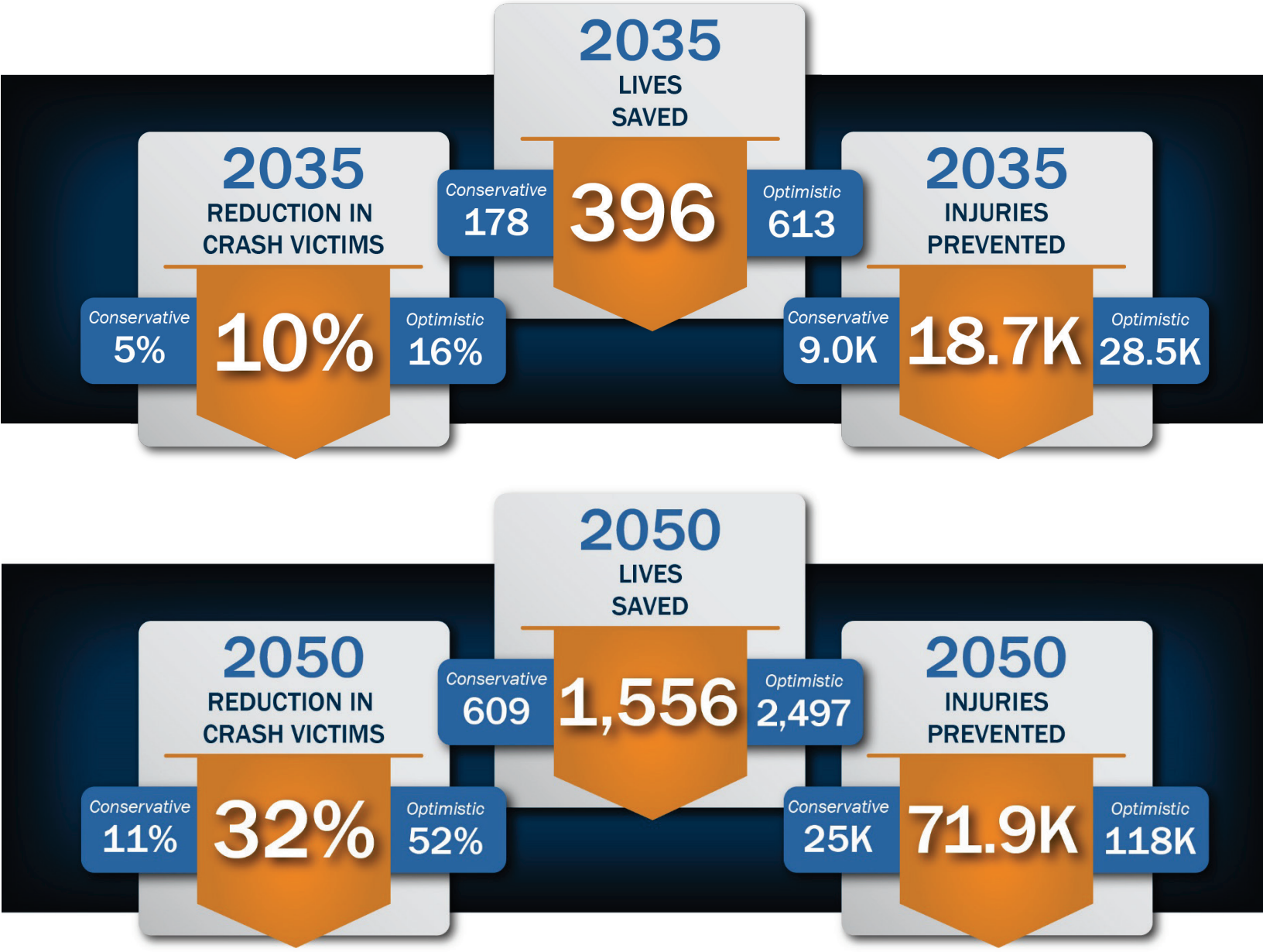
- *Provide enhanced communication of system delays, crashes, and other operational challenges to vehicle operators.*
- *Ensure safe vehicle operation by requiring operators to address vehicle maintenance dangers such as low tire pressure, broken or malfunctioning lights, etc.*

Note that ADS will need to evolve to operate safely in a mixed fleet environment. In the current mixed fleet ADS testing environment, there is some evidence of low-speed collisions as drivers are unused to the behavior of ADS. It is assumed that increased awareness and familiarity will address these issues.

Analysis Results for ADS and CDS Impacts on Driver and Public Safety

ADS and CDS adoption can improve driver and public safety statewide by reducing crashes, injuries, and fatalities.

To measure the impacts of ADS and CDS technologies on public and driver safety, the S.B. 1308 Working Group compared crash activity for the Low (conservative), Medium, and High (optimistic) scenarios to the baseline years of 2035 and 2050. The study estimated lives saved, injuries prevented, and crashes prevented. It is estimated that the implementation of ADS and CDS technologies has the potential to **save up to 613 lives and prevent 28,500 injuries in 2035**. These numbers increase to almost **2,500 and more than 118,000 respectively in 2050**.



The impacts of ADS and CDS technologies on motor vehicle crashes, injuries, and fatalities can lead to economic growth.

ADS and CDS technologies could **save up to $11.3 billion in economic or societal costs** based on the reduction in motor vehicle crashes in Texas by 2035 and **as much as $47 billion in economic costs based on the reduction in motor vehicle crashes in Texas by 2050**. These cost estimates include wage and productivity losses, medical expenses, administrative expenses, motor-vehicle damage, and employers' uninsured costs.

Improved public safety has a positive impact on workers and business productivity, adding economic value to the state.

The avoided motor vehicle crashes are expected to generate the following total economic impacts in Texas:

Additional Jobs

Up to **138,700 additional jobs** in **2035** and **317,200 additional jobs** in **2050**.

Labor Income

As much as **$10.8 billion in labor income** in **2035** and **$30.4 billion in labor income** in **2050**.

GDP and Tax Revenue

Up to **$14.0 billion in GDP** and **$4.4 billion in tax revenue** in **2035** and as much as **$42.1 billion in GDP** and **$6.7 billion in tax revenue** in **2050**.

A more automated vehicle fleet on Texas roadways will require policy and institutional changes. Stakeholders identified ADS and CDS technologies as a critical opportunity for Texas to achieve the Road to Zero vision. Driving laws, law enforcement training and practices, and crash data collection procedures will need to be updated to reflect the changing technologies and driving environment.

Changes in Driving Laws —Several laws are in place to ensure the safety of the traveling public. Some laws related to safety belt usage, child passenger restraints, distracted driving, and driving under the influence will need to be revisited to determine if additional circumstances related to AVs should be included in the statutes. As the number of AVs increases, additional laws related to occupancy and age requirements for passengers may be necessary to ensure AVs can be properly handled in emergency or crash situations. While passengers will not have driving responsibilities in AVs, laws will need to determine proper passenger requirements to ensure safe operations.

WHAT WE LEARNED FROM STAKEHOLDERS

Efforts are underway to develop standards and protocols for driverless ADS trucks to be able to respond to commercial vehicle enforcement operations.

Changes in Law Enforcement. —Law enforcement and first responders (i.e., firefighters, emergency medical technicians) will need to understand how to identify and interact with AVs. Responding to crashes or emergencies requires law enforcement to direct drivers and vehicles in situations that may be contradictory to traffic control devices. Crash response procedures will need to be adjusted to ensure law enforcement can safely document traffic crashes that involve both autonomous and traditional vehicles. Additionally, law enforcement will need to be able to properly cite parties responsible for crashes, whether they be human drivers or AV manufacturers. Vehicle inspection laws and procedures may require adjustments to accommodate more AVs. Law enforcement will need to define procedures and standard operating practices for vehicles equipped with ADS and CDS technologies.

Changes in Crash Data Collection and Reporting —The information collected and reported at the scene of motor vehicle crashes provides critical data for crash reporting and informs the transportation agencies where needed traffic safety improvements should be implemented. The crash data report will need to be updated to include information on AVs and to allow for reporting of various crash causation factors. AVs will further need new data sharing standards, security protocols, and safety performance measures.[21]

Summary of ADS and CDS Impacts on Driver and Public Safety

ADS and CDS technologies will enhance driver and public safety in Texas.

Driver and public safety are crucial to everyone's daily life. Texas is already focused on reducing the most severe motor vehicle crashes by deploying engineering, education, and enforcement efforts across the state. ADS and CDS technologies will complement the state's safety improvement efforts and help ensure people and goods are safely transported. These technologies will provide the opportunity to:

- **Save lives and reduce fatalities, injuries, and crashes in Texas.** No one should lose their life while driving, walking, or biking. ADS and CDS technologies have the potential to save lives each year, building to approximately 2,500 avoided fatalities and more than 118,000 injuries avoided by 2050. These avoided crashes can save the Texas economy up to $47 billion in societal costs which is the equivalent of 317,200 jobs and $42.1 billion in GDP.
- **Reduce driver errors and provide a safer driving environment for vulnerable road users.** Every driver able to transition to an ADS and CDS-equipped vehicle will be able to reduce driving errors and challenges that contribute to motor vehicle crashes. ADS and CDS-equipped vehicles provide a 360-degree view of the vehicle and its surroundings and utilizes a system of detectors that warn the driving system of obstacles in the roadway, including pedestrians or other non-motorized users in the path of vehicles.
- **Reduce and eliminate risky driver behaviors**. Several risky driving behaviors contribute to roadway fatalities and injuries. Distracted and aggressive driving behaviors and impairment contribute to a significant percentage of fatalities and injuries in Texas. Speeding also contributes to crashes and increases the likelihood and severity of injury or death for pedestrians and other non-motorized users. ADS and CDS technologies will provide an alternative operating environment that removes the human driver and reduces the likelihood and impact of risky behaviors that contribute to crashes.

[21] To learn more about the data advances needed for AVs, see https://www.nhtsa.gov/press-releases/initial-data-release-advanced-vehicle-technologies.

- **Increase compliance with safety laws.** ADS and CDS-enabled vehicles also monitor driver and passenger habits such as safety belt usage and require vehicle occupants to buckle up for all trips. This increases the safety of all passengers in the event of a crash.
- **Enhance communications that improve safety.** ADS and CDS technologies also offer system redundancies that make operation of a motor vehicle safer for all road users. CDS technologies allow enhanced communication of system delays, crashes, and other operational challenges that often result in delays and sometimes secondary crashes.

Texas can galvanize the large group of stakeholders already working to address traffic safety, and the public and private sector partners working hard to bring ADS and CDS technologies to Texas. Working together, these groups can lead the way to the Road to Zero!

In the next section, the study discusses how ADS and CDS can impact the Texas transportation workforce, creating exciting opportunities.

5

POTENTIAL IMPACTS OF ADS/CDS ON TRANSPORTATION INDUSTRY WORKFORCE AND TEXAS ECONOMY

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5.0 Potential Impacts of ADS/CDS on Transportation Industry Workforce and Texas Economy

The transportation sector is a significant and constantly changing part of the Texas economy.

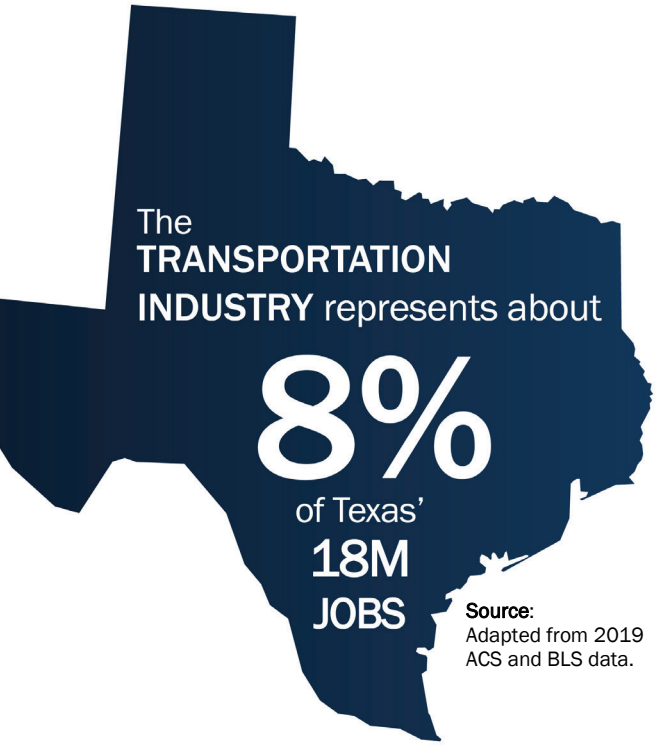
Background on Transportation Industry Workforce

The Texas economy depends on transportation of people and goods; **the transportation sector depends on a large and well-trained workforce**. Currently, an industry-wide shortage of qualified and credentialed workers—particularly vehicle operators—constrains many aspects of industry and services in the state.

RESEARCH POINTS TO AN EVOLVING WORKFORCE

- USDOT - Macroeconomic Impacts of Automated Driving Systems in Long-Haul Trucking
- Massachusetts Institute of Technology - Autonomous Vehicles, Mobility, and Employment Policy: The Roads Ahead
- Michigan State University/TTI - Preparing the Workforce for Automated Vehicles

Traditionally, technological advancements have had complex effects on the workforce. Just as containerization, just-in-time deliveries, and smartphones have revolutionized freight and passenger movement to date, the advent of automation, connectivity, and other technologies will have both predictable and unanticipated effects.



While some sectors are vulnerable to automation—consider the toll both operator—the current shortage of labor to fill some positions, especially long-haul trucking, coupled with the increase in research, development, and manufacturing sectors over the past decade gives weight to the idea that **the net impact to the Texas economy and workforce will be positive**. Conversely, to take advantage of the increases in productivity and secondary economic effects of automation, Texas will need to ensure it has a pool of well-trained workers in a variety of sectors.

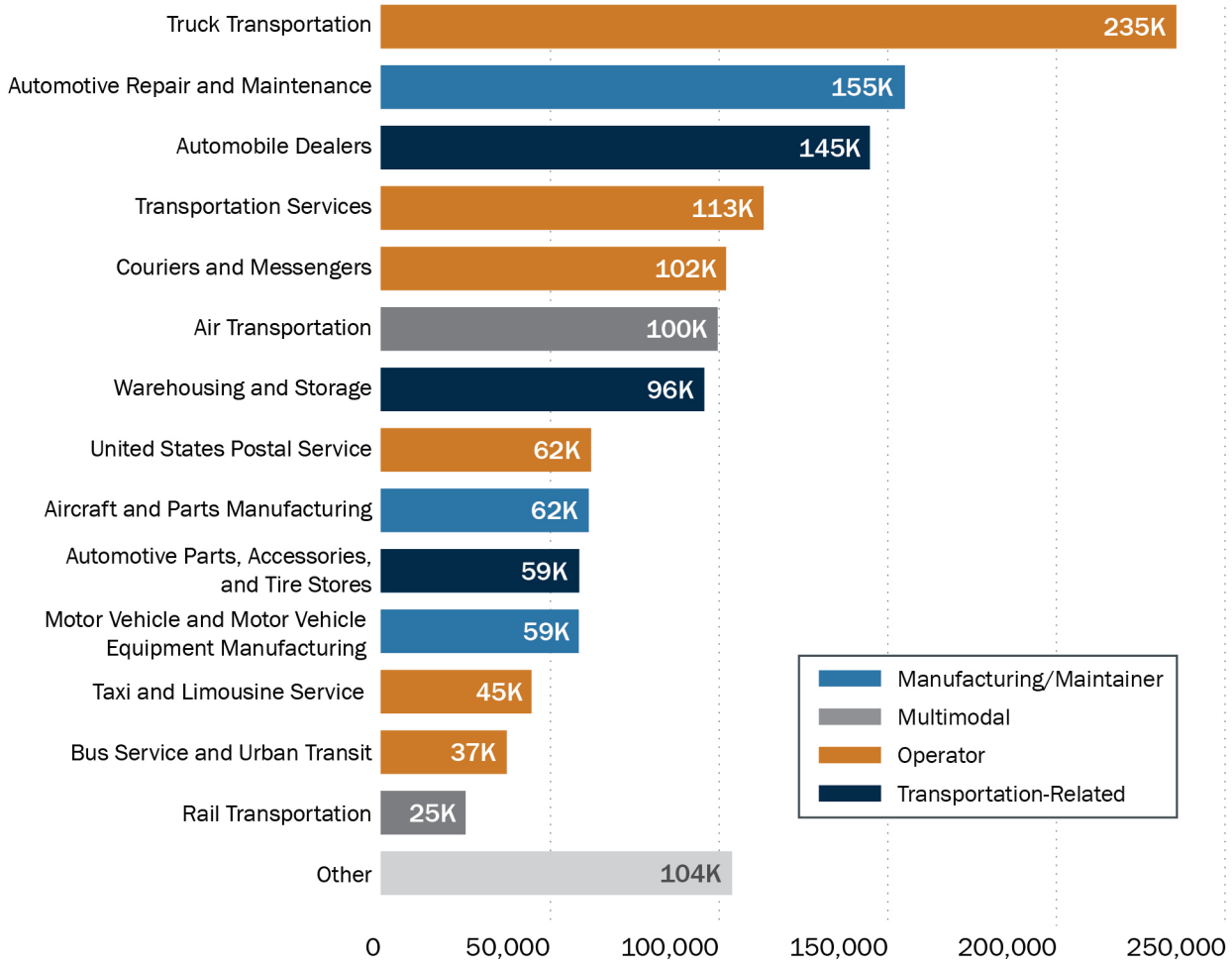
WHAT WE LEARNED FROM STAKEHOLDERS

As technology evolves, new job opportunities will be created. Technology will not replace workers, just change what workers do, requiring new skills.

Current employment trends show the effects of operator shortages and disruptive technologies on the workforce and economy.

Truck operators are the largest transportation sector in Texas, followed by automotive repair and maintenance and automobile dealers (Figure 16). **Each of these sectors has some exposure to automation but will be affected differently.** The role of the truck operator may shift to a different set of responsibilities, while automobile dealers may face a decrease in demand as mobility-as-a-service transportation becomes more widespread. Manufacturing and maintenance may see a dramatic increase in demand for services as vehicles become more complex.

Figure 16: Texas Transportation Employment in Thousands by Subsector, 2019



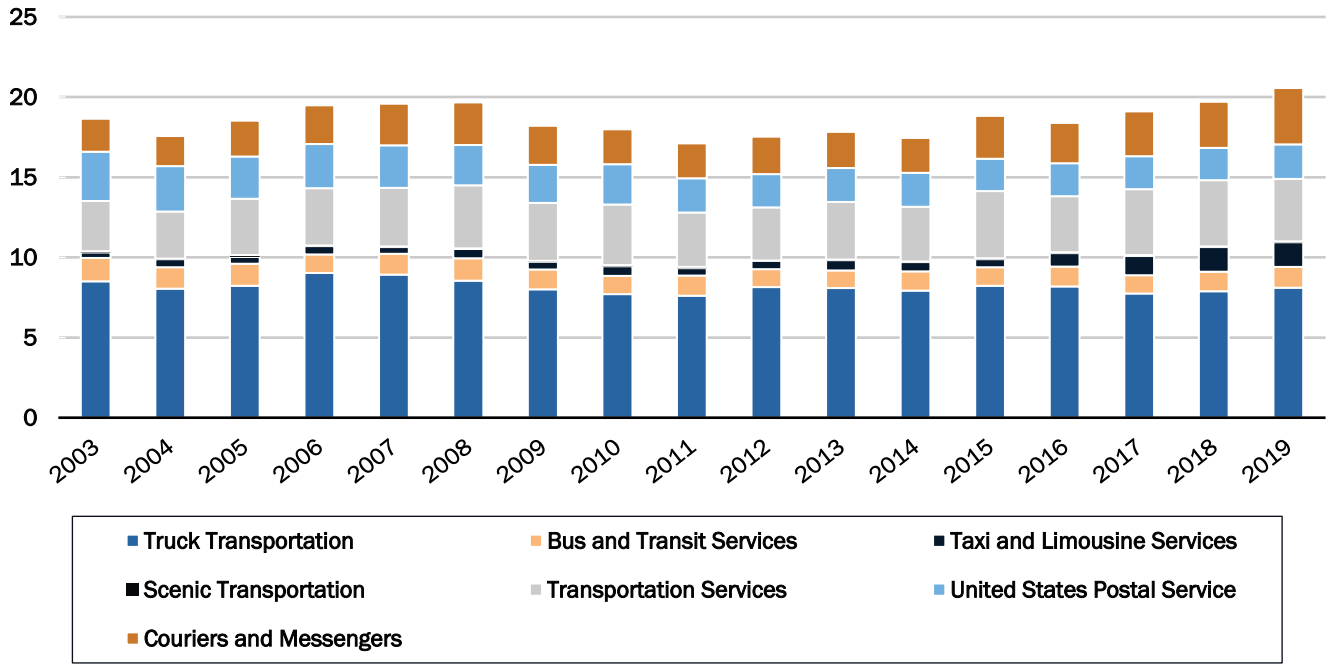
Source: Adapted from U.S. Census Bureau American Community Survey One-Year Sample (2019). "Other" category includes subsectors from each of the four sectors with fewer than 25,000 employees.

Truck transportation fell by 5 jobs per thousand residents between 2003 and 2019, while bus and transit jobs per capita and U.S. Postal Service jobs per capita decreased by 12.2% and 30.0% respectively. These losses were offset by significant growth in taxi and limousine service jobs per capita and couriers and messengers jobs per capita, which grew by 365% and 70%, respectively, between 2003 and 2019—likely due to the emergence of transportation network companies (TNC) like Uber and Lyft (Figure 17). However, average wages for jobs in this sector decreased over the same

period. **This shift is an example of the effects of disruptive technology**—in the case of TNCs, ubiquitous smartphones—on a transportation sector.

While **these trends will continue over the short term**, the advent of autonomous and connected vehicles has begun to shift trends. Indeed, the current truck operator shortage is a key motivating factor for the shift to autonomous operations. Soon, investment in research, development, and pilot programs may increase the need for qualified employees before leveling out over the long term.

Figure 17: Transportation Operator Subsector Jobs per 1,000 Residents, 2003 to 2019



Source: Adapted from U.S. Census Bureau American Community Survey One-Year Samples (2003–2019).

Potential Impacts of ADS and CDS on Workforce

Impacts of ADS/CDS on the workforce will vary widely by sector.

While the most visible and immediate image of the impact of ADS and CDS technologies is the potential replacement of vehicle operators by automated systems, **the effect on the workforce is likely to depend on several factors** including capabilities of technology, rate of adoption, and the response of industry and government to both **prepare the workforce for changing requirements and take advantage of new opportunities** offered by these technologies.

WHAT WE LEARNED FROM STAKEHOLDERS

Changes in workforce will be gradual and will complement the truck driver shortage in the near to medium term. For examples, drivers may do local deliveries while AVs handle long-haul movements.

Commercial Vehicle Operations

The vehicle operator of the future may have a diminished role in the direct operation of vehicles; however, it is unlikely that human positions in these sectors will be eliminated. Instead, the **workforce may see a shift in responsibilities from operation to specialized tasks**: oversight, maintenance, or in the case of passenger transport, service, and safety.

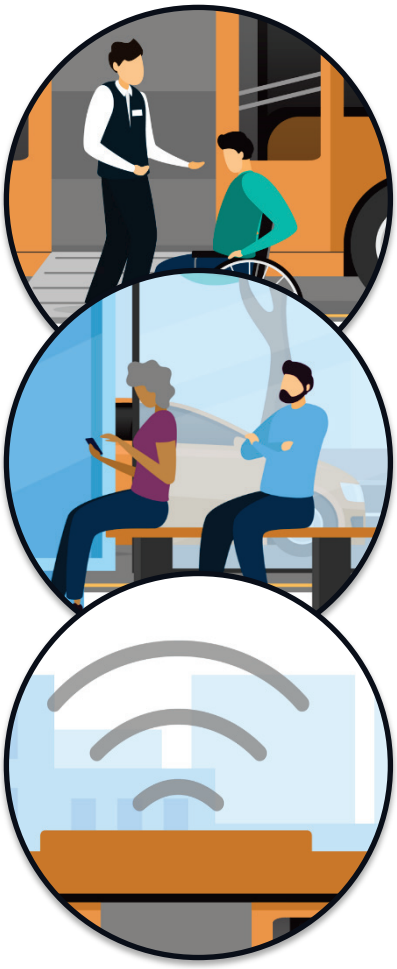
In the short term, the presence of both a supervision operator and technical specialist may increase the per-vehicle worker need.

Ultimately, these positions may or may not require the operator to be onboard the vehicle, but **the need for workers in this sector is not likely to decrease**. Offboard positions may allow workers to remain closer to their homes, removing a disincentive to the industry. Other benefits to vehicle operators include potentially less physically strenuous tasks or more highly-compensated positions commiserate with increase in technical job requirements.

Shifting away from direct operation will allow vehicles to become unbound from hours-of-service requirements, allowing rolling stock to be used more efficiently and increasing productivity while improving quality of life for operators.

The effect of ADS/CDS on workforce sectors related to commercial vehicle operators is expected to be neutral.

Passenger Transport and Vehicle Operations



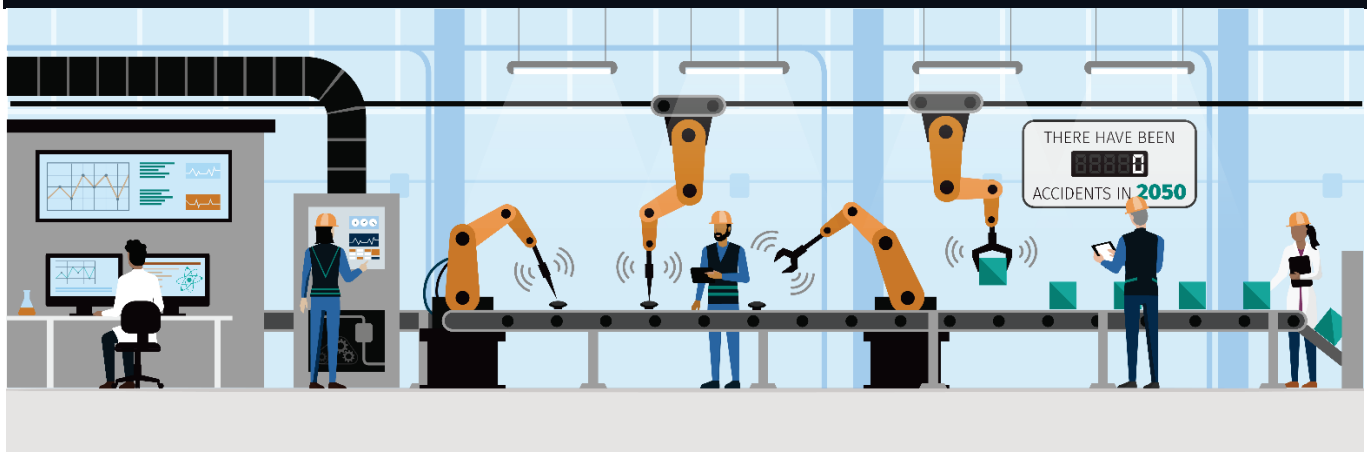
While the adoption rates for POVs are anticipated to be lower than those for CMVs, any significant market penetration has the potential to affect the transportation workforce. A shift to "mobility-as-a-service" delivery models or an increase in the ability for consumers to buy vehicles directly from the manufacturer may significantly decrease the role of the dealership industry.

A shift to the use of automated and connected vehicles to deliver goods may replace some shopping trips currently taken by private vehicles, reducing vehicle ownership further. While freight movement may not displace many jobs, taxi and ride-hailing services will likely not keep an onboard attendant—reducing jobs in this area substantially.

For public transit, a shift towards specialization of services—automated low-capacity vehicles in lower-density areas and higher-capacity vehicles in denser-areas—will reduce the number of operators needed per trip, though staff may still serve as "transit ambassadors" or attendants.

ADS/CDS is expected to reduce total employment in workforce sectors related to passenger travel.

Manufacturing and Maintenance



The addition of ADS/CDS components to vehicles represents a net increase in the complexity of each vehicle. New facilities for manufacturing, assembling, and maintaining these systems represent a clear increase in the need for a skilled labor force.

Both original equipment manufacturing (OEM) and final vehicle assembly are historical strengths of the Texas labor market, and Texas has been selected as a site for numerous pilot, research, and implementation projects in the autonomous sector.

Over the short term, some of these positions may be somewhat more research-based, but **as industries mature, manufacturing and maintenance will come to dominate the sectors supporting deployment of autonomous and connected vehicles.**

Maintenance of increasingly-complex vehicle systems—many of them critical safety features—will require additional skilled technicians. Increased safety, wages, and quality of life for employees should make this an attractive sector to work in, but **Texas will need to ensure that its workforce development programs are capable of training and attracting the skilled employees** needed to support this sector.

The effect of ADS/CDS on workforce sectors related to manufacturing and maintenance is expected to be positive.

WHAT WE LEARNED FROM STAKEHOLDERS

AV systems are complex, and there will likely be a greater demand for maintenance-oriented jobs for such systems.

Secondary Industries

Beyond operation, manufacture, and maintenance, many secondary industries will see an increase in level of employment and/or compensation. In general, **each new job created in the transportation industry results in as many as four jobs in related industries**—from service sector positions to the education and research roles needed to support a high-tech workforce.

Classrooms of the future will look different. Access to real-time analytics information will enable everyone from mechanics to logisticians to take advantage of a data-rich and connected future; the skills to do so must be prioritized at every level of education.

Likewise, **multimodal transportation sectors**—maritime, rail, and other emergent areas—**will be able to take advantage of downstream economic benefits** from the on-road transportation sector.

Warehousing and storage facilities should continue their trend of extending the benefits of just-in-time delivery to the consumer while identifying areas where supply chains can be made more robust to external shocks. Centralized command and control facilities will be able to better react to information about weather, traffic, and safety conditions and keep goods moving.

The effect of ADS/CDS on workforce sectors related to secondary industries is expected to be positive.

WHAT WE LEARNED FROM STAKEHOLDERS

Industry's relationship with colleges is critical, and many businesses are working with colleges to ensure appropriate training programs are available.

Analysis Results for ADS and CDS Impacts on Workforce

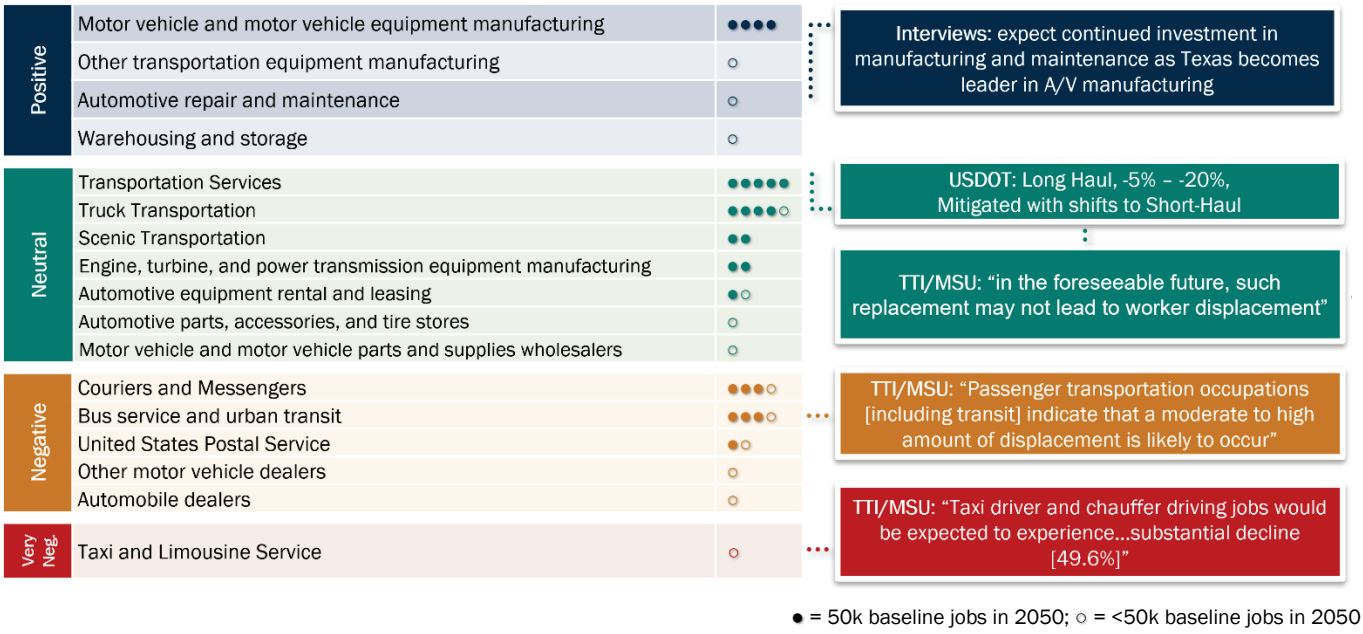
Future impacts of autonomous and connected vehicles will take place within a strong statewide economy.

The S.B. 1308 Working Group's scenario planning process examined the effects of ADS/CDS on the transportation industry workforce and the Texas economy. Each scenario—Low, Medium, and High adoption of ADS/CDS systems—affects the number of jobs in each transportation sector and amount of the overall Texas economy that may be impacted by these technologies. Within each scenario, it is assumed that sector-specific changes will occur within the context of automated and connected vehicle usage. Broad ranges—from positive to very negative—were used to reflect the **inherent uncertainty in the long-term effects of ADS/CDS implementation for reach industry sector** (Figure 18 and Figure 19).

Figure 18: Sector-Specific Impact Factor Framework

Job Impact	Positive	Neutral	Negative	Very Negative
Adjustment Factor	+10 – 25%	±10%	-10 – 25%	-25 – 50%

Figure 19: Sector-Specific Impact Estimates



The net impact of a highly automated future in 2050 was estimated to represent a change in total jobs ranging from -1.2% to +1.7% of 2050 employment levels (Figure 20). The impact of this future on transportation employment contributions total statewide GDP was estimated to range from -0.8% to +2.6% in 2050 (Figure 21). **Each of these forecasts represent a substantial increase over 2019 levels of employment and economic activity.**

Figure 20: Change in Number of Jobs in 2035 and 2050 versus Baseline Projected Number of Jobs

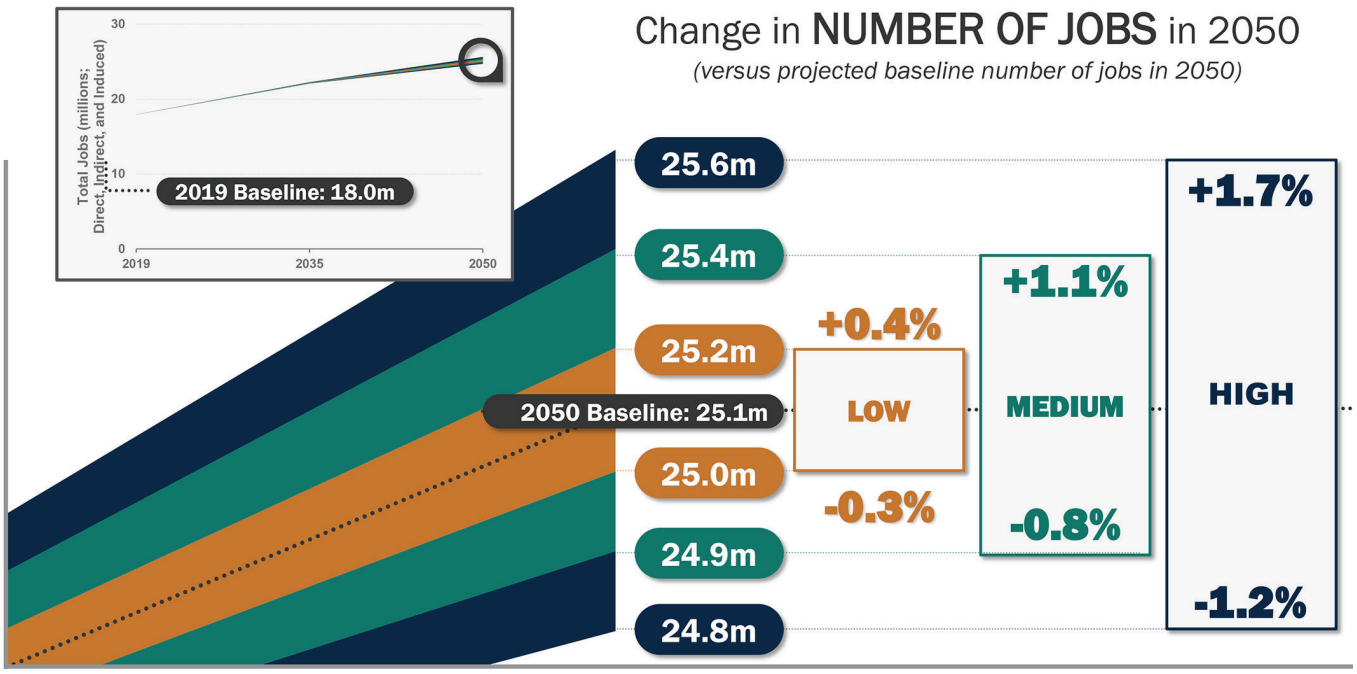
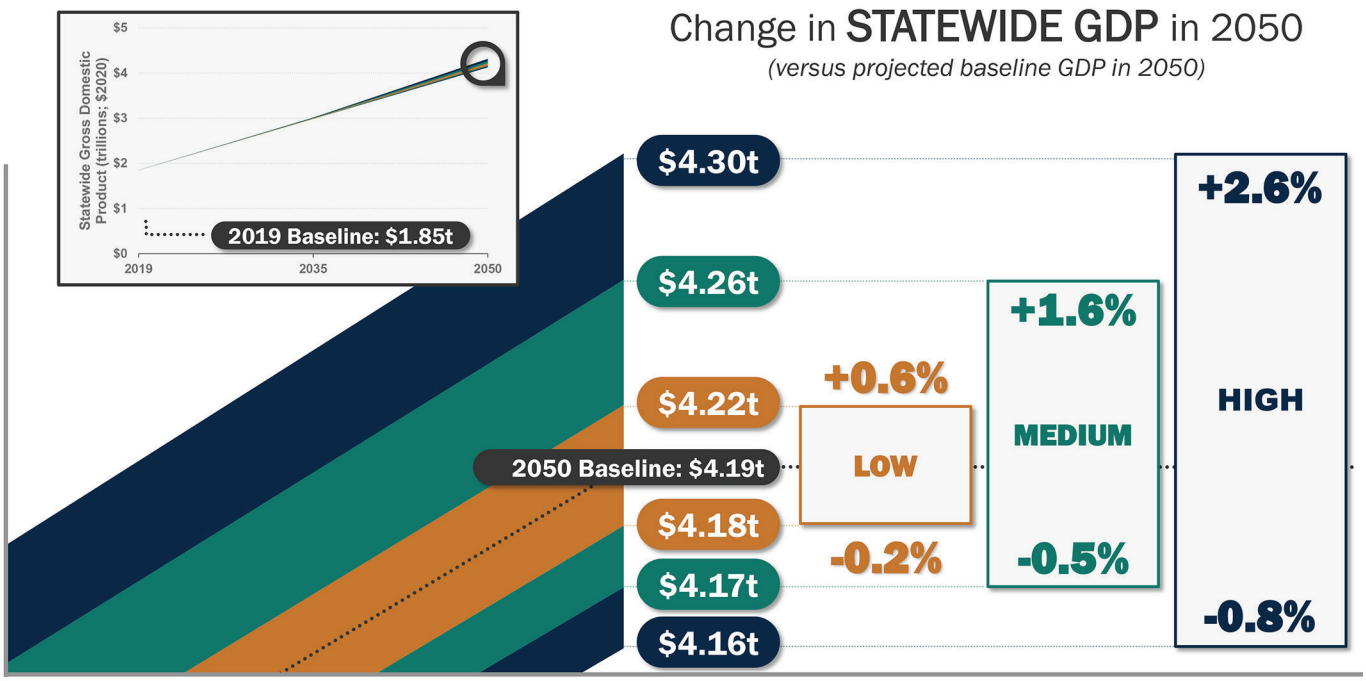


Figure 21: Change in sector contributions to Statewide GDP in 2035 and 2050 versus Baseline Projected GDP



Summary of ADS and CDS Impacts on Workforce

Despite uncertainty regarding when and to what degree ADS and CDS technologies will be implemented, their impact on the workforce represents both opportunities and challenges for industry and government alike.

While impacts over the short term may vary by sector, in general, these technologies represent an economic opportunity—if Texas can invest in its workforce sufficiently to take advantage of it.

There is a great deal of uncertainty on sector-specific effects of ADS/CDS systems. While the advent of autonomous, connected, and otherwise advanced vehicle technologies has already arrived, **the rate of adoption and ultimate capabilities of these systems is unknown.** A scenario-based approach is critical in understanding the differing potential effects of automation in both transportation sectors (such as manufacturing and long-haul trucking) and secondary sectors (such as sales and maintenance).

Autonomous vehicles should not result in a net loss of jobs over time. In every scenario, the general expansion of the economy between the present day and 2035 and 2050 outweighs most scenarios. **Jobs and residents will continue to move to Texas cities and towns** for economic opportunity; it is incumbent upon both industries and governments to identify opportunities to support and encourage economic development in the field of automation in order for workers and employers to see the benefits of automation.

Automated and connected vehicles represent an opportunity. By continuing to invest in a robust research and implementation pipeline, Texas should be able to create opportunities in manufacturing, maintenance, and supporting industry sectors. **Texas' regulatory environment should anticipate the needs of the transportation sector**, ensuring that autonomous vehicles are addressed explicitly in the context of operational need, safety, and infrastructure.

Texas needs a workforce prepared for the future. The skills and qualifications needed to support the transportation industry of the future are different than those needed today. **A robust workforce training program will help ensure Texas' economic competitiveness to attract jobs to the state.** Existing programs such as targeted, paid opportunities to obtain a CDL through programs in schools and prisons form a strong foundation for these efforts. Continued focus and investments in these programs will support the development of the workforce to support Texas' economic future.

In the final section, the study summarizes findings and discusses considerations for the future.

6

SUMMARY AND CONSIDERATIONS

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6.0 Summary and Considerations

Texas' Unique Opportunity

Texas is a proven leader and champion of ADS and CDS with a successful record in technology deployments and the ability to attract private industry.

The ongoing use of ADS and CDS within the state, as well as the working relationships that have been established to support these emerging technologies, are fueling a thriving economic engine that will **position Texas for future success as a hub of transportation innovation**.

The regulatory environment for ADS/CDS technology in Texas **is highly favorable to private industry.** The Texas Legislature has passed bills (notably S.B. 2205 and H.B. 3026) that allow for the operation of an automated motor vehicle on Texas roads, regardless of whether a licensed human operator is physically present in the vehicle and prohibits political subdivisions and state agencies from regulating or imposing fees on the use and operation of automated motor vehicles.

Reuters recently published an article calling Texas "…the self-driving trucking industry's promised land," primarily because of its open regulatory environment, which actively encourages the testing of ADS/CDS on public roads.

There is a critical role for federal agencies with regulatory authority such as the National Highway Traffic Safety Administration (NHTSA), Federal Motor Carrier Safety Administration (FMCSA), and USDOT to establish an environment where ADS and CDS can be safely deployed and widely utilized. Notable activities include:

- In May 2019, FMCSA requested public comment on an advanced notice of proposed rulemaking (ANPRM) about how federal motor carrier safety regulations (FMCSRs) may need to be amended, revised, or eliminated to facilitate the safe introduction of automated CMVs onto the nation's roadways and to account for significant differences between human operators and ADS.
- In December 2020, NHTSA issued an ANPRM that requested public comment on their proposal to develop a framework for ADS safety. A notice of proposed rulemaking (NPRM) on this subject is expected from NHTSA in late 2022 that could set the stage for how NHTSA assesses and regulates ADS safety, including automated CMVs.
- USDOT has provided guidance documents to promote alignment and understanding of how ADS can safely, equitably, and efficiently be integrated with the overall transportation system.

A friendly regulatory environment clearly promotes ADS use cases and prepares Texas to be in the driver's seat as the trucking industry embraces technology innovations to reduce the cost of transporting goods across the state. Companies are investing in Texas **because of its supportive regulatory environment**, more so than any other state.

Demonstrations of ADS and CDS technologies have become increasingly more common in Texas and the nation over the past decade. These **deployments enable stakeholders to closely observe the feasibility, impacts, and sustainability of emerging technologies**. They range from few-day AV shuttle demonstration to multimillion-dollar statewide deployments of vehicle-to-everything (V2X) technology intended to be adopted permanently.

These **deployments are spread across the state, primarily in major cities and along interstate highway corridors**. Companies such as TuSimple, Aurora, Kodiak, Waymo, and Embark are currently testing ADS systems for heavy-duty trucking use on Texas roads.[22] Nuro, in a notable demonstration in Houston, is utilizing small freight delivery vehicles to deliver groceries.[23] Smaller ADS-equipped vehicles known as personal delivery devices also are being tested or being prepared to be tested throughout Texas by companies such as Starship and Marble.[24] Lyft, supported by technology from Ford/Argo, and Uber have worked on providing ADS platforms for ride hailing in Austin and Dallas.[25] Drive.ai also provided a similar service as an 8-month demonstration program in Frisco starting in July 2018.[26] A summary map showcasing some of the ongoing Texas ADS/CDS demonstrations is shown on the next page.

WHAT WE LEARNED FROM STAKEHOLDERS

Cities like Frisco, TX have experienced rapid growth over a short amount of time, spurring investment in modern infrastructure and interest in demonstrating new technologies to help manage the growth.

22 TuSimple. TuSimple Autonomous Trucking. https://www.tusimple.com/.
Transport Topics. "Aurora Expands Autonomous Trucking Tests in Texas." https://www.ttnews.com/articles/aurora-expands-autonomous-trucking-tests-texas.
Waypoint. "Expanding out Waymo Via operations."https://blog.waymo.com/2021/08/expanding-our-waymo-via-operations.html.
GlobeNewswire. "Embark Expands Operations into Texas and Opens New Autonomous Trucking Hub to Accommodate Rapid Growth in US Sunbelt." https://www.globenewswire.com/news-release/2021/12/09/2349047/0/en/Embark-Expands-Operations-into-Texas-and-Opens-New-Autonomous-Trucking-Hub-to-Accommodate-Rapid-Growth-in-US-Sunbelt.html.
Alliance Texas. "The Mobility Innovation Zone." https://www.alliancetexasmiz.com/.

23 Progressive Grocer. "Kroger, Nuro to bring Autonomous Delivery Service to Houston." https://progressivegrocer.com/kroger-nuro-bring-autonomous-delivery-service-houston.

24 Paper City. "Food Delivery Robots Invade University of Houston, Turning it Into Campus of Future." https://www.papercitymag.com/culture/food-delivery-robots-invade-university-houston-create-campus-future/.
City of Arlington. "Marble begins Mapping Arlington Sidewalks Future Robotic Delivery." https://www.arlingtontx.gov/news/my_arlington_t_x/news_archive/2018_archived_news/august_2018/marble_begins_mapping_arlington_sidewalks_for.

25 Ford Media Center. "Argo AI and Ford to launch self-driving vehicles on Lyft network by end of 2021." https://media.ford.com/content/fordmedia/fna/us/en/news/2021/07/21/argo-ai-ford-lyft-network.html.
The Verge. "Uber is bringing its self-driving cars to Dallas." https://www.theverge.com/2019/9/17/20870969/uber-self-driving-car-testing-dallas.

26 City of Frisco. Driverless Car Pilot Program. https://www.friscotexas.gov/1573/Driverless-Car-Pilot-Program.

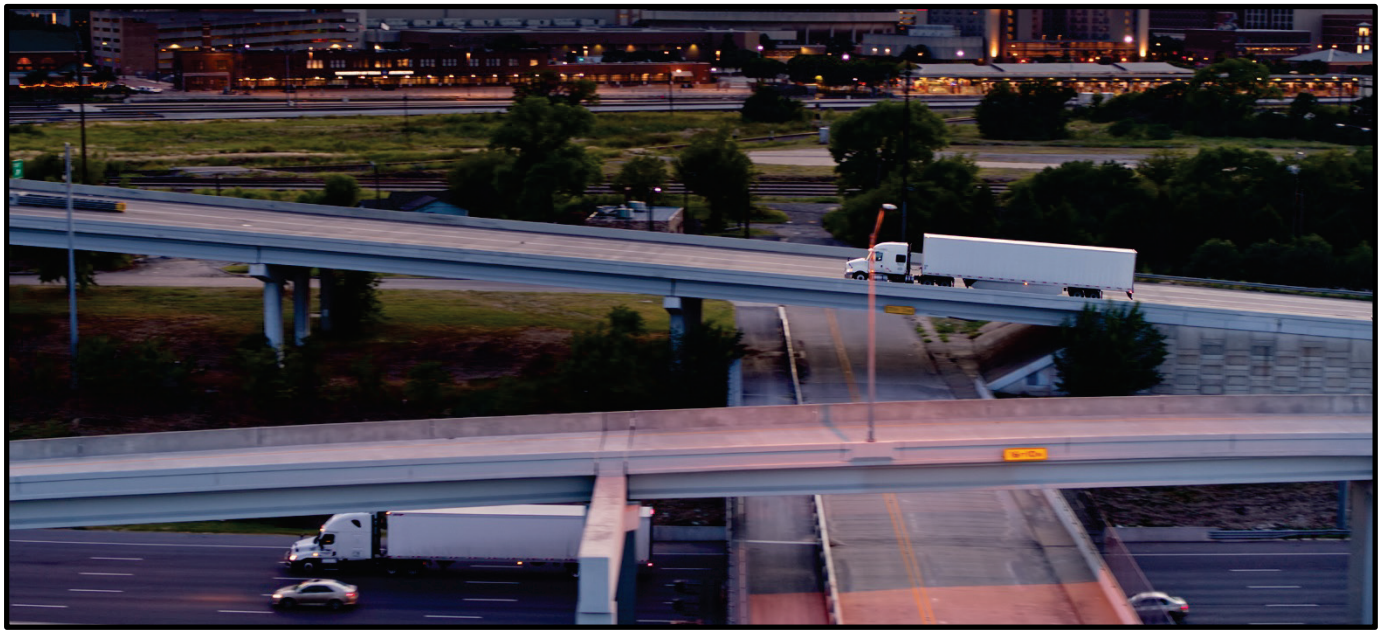
Major Texas ADS/CDS Activities

The current ADS and CDS activities within the state suggest Texas will continue to remain at the forefront of mobility innovation and operations and continue to be a testbed and early adopter of beneficial ADS/CDS applications.

Summary of S.B. 1308 Study Findings

The analysis of ADS and CDS opportunities shows significant potential benefits to border crossing, public and driver safety, and the Texas transportation workforce.

S.B. 1308 provided the state of Texas with the opportunity to conduct a comprehensive analysis of the potential benefits and impacts of ADS, CDS, and other emerging technologies over the next few decades to tackle some of the state's critical transportation challenges, namely the increasing congestion at the Texas-Mexico border, continued highway injuries and fatalities, and the need for an adequate and trained workforce.



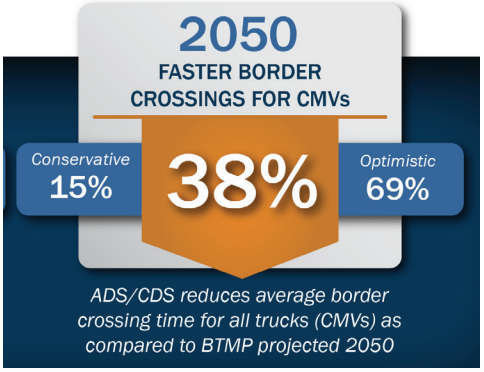
Private industry has continued to advance ADS and CDS capabilities throughout the world for some time, and Texas' **open regulatory environment has placed the state at the forefront** of testing and for-revenue generating deployments of a variety of passenger and freight operations in the United States. Many do not realize the extent to which these technologies are in operation today.

Through the conduct of this study, **interviews with industry partners shed light on current operations and challenges** and their plans for full scale deployment. Several partners further engaged with the S.B. 1308 Working Group, providing presentations on active technology developments, testing, and deployments. **Private industry is focused on bringing these technologies to market safely**. Their planning horizons are three to five years, making it more difficult for them to hypothesize about level of deployment by a more distant planning horizon such as 2035 or 2050 other than to say they expect significant market penetration by that timeframe given current progress.

The future success of ADS and CDS will be driven by three key factors: technology capabilities, infrastructure system readiness, and market penetration. At the highest level, the results of this study suggest that ADS and CDS will help reduce border congestion, reduce crashes, and create new opportunities for the Texas workforce in all future scenarios.

Potential benefits of using ADS/CDS to alleviate motor vehicle congestion at ports of entry.

- **Motor vehicle congestion at the Texas-Mexico POEs is significant and forecasted to grow.** Likewise, the costs of delays at the Texas-Mexico border are significant and are anticipated to grow. For example, according to a 2019 study from the Waco-based Perryman Group, wait times at Texas POEs cost the state more than $32 billion in just over three years. New technologies can be part of the solution.
- **ADS and CDS are developing technologies but have a strong likelihood for adoption by POE users.** Market forces—namely the need to improve operational efficiencies and transport more volume—are driving the need for solutions offered by this technology, and as stated earlier trucking companies in Texas are deploying ADS.
- **ADS and CDS applications at the Texas-Mexico border can directly target congestion.** CDS has the potential to allow travelers greater access to actionable information and to conduct efficient electronic data exchanges with safety and security monitoring agencies. ADS provides more efficient operations on the approach, at the POE, and on the exit, which leads to less congestion.
- **Electric vehicles will accompany ADS and CDS adoption and provide additional benefits.** It is likely they will be grouped together as they are deployed at scale to reduce costs while maximizing other benefits.
- **Texas has an opportunity to be a frontrunner in ADS/CDS border applications.** Texas currently has an in-state presence of several key ADS developers with a focus on CMV, and there is stakeholder enthusiasm for border crossing as a use case for ADS-equipped trucks.



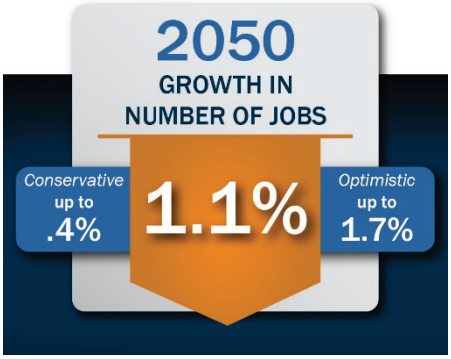
Potential impacts of ADS/CDS on driver and public safety

- **ADS/CDS technologies will enhance driver and public safety in Texas.** These technologies will provide the opportunity to reduce driver errors and risky driving behaviors making Texas roadways safer for all users by saving lives, preventing injuries, and reducing crashes.
- **ADS and CDS may lead to reduced fatalities, injuries, and crashes in Texas.** Fatalities should not occur while driving, walking, or biking. ADS/CDS technologies are expected to save lives each year they are implemented.
- **The primary impact of ADS is to reduce driver errors.** ADS/CDS-equipped vehicles provide a 360-degree view of the vehicle and its surroundings and utilizes a system of detectors that warn the driving system of obstacles in the roadway, including pedestrians or other non-motorized users in the path of vehicles.
- **ADS can also reduce risky driver behaviors.** ADS/CDS technologies will provide an alternative operating environment that removes the human driver and reduces the likelihood and impact of risky behaviors that contribute to crashes.

- **ADS/CDS-equipped vehicles can increase compliance with safety laws.** ADS/CDS-enabled vehicles also monitor driver and passenger habits such as safety belt usage and require vehicle occupants to buckle up for all trips.
- **CDS technologies can enhance communications that improve safety.** CDS technologies allow enhanced communication of system delays, crashes, and other operational challenges that often result in delays and sometimes secondary crashes.

Potential impacts of ADS/CDS on transportation industry workforce and Texas economy

- **Autonomous vehicles should not result in a net loss of jobs over time.** In every scenario, the general expansion of the economy between the present day and 2035 and 2050 dramatically outweighs even the most pessimistic scenarios. **Jobs and residents will continue to move to Texas cities and towns** for economic opportunity.



- **Automated and connected vehicles represent an opportunity.** By continuing to invest in a robust research and implementation pipeline, Texas should be able to create opportunities in manufacturing, maintenance, and supporting industry sectors.
- **There is a great deal of uncertainty on sector-specific effects of ADS/CDS systems.** While the advent of autonomous, connected, and otherwise advanced vehicle technologies has already arrived, the rate of adoption and ultimate capabilities of these systems is unknown.

- **Texas needs a workforce prepared for the future.** The skills and qualifications needed to support the transportation industry of the future are different than those needed today. Changes in the nature of the workforce—the type, quantity, and economic characteristics of each sector—may be rapid or incremental, but **a robust workforce training program will help ensure Texas' economic competitiveness to attract jobs to the state.**

Considerations for the Future

Texas can consider key steps to pursue the benefits of ADS and CDS.

The legislative intent of this study is to document the potential benefits and impacts of ADS and CDS deployments on border congestion, public safety, and transportation workforce. It stops short of making recommendations for how to achieve these benefits. However, the study includes a set of considerations to help guide and inform possible future efforts by the state of Texas should there be a desire to pursue the potential benefits of transportation innovation. Many of these considerations complement or expand established state programs in place today. Considerations include the following:

Developing a coordinated technology program. TxDOT is actively engaged in several technology-driven initiatives today that informed this study and will continue as a partner to prepare the state for a more automated future. The CAT program, Texas Connected Freight Corridors program, and CAV Task Force are three examples of initiatives currently advancing the state's technology interests. These efforts should inform and be actively integrated with TxDOT's Texas-Mexico BTMP, SHSP, long-range plan (LRP), Texas Freight Mobility Plan (TFMP), and ongoing workforce development programs to ensure technology advancements are sufficiently addressed.

Monitoring and engaging with private industry. Through the conduct of this study, the S.B. 1308 Working Group sought extensive stakeholder engagement to capture input from numerous private sector technology firms, including several directly involved in the development, testing, and deployment of ADS and CDS. The successes of these companies will be key to determining the timeline of adoption, as well as any areas of government support needed to address statutes, regulations, and standards.

Assessing compatibility of border improvements with future technology investments. Numerous projects to address capacity and operational needs at the Texas-Mexico border are planned or underway. While much work is taking place to ensure technology is a beneficial part of many of these projects, there is no fully developed border technology strategy. TxDOT and binational partners should continue to emphasize technology as a solution and collaborate with ongoing efforts such as work by CBP and GSA to define "border crossings of the future" to improve operations. This could be a key responsibility of existing groups such as the CAV Task Force or BTAC or be a key role for a new ADS/CDS Border Working Group.

Conducting demonstrations that advance the integration of ADS-equipped vehicles with border crossing safety and security screening procedures. Numerous demonstration efforts are taking place in Texas and elsewhere that test and develop ADS-equipped vehicle interactions with law enforcement. Conducting such a demonstration (collaborative between the public and private sector) within the border operating environment could advance the ADS border crossing use case. This could include practical demonstrations as well as the creation of digital twins of POEs to facilitate simulation by private sector testers as well as the public sector and academia.

Continuing to incorporate technology into the state's safety program. The Texas SHSP defines the focus areas and goals of the state's safety program. ADAS and ADS technologies are well positioned to help reduce crashes, particularly those caused by human error/behavior. As technology advances from ADAS to ADS, the SHSP and specific safety projects should continue to incorporate technology considerations and/or technology compatible components.

Promoting workforce training. Many stakeholders identified the availability of a qualified workforce as a key constraint. A few of the OEMs even reported working with local colleges to develop training programs specific to their ADS and CDS components. In the coming years workforce development, including retraining and new training programs, will be critical to the success of these technologies.

Advancing system integration and shared data. The success of many technology deployments will depend on the ability to share data between systems and operations. Border operations provide a prime example. As noted in the results above, for ADS and CDS to improve border operations, it is imperative that agencies involved in border crossing operations continue to share information among themselves. Smart roadways are another example. Signals, traffic conditions, and roadway geometrics all will help advance ADS and CDS. User acceptance of advanced system integration and data sharing will in part be based on guaranteed data security and confidentiality.

Supporting education and promotion. One finding from this study is that many stakeholders are not aware of today's advancements in ADS and CDS. A key factor in building trust and acceptance of new technologies is to get them out there where users of the system can learn about and experience their capabilities. This builds comfort levels and provides feedback to developers on what works and what needs improvement.

Retaining legislative and regulatory authority. Texas has been lauded by industry, confirmed by this study's stakeholders, as a progressive state for the advancement of ADS and CDS, based on multiple legislative actions that have made testing and deployment possible. As technologies continue to advance, it will be important for the state to keep pace and to serve as a best practice for its adjacent states, allowing for efficient interstate travel for ADS.

Supporting testing and deployment. The state can partner with local and regional partners and the private sector to help demonstrate the capabilities of ADS and CDS. Projects like the Texas Connected Freight Corridors program provide a platform and opportunity for innovation. The state can actively engage in and direct projects of this type to help advance technology adoption.

These considerations could help ensure **Texas remains a leader in ADS and CDS and stays well positioned to generate the benefits described in this S.B. 1308 study.**

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APPENDIX

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Appendix

List of Acronyms

ADAS	Advanced Driver Assistance Systems
ADS	Automated Driving Systems
ANPRM	Advanced Notice of Proposed Rule Making
AV	Autonomous Vehicle
BCIS	Border Crossing Information System
BNRSC	Binational Regional Steering Committees
BSIF	Border Safety Inspection Facility
BTAC	Border Trade Advisory Committee
Texas-Mexico BTMP	Texas-Mexico Border Transportation Master Plan
CAT	Cooperative Automated Transportation
CAV	Connected and Automated Vehicle
CBP	Customs and Border Protection
CDL	Commercial Driver's License
CDS	Connected Driving Systems
CMV	Commercial Motor Vehicle
CRIS	Crash Record Information System
DOT	Department of Transportation
DPS	Department of Public Safety
EV	Electric Vehicle
FAST	Free and Secure Trade for Commercial Vehicles
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FMCSR	Federal Motor Carrier Safety Regulation
GDP	Gross Domestic Product
GSA	General Services Administration
ITD	Information Technology Division
LRP	Long-Range Plan
NAFTA	North American Free Trade Agreement
NEVI	National Electric Vehicle Infrastructure
NHTSA	National Highway Traffic Safety Administration
NII	Non-Intrusive Inspections
NPRM	Notice of Proposed Rule Making
OEM	Original Equipment Manufacturer
POE	Port of Entry

POV	Personally Owned Vehicle
RSU	Roadside Unit
S.B.	Senate Bill
SAE	Society of Automotive Engineers
SENTRI	Secure Electronic Network for Travelers Rapid Inspection
SHSP	Strategic Highway Safety Plan
STR	Strategic Planning Division
TFMP	Texas Freight Mobility Plan
TNC	Transportation Network Company
TPP	Transportation Planning and Programming
TRF	Traffic Safety Division
TTI	Texas Transportation Institute
TWC	Texas Workforce Commission
TxDOT	Texas Department of Transportation
TxFAC	Texas Freight Advisory Committee
UCP	Unified Cargo Processing
USDOT	United States Department of Transportation
USMCA	United States-Mexico-Canada Agreement
V2I	Vehicle-to-Infrastructure
V2P	Vehicle-to-Pedestrian
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Everything
VMT	Vehicle-Miles Traveled
ZOV	Zero Occupancy Vehicle

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