TEXAS DELIVERS 2050

March 2023

Texas Department of Transportation

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LIST OF EXHIBITS

ACRONYMS

AADT	Annual Average Daily Traffic
ACS	American Community Survey
ADAS	Advanced Driver Assistance Systems
ADS	Automated Driving Systems
AFVN	Automated Freight Vehicle Network
AFW	Fort Worth Alliance Airport
AV	Autonomous Vehicle
BNSF	BNSF Railway
BTMP	Texas-Mexico Border Transportation Master Plan
BTS	Bureau of Transportation Statistics
CAT	Cooperative Automated Transportation
CAV	Connected and Autonomous Vehicle
CBP	Customs and Border Protection
CCTV	Closed-Circuit Television
CDS	Connected Driving Systems
CMAQ	Congestion Mitigation and Air Quality
CMV	Commercial Motor Vehicle
CP	Canadian Pacific Railway Limited
CRFC	Critical Rural Freight Corridor
CRIS	Crash Records Information System
CUFC	Critical Urban Freight Corridor
CY	Calendar Year
DFW	Dallas-Fort Worth International Airport
DMS	Dynamic Message Sign
EAL	Expected Annual Loss
ELP	El Paso International Airport
FAST	Free and Secure Trade, also Fixing America's Surface Transportation Act
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIO	Freight Investment and Optimization
FIP	Freight Investment Plan
FNTOP	Freight Network Technology Operations Plan
FRA	Federal Railroad Administration
FY	Fiscal Year
GDP	Gross Domestic Product
GIWW	Gulf Intracoastal Waterway
GSP	Gross State Product

HPMS	Highway Performance Monitoring System
HRL	Valley International Airport
IAH	George Bush Intercontinental Airport (Houston)
IIJA	Infrastructure Investment and Jobs Act
IoT	Internet-of-Things
IRI	International Roughness Index
ITS	Intelligent Transportation Systems
KCS	Kansas City Southern Railway
LNG	Liquefied Natural Gas
LRD	Laredo International Airport
MIZ	Mobility Innovation Zone
ML	Machine Learning
MPO	Metropolitan Planning Organization
MUTCD	Manual on Uniform Traffic Control Devices
NETEX	Northeast Texas Rural Rail Transportation District
NEV	Neighborhood Electric Vehicle
NEVI	National Electric Vehicle Infrastructure Plan
NHFN	National Highway Freight Network
NHFP	National Highway Freight Program
NMFN	National Multimodal Freight Network
NRI	National Risk Index
NTSB	National Transportation Safety Board
OEM	Original Equipment Manufacturer
OS/OW	Oversize/Overweight
PA	Predictive Analysis
PCE	Personal Consumption Expenditure
PDD	Personal Delivery Device
PHFS	Primary Highway Freight System
PHMSA	Pipeline and Hazardous Material Safety Administration
PM-DIS	Performance Metrics: Data Integration System
PPE	Personal Protective Equipment
REAL	Regional Express Access Lanes
RMA	Regional Mobility Authority
SAE	Society of Automotive Engineers
SAP	Highway-Rail Grade Crossing State Action Plan
SAT	San Antonio International Airport
SCIRF	Ship Channel Improvement Revolving Fund
SCWG	Supply Chain Working Group
SKF	Port San Antonio Airport (Kelly Field)
SORR	South Orient Railroad

STB	Surface Transportation Board
STOC	Statewide Traffic Operations Center
STRACNET	Strategic Rail Corridor Network
STRAHNET	Strategic Highway Network
TCFC	Texas Connected Freight Corridors
TFMP	Texas Freight Mobility Plan
THFN	Texas Highway Freight Network
TMC	Traffic Management Center
TMFN	Texas Multimodal Freight Network
TOC	Traffic Operations Center
TOSCo	Traffic Optimization for Signalized Corridors
TPAS	Truck Parking Availability System
TPP	Transportation Planning and Programming Division (TxDOT)
TRRIF	Texas Rail Relocation and Improvement Fund
TSMO	Transportation Systems Management & Operations
TTI	Texas A&M Transportation Institute
TTTR	Truck Travel Time Reliability
TxDMV	Texas Department of Motor Vehicles
TxDOT	Texas Department of Transportation
TxDPS	Texas Department of Public Safety
TxFAC	Texas Freight Advisory Committee
TXPF	Texas Pacifico Transportation
UAS	Unmanned Aircraft Systems
UCP	Unified Cargo Processing
UP	Union Pacific Railroad
USACE	United States Army Corps of Engineers
U.S. DOT	United States Department of Transportation
USMCA	United States-Mexico-Canada Agreement
UTP	Unified Transportation Program
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Everything
WIM	Weigh-in-Motion
WIM/VC	Weigh-in-Motion and Vehicle Classification
WRRDA	Water Resources Reform and Development Act of 2014

Chapter 1 Texas Delivers 2050: The Texas Freight Mobility Plan

The movement of goods is vital to every resident, business, and visitor in Texas, and Texas is home to a vast multimodal freight system that plays a pivotal role in statewide, national, and global trade and commerce. Texas Delivers 2050 provides Texas with a blueprint for facilitating continued economic growth through a comprehensive, multimodal strategy for ensuring safe, efficient, resilient and equitable movement of goods necessary to support the state's growing population and essential supply chains.

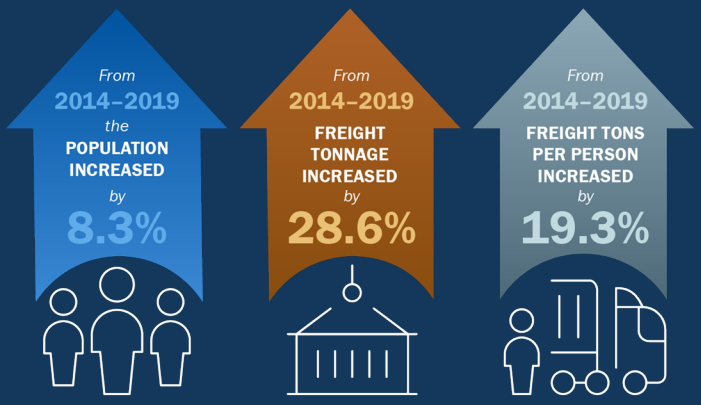
This chapter documents the importance of freight in Texas and discusses key factors impacting freight transportation demand in Texas.

1.1 A GROWING ECONOMY MEANS GROWING FREIGHT DEMAND

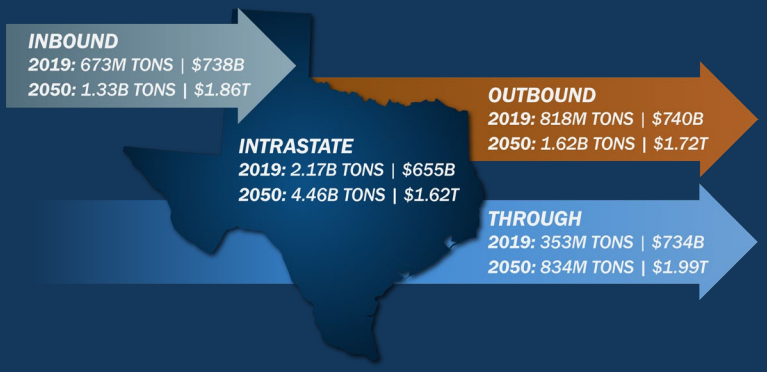
Texas has the **second largest economy in the United States**. Integral to the state's robust economy is the transport and distribution of freight, including raw materials, intermediate and final goods to, from and within the state. Without freight, the economy would come to a stop.

Highlights

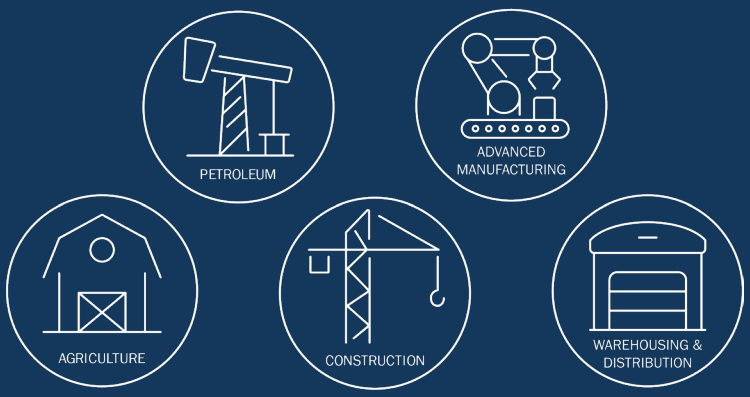
The Texas economy and population have experienced robust growth over the past decade, which is fueling the demand for freight transportation



The trend is projected to continue, with freight volumes projected to more than double and freight value increasing by 151% by 2050



Texas' key industry clusters and their supply chains depend on safe and efficient freight movement



Source: Transearch, FAF, Waybill, USA Trade Online, Enverus. Analysis by Cambridge Systematics.

In 2019, Texas contributed about $1.9 trillion or 8.8% of the U.S. total gross domestic product (GDP).[1] Texas continues to **lead the nation in economic growth** and remains one of the strongest and most diverse economies in the nation. In 2019, the state of Texas had a population of 29 million and annual population growth of 1.5% from 2014 to 2019.[2] Along with a growing population comes a growing demand for goods and an increased need for a clear freight mobility vision and plan.

Texas Economy at a Glance

- 29 million people
- 12.6 million jobs
- $1.9 trillion in Gross State Product
- If Texas were a nation, it would rank as the 9th largest economy in the world.
- $622 billion in international trade
- Texas is #1 in the nation for exports for 20 consecutive years.

Texas Freight at a Glance

- In 2019, 4 billion tons of freight worth $2.9 trillion.
- In 2050, over 8 billion tons of freight worth over $7 trillion.
- The direct and indirect economic impact of goods movement businesses in Texas is significant, representing nearly 1 in every 8 jobs in the state.

Freight tonnage moving to or from Texas has grown nearly 29% between 2014 and 2019 from 2.8 billion tons to about 3.7 billion tons. This amounts to **130 tons per resident** and **274 tons per job**. The average freight tonnage per person coming to or from Texas has grown from 109 tons per person to 130 tons, with a five-year average of 117 tons per person.[3]

Population is not the only driver of freight demand. Every business, individual and household in Texas generates some freight traffic. Manufacturing businesses move raw materials in and finished products out. Service industries such as hospitals and schools generate freight traffic for office supplies, food, furniture and other finished goods. As these businesses and jobs relocate and grow in Texas, so does the freight generated by those businesses.

Average **freight tons per job** in Texas has grown from about **231 tons** per job in 2014 to an average of **274 tons** per job in 2019 (see **Exhibit 1**).[4]

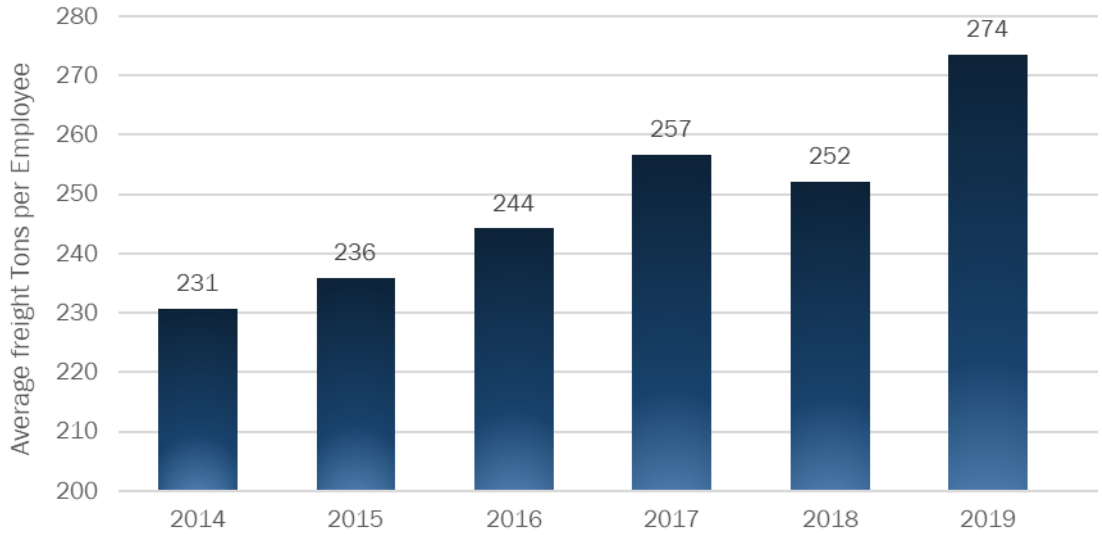
1 U.S. Bureau of Economic Analysis.

2 Texas Demographic Center (TDC). Texas Population Estimates Program. https://demographics.texas.gov/data/tpepp/estimates/

3 Cambridge Systematics based on analysis of enhanced 2019 TRANSEARCH data from IHS Markit and population and employment data from the Texas Labor Market Information.

4 Ibid.

EXHIBIT 1: AVERAGE FREIGHT TONS PER JOB IN TEXAS, 2014–2019



Source: Analysis of Commodity Flow data for Texas Freight Mobility Plan for years 2016 and 2018 and Texas Delivers 2050 and employment data from Texas Labor Market Information (LMI). Texas Industries Depend on Freight

This increase in tonnage per job is a result of the increase in employment in freight-intensive industries relative to overall employment, especially those moving heavy, bulky goods, such as oil and gas and construction. This increase in tons per job also corresponds to a similar increase in household spending with purchases of consumer goods and services leading to more freight activity. Texas households have **increased their personal consumption expenditure** (PCE) by almost **30%** over the last decade from $30,588 in 2010 to $39,661 in 2020.[5]

Population growth drives construction as well. As one of the highest-growth states in the nation, Texas has seen considerable growth in new home construction since the 2009 recession. According to the Texas A&M University Texas Real Estate Research Center, new dwelling unit permits have exceeded 100,000 every year since 2014 and topped 180,000 in 2021.[6] This is a significant driver of freight demand for concrete, lumber, shingles and other materials that requires trucks to transport to job sites.

The strength of Texas' economy is due, in part, to the diversity of its major industries. In Texas, many of the most concentrated and strongest industries are oil and gas extraction, support for mining and construction activities, and manufacturing and transportation industries. The state is a **national leader in the energy sector**, private sector capital investment and access to a robust multimodal transportation infrastructure.

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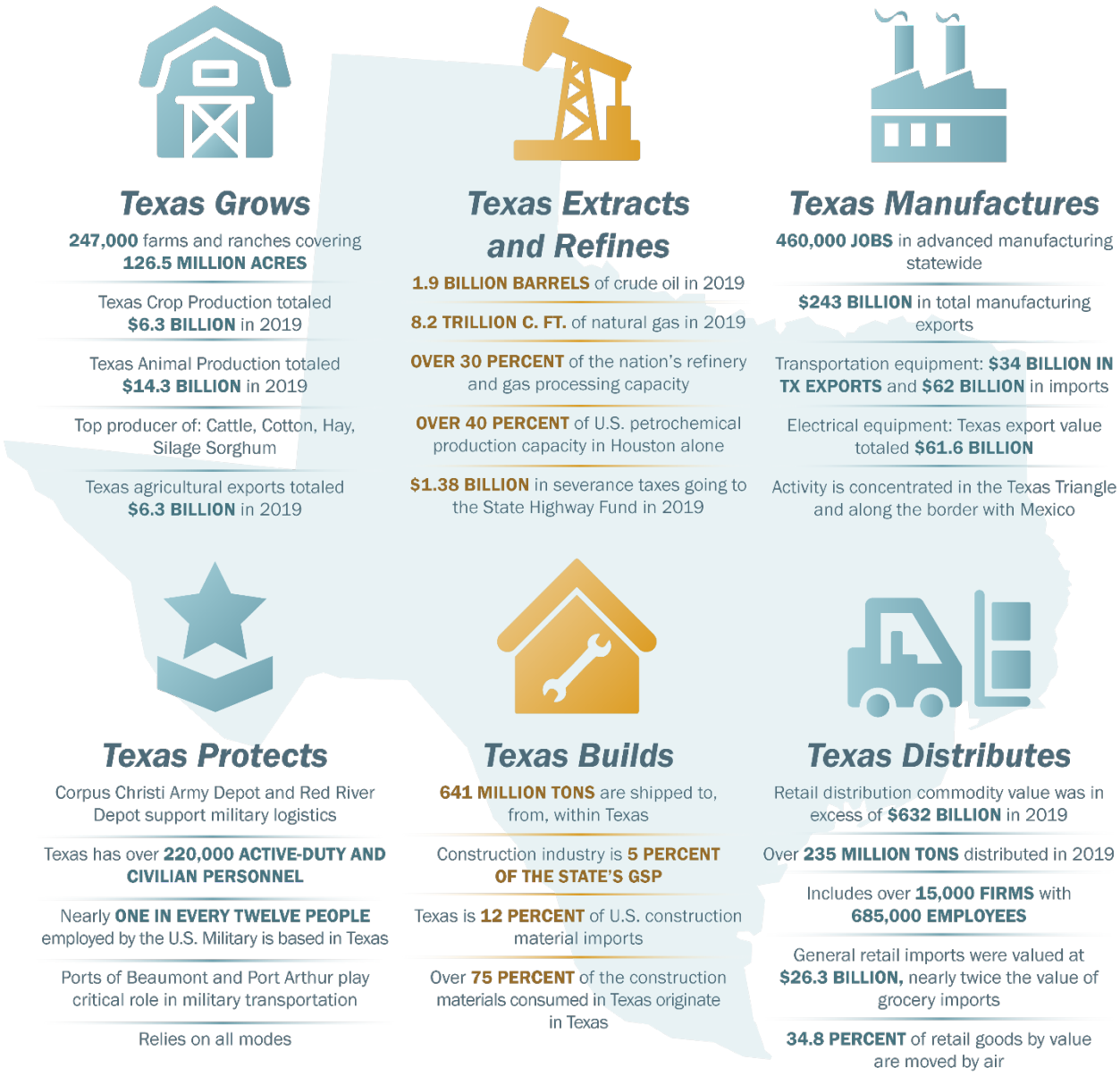
5 Statista Research Department. September 30, 2022. https://www.statista.com/statistics/1128276/texas-per-capita-personal-consumption-expenditures/.

6 Texas A&M University. Texas Real Estate Research Center. Building Permit Data for Texas. https://www.recenter.tamu.edu/data/building-permits#!/state/Texas.

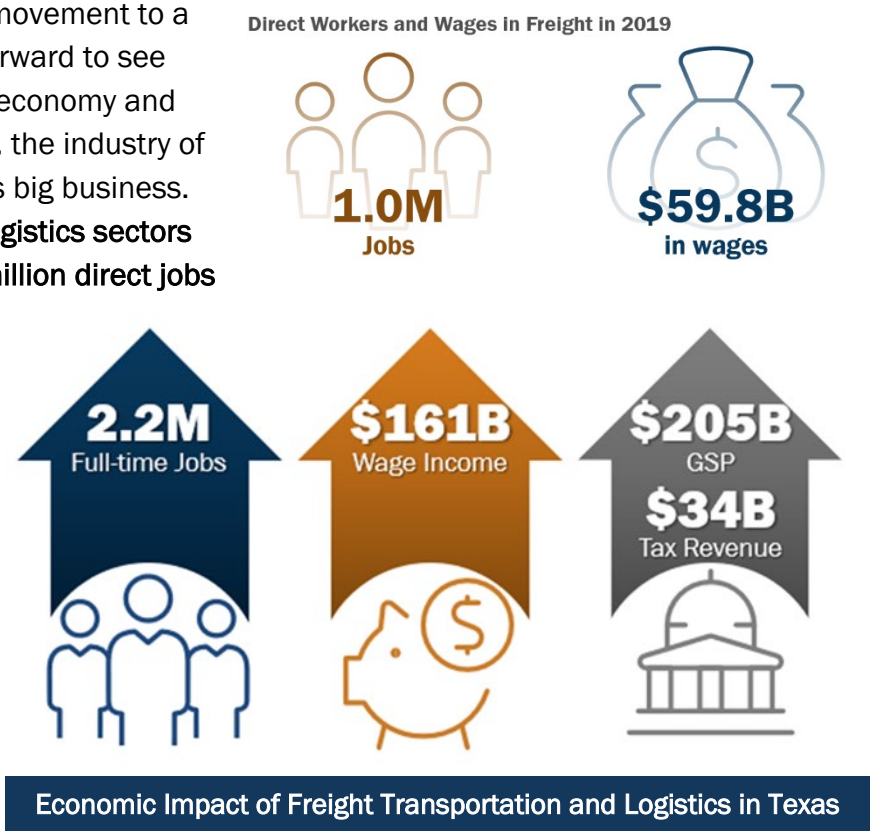


Source: 1) Texas Grows*: 2020 Texas Agricultural Statistics published jointly by U.S. Department of Agriculture and Texas Department of Agriculture. 2)* Texas Extracts and Refines*: U.S. EIA Agency Natural Gas Summary (2019), U.S. EIA Crude Oil Production (2019), U.S. EIA Number and Capacity of Petroleum Refineries (2019), U.S. EIA. Natural Gas Annual Respondent Query System (2019), Greater Houston Partnership (2021), TxDOT Proposition 1 Funds (2019). 3) Transearch (2019) adapted by Cambridge Systematics, Texas Workforce Commission (2019). 4)* Texas Protects*: Defense Logistics Agency, Governing.com (2021), TxDOT 2022-2023 Texas Port Mission Plan. 5)* Texas Builds*: Transearch (2019) adapted by Cambridge Systematics, U.S. Bureau of Economic Analysis (2020), US Census Foreign Trade Data (2019). 6)* Texas Distributes*: Transearch (2019) adapted by Cambridge Systematics, Texas Workforce Commission (2019).*

Some jobs and industries are more freight-intensive than others. Goods-producing industries such as agriculture, manufacturing, and oil and gas are examples of freight-intensive industries. In fact, safe and efficient freight movement is so important to these industries that it often determines the location and competitiveness of firms within the industry. These freight-intensive industries are also vital to the Texas economy.

1.1.1 ECONOMIC IMPACT OF FREIGHT MOVEMENT IN TEXAS

All industries depend on goods movement to a certain degree, so it is straightforward to see goods movement as vital to the economy and quality of life. However, in Texas, the industry of moving and handling of freight is big business. The **freight transportation and logistics sectors** in Texas generated **nearly one million direct jobs** in 2019 compared to just over 655,000 jobs in 2009. Wage incomes increased by 6.3% annually over this 11-year period, from $30.4 billion in 2009 to $59.8 billion in 2019. Overall, the number of jobs and labor income generated by the freight transportation sectors in the state increased by 3.9% and 6.3% over the 2009-2019 period.



Economic Impact of Freight Transportation and Logistics in Texas

Source: 2019 TREDIS model for Texas.

The one million direct jobs in freight **transportation and logistics sectors** support nearly 2.2 million jobs, or **1 in 8 jobs in Texas**. These jobs add close to $161 billion in labor income and lead to $205 billion in gross state product (GSP). This yields $34 billion in tax revenues.[7]

[7] Source: 2019 TREDIS model for Texas. To perform the analysis, the total number of direct jobs by sector was used as the reference for the calculation of the total (combined direct, indirect and induces) economic impacts in terms of employment, labor income, GDP, and taxes.

1.2 KEY TRENDS IMPACTING GOODS MOVEMENT IN TEXAS

In 2050, more than **8 billion tons** of goods valued at more than **$7 trillion dollars** are projected to be moving in Texas.[8] While the economy, including population and employment growth discussed above, is the primary driver of freight demand. There are many factors that can impact both the volume and the way freight flows in Texas, including changing business and consumer practices, international trade and energy policy, new technologies and increasing supply chain disruptions will all impact the volume of freight and how it moves in the coming decades.

1.2.1 BUSINESS AND CONSUMER PRACTICES

E-commerce has transformed the way many Texans shop for retail goods. In 2020, the COVID-19 pandemic created an unprecedented and immediate jump in e-commerce demand, as consumers avoided in-person shopping to adhere to social distancing and work-from-home protocols. **E-commerce is estimated to comprise 14.4% of total U.S. retail sales,** an increase of 4.5% over its retail share in 2018, for a total industry value of $794 billion. E-commerce is expected to lead to an increase in consumption as it reduces time and effort needed to find products and provides access to a much wider array of goods and options. It will also have implications on how freight moves with many e-commerce fulfillment centers located in and nearby large metro areas, and the first and last fifty feet becoming critical. Automated and/or electric delivery options, such as drones or electric cargo bikes are expected to become more mainstream.

Freight Impacts of COVID-19

In the span of a few weeks of the pandemic in 2020, consumer habits radically changed as people turned to online ordering, curbside pickup and remote work. Some trends were accelerated (such as e-commerce), while others were disrupted (such as employment growth in food service). Freight transportation and logistics played a huge role in responding to the start of the pandemic.

As we continue to understand the lasting impacts of the pandemic, Texas logistics has an opportunity to think critically about how freight supports these longer-term behavior changes. For instance, if smaller distribution centers continue delivery of goods to homes, then roadway geometries and capacity may need to adapt to that continued growth. In the coming months and years, statistical reports and studies will help us to understand what those lasting impacts are and the implications for the freight system.

E-commerce has also led to **changes in consumer preferences** between goods and services. An example is the change from restaurant meals to meal kits delivered to a consumer's doorstep.

[8] Transearch, Waybill, USA Trade Online, Enverus, FAF5.4. Analysis by Cambridge Systematics

Citing the market research firm Absolute Reports, Yahoo News reported in August 2022 that this industry is expected to grow by nearly 17% per year to 2027, putting further pressure on delivery services in residential areas.[9]

The sharing economy has been fueled by the internet and refers to the sharing of goods or services between private individuals. Examples include "Rent the Runway" which rents name brand clothing to users for a fee and ridesharing applications, such as Uber and Lyft. The sharing economy may reduce the purchase of consumer goods, especially those with limited or one-time uses. One example is Fat Llama, a peer-to-peer platform, allows neighbors to rent every day- and occasional-use items, such as tools, picnic baskets, lawn care equipment, sporting equipment and many more household goods.[10] When consumers rent goods as opposed to buying them, it impacts consumer spending and the shipping of the inputs necessary to produce them.

Reshoring and nearshoring also **have implications on freight mobility**, though less visible to end-users. Perhaps the trend with the most significant impact on freight flows in Texas relates to the location of manufacturing of consumer products. Over the past three decades, China became the dominant sourcing location for many U.S. manufacturers. The trend of reshoring or nearshoring, where manufacturing either comes back or is expanded in or close to the United States, will have significant implications on the volume and manner of freight movement in Texas. For example, the CHIPS Act is expected to bring increased production of advanced microprocessors to America over the next several years.

Nonetheless, international trade via waterborne and airborne transportation remains critical to the Texas economy. Most microprocessors are manufactured in Asia, and it will take years before domestic manufacturing capacity can meet domestic demand. The Ports of Los Angeles and Long Beach handle over half of waterborne electronics imports from Asia,[11] and a shift to domestic production would shift existing origins from Southern California to more points of origin and possibly a greater diversity of modes.

These changes in business and consumer practices have made a significant impact on the **workforce**. Shifts in distribution patterns created by e-commerce have changed consumer expectations and delivery services. In addition, nearshoring is creating new transportation patterns, as well as new manufacturing and distribution practices. These, and other shifts

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9 Yahoo News. Meal Kit Market. August 2022. https://www.yahoo.com/now/meal-kit-market-growth-usd-124900548.html

10 Knowles, Kitty. "Fat Lama: The Airbnb For Renting Almost Anything' Raises $10 Million". Forbes. Retrieved October 24, 2022, from: https://www.forbes.com/sites/kittyknowles/2018/04/25/fat-lama-the-airbnb-for-renting-almost-anything-raises-10-million/?sh=35ff58adb7be.

11 U.S. Census Bureau, USA Trade Online. Port-Level Imports. Import value for Harmonized System code 85.

including the impact of emerging technologies, are **creating new demands on the workforce**, both regarding skills and capacity. This demand makes expanded and new workforce training and development programs critical.

NEARSHORING TRENDS IN MEXICO

The COVID-19 pandemic illustrated the fragility of complex supply global chains, encouraging some manufacturers to shift production closer to the U.S. market. Called "nearshoring," these relocations are defined as sourcing previously offshored manufacturing to a nearby country with lower costs.

Even before the COVID-19 pandemic, nearshoring was becoming more frequent because of:

- Opportunity to reduce transportation costs.
- Rising labor costs in China.
- Improved productivity in Mexico.
- Corporate goals to reduce greenhouse gas emissions.
- Loss or theft of intellectual property.
- Faster responses to market demands.
- Improved supply chain resilience.
- Greater control over supply chains.
- Better contact with sourcing partners.
- Reduced transportation time.
- Ease of business (e.g., language, time zone differences, etc.).

TxDOT's recently completed *Texas-Mexico Nearshoring Study* engaged more than 50 private and public sector stakeholders (mostly from Mexico). They helped identify a broad spectrum of industries attractive for nearshoring including:

- Computers and electronics.
- Machinery and equipment.
- Aviation and aerospace.
- Pharmaceuticals.
- Automotive.
- Furniture.
- Plastics.
- Textiles.

1.2.2 TECHNOLOGY ADOPTION

Technology adoptions are likely to impact the overall volumes of freight as well as types of movement. The impact on volumes will arise from consumers "trading-up" for the latest technology including connected and autonomous vehicles (CAV), electric bicycles, etc. The impact on the way goods move will arise from **technology solutions that optimize movements** and operations associated with existing assets and infrastructure. For example, advances in connected and autonomous vehicles can help to reduce crashes on the roadway network which, in turn, reduces congestion and travel delays. When collisions or crashes occur and impact roadway operation, technologies and tools such as the Internet-of-Things (IoT), data sharing and predictive analysis, can help divert traffic and find more reliable routes. Intelligent Transportation Systems (ITS) solutions can also help reduce traffic congestion.

The largest potential for decreases in vehicle miles traveled, while maintaining similar freight volumes, arises with emerging freight modes (e.g., drones) that can replace local delivery trucks. The Texas Department of Transportation (TxDOT) is also leading an effort on **Connected Freight Corridors that can leverage advances in sensors and data communication** to create a "smart" freight network that allows vehicles to communicate with one another and algorithmically minimize overall delay times and vehicle miles traveled.

TEXAS ENCOURAGES TESTING AND DEPLOYMENT OF AUTONOMOUS VEHICLES

- **Senate Bill 2205,** passed in 2017, allows for the commercial use and operation of any automated motor vehicle on public roads, provided the vehicle complies with all federal laws and requirements, is registered in the state, has proper insurance, and is equipped with a recording device for recording information that can be retrieved after a crash.
- **House Bill 1791,** passed in 2017, allows for use of a connected braking system between a lead and a following vehicle.
- **House Bill 3026,** passed in 2021, exempts AVs from certain motor vehicle equipment laws and regulations. The law provides that AVs are "designed to be operated exclusively by the automated driving system for all trips" and are exempt from motor vehicle equipment laws or regulations that relate to or support motor vehicle operation by a human driver that are irrelevant for an automated driving system (ADS).
- **Senate Bill 1308,** passed in 2021, called for a study to estimate the benefits and impacts of automated and connected driving systems on congestion at the Texas-Mexico border crossing, drive and public safety and transportation industry workforce.

1.2.3 AUTOMATED VEHICLES IN TEXAS

Over the past several years, Texas legislators have approved three bills that have helped expand the use of automated vehicles in the state and a fourth to estimate the benefits and impacts of CAV in Texas.

The **non-restrictive regulatory environment for automated vehicles** in Texas contributes to an atmosphere of robust testing, which is occurring in many forms. Texas is at the forefront of mobility innovation and operations and continues to be an example and early adopter of beneficial ADS/Connected Driving Systems (CDS) applications. TxDOT is currently home to about **40 different deployment demonstrations that include ADS/CDS applications** that range across a variety of vehicle types and applications. Major categories include freight-focused applications to add efficiency to long-haul trucking; last-mile delivery, transit, and rideshare applications to support urban mobility; and system communications enhancements to yield greater efficiency and safety from the transportation system.

1.2.4 ENERGY

The potential implications of energy policies and emerging energy trends for Texas include: increased focus on renewable energy transportation needs, diversified fuel infrastructure, and continued growth in natural gas products.

Texas Leads on Energy

According to the Energy Information Administration, in 2021 Texas was:

- #1 in the nation for wind energy production
- Top crude oil and natural gas producing state
- Leading the nation in net electricity generation

Source: USEIA, State Profile and Energy Estimates, May 2022.

Increased Focus on Renewable Energy Transport Needs. As U.S. energy and transportation policy continues to push toward carbon reduction, the transport needs of producing and consuming alternative fuel sources will become increasingly important. The production of renewable energy sources may have transport needs that require diverse types of investments. For example, wind turbines can exceed 260 feet in length requiring an oversize/overweight (OS/OW) truck trip to reach their final destination. As a result, an increase in wind energy capacity may require TxDOT to invest more resources in the state's ability to accommodate these loads, such as increased vertical clearances or rehabilitating bridges and pavements to handle heavier loads. The geography of energy production may also change, leading to changing modal and corridor demands.

Growth in renewable energy also has implications for non-renewable energy sources based on historical data. Specifically for Texas, coal's loss in market share is largely driven by increasing

wind energy capacity. As wind energy (as well as natural gas and solar) continues to grow as a source of electricity generation, there will be less demand for coal shipped by rail.

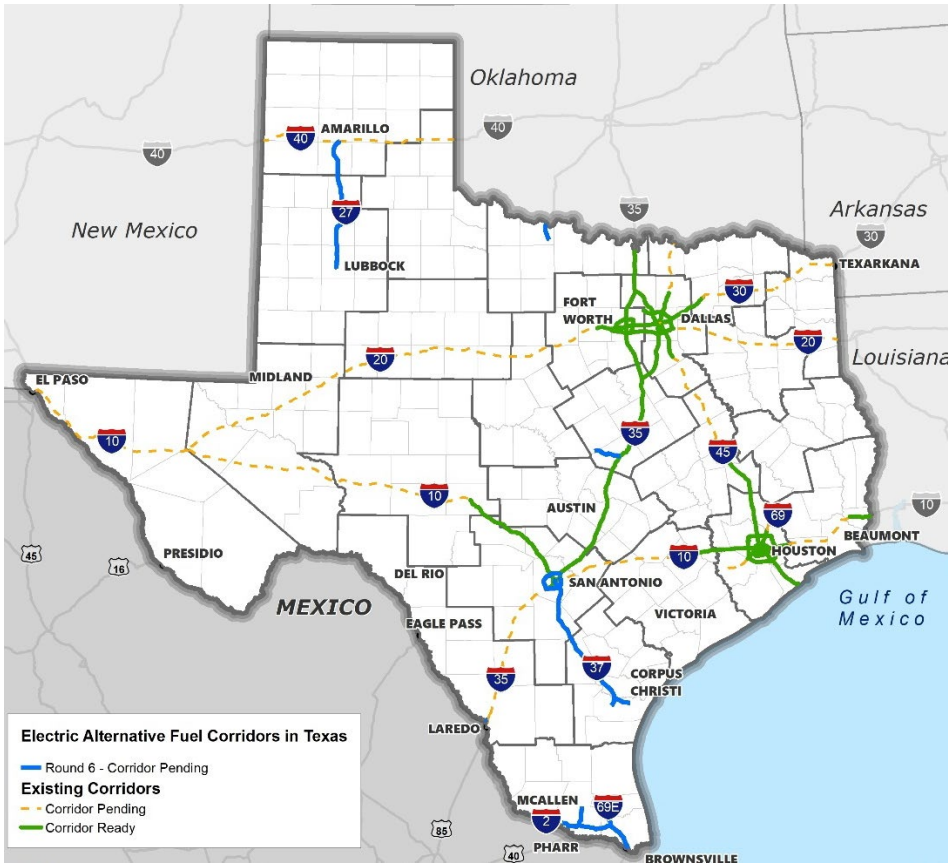
Diversified Fuel Infrastructure. Related to the push toward alternative fuels is the need for fueling infrastructure to support electric and alternative fuel vehicles. While at-home and fleet facility charging stations are a good starting point, alternative fuel availability such as hydrogen, biodiesel or electric charging located at public facilities and along major highway corridors is needed for broader market acceptance. Transportation of hydrogen and hydrogen carriers such as ammonia to supply infrastructure will also introduce increased freight flows related to alternative fuels. For state DOTs including Texas, this requires planning to estimate the potential demand for alternative fuels, identifying corridors on which they should be deployed and determining specific locations along those corridors for fueling stations.

The Texas Electric Vehicle Infrastructure Plan identified Electric Alternative Fuel Corridors in Texas for the deployment of charging infrastructure (**Exhibit 2**).[12] As battery-electric vehicles continue penetration of the transportation market, these corridors would provide the skeleton framework for deployment of electric charging stations as well as other zero-emissions or carbon-neutral fueling locations (e.g., hydrogen fuel cell).

Biodiesel and hydrogen fuel cell technology may be particularly important for truck, rail and maritime freight modes. Long-haul trucking is more difficult to electrify because of the distances traveled, unpredictability of duration and route and weight of batteries that impact the carrying capacity of trucks. In this context, hydrogen fuel cell technology could be more promising for meeting environmental goals, while supporting freight mobility.

[12] TxDOT. Texas Electric Vehicle Infrastructure Plan. July 8, 2022. https://ftp.txdot.gov/pub/txdot/get-involved/statewide/EV%20Charging%20Plan/TexasElectricVehicleChargingPlan.pdf.

EXHIBIT 2: ELECTRIC ALTERNATIVE FUEL CORRIDORS IN TEXAS



Source: Texas Electric Vehicle Infrastructure Plan, TxDOT, July 8, 2022.

Continued Growth in Natural Gas Production and Liquefied Natural Gas (LNG) Exports. Continued growth in Texas' natural gas production and exports has implications for future investments in domestic and export distribution capacity. Foreign demand for natural gas is met through LNG, which is exported by ship. The transportation implications for increased LNG demand are increased vessel calls to Gulf Coast ports and additional, or increased capacity, at LNG export facilities. Investments in LNG export facilities are already underway in Texas, with additional projects being considered.

While these trends present challenges to Texas, they also represent opportunities for enhancing goods movement in the state to better support economic competitiveness and efficient movement of freight on the Texas Multimodal Freight Network (TMFN).

1.2.5 INTERNATIONAL TRADE

As previously noted, **Texas is the top exporting state** for many key commodities, and its growing population makes it a key importing state for consumer goods. **The growing trend toward moving supply chains closer to the end users (reshoring and nearshoring) has the potential to change freight movements.** While this and other trends in international trade will impact future freight flows, the most significant is the United States-Mexico-Canada Agreement (USMCA). Provisions of the USMCA impact many of the key industry clusters in Texas including:

Source: Texas Comptroller of Public Accounts, 2020.

- **Automotive industry**—Key provisions of USMCA are anticipated to increase freight volume on the north/south interstate highways (I-35 and I-45) and the east/west interstate highways (I-10 and I-20). The continued growth of maquiladoras (factories in Mexico along the U.S. border) are continuing to drive international freight growth, especially in the automotive industry. Due to the binational nature of the automotive industry, truck tonnage of freight is also anticipated to increase at the border crossings in El Paso, Eagle Pass and Laredo. Both highway and rail access to Texas' major ports on the Gulf of Mexico are critical to automotive manufacturing processes as well. For example, the Port Freeport receives 7,000 vehicles per month from Mexico.[13]

- **Electronics industry**—Key provisions are anticipated to increase freight volume on the roadways serving the Texas Triangle given the concentration of the industry in this region. Due to the binational nature of the electronics industry, truck tonnage of freight is anticipated to increase at the border crossings in El Paso, Laredo and the Rio Grande Valley.

- **Agriculture and food manufacturing industries**—Key provisions are anticipated to increase freight volume on network facilities connecting the Panhandle, Texas Triangle and Gulf Coast to Texas-Mexico border crossings in El Paso and the Rio Grande Valley, including on the north/south interstate highways (I-27, I-35, I-37, I-45 and I-69) and Class I railroads serving the trade between the United States and Canada.

[13] Port Freeport.

1.2.6 DISRUPTIONS

Over the past few decades, Texas has experienced many disruptions through a wide variety of events including extreme weather, labor shortages, the COVID-19 pandemic, cyberattacks and infrastructure failures. These **disruptions bring a myriad of impacts to residents, businesses, the supply chains and the transportation system**. The changing impacts to the transportation system require additional coordination among infrastructure owners and transportation providers. Understanding the range of disruptions and their impacts is essential to ensuring the TMFN can support goods movement and resilient supply chains.

EXTREME WEATHER EVENTS

Extreme weather events can **disrupt travel, destroy communities and lead to tragic loss of life.** In addition, these weather events disrupt goods movement in Texas and more specifically going into and out of the impacted regions. Two recent events underscore the risk extreme weather can play. The winter storm of February 2021 saw energy infrastructure knocked offline, shortages in goods of all types and at least 246 fatalities. In August 2017, Hurricane Harvey dropped more than 60 inches of rain over parts of Southeast Texas, displacing 30,000 residents and inflicting an estimated $125 billion in damage.

These were high-profile events that will linger in the minds of policymakers and the public for years to come. In the aftermath of both, **distribution of critical goods was essential to mitigating loss of life and damage to communities.** The state's highways, railways, airports and

What's Going on with the Global Supply Chain?

There are several factors contributing to recent and in some cases ongoing supply chain disruptions and product shortages (though this may be beginning to shift). The most notable factor has been the surge in consumer demand for durable goods. Spending on services and activities such as travel, sporting events and concerts declined by 6.8% in 2020. At the same time, durable good purchases, such as home, gym and office furnishings and equipment; computers and desks for home schooling and offices; furniture; and fixtures for home expansions and outdoor recreational equipment increased by almost 12%. At the same time, demand was booming and a growing number of workers across all sectors were quitting their jobs, key manufacturing sourcing regions were shut down, equipment shortages, such as container chassis at container ports were prevalent and shortages increased in truck drivers and logistics and freight transportation labor.

Disruptions to the supply chain at the pandemic's onset continue to linger in some industries, such as computer chip manufacturing.

maritime infrastructure were all put to the test to transport food, medical equipment and construction materials to endure and recover from the severe weather. Awareness of the essential nature of the freight system is an opportunity for the state to make strategic investments in preparation for the next such event.

LABOR SHORTAGES

Supply chain vulnerabilities have persisted because of labor shortages since the height of the COVID-19 pandemic in 2020. Structural shifts in the labor market saw the **rise of the "Great Resignation" phenomenon**, early retirement among older workers, and companies competing for a shrinking pool of workers. Before the pandemic, the trucking industry was already facing a shortage of drivers; in 2019, the average age of the workforce was 46.[14] The labor shortage is now broadly affecting the freight transportation sector with **fewer workers** available to operate the nation's ports, cargo airports, warehouses, railroads and other logistical sectors. Delays affecting one part of the logistics chain can have a domino effect, increasing freight transit times and overall costs for businesses, industries and consumers. This accumulates into efficiency losses across the freight transportation system, affecting supply chains and the Texas economy.

While it is unclear when current general labor shortages will end, **a long-term shortage in the freight and logistics workforce makes the supply chain more fragile** in the face of increasing demand and could contribute to escalating prices of goods. However, there are technological opportunities that could help to assuage the decreased supply of labor. Automation within various supply chain functions could increase efficiency and reduce labor needs. Automated vehicle technology is unlikely to replace truck drivers entirely in the near future, but there are specific applications of the technology which may mitigate the impact of the driver shortage. Large vehicles operating on fixed guideways can be more easily automated than those driving in mixed traffic, which could reduce the need for commercial drivers in some instances (e.g., fixed guideway transit or industrial parks). Robotics and artificial intelligence could also offset some of the labor shortages in warehousing and manufacturing.

CYBERATTACKS AND INFRASTRUCTURE FAILURES

The opportunities of connected and autonomous vehicles (CAVs) and smart infrastructure also bring increased consequences in the event of a successful cyberattack. Freight systems that depend on computerized coordination to function could halt if hackers hold those computers hostage. Given the overall importance of freight transportation to businesses, this could be devastating to the Texas economy.

[14] American Trucking Associations. "ATA Releases Updated Driver Shortage Report and Forecast." https://www.trucking.org/news-insights/ata-releases-updated-driver-shortage-report-and-forecast.

However, the fact that this is a statewide vulnerability suggests a compelling motivation for a highly collaborative approach to resilience planning. Businesses, institutions, counties, municipalities and non-governmental organizations all have a stake in **emergency preparedness planning for what would happen in the case of a sophisticated cyberattack**. Redundancies in the system, walls of separation for critical functions and designing "graceful exits" in software (a concept where software that is disabled fails in a way to minimize disruption) are all opportunities for taking on this challenge.

GEOPOLITICAL CONFLICT

Texas supply chains are connected to global markets and can be impacted by geopolitical conflicts. Conflicts can be expressed through the exercise of **"soft power"** using trade sanctions and embargos to deter or punish the actions of certain countries and leaders. Geopolitical conflicts of a **military nature** include warfare between countries that affects individual nations as well as alliances and trade blocs. Both these types of conflicts can disrupt or shift the production and movement of key commodities and goods around the world. This requires supply chains to adapt by substituting suppliers and adjusting production and fulfillment based on changing marketing conditions driven by commodity prices and trade relations.

A recent example of geopolitical conflict affecting global freight and supply chains is the war between Ukraine and Russia. The current conflict started in February 2022 has **disrupted global supplies of natural gas and wheat.** The conflict will see a reordering of international trade that could create market opportunities for Texas producers to increase exports of LNG and agricultural products. This strategy would increase supply chain activity and the movement of freight across the different modes of the network. The supply chain disruptions in the U.S. resulting from the COVID-19 pandemic point to the **vulnerabilities of manufacturing** that relies on imports of hard to substitute components such as semiconductors. Some automakers in the U.S. have cut production because of the shortage. Should the conflict in the Taiwan Strait break into war between U.S. and China, manufacturing supply chains around the world, including Texas, would be **cut off from the vital supply** of semiconductors from Taiwan. The risk of losing access to semiconductors from Taiwan could further accelerate the nearshoring of chip fabrication and assembly facilities in North America. With advanced manufacturing well established in Texas, the state is poised to increase its share of the chip market.

This Chapter discussed the role of freight in supporting Texas' growing population and economy and provided a summary of the key trends impacting freight demand in Texas. Chapter 2 presents the Texas goods movement vision and presents an overview of Texas Delivers 2050.

Chapter 2 TxDOT's Multimodal Goods Movement and Supply Chain Vision

TxDOT has one of the most robust and well-funded freight planning programs in the nation. TxDOT developed Texas Freight Mobility Plans (TFMP) in 2016 and 2018. Texas Delivers 2050 represents the most recent iteration of the state's long range freight transportation plan. Not only does the plan ensure TxDOT meets federal requirements, but it also provides a comprehensive set of strategies and recommendations to ensure the state's economic competitiveness and reputation as a national freight and logistics hub is preserved and enhanced.

2.1 THE TEXAS GOODS MOVEMENT AND SUPPLY CHAIN VISION

TxDOT's mission statement highlights the core business of the organization, which is providing connectivity to all transportation users in the state, including freight. The vision statement states the purpose of TxDOT and the goals and objectives it aims to accomplish as a leader in transportation. Together, the statements serve as a north star that guides the development of Texas Delivers 2050. TxDOT's mission and vision and the TFMP complement each other by addressing freight needs within the context of the multimodal transportation system.

Highlights

Texas Delivers 2050 builds on the **success** of Texas' **state of practice freight** planning program.

Goals:

- ***Safety***
- ***Economic Competitiveness***
- ***Asset Preservation***
- ***Mobility and Reliability***
- ***Connectivity***
- ***Resiliency and Security***
- ***Equity***
- ***Stewardship***
- ***Sustainable Funding***

Texas Delivers 2050 was **stakeholder informed** throughout plan development, effectively engaging two critical vehicles – the **Texas Freight Advisory Committee** and the **Supply Chain Working Group.**

In keeping with the TxDOT mission of connecting people and commerce with Texas, the Texas goods movement and supply chain vision encompasses what TxDOT must do to connect shippers, carriers, businesses and consumers to goods and markets and to connect the various freight modes.

TxDOT Mission

Connecting you with Texas.

TxDOT Vision

A forward-thinking leader delivering mobility, enabling economic opportunity and enhancing quality of life for all Texans.

Texas Multimodal Goods Movement and Supply Chain Vision

A leader in delivering first-in-class multimodal goods movement to support Texas' growing population, economy and quality of life through supporting safe, secure and resilient supply chains and connecting Texas to the global trade market.

2.2 ADVANCING FREIGHT PLANNING IN TEXAS

Implementation of the 2018 TFMP

The 2018 TFMP has led to numerous implementation efforts, including a statewide truck parking plan and program, a weigh-in-motion strategic plan and program, a freight network technology and operations plan and freight infrastructure design considerations. In addition, 1,176 of the 2,377 freight projects on the Texas Highway Freight Network (THFN) included in the 2018 TFMP list (49%) were let for nearly $13 billion. 563 (24%) of these projects have been completed.

Source: TxDOT.

Texas Delivers 2050 builds on the success of the 2018 TFMP and advances the state of practice of freight planning by TxDOT. The most significant change in developing Texas Delivers 2050 was incorporating a **supply chain focused perspective**. Ongoing supply chain disruptions, originally resulting from the COVID-19 pandemic shutdown in 2020, continue due to a myriad of factors. These disruptions have made the average consumer more aware of the implications of global manufacturing and the importance of freight transportation. Doing a deep dive into the supply chains of Texas' key goods-producing and warehousing and distribution industries allows TxDOT to understand the role of the Texas Multimodal Freight Network (TMFN) and to understand the implications of disruptions to that network.

The numerous extreme weather events over the last several years underscore the importance of a resilient transportation network. The recent supply chain disruptions have only made **freight network resiliency** an even higher priority. Texas Delivers 2050 examines resiliency through a series of case studies covering a wide range of disruptions.

The movement and handling of freight is big business in Texas, and it is vital to keeping the economy running. Freight-intensive industries provide employment opportunities across a spectrum of skill levels. However, it can also lead to unintended consequences in the communities near and around major freight generators and the THFN. Examining ways to mitigate the negative impacts arising from freight transportation, such as the health impacts of increased emissions, noise, vibrations from heavy trucks and trains and occupied rail crossings is necessary to ensure **equity in freight planning**. Texas Delivers 2050 examines the exposure of vulnerable communities to freight transportation impacts and opportunities and puts forth recommendations for ensuring equitable solutions.

Advances in Texas Delivers 2050

- Convened a Supply Chain Working Group.
- Considered key industry clusters and supply chain perspectives.
- Addressed community impacts and equity.
- Conducted in-depth truck crash hotspot analysis.
- Enhanced commodity flow data to include hard-to-quantify commodities.
- Examined freight and supply chain resiliency.
- Focused on technology and operations.
- Advanced project prioritization.

2.3 PLAN GOALS AND OBJECTIVES

Goals and objectives are a crucial part of transportation plans for two reasons. First, they provide TxDOT with the opportunity to set high-level policy priorities at the beginning of the planning process. Second, goals and objectives are an element that coordinate across other TxDOT plans and regional plans. They are a way to connect short-range, long-range, modal and regional plans to ensure TxDOT internal policies and interests are aligned. Goals and objectives also help articulate how **TxDOT's freight planning efforts align with federal priorities outlined in the Infrastructure Investment and Jobs Act (IIJA) and prior transportation legislation to enhance reliability of freight transportation.**

Goals and objectives for Texas Delivers 2050 were developed based on two key inputs:

- Alignment with national freight goals and objectives, as well as TxDOT's vision, mission and other statewide transportation plans.
- Stakeholder input from virtual statewide workshops, the Supply Chain Working Group (SCWG) and the Texas Freight Advisory Committee (TxFAC).

In addition, the goals and objectives support TxDOT's priorities **including safety, equity, technology deployment and diversity**.

Safety — Improve the safety, efficiency and performance of the TMFN.

- Reduce traffic fatalities and serious injuries.
- Reduce crashes.
- Improve safety at rail crossings.

These proposed objectives align with existing plans and performance measures, while also focusing on two major freight-related safety issues: truck-involved crashes and at-grade rail crossing crashes.

Economic Competitiveness — Improve the performance of the TMFN to enhance the contribution of transportation infrastructure to economic competitiveness, productivity and development throughout the state.

- Support job growth and retention.
- Support manufacturing and research & development.
- Work with other state and local agencies to connect residents to freight employment opportunities.
- Identify critical freight infrastructure for the near-term and long-term.

These proposed objectives connect the priorities from the IIJA to the freight plan. They also provide priorities for agency work in prioritizing critical infrastructure.

Asset Preservation and Modernization — Maintain, preserve and modernize assets on the TMFN to support multimodal movement of goods and people.

- Maintenance and improvement of bridges.
- Maintenance and improvement of pavement.
- Modernize freight infrastructure to ensure it operates efficiently and will meet the needs of future freight movements.
- Innovative technologies and operational strategies including intelligent transportation systems, which improve the safety and efficiency of freight movement.

These proposed objectives align existing performance measures with the new freight plan, while also incorporating an objective that speaks to the federal priority of modernizing the existing infrastructure.

Mobility and Reliability — Reduce congestion and improve system efficiency and performance on the TMFN.

- Reduce congestion and delay.
- Improve travel time reliability.
- Improve cross-border travel time reliability.

These proposed objectives speak to regional issues, such as cross-border travel and efficient freight movements across the state and at ports.

Connectivity — Improve urban and rural system connectivity between all freight modes and all industry sectors to regional, statewide, national and international markets.

- Increase the number of intermodal connections and improve existing connections/hubs.
- Improve first- and last-mile connections between freight modes and freight generators.
- Maintain and improve access to critical regional, statewide and national freight facilities.

These proposed objectives tackle critical connections between freight modes and customers. They also incorporate federal priorities around supply chains and resiliency.

Resiliency and Security — Develop and maintain a resilient and secure multimodal system that can withstand and respond to various sources of disruptions including extreme weather and stormwater runoff and flooding.

- Maintain and improve multiple connections between freight hubs to ensure the system can operate efficiently.
- Strengthen and secure supply chains throughout Texas.

These proposed objectives tackle the importance of redundancies in the system to maintain a reliable freight network, and they incorporate federal priorities around supply chains.

Equity — Encourage equitable distribution of the positive and negative impacts of freight movement across all Texans.

- Minimize, mitigate or eliminate adverse impacts (e.g., emissions and wildlife habitat loss) from transportation projects on historically disadvantaged communities.
- Work with historically disadvantaged communities to encourage and increase access to economic opportunities within the freight and logistics sectors.

These proposed objectives call attention to the need for building consideration of equity impacts into all funding, project and policy decisions.

Stewardship — Manage environmental and agency resources responsibly, and foster accountability and transparency in decision-making.

- Build strategic projects that add capacity to the system in the right locations at the right time.
- Be accountable to customers and taxpayers and incorporate their feedback into policies, programs and projects.
- Strategically advance innovative transportation projects and policies to position Texas as a leader in energy, manufacturing and research and development.
- Partner with freight providers to support the opportunities for alternative fuels.
- Communicate information and provide intelligent transportation systems (ITS) solutions that continue to improve safety and facilitate the movement of goods and people.

These objectives speak to the need for TxDOT to be accountable to customers and taxpayers. Making strategic decisions regarding projects, risks and innovations is critical to maintaining a good reputation and preserving public confidence.

Sustainable Funding — Identify sustainable funding sources for all freight transportation modes.

- For capacity adding projects, conduct rigorous analysis to ensure that projects that get built have a significant return on investment.
- Document and prioritize funding needs for freight transportation in the near-term and long-term.
- Educate the public and stakeholders about transportation funding issues and the need for more sustainable funding sources.
- Partner with freight providers and operators to identify ways to jointly build and operate new infrastructure.
- Describe how the State will invest and match its National Highway Freight Program funds.
- Support policies that incentivize private sector investments.

These objectives call attention to the need for sustainable funding sources, the necessity of making good choices with limited funding and encourage partnerships with freight providers to build and operate projects. They also emphasize the need to continue educating the public on transportation funding.

2.4 INSIDE TEXAS DELIVERS 2050

Texas Delivers 2050 is a data-driven, stakeholder-informed plan led by TxDOT's Freight Systems Planning Branch in coordination with the Rail, Maritime and Aviation Divisions, TxDOT's 25 districts and the Transportation Planning and Programming (TPP) Division.

2.4.1 PLAN OVERVIEW

Data Impacts of the Pandemic

The pandemic was a massive disruption across sectors, processes, supply chains and general behaviors. To capture a concise representation of freight movement before these disruptions occurred, Texas Delivers 2050 uses 2019 as the base year.

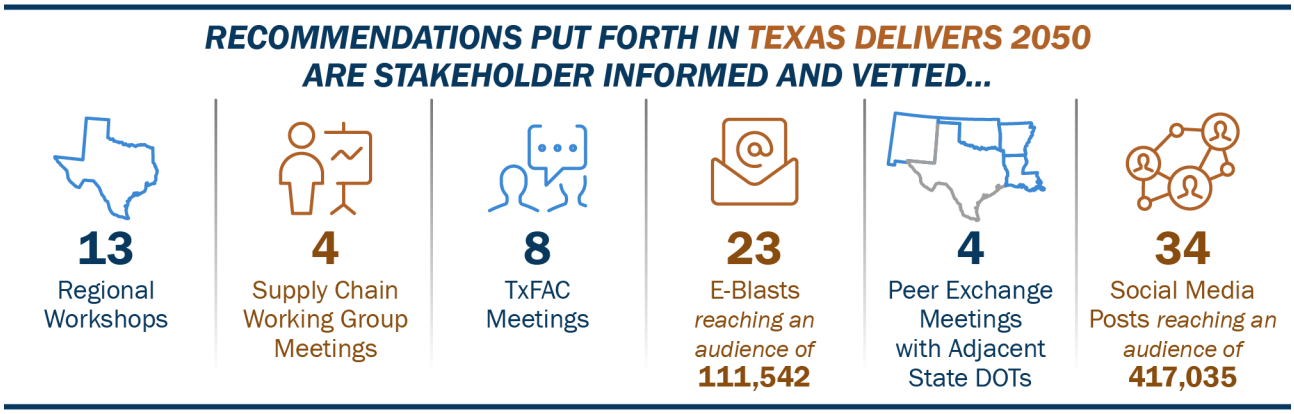
The development phase of the TFMP came during a time of great uncertainty. The United States and Texas were just coming out of the COVID-19 shutdown, supply chains were disrupted, the labor force was changing drastically and the IIJA was enacted. This required careful consideration of how relevant historical trends were relative to the "new normal."

The TFMP was developed through the lens of the supply chains for the state's most notable freight traffic-generating industries. Key industries for analysis in this plan were identified by the Governor's Office of Economic Development. The early tasks included data collection and analysis and evaluating previous plans and studies on relevant on-going planning efforts. Critical

supply chains were identified through the collection and analysis of data, combined with TxFAC and Supply Chain Working Group input. Once identified, the current and forecasted freight flows and the multimodal network carrying those flows were analyzed. The result was the identification of needs, challenges and opportunities. Strategies and recommendations to address the needs and leverage the opportunities were developed and tested with stakeholders.

2.4.2 A STAKEHOLDER-LED PLAN

Stakeholder input was critical throughout the update of the TFMP, but perhaps the most critical input was in key issues, project identification, and prioritization. **Fourteen virtual and in-person stakeholder workshops were held throughout the state** in November 2021 and May through June 2022. At these workshops, stakeholders provided input on key needs and issues. The needs identified ranged from general economic trends observed in regions and the state, as well as specific projects. In addition, stakeholders evaluated project prioritization criteria and were polled on the relative weights the criteria should have in terms of evaluating the impact of projects. Stakeholder input was instrumental in designating the TMFN, and identifying and prioritizing projects, programs, and policies to enhance freight mobility.



Source: TxDOT. Texas Delivers 2050.

FREIGHT STAKEHOLDER INPUT

Although freight stakeholder input was gathered throughout plan development, the two most critical vehicles for input were through the **Texas Freight Advisory Committee** and the **Supply Chain Working Group**. These groups include a cross-section of public and private sector stakeholders representing the state's most critical freight generation industries, freight modal asset owners and operators, key public agencies and economic development officials among others (see **Exhibit 3**).

EXHIBIT 3: TEXAS FREIGHT ADVISORY COMMITTEE AND SUPPLY CHAIN WORKING GROUP REPRESENTATION

Texas Freight Advisory Committee (TxFAC) Organizations		
AllianceTexas	Kirby Corporation	Rice University
BNSF Railway	Landgraf, Crutcher & Associates	Texas Association of Metropolitan Planning Organizations
Brogoitti Construction	Marathon Petroleum Company	Texas Farm Bureau
Coca Cola Southwest Beverages	McAllen Economic Development Corp.	Texas International Freight, LLC
Gulf Winds International	North American Strategy for Competitiveness	Texas Trucking Association
H-E-B	Governor's Office of Economic Development	The Lubrizol Corp.
IBC Bank	Port Houston	TNW Corporation
Killam Development, Ltd.	Port of Corpus Christi	Union Pacific

Supply Chain Working Group (SCWG) Organizations		
American Electric Power	Laredo Chamber of Commerce	Texas Citrus Mutual
Association of Logistics & Forwarding Agents	Laredo Economic Development Corporation	Texas Forestry Association
Atlas Sand	Laredo Licensed U.S. Customs Brokers Association, Inc.	Texas International Produce Association
Cargill	Laredo Motor Carriers Association	Texas Ports Association
City of Eagle Pass	PACCAR	The Friedkin Group
City of Laredo	Permian Basin Petroleum Association	Toyota Motors North America
Consulate General of Mexico	Phoenix Innovations and Recycling	Tyson Foods
Farmers Cooperative Compress	REMAX Commercial	United Corpus Christi Chamber of Commerce
Fasken Oil and Ranch	Samsung	US Auto Logistics
Kraus Development	SH 130 Concession Company	W.W. Rowland
Kroger	Texas Cattle Feeders Association	

Source: TxDOT.

The **TxFAC** is a body of 24 public and private sector leaders who advise TxDOT on freight issues in the state. The TxFAC met eight times during plan development to ensure that the goals, trends, projects and priorities reflect the challenges facing the state. The TxFAC helped identify critical multimodal freight infrastructure needs and provided input on strategic projects that addressed gaps where needs are not currently being addressed. Input was solicited directly from members including private freight infrastructure owners and operators such as railroads, ports, and airports to identify multimodal infrastructure projects under development on their assets, as well as those on the adjacent THFN.

The **Supply Chain Working Group (SCWG)** was comprised of representatives from the state's key industry clusters including the oil and gas sector, agriculture, advanced manufacturing, construction, and warehousing and distribution. In addition, membership included representation from the trucking, rail, air cargo, pipeline and port industries.

Engaging the both the TxFAC and the SCWG ensures that Texas Delivers 2050 puts forth a set of recommendations that strengthens Texas supply chains and encourages economic competitiveness, safety and security, and resiliency of the TMFN.

Chapter 2 presented the vision and goals of development of Texas Delivers 2050. Chapters 3 discusses the designation of the TMFN and the supply and demand for each mode.

Chapter 3 The Texas Multimodal Freight Network

A key outcome of Texas Delivers 2050 is the designation of the TMFN. The network consists of key roadways (the THFN), railroads, pipelines, ports and waterways, airports and international border crossings. The multimodal network outlines the key corridors that facilitate the efficient and safe movement of goods in Texas and are most critical for focusing investment. At the federal level, the National Multimodal Freight Network (NMFN) includes highways, railways, waterways and pipelines, ports, airports, border crossings and intermodal facilities.

This chapter summarizes the freight demand on Texas' multimodal system and discusses designation of the TMFN and the freight demand on that network.

3.1 DEMAND ON THE TEXAS MULTIMODAL FREIGHT NETWORK

Freight mobility requires a multimodal network that includes roadways, railroads, maritime ports and waterways, airports and pipelines. In Texas, freight mobility also requires efficient commercial international border ports of entry.

As stated previously, over 4 billion tons of freight were moved in Texas in 2019. **Trucks carried more freight than any other mode** in

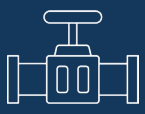
Highlights

Over **80,000** miles of TxDOT system roadways
- ► Over 23,000 miles on THFN
- ► 745 miles of Critical Rural Freight Corridors
- ► 372 miles of Critical Urban Freight Corridors

14,771 miles of railroad operated on the TMFN
- ► **3** Class I railroads
- ► 55 Class III or short line railroads

20 ports and the Gulf Intracoastal Waterway (GIWW) system
- ► **11** deep water ports | 9 on the TMFN
- ► 9 shallow draft ports | 1 on the TMFN
- ► 379 miles of GIWW |all on TMFN

24 commercial airports
- ► **10** cargo airports on TMFN



426,000 miles of pipeline
- ► 59% intrastate
- ► 41% interstate

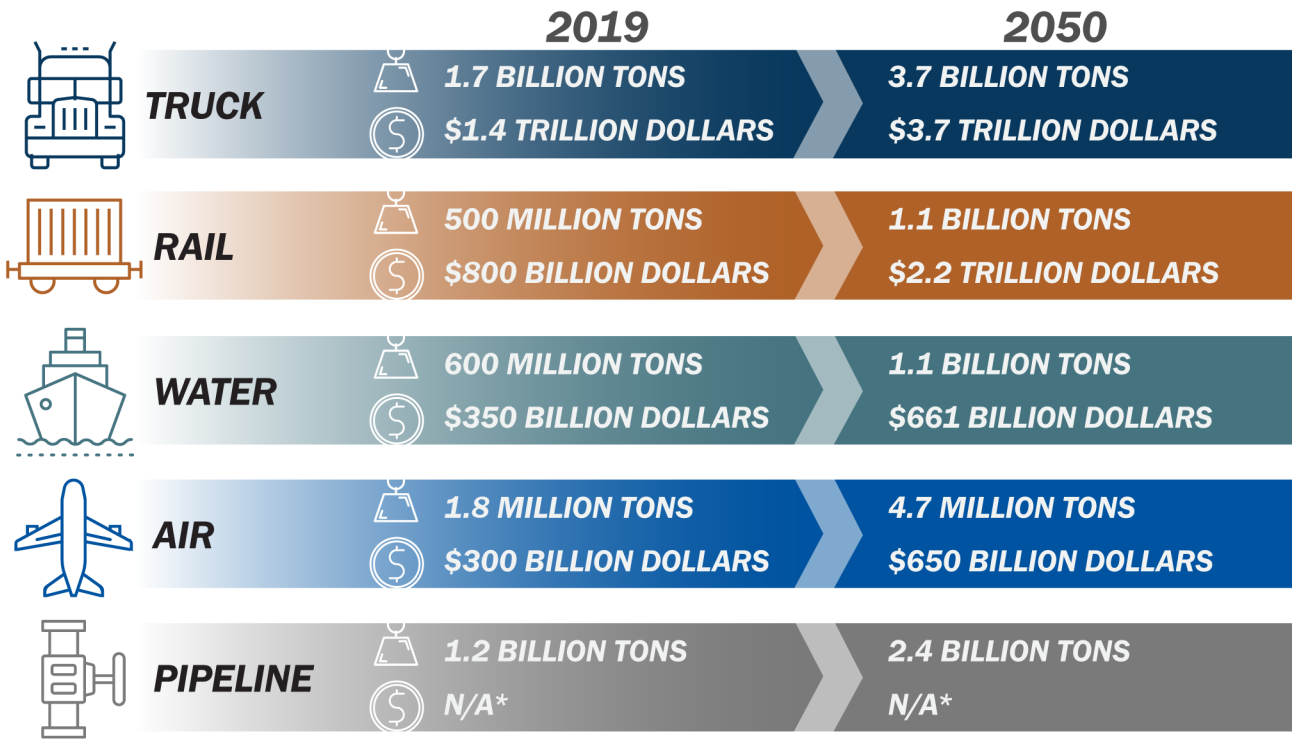
20 commercial international border crossings, all on the TMFN
- ► **15** commercial vehicle crossings
- ► 5 rail crossings

Source: TxDOT.

Texas, in terms of both tonnage and value in 2019 (1.7 billion tons or 43%), and the same is forecast to remain true in 2050 (3.7 billion tons or 45%). Pipeline is the second largest mode by weight, carrying 30% of freight by tonnage in Texas. Rail and water each carry between 10–15% of freight tonnage in both years, and air and other accounts for less than 1% of tonnage in both years, but almost 10% of value. The tonnage and value split for all modes and approximate totals for each are shown in **Exhibit 4.**

These industry-standard forecasts assume goods will generally move on the same modes in the future as they do today, and they do not take into account potential for mode shift due to cost, reliability, or policy changes. Owners and operators of freight infrastructure for all modes report preparing for more aggressive growth than forecasted in order to capture potential growth, mode shifts, or changing preferences.

EXHIBIT 4: TONNAGE BY MODE AND VALUE, 2019 AND 2050



* *Value information is not available for a large percentage of pipeline movements.*

Source: Transearch, FAF, Waybill, USA Trade Online, Enverus. Analysis by Cambridge Systematics.

Shippers will make modal decisions based on cost, shipping time, connectivity and reliability. The inventory, performance and conditions of the Texas multimodal transportation network impact all of these factors. The remainder of this chapter covers the inventory assets, while the condition and performance of the network are covered in **Chapters 5, 6 and 7**.

3.2 THE TEXAS HIGHWAY FREIGHT NETWORK

There are more than 80,700 centerline miles of state-maintained highways in Texas. The THFN is the portion of that network that is most critical to moving freight and supporting the state's key goods-producing industries and supply chains. The National Highway Freight Network (NHFN) is included in the THFN.

Facility Designations

Texas Highway Freight Network (THFN) is the freight highway network prioritized by the state for freight movements.

Texas Multimodal Freight Network (TMFN) consists of key highways, railroads, airports, pipelines, ports and waterways prioritized by the state for freight movements.

National Highway Freight Network (NHFN) is the nationally prioritized network for freight movements; all of the NHFN is included in the THFN.

Primary Highway Freight System (PHFS) is the network of highways within the NHFN most critical to U.S. freight movements.

Critical Rural/Urban Freight Corridor (CRFC/CUFC) are designations by the state of Texas for those critical freight routes on rural or urban corridors within the NHFN.

3.2.1 NATIONAL HIGHWAY FREIGHT NETWORK IN TEXAS

The NHFP is focused on improving the efficient movement of freight on the NHFN. The Fixing America's Surface Transportation (FAST) Act funded the NHFP at $1.49 billion in Fiscal Year (FY) 2021 under the extension of the FAST Act. The **IIJA authorizes $1.37 billion in FY2022 and $1.40 billion in FY2023.**[15] The FAST Act required the Federal Highway Administration (FHWA) to establish a NHFN which has been continued under the recent IIJA and is comprised of the following components:

- **Primary Highway Freight System (PHFS)** – The PHFS, as designated by FHWA, is a network of highways identified as the most critical highway portions of the U.S. freight transportation system. Texas' portion of the PHFS totals 3,727.77 miles.
- **Other Interstate portions not on the PHFS** – These highways consist of the remaining portion of interstate highways not included in the PHFS. These routes provide important continuity

[15] Federal Highway Administration, National Highway Freight Program. https://www.fhwa.dot.gov/bipartisan-infrastructure-law/nhfp.cfm

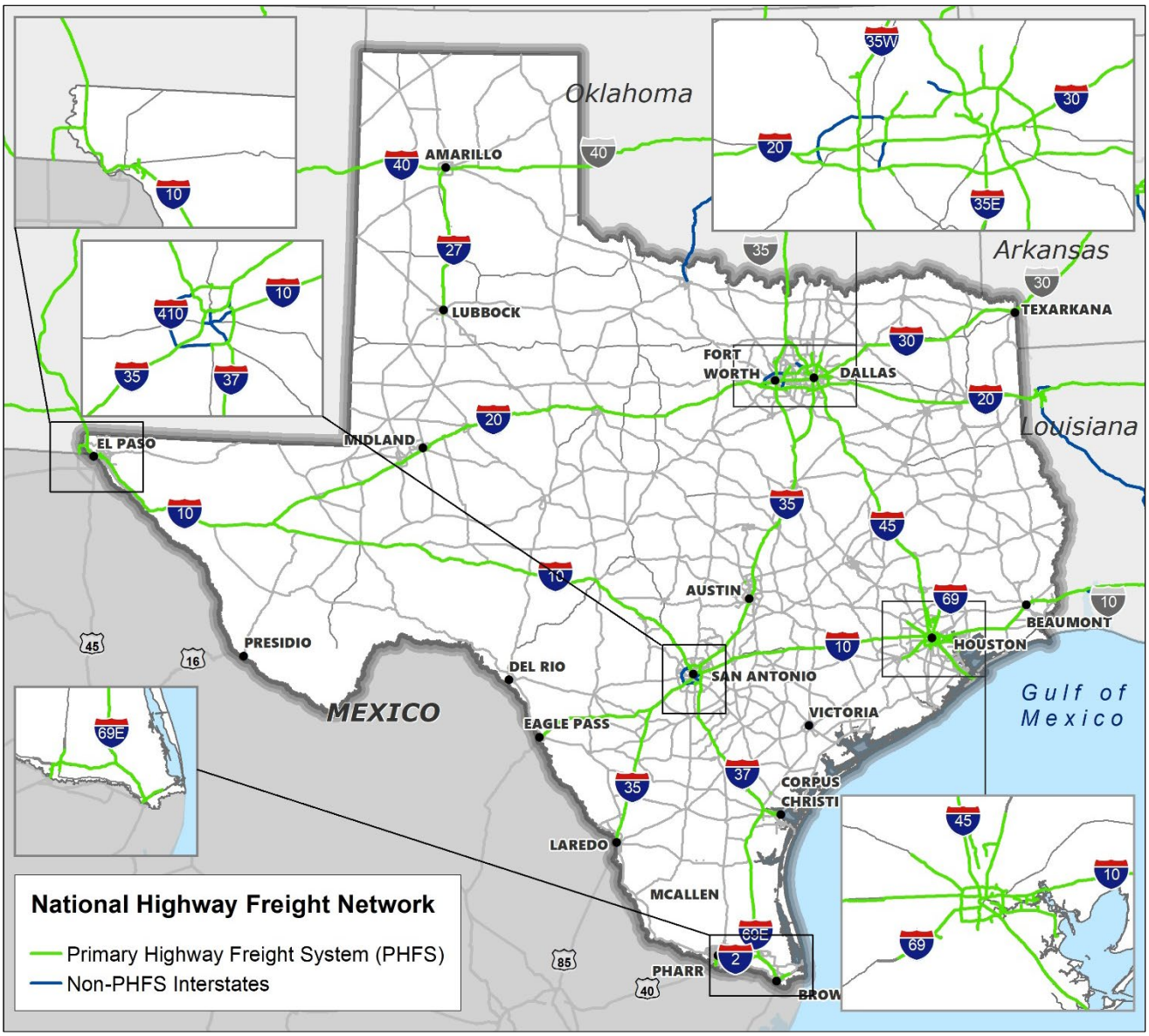
and access to freight transportation facilities. Texas has a total of 95 miles of non-PHFS Interstates.

- **Critical Urban/Critical Rural Freight Corridors** – These designations were created at the federal level to allow TxDOT and metropolitan planning organizations (MPOs) to add to the NHFN. CUFCs are determined by TxDOT in partnership with metropolitan planning organizations (MPOs), and CRFCs are designated by TxDOT. TxDOT is limited by federal law to approximately 745 miles of CRFC corridors and 382 miles of CUFC corridors. These locations must meet federal criteria and are submitted to FHWA to become eligible for NHFP funding.

The FAST Act restricts NHFP funding on non-PHFS interstates in states deemed high mileage states, defined as containing more than 2% of the national PHFS. Texas is a high mileage state, and thus, cannot use NHFP funding on non-PHFS interstate locations. **Exhibit 5** displays the PHFS and non-PHFS interstates on the NHFN in Texas.

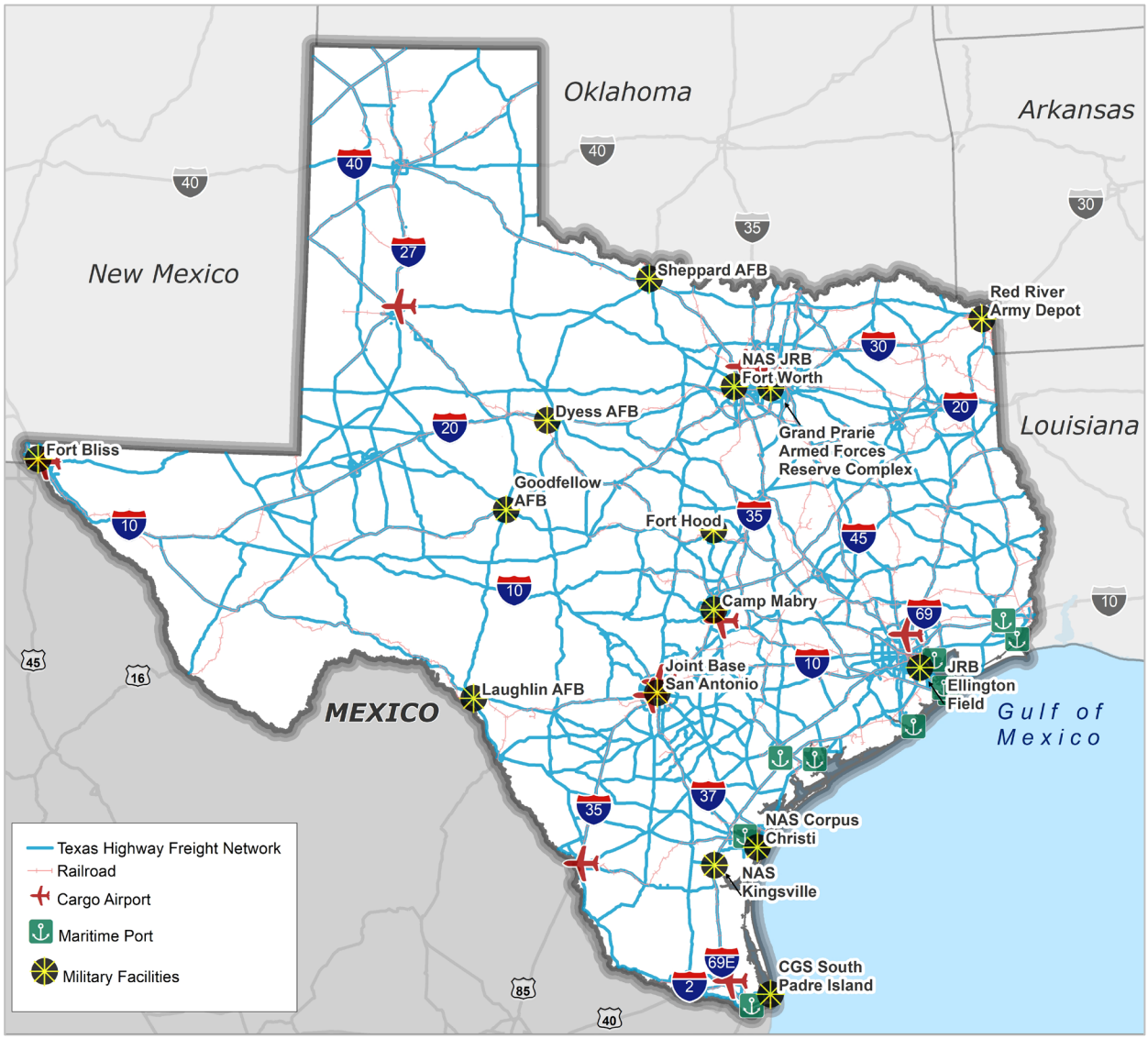
In addition to these national freight designations, the U.S. DOT has designated the Strategic Highway Network (STRAHNET) and Strategic Rail Corridor Network (STRACNET), which identify the highways and railroads most important for military transportation. In Texas, the STRAHNET consists of Interstate, Non-Interstate and STRAHNET Connectors, and the STRACNET includes all Class I railroads. Both the STRAHNET and STRACNET are part of the TMFN. **Exhibit 6** displays the locations of major military facilities in Texas in relation to the TMFN. Texas is home to almost 7% of the nation's STRAHNET and almost 10% of the STRACNET. In general, all military facilities in Texas are located near the THFN. To connect these facilities, the U.S. Military relies on the extensive road, rail, and pipeline networks that crisscross the U.S. In Texas, STRAHNET and STRACNET corridors ensure that primary deployment centers (Fort Bliss and Fort Hood) along with key military arsenals (namely Red River Army Depot) are connected to both the national distribution network and civilian ports.

EXHIBIT 5: NATIONAL HIGHWAY FREIGHT NETWORK IN TEXAS



Source: National Highway Freight Network, Federal Highway Administration.

EXHIBIT 6: TEXAS MILITARY FACILITIES AND THE TEXAS MULTIMODAL FREIGHT NETWORK



Source: TxDOT Transportation Planning and Programming Division.

3.2.2 DESIGNATING THE TEXAS HIGHWAY FREIGHT NETWORK

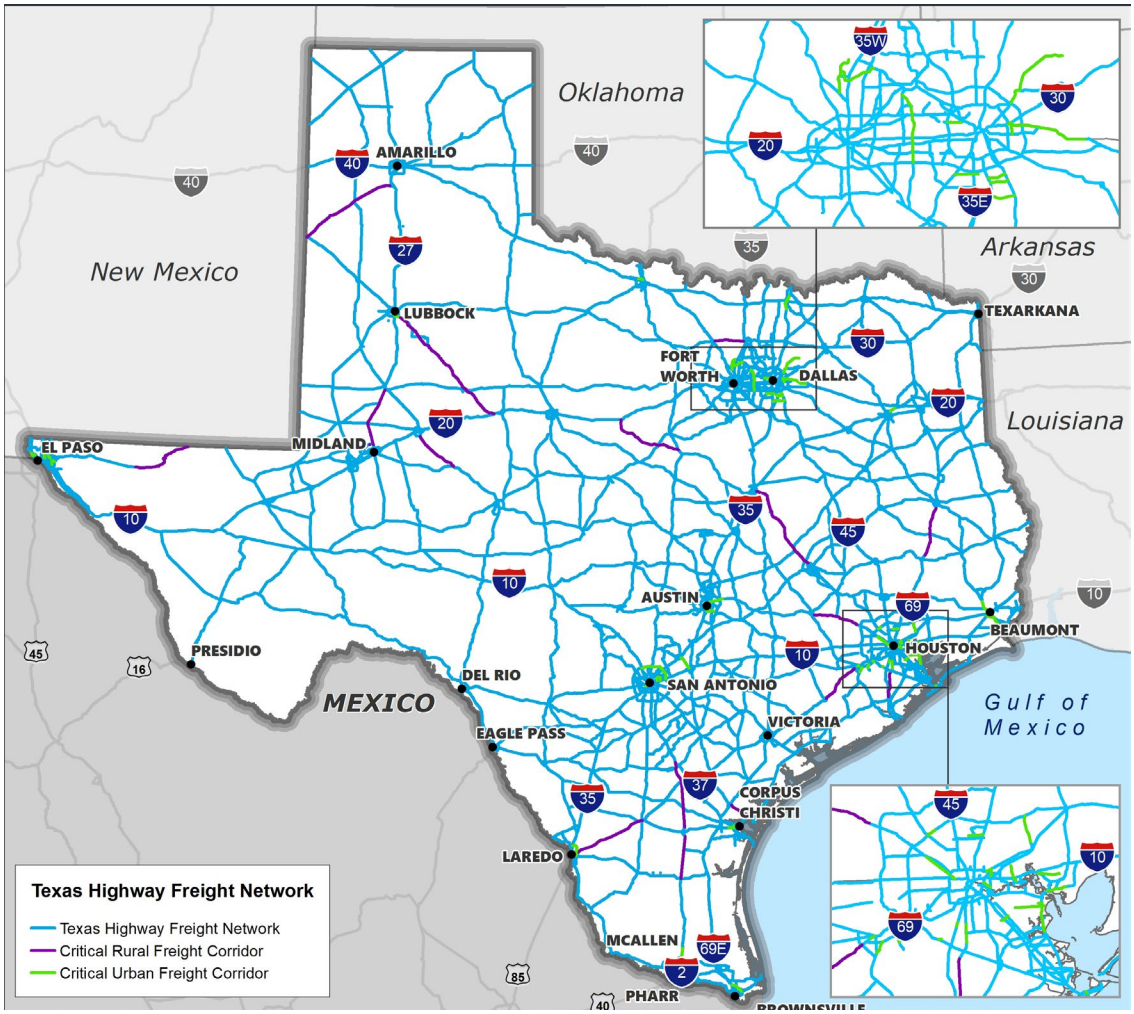
The designation of the THFN is based on a data-driven, stakeholder-informed process. The evaluation process scores every roadway network segment on the state-maintained system based on criteria measuring the role of the roadway in supporting four key factors: economic competitiveness, goods movement, strategic supply chain and market access and connectivity (**Exhibit 7**).

EXHIBIT 7: FOUR FACTORS OF THFN DESIGNATION PROCESS

The process uses multiple metrics for each factor. This is the data-driven part of the designation process. Stakeholders also provide input on the network, identifying important freight facilities the scoring process should include and suggesting facilities be removed if the scoring process overstated their importance or based it on community input.

The resulting designated network consists of over 23,300 miles, an increase of 1,500 miles since the 2018 TFMP. U.S. and State Highways in South and Central Texas were added because of the data-driven analysis. Stakeholders further recommended the addition of corridors linking urban and rural areas, predominantly State Highways located at the periphery of Dallas-Fort Worth; in the Permian Basin; west of Waco; and north of Amarillo. **Exhibit 8** displays the THFN, including the CRFCs and CUFCs described above.

EXHIBIT 8: TEXAS DELIVERS 2050 TEXAS HIGHWAY FREIGHT NETWORK



Source: TxDOT, 2022.

3.2.3 DEMAND FOR HIGHWAY FREIGHT IN TEXAS

The vast highway network in Texas and throughout the nation provides more access and flexibility than any other mode. As a result of this public investment in infrastructure, **trucking is the dominant freight mode in Texas, in terms of both tonnage and value.** Highways provide first-and-last mile connections to and from intermodal terminals, warehouses and customers. Trucking also is cost-competitive

Freight Value Matters

Advanced manufacturing is among the key sectors in Texas that produce commodities and goods high in the value chain. Transportation delays and bottlenecks impacting high-value freight can lead to greater costs and losses in productivity throughout the economy. Therefore, an efficient and safe multimodal freight system enables industries to better compete in the global marketplace and contribute to the vibrant Texas economy.

and flexible over long-haul distances, moving freight cross-country and internationally. Intermediate distance truck trips support regional economies, connect rural and urban areas and reach nearby markets.

Texas highways moved an estimated 1.7 billion tons of freight valued at $1.4 trillion in 2019, a 28% increase in tonnage from 2014. By 2050, highway freight is forecast to grow to 3.7 billion tons valued at $3.7 trillion. **Exhibit 9** highlights major commodity movements by highway tonnage and value in 2019. Secondary traffic consists of movements of consumer goods between warehouse and distribution centers.

EXHIBIT 9: TOP FIVE TONNAGE AND VALUE HIGHWAY FLOWS BY COMMODITY, 2019

Top 5 Highway Flows by Tonnage (in thousands), 2019		Top 5 Highway Flows by Value (in millions), 2019	
Commodity	**Tonnage**	**Commodity**	**Value**
Nonmetallic Minerals	396,910	Secondary Traffic	$238,280
Wastewater	342,680	Machinery	$163,970
Petroleum or Coal Products	217,580	Transportation Equipment	$158,580
Clay, Concrete, Glass or Stone	127,040	Electrical Equipment	$123,920
Secondary Traffic	106,950	Food or Kindred Products	$114,650
Subtotal for Top 5	**1,191,160**	**Subtotal for Top 5**	**$799,400**
Total Tonnage	**1,737,813**	**Total Value**	**$1,401,890**

Source: Transearch 2019-2050, modified by Cambridge Systematics.

3.3 FREIGHT RAIL NETWORK IN TEXAS

Most of the rail infrastructure in Texas is owned and operated by three private sector Class I railroads: BNSF Railway (BNSF), Kansas City Southern Railway (KCS) and the Union Pacific Railroad (UP). UP operates the most miles of track (6,307) in Texas, while BNSF operates the second highest miles of track (4,984). KCS operates 929 track-miles within Texas. As described above in Section 3.2.1, all of the Class I railroads are part of the STRACNET, the national network of rail corridors most important for defense.

The Surface Transportation Board (STB) classifies rail carriers as Class I, Class II and Class III, separated by annual operating revenues. Class I carrier operating revenues must be greater than $900 million annually, while Class II carrier operating revenues are between $40.4 million and $900 million annually. Class III carriers have annual operating revenues below $40.4 million.

While Class I railroads make up most of the rail infrastructure in Texas, short line railroads (Class III) make up 12% of the rail network. Short lines provide critical first-mile/last-mile connections for shippers and are crucial links in the supply chain. As the first and last mile of the shipment, short lines provide flexibility and responsiveness to shippers, especially in rural Texas where access to the rail network provides a vital transportation link and limits pressure on the highway system.

Freight railroads are a capital-intensive industry. According to the American Association of Railroads, on average, freight railroads spend six times more on capital expenditures as a percentage of revenue than the average U.S. manufacturer.[16] The Class I railroads in Texas made substantial capital investments in 2021:[17]

- BNSF invested $205 million in Texas of an overall systemwide investment of $2.97 billion.
- KCS invested $156 million in Texas of an overall systemwide investment of $380 million.
- UP invested $647 million in Texas of an overall systemwide investment of $3.3 billion.

The American Short Line and Regional Railroad Association reports that most short lines invest a minimum of 25% of their annual revenues in rehabilitation and maintenance.[18] In Texas, the short lines report that additional capital investment beyond required maintenance is a challenge because of constrained budgets.

16 Association of American Railroads. “Freight Rail’s Investments Generate Huge Returns for America”. Available at: https://www.aar.org/article/freight-rails-private-investments/

17 Investment figures provided to TxDOT by the railroad companies.

18 American Short Line and Regional Railroad Association. About Us, Industry Facts. Available at: https://www.aslrra.org/about-us/industry-facts/

3.3.1 FREIGHT RAIL ASSETS IN TEXAS

Exhibit 10 depicts the Class I and Class III railroads operating throughout Texas. These include railroads leading into international rail crossings. Currently, there are no Class II operators in Texas. According to information included in the Texas Rail Plan, the existing major rail freight system consists of the Class I and Class III mileages shown at right.

Class I Rail Statistics:

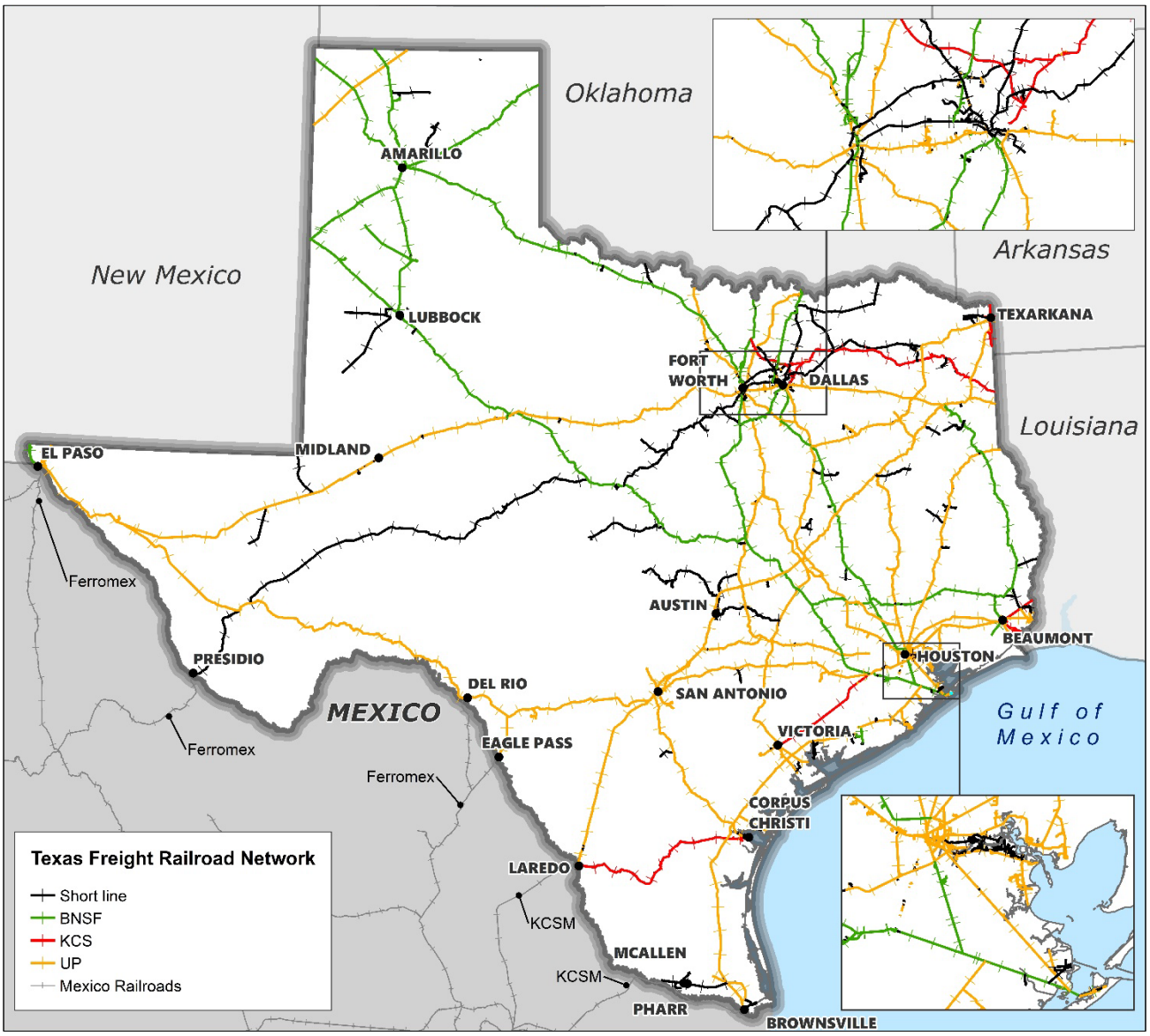
- Three Class I Railroads
- 8,396 Total Miles Owned
- 12,221 Total Miles Operated

Class III Rail Statistics:

- Fifty-five Class III Railroads
- 1,148 Total Miles Owned
- 2,550 Total Miles Operated

Source: Texas Rail Plan, 2019.

EXHIBIT 10: TEXAS FREIGHT RAILROAD NETWORK



Source: National Transportation Atlas Database, TxDOT Transportation Planning and Programming Division.

Railroads Use Trackage Right Agreements to Access Key Facilities

While **Exhibit 10** shows railroad ownership in Texas, there are trackage right agreements in place that provide some railroads with access to facilities and gateways along infrastructure owned by other railroads. Examples include trackage rights through the Houston rail network or "complex" where BNSF, KCS, and UP operate on track other than their own.

Reconstruction of the South Orient Railroad (SORR) and Presidio International Rail Bridge

Texas Pacifico Transportation (TXPF) implemented a large capital improvement plan to rehabilitate and upgrade the state-owned facilities on the SORR. TXPF recently completed $110 million in upgrades, including construction of the new international rail bridge in Presidio. An additional $40 million is planned in improvements. TxDOT and the Federal Railroad Administration (FRA) contributed additional funds and resources to improve grade crossings, ties and bridges in Presidio County.

Source: 2021 Annual Report South Orient Rail Line. TxDOT Rail Division. October 2021.

3.3.2 FREIGHT RAIL DEMAND IN TEXAS

Rail transported 486 million tons worth $850 billion in Texas in 2019 and is projected to grow to more than one billion tons by 2050. Major commodities transported by rail include chemicals and allied products, nonmetallic minerals, coal, miscellaneous mixed shipments, and farm products (**Exhibit 11**). The most rapidly growing commodity groups as a percentage of 2019 tons include shipping containers, apparel or related products, textile mill products, chemicals or allied products and food or kindred products. Coal, the third highest commodity by tonnage in 2019, is forecast to decrease by 87% by 2050, in part due to the availability of other electricity generating fuels such as natural gas, solar and wind.

EXHIBIT 11: TOP FIVE TONNAGE AND VALUE FORECAST BY COMMODITY, 2019

Top 5 Rail Flows by Tonnage (in thousands), 2019		Top 5 Rail Flows by Value (in millions), 2019	
Commodity	**Tonnage**	**Commodity**	**Value**
Chemicals or Allied Products	92,500	Misc. Mixed Shipments	$256,769
Nonmetallic Minerals	55,863	Transportation Equipment	$198,639
Coal	52,427	Chemicals or Allied Products	$149,179
Misc. Mixed Shipments	50,434	Small Packaged Freight Shipments	$55,464
Farm Products	49,865	Food or Kindred Products	$38,375
Subtotal for Top 5	**301,089**	**Subtotal for Top 5**	**$698,426**
Total Tonnage	**485,711**	**Total Value**	**$849,978**

Source: Transearch with Waybill 2019-2050

3.4 MARITIME AND WATERWAY NETWORK IN TEXAS

Texas ports and waterways handle a large and growing share of total U.S. waterborne freight cargo. With the largest port system in the Gulf of Mexico, **Texas handled more waterborne tonnage than any other state in the country: more than 590 million tons of foreign and domestic cargo in 2019**. [19] Most of this freight is also transported by truck, rail or pipeline at some point in time. As such, the state's ports and waterways play a large part in the Texas economy and throughout the U.S. — generating close to $450 billion in total economic value to Texas and contributing 25% of the state's GSP.[20]

Ports included in the TMFN are those with two million or more short tons of cargo annually, aligned with federal criteria for inclusion on the NMFN. It should be noted that a number of additional Texas ports do not meet the 2-million-ton threshold for inclusion in the TMFN, but handle significant tonnage important for manufacturing, energy and agricultural users. Three ports are also strategic military ports identified by the U.S. DOT Maritime Administration: Beaumont, Corpus Christi, and Port Arthur.

Seven Texas ports handled at least 10 million tons of cargo annually as of 2019: Houston, Corpus Christi, Beaumont, Texas City, Port Arthur, Freeport and Galveston. This qualifies those ports as designated High Use Harbors under the Water Resources Reform and Development Act of 2014 (WRRDA). WRRDA authorizes federal spending to improve critical U.S. waterway infrastructure

Waterways are also part of the TMFN and are critical for providing maritime access to Texas ports and port ship channels off of the Gulf of Mexico. The primary shallow draft waterway in Texas is the Gulf Intracoastal Waterway (GIWW) which runs the length of the Gulf of Mexico from Texas to Florida and serves as a vital inland waterway for freight barge transportation. The entire length of the GIWW is designated as Marine Highway 10 (M-10). In 2016, the U.S. Department of Transportation (USDOT) added a dual designation within Texas: M-69.[21] The main channel of the GIWW in Texas is 379 miles from Brownsville near the border with Mexico to the Sabine River at the Texas-Louisiana border. **Exhibit 12** displays the GIWW (M-10/M-69) with the 10 ports on the TMFN.

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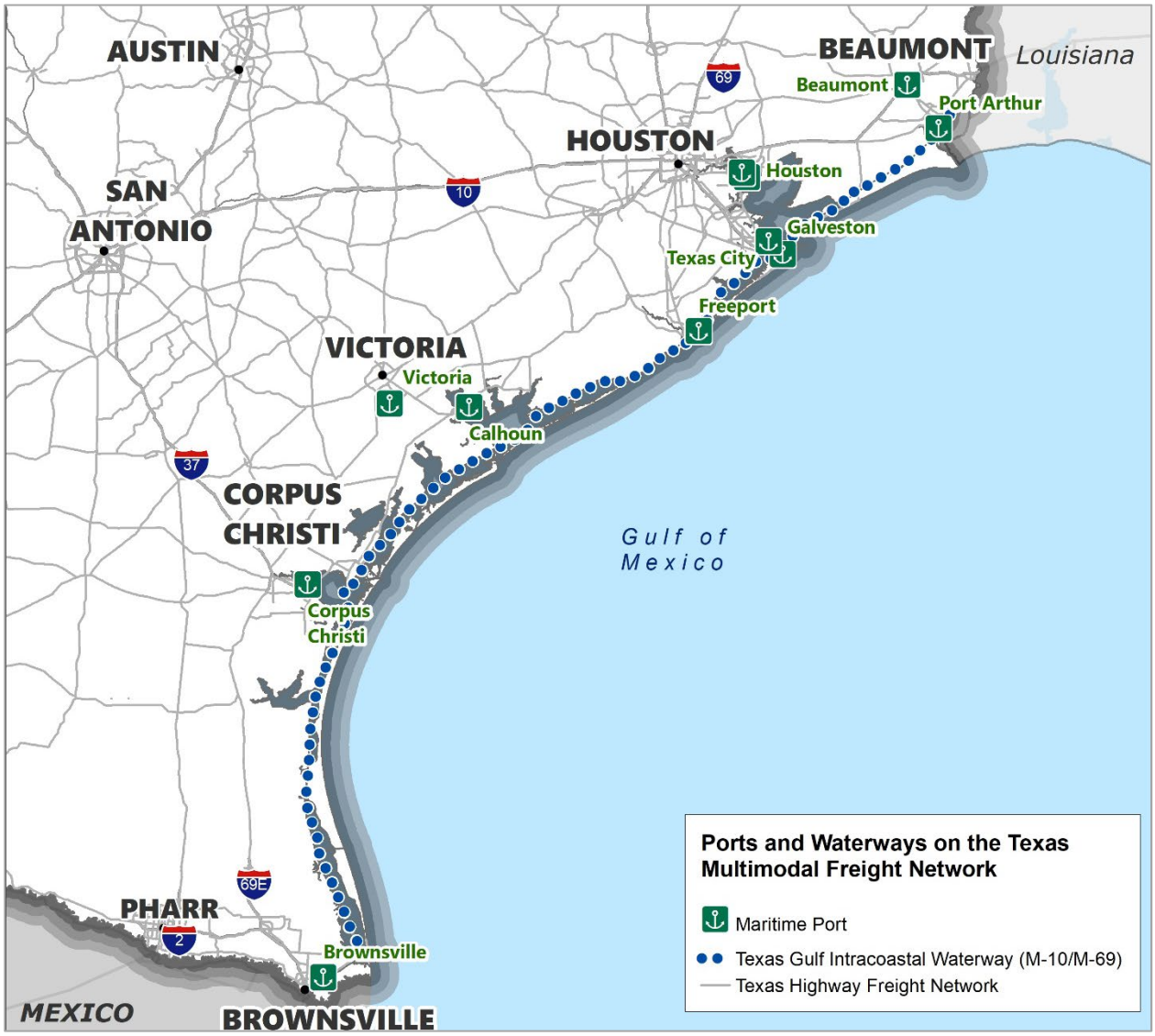
19 USACE. Waterborne Commerce Statistics Center: CY 2019 Waterborne Tonnage by State (In Units of 1000 Tons). Available at: https://usace.contentdm.oclc.org/digital/collection/p16021coll2/id/6753

20 Texas Ports Association. Economic Impact of the Texas Ports on the State of Texas and the United States, 2018. Available at: https://www.texasports.org/wp-content/uploads/2020/10/NationalEconomicImpactoftheTexasPorts-2018-7-25-2019.pdf

21 TxDOT. Statewide News. "Texas' Intracoastal Waterway Wins Marine Highway Status", June 8, 2016. https://www.txdot.gov/about/newsroom/statewide/2016/018-2016.html.

EXHIBIT 12: PORTS AND WATERWAYS ON THE TEXAS MULTIMODAL FREIGHT NETWORK



Source: TxDOT Transportation Planning and Programming Division.

3.4.1 DEMAND FOR MARITIME FREIGHT IN TEXAS

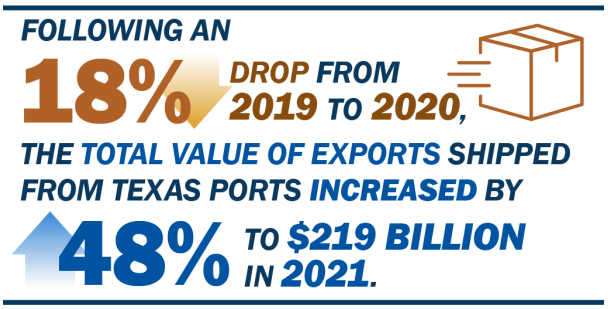
Among the 10 ports on the TMFN, seven ports rank in the top 50 in the United States in terms of total tonnage. Port Houston handled the most volume of all Texas and U.S. ports with over 284 million tons in 2019. Overall, foreign tonnage handled by the top 10 ports in Texas represented 71% of the total compared to 29% for domestic tonnage (**Exhibit 13**).

EXHIBIT 13: WATERBORNE TONNAGE, PORTS—TEXAS MULTIMODAL FREIGHT NETWORK, 2019

Port/City Name	Total Tonnage	U.S. Total Ranking	Foreign Tonnage	Domestic Tonnage
Houston	284,944,468	1	209,751,223	75,193,245
Corpus Christi	111,223,976	4	85,439,257	25,784,719
Beaumont	101,089,801	5	64,176,881	36,912,920
Texas City	41,338,934	16	24,637,039	16,701,895
Port Arthur	33,943,782	19	22,674,154	11,269,628
Freeport	29,844,416	23	25,971,619	3,872,797
Galveston	10,958,425	47	6,070,169	4,888,256
Brownsville	6,632,612	68	3,939,985	2,692,627
Calhoun Port Authority	5,220,760	76	2,203,654	3,017,106
Victoria	2,672,649	102	0	2,672,649
Total	**627,869,823**	**N/A**	**444,863,981**	**183,005,842**

Note: (1) The total shown for the top 10 ports is reported in port tonnage per U.S. Army Corps of Engineers (USACE). (2) Texas has seven ports that exceed 10 million tons annually, which qualifies these ports as designated High Use Harbors under the WRRDA; the WRRDA authorizes federal spending on critical waterway projects.

Source: USACE. Waterborne Commerce Statistics Center: CY 2019 Waterborne Tonnage by State (In Units of 1000 Tons). Available at: https://usace.contentdm.oclc.org/digital/collection/p16021coll2/id/6753



Source: U.S. Census Bureau. USA Trade® Online, HS Port-level data. https://usatrade.census.gov/.

Crude petroleum and refined petroleum products (principally fuels) have been the top two commodity groups at Texas ports by tonnage for many years, representing over 70% of total volumes from 2015 through 2019.[22] Energy products refined and exported from the Texas Gulf Coast have continued to diversify with the approval and construction of liquefied natural gas (LNG) plants. These plants require significant landside freight access during construction for workers and materials, and transition to primarily pipeline and maritime modes once operational. Once operational, LNG facilities result in significant liquid cargo flows transported by water modes. Waterborne exports of energy products are expected to continue to grow rapidly as more plants are approved and constructed.

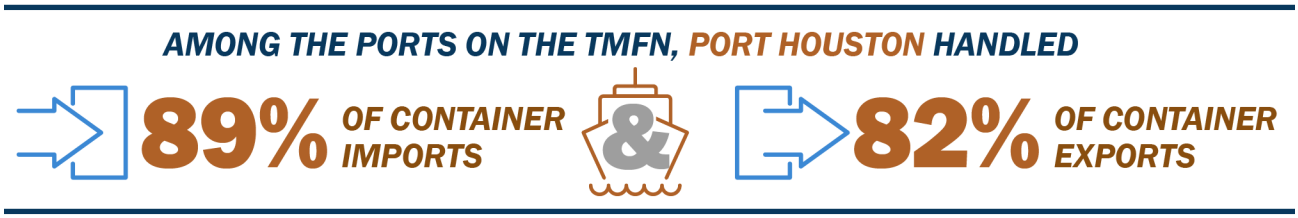
22 USACE. Waterborne Commerce of the United States: Manuscript cargo and trips data files, statistics on foreign and domestic waterborne commerce move on the United States waters (2000-2020). Available at: https://usace.contentdm.oclc.org/digital/collection/p16021coll2/id/1794/rec/1

3.4.2 CONTAINER IMPORTS AND EXPORTS

Three major points characterize container trade at Texas ports. First, given the dominance of crude oil and petroleum products in Texas' foreign waterborne trade, containerized trade comprises a smaller portion of Texas' total trade tonnage than the U.S. average. For imports, containerized tons represented almost 30% of total U.S. waterborne tonnage in 2019, while the share in Texas was 12%. For exports, containerized tons represented 17% of total U.S. waterborne tons, while the Texas share was 6%.[23]

The second feature is that Texas' container trade balance is fluid. In 2019, Texas container exports significantly outweighed container imports, reflecting Texas' role as a major manufacturing exporter. Texas' share of import container tonnage was 7% of the U.S. total during the 2015 to 2020 period. In contrast, Texas' share of U.S. containerized export tonnage was 15% in 2019.This trend began to shift in 2020. Since the start of the COVID pandemic, imports have increased to record levels as shippers seek alternatives to bottlenecks at West Coast ports. This has resulted in more balanced trade flows.

The third key point is that Port Houston is the predominant Texas container port for both imports and exports, handling the most tonnage for Texas and the U.S. From 2015 to 2020, Houston's containerized import volumes increased by 25% and export volumes by 36%.[24]



Source: U.S. Census Bureau. U.S. International Trade Data: USA Trade Online.

3.5 AIR CARGO IN TEXAS

Texas has one of the largest state airport systems in the United States with nearly 400 public use airports and 24 commercial service airports. Five of the top 50 cargo airports in the United States (by total landed weight) in 2019 are in Texas.[25] Although air cargo carried less than 1% of the freight in Texas by tonnage in 2019, air cargo provides an important service for time-

23 U.S. Census Bureau. U.S International Trade Data: USA Trade Online. Retrieved March 4, 2022, from https://www.census.gov/foreign-trade/data/index.html

24 Ibid.

25 FAA. (2022, January 11). Passenger Boarding (Enplanement) and All-Cargo Data for U.S. Airports. Retrieved January 20, 2022, from https://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/

sensitive goods. Major cargo airports are generally located within or near major metropolitan areas, as they provide the most efficient access to markets.

Air cargo encompasses the smallest amount of freight by volume as it typically consists of lightweight, time-sensitive, and high-value items. A recent example of such a commodity was COVID-19 vaccines and tests. Air freight includes perishables (fish and produce), electronics, automotive parts, pharmaceuticals and medical supplies. Costs of shipping by air exceed those of other modes, but the overall value per ton of goods is much higher, mitigating to some degree the financial impact to shippers. Air cargo is increasingly used for e-commerce shipments, because of changing consumer shopping habits, in part because of restrictions imposed at the beginning of the COVID-19 pandemic and estimates suggest the pandemic may have accelerated e-commerce growth by as much as five years.[26] There have also been instances of companies using air cargo as a method of bypassing or avoiding congestion at ports. Texas, especially Houston's airports ship specialty equipment worldwide by air, mostly for the oil and gas industry.

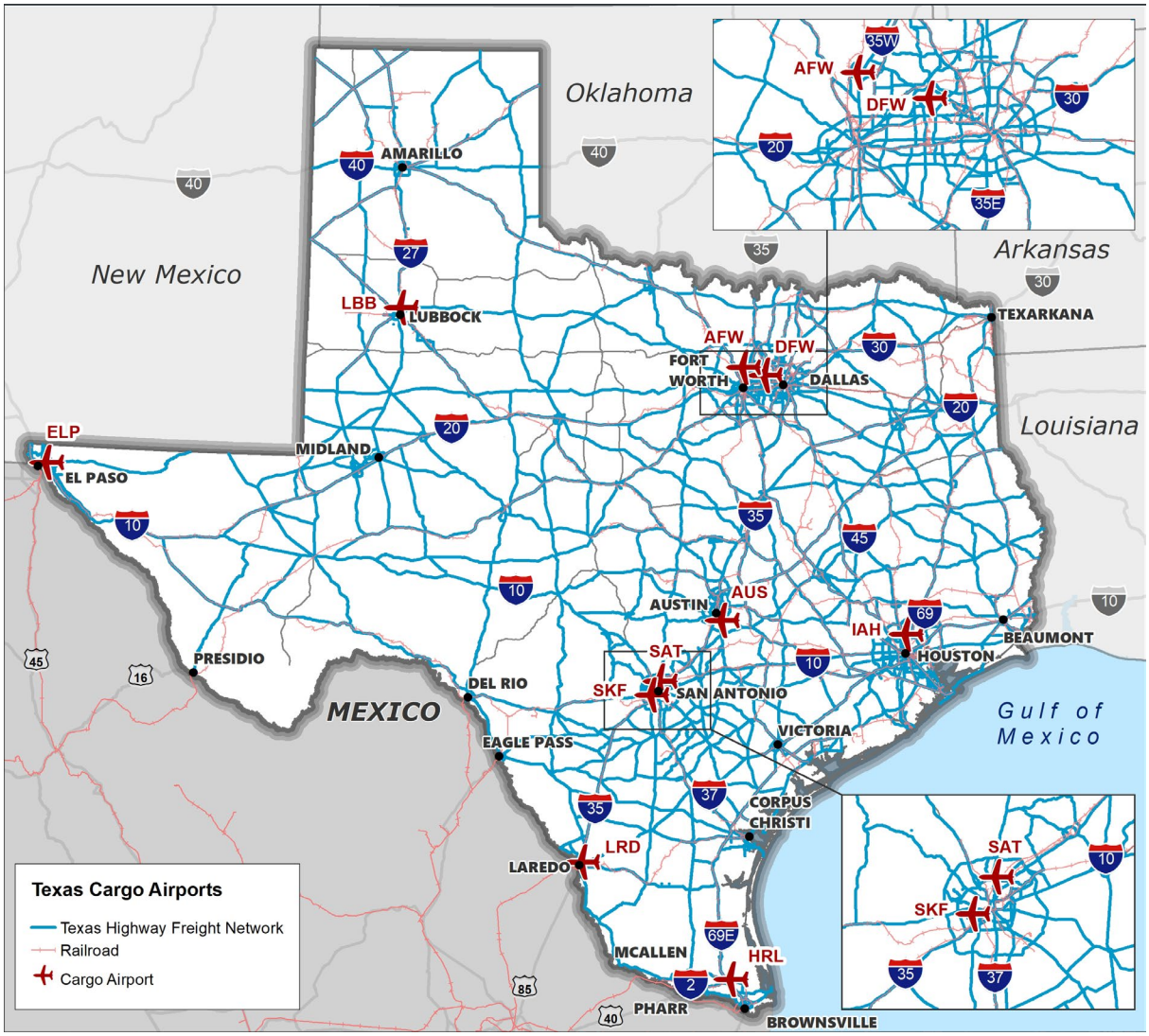
3.5.1 AIR CARGO FACILITIES ON THE TMFN

FHWA includes Fort Worth Alliance (AFW), Austin (AUS), Dallas-Fort Worth International (DFW), El Paso International (ELP), George Bush Intercontinental/Houston (IAH) and San Antonio (SAT) airports as part of the NMFN. During the 2018 TFMP, these six airports plus the Laredo International Airport (LRD) were included in the TMFN. TxDOT added Kelly Field in San Antonio (SKF), Lubbock Preston Smith International (LBB) and Harlingen Valley International (HRL) airports during the Texas Delivers 2050 designation process based on analysis of data from the Bureau of Transportation Statistics (BTS) T-100 Market (All Carriers) dataset, which includes weight of freight and mail enplaned (**Exhibit 14**) and the increased importance of air cargo in Texas.[27]

[26] Cargo Trends. (September-October 2021). Retrieved January 23, 2022, from https://drive.google.com/file/d/1HgHeLLYY7j06B2XCMdLmuLkIXPlhTQSU/view

[27] Air Carrier Statistics (Form 41 Traffic)- All Carriers Overview. BTS. (n.d.). Retrieved January 14, 2022, from https://www.transtats.bts.gov/DatabaseInfo.asp?QO_VQ=EEE&DB_URL=.

EXHIBIT 14: AIRPORTS ON THE TEXAS MULTIMODAL FREIGHT NETWORK



Source: TxDOT Planning and Programming Division.

3.5.2 DEMAND FOR AIR CARGO IN TEXAS

Exhibit 15 shows the top 10 cargo airports in Texas by enplaned weight for 2019.

EXHIBIT 15: TOP 10 CARGO AIRPORTS IN TEXAS BY ENPLANED WEIGHT (POUNDS), 2018-2020

ID	Airport Name	2018 (lb.)	2019 (lb.)	2020 (lb.)
DFW	Dallas/Fort Worth International	1,789,746,863	1,905,814,041	1,773,748,224
IAH	George Bush Intercontinental	1,143,681,047	1,126,751,783	1,017,127,282
AFW	Fort Worth Alliance	340,805,359	364,706,105	558,259,090
SAT	San Antonio International	283,812,914	287,999,579	285,299,960

ID	Airport Name	2018 (lb.)	2019 (lb.)	2020 (lb.)
AUS	Austin-Bergstrom International	209,365,576	211,889,945	222,617,290
ELP	El Paso International	217,642,826	207,672,645	214,835,390
LBB	Lubbock Preston Smith International	123,460,008	141,535,081	137,609,202
HRL	Valley International	105,215,352	101,787,305	102,098,795
LRD	Laredo International	75,348,200	51,238,758	40,721,507
SKF	Port San Antonio (Kelly Field)	31,762,086	35,882,758	28,477,812

Source: T-100 Market (all-carrier). 2018-2020. Bureau of Transportation Statistics.

Nearly 1.8 million tons of air cargo valued at nearly $258 billion moved in Texas in 2019 (**Exhibit 16**). Air cargo volumes are projected to grow by about 250% by 2050 to over 4.6 million tons. The top commodity by tonnage is small, packaged freight shipments fueled by e-commerce. The top commodity by value is electrical equipment. The top five commodities by weight represent approximately 60% of air cargo tonnage, while the top five commodities by value represent approximately 80% of air cargo value.

EXHIBIT 16: TEXAS AIR CARGO TONNAGE AND VALUE FOR TOP COMMODITIES, 2019

Top 5 Air Flows by Tonnage (in thousands), 2019		Top 5 Air Flows by Value (in millions), 2019	
Commodity	**Tonnage**	**Commodity**	**Value**
Small Packaged Freight Shipments	376	Electrical Equipment	$78,589
Electrical Equipment	267	Misc. Manufacturing Products	$44,578
Machinery	198	Transportation Equipment	$35,030
Chemicals or Allied Products	114	Machinery	$26,293
Transportation Equipment	89	Chemicals or Allied Products	$26,089
Subtotal for Top 5	**1,044**	**Subtotal for Top 5**	**$210,579**
Total Tonnage	**1,797**	**Total Value**	**$257,682**

Source: Transearch, 2019-2050. USA Trade Online, 2019.

Air cargo relies on connections to other modes, primarily highways, to get the goods to their final destinations. Therefore, efficient access to major highways and interstates is important for airports that handle large volumes of air cargo.

3.6 PIPELINES IN TEXAS

Texas is the leading domestic producer of oil and natural gas. The petroleum industry in the state relies on pipelines as a primary mode for transporting natural gas, crude oil, and a variety of liquefied products. As a result, **Texas has the most extensive pipeline network of any state** with nearly 470,000 miles of pipelines, representing 1/6th of the total pipeline mileage in the country.[28]

Pipeline Statistics:

- 412,463 miles of distribution and gathering pipelines
- 57,274 miles of long distance transmission pipelines
- 469,737 total miles of pipelines in 2019
- 89% of network are intrastate pipelines

Source: Railroad Commission of Texas (RRC). Texas Pipeline System Mileage.

Petroleum industry supply chains are organized into upstream, mid-stream and downstream operations. Pipelines and product terminals are a part of midstream operations involved in the storage and transport of crude oil and natural gas. Pipelines link upstream producers with downstream refineries and processing plants, which produce petrochemicals used by manufacturers to create plastic and synthetic rubber that find their way into various consumer and industrial products. The industry depends heavily on pipelines as safe, efficient and reliable mode of freight transportation. Compared to other freight modes, pipelines are not impacted by most weather conditions, operational conflicts with other modes and congestion on highways and waterways. Pipelines are also important to the economic competitiveness of the industry in Texas by providing a cost-effective mode for transporting bulk, liquefied products to markets in other states and with trading partners in Mexico and Canada, as well as overseas via maritime ports.

The private sector owns, operates and maintains the pipelines in the state. Texas has about 1,500 operators who transmit and distribute natural gas and liquified petroleum products to downstream users, such as refineries and petrochemical plants, powerplants, airports and residential customers.

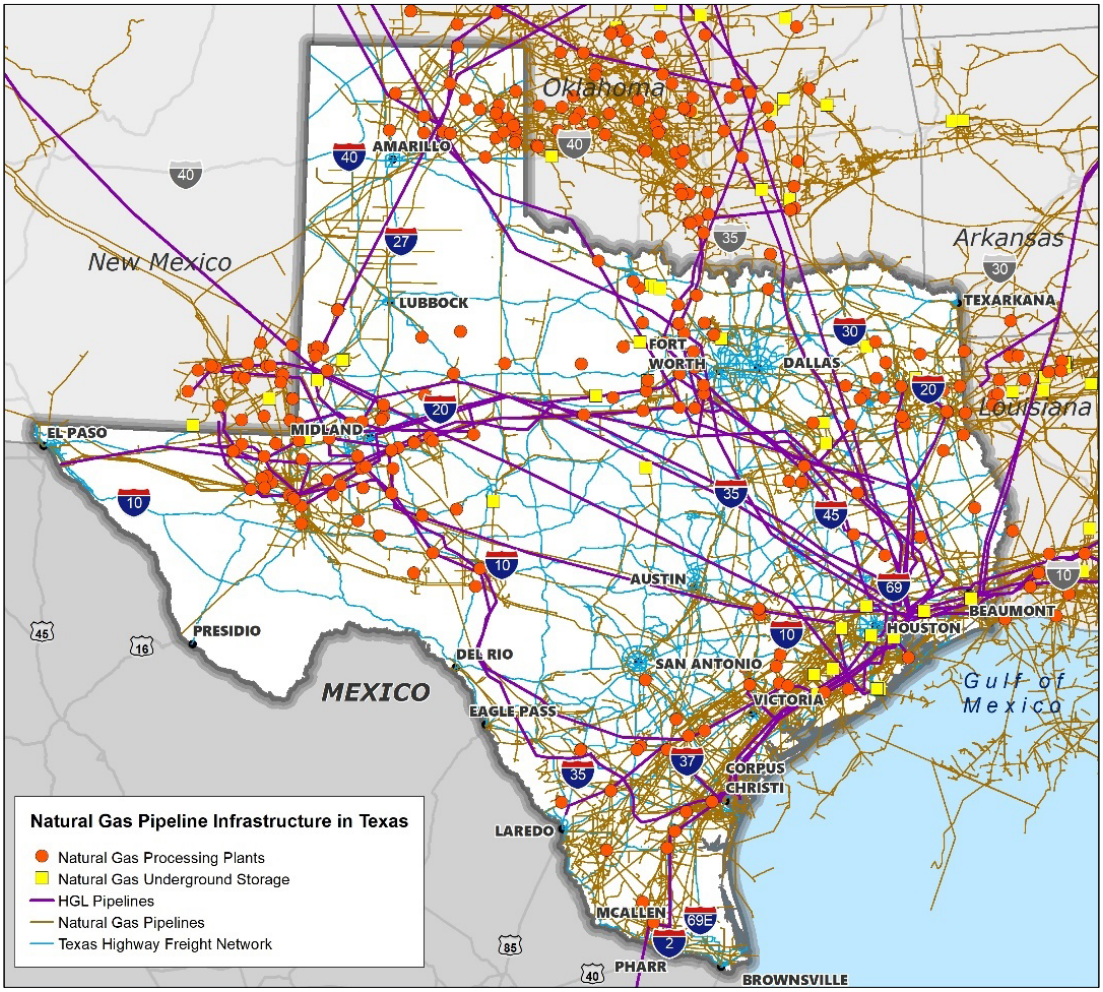
3.6.1 NATURAL GAS PIPELINE INFRASTRUCTURE IN TEXAS

Exhibit 17 shows the natural gas pipeline infrastructure in Texas, highlighting the network of pipelines that gather and transport raw natural gas to processing plants. Processing plants remove natural gas liquids, water and other contaminants to produce dry gas that is ready for consumption. Processed natural gas is distributed directly by pipeline to a variety of end users,

[28] Railroad Commission of Texas (RRC). Texas Pipeline System Mileage. https://www.rrc.texas.gov/pipeline-safety/reports/texas-pipeline-system-mileage.

from electric power plants, industrial facilities and manufacturers to smaller sources of demand, such as commercial and residential customers and vehicle fueling stations. The plants also produce hydrogen gas liquids (HGLs), which has a variety of uses from heating and cooking to serving as feedstocks for petrochemical manufacturing. Shown on the map are 44,978 miles of natural gas pipelines and 976 miles of HGL pipelines. The network supplies natural gas to 35 underground storage sites and 176 natural gas processing plants in Texas.

EXHIBIT 17: NATURAL GAS PIPELINE INFRASTRACTURE IN TEXAS



Source: U.S. Energy Information Administration (EIA).

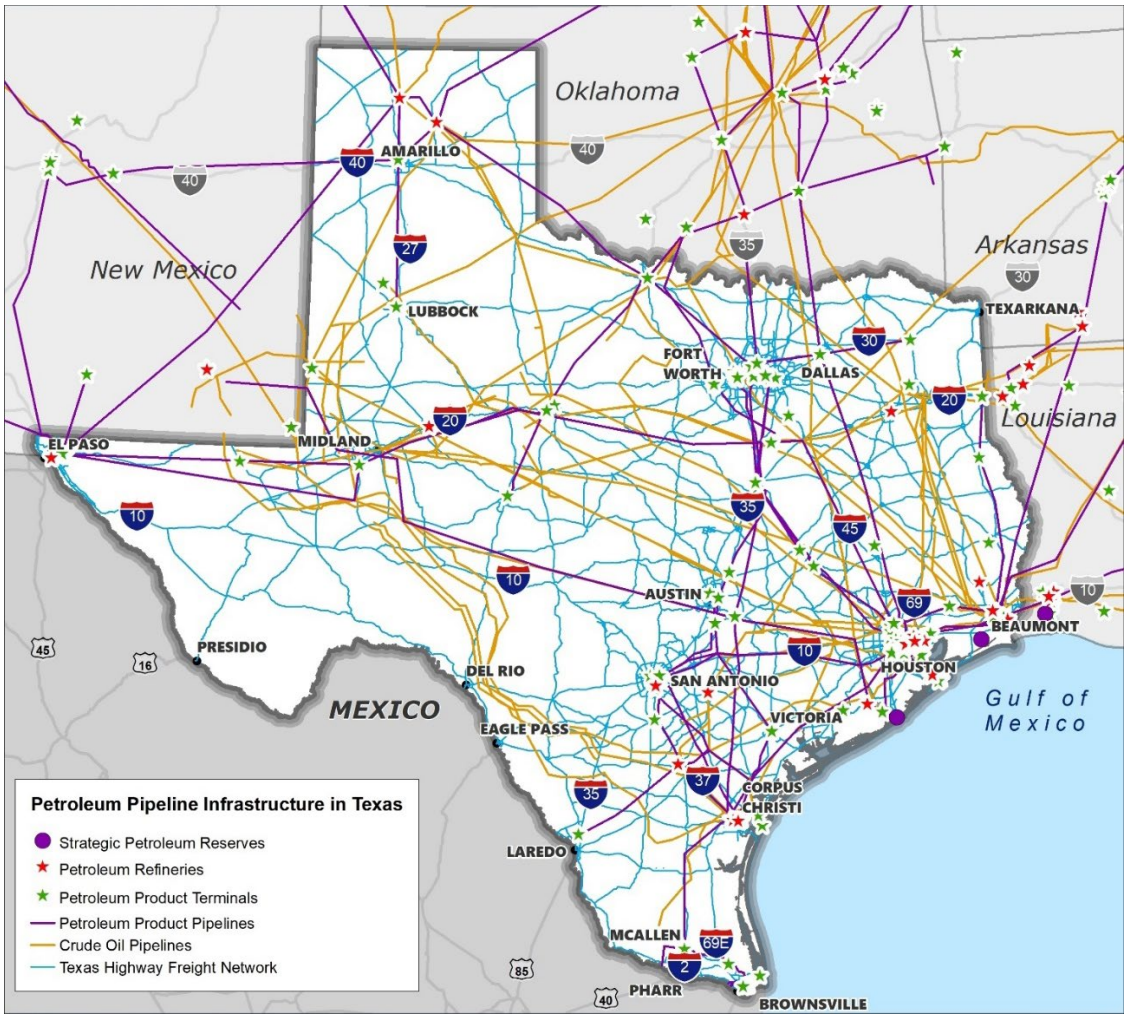
3.6.2 PETROLEUM PIPELINE INFRASTRUCTURE IN TEXAS

Exhibit 18 shows the petroleum pipeline infrastructure in Texas, highlighting the pipelines that transport crude oil to refineries and the product pipelines that transport gasoline, fuels, lubricants, and other liquids. Note, the small diameter pipes representing the "gathering" pipelines that connect to the wells are underrepresented in the exhibit. There are 31 refineries concentrated along the Gulf Coast, with the largest refinery and petrochemical complexes

located in Houston, Beaumont, Corpus Christi and Galveston. There are 170 product terminals that store and distribute motor gasoline and various finished fuels. The terminals are concentrated in and around metropolitan areas to serve regional demand.

The map also shows Texas' two storage sites for the Strategic Petroleum Reserve (SPR) that serves as the national emergency stockpile of crude oil (the other two SPR sites are in Louisiana). The SPR sites are located near the major refinery complexes on the Gulf Coast. The Big Hill and Bryan Mound sites in Texas are connected to refineries via pipelines in Houston and Beaumont.[29]

EXHIBIT 18: PETROLEUM PIPELINE INFRASTRUCTURE IN TEXAS



Note: the small diameter pipes representing the "gathering" pipelines that connect to the wells are underrepresented in the exhibit.
Source: U.S. Energy Information Administration (EIA).

[29] U.S. Department of Energy. Strategic Petroleum Reserve Annual Report for Calendar Year 2017. December 2018. https://www.energy.gov/sites/prod/files/2019/02/f59/EXEC-2018-001277%20-%202017%20SPR%20Report.pdf.

3.7 INTERNATIONAL BORDER CROSSINGS IN TEXAS

The international border crossings on the Texas border with Mexico are important gateways for trade between the U.S. and Mexico. A significant portion of trade is between the economies of Texas and Mexico, where Mexico the is state's top trading partner; in 2019, the amount of trade between the two economies was worth $213 billion.[30] The commercial vehicle and rail crossings on the TMFN facilitates the movement of goods and commodities that are vital to businesses and industries in Texas, as well as the rest of the country. Texas supply chains for key manufacturing industries such as automobiles and electronics are integrated with factories in Mexico that produce parts and assemble components into finished products such as passenger vehicles. The transportation infrastructure at the border crossing locations provides important connectivity between the TMFN and the flow of imports and exports that cross the border each day. In 2019, 49.3 million tons of freight worth $249.2 billion entered Texas from Mexico by truck or rail. Flows in the southbound direction amounted to 64.9 million tons of freight worth $167.8 billion.[31]

Exhibit 19 shows the 18 border crossing locations on the TMFN that allow truck or train traffic. Fifteen of the 18 crossing locations allows for trucks. The Bridge of the Americas in El Paso and the Camino Real International Bridge in Eagle Pass are the only two crossings that allow both trucks and trains. The World Trade Bridge in El Paso is the only crossing closed to passenger vehicles. The Presidio Rail Bridge is currently undergoing reconstruction as the result of a fire in 2009 that damaged the bridge and suspended rail service.[32] Once reopened, the Presidio Rail Bridge will join the West Rail Bridge in Brownsville and the El Paso Rail Bridges as the only five crossings dedicated to rail, and the sixth overall that allows train traffic.

EXHIBIT 19: COMMERCIAL VEHICLE AND RAIL CROSSINGS ON THE TEXAS-MEXICO BORDER

ID	Crossing Name	Port of Entry	Commercial Vehicles	Passenger Vehicles	Rail
1	El Paso Rail Bridges (UP and BNSF)	El Paso			●
2	Bridge of the Americas	El Paso	●	●	
3	Ysleta-Zaragoza Bridge	El Paso	●	●	
4	Tornillo-Guadalupe International Bridge	Tornillo	●	●	
5	Presidio Bridge	Presidio	●	●	

30 TxDOT, Border Transportation Master Plan. 2021.

31 Ibid.

32 FreightWaves. "New rail port to connect Texas and Mexico." November 17, 2020. https://www.freightwaves.com/news/rail-port-connect-texas-and-mexico.

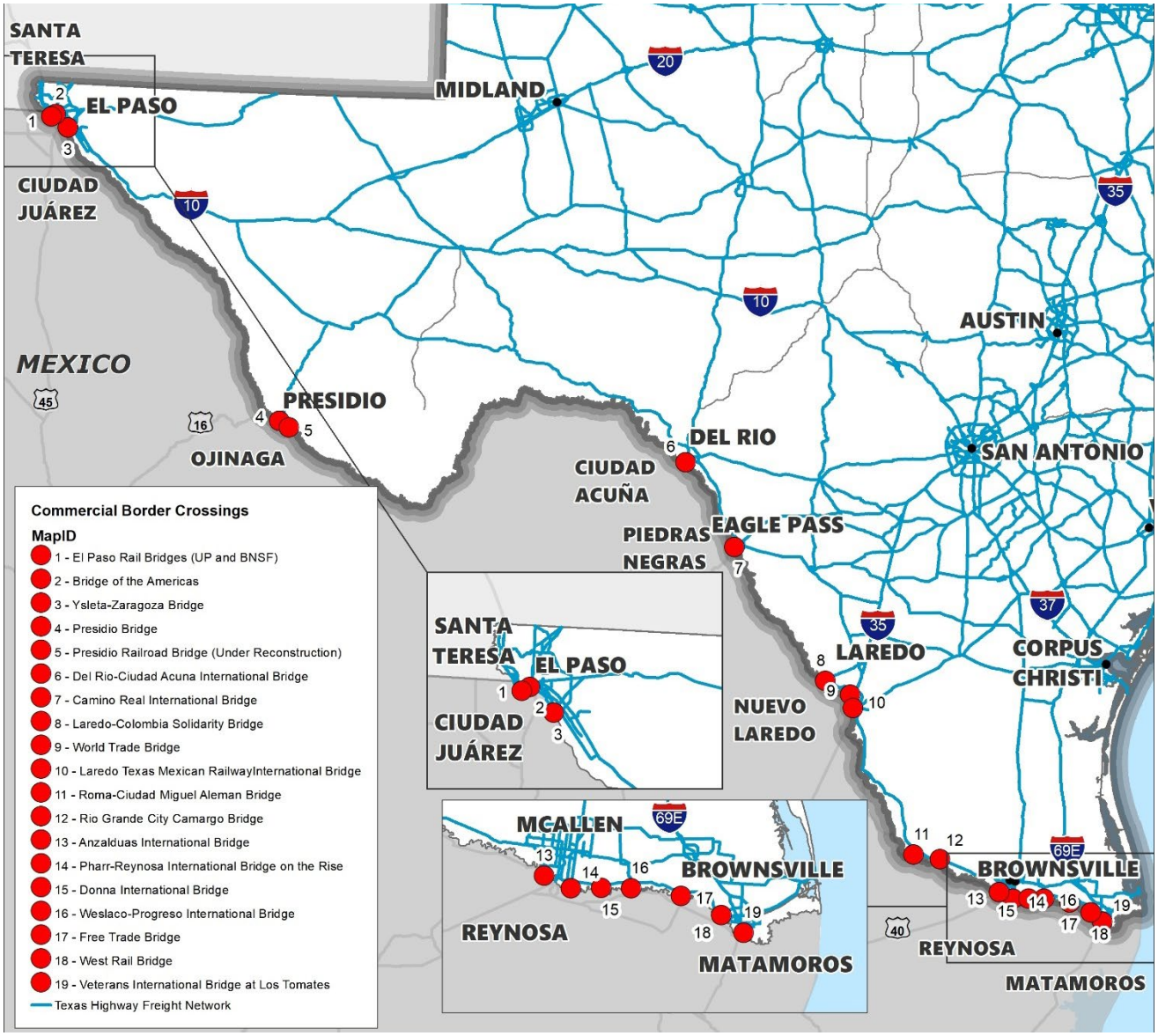
ID	Crossing Name	Port of Entry	Commercial Vehicles	Passenger Vehicles	Rail
6	Del Rio-Ciudad Acuna International Bridge	Del Rio	●	●	
7	Presidio Railroad Bridge (Under Reconstruction)	Presidio			●
8	Camino Real International Bridge	Eagle Pass	●	●	●
9	Laredo-Colombia Solidarity Bridge	Laredo	●	●	
10	World Trade Bridge	Laredo	●		
11	Laredo Texas Mexican Railway International Bridge	Laredo			●
12	Roma-Ciudad Miguel Alemán Bridge	Roma	●	●	
13	Rio Grande City Camargo Bridge	Rio Grande City	●	●	
14	Anzalduas International Bridge	Hidalgo	●	●	
15	Pharr-Reynosa International Bridge on the Rise	Hidalgo	●	●	
16	Donna International Bridge	Progreso	●	●	
17	Weslaco-Progreso International Bridge	Progreso	●	●	
18	Free Trade Bridge	Brownsville	●	●	
19	West Rail Bridge	Brownsville			●
20	Veterans International Bridge at Los Tomates	Brownsville	●	●	

Source: TxDOT. Texas Border Crossings. Border Transportation Master Plan. 2021.

Between 2009 and 2019, northbound train movements from Mexico increased 163% to 10,473. For northbound movements by truck into Texas, the number of trucks entering increased 157% to 4.4 million in 2019.[33] **Exhibit 20** shows the location of the commercial border crossings on the TMFN.

[33] Bureau of Transportation Statistics (BTS). Border Crossing/Entry Data. https://explore.dot.gov/views/BorderCrossingData/Annual?%3Aembed=y&%3AisGuestRedirectFromVizportal=y.

EXHIBIT 20: COMMERCIAL BORDER CROSSINGS ON THE TEXAS-MEXICO BORDER

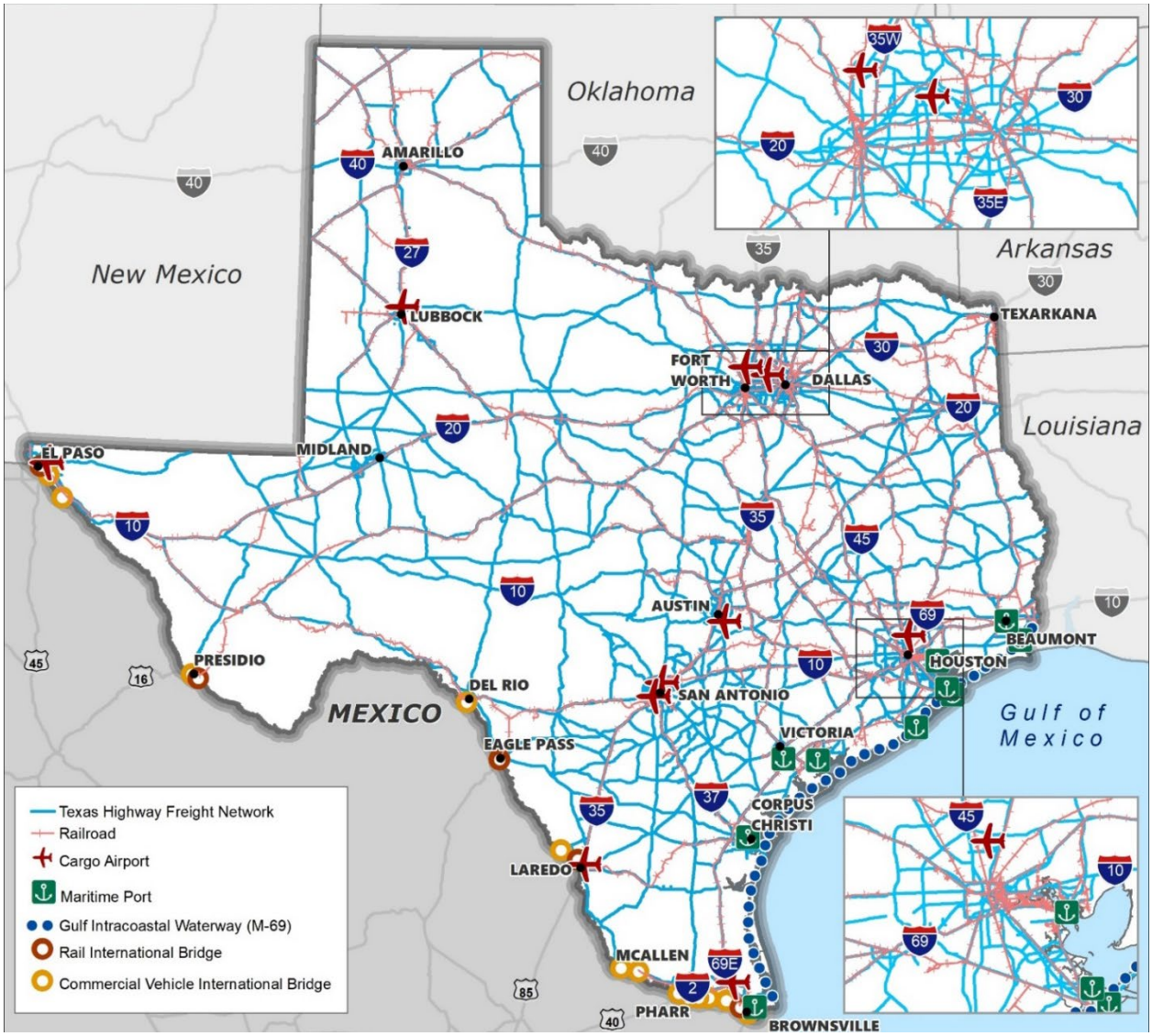


Source: TxDOT. Texas Border Crossings.

3.8 TEXAS MULTIMODAL FREIGHT NETWORK

The TMFN, shown in **Exhibit 21**, is the basis of each analysis step in the development of Texas Delivers 2050. These facilities are central to the analysis of conditions, needs, supply chains and opportunities related to freight movement in Texas. The updated TMFN includes an additional 1,500 miles of highway and three additional airports when compared to the 2018 TFMP. Railroads, ports and pipeline designations remained unchanged.

EXHIBIT 21: TEXAS MULTIMODAL FREIGHT NETWORK



Source: TxDOT Planning and Programming Division.

This Chapter presented an overview of the TMFN, including a summary of each mode and designation of the TMFN. Chapter 4 describes the role of the TMFN, specifically, how it is used by six of Texas' key industry clusters.

Chapter 4
The Role of the Texas Multimodal Freight Network

The state's key industries depend on safe, reliable freight transportation to keep business moving. Texans depend on freight movement for food, clothing, shelter and everything else they consume. Therefore, it is undeniable that a well-performing freight network is vital to the economic prosperity and well-being of every Texan. The previous chapter presented the designated TMFN. This chapter examines the role of the TMFN network in supporting key Texas industries and our way of life.

4.1 OVERVIEW OF SUPPLY CHAIN ANALYSIS

The movement and handling of freight is an industry that generates significant economic benefits. It is also critical to the competitiveness of the state's largest and most strategic industries. With the recent national focus on supply chains and their sensitivity to disruption, Texas Delivers 2050 further informs freight transportation investments and decision-making by analyzing the role, responsibility and support the TMFN provides to the state's crucial supply chains. In coordination with the TxFAC, SCWG and targeted industry clusters identified by the Texas Governor's Office on Economic Development, Texas Delivers 2050

Highlights

Six key supply chains in Texas **rely on shared infrastructure** on the TMFN, reinforcing the criticality of this network to the Texas economy and quality of life.

Every supply chain relies on a **mix of freight modes** to collect, transport and distribute goods.

High-capacity facilities facilitate movement for multiple supply chains. **Interstates, Class I and Class III railroads, deep draft ports and major cargo airports support a variety of commodities** and can accommodate diverse shipping needs.

First-mile connections from freight generating regions may **serve primarily only one or two supply chains,** reaching shared infrastructure later in the journey.

Each supply chain has **unique needs**, such as specialized vehicle types, transload equipment or time sensitivity.

Supply chains have global linkages and rely on import and export capabilities for raw materials, intermediate products and final goods.

Coordination with the Supply Chain Working Group (SCWG) provided insights on the role of the TMFN in transporting freight for critical industry supply chains in Texas.

examines the role of the TMFN through the lens of the supply chain for the following key industries:

- Advanced Manufacturing:
  - Automotive and Aerospace; Electronics
- Agriculture
- Construction
- Petroleum:
  - Oil and Gas; Petrochemicals
- Warehousing and Distribution

The analysis of these critical supply chains includes all aspects of a product's lifecycle, including raw materials, production facilities, warehousing, local distribution, retail outlets, recycling/waste and receipt or distribution of various contributing inputs and outputs. As materials move through the supply chain, they often rely on multiple modal elements of the TMFN. A disruption to any process or movement can have a dramatic impact on the overall supply chain. Analyzing these supply chain activities and movements, and validating the information with the SCWG, support Texas Delivers 2050 by providing insight to the following questions:

- What are the major assets of the TMFN for a particular industry?
- How much freight do businesses in these key industries move on the TMFN?
- What are the economic implications of these industries and the freight they move for Texas?

The analysis and depiction of the supply chains of these industries are not meant to capture the intricate details of the supply chain for any specific business but rather capture the general and most critical aspects of the industry's supply chain in Texas. For example, the role of the TMFN for each industry supply chain based on industry specific commodities represents:

- Highway and rail corridors — corridors that account for 75% or more of the total tonnage
- Seaports — the top two or three seaports based on total volumes
- Border ports of entry — the most heavily used border crossings based on volume
- Air cargo facilities — the top one or two air cargo facilities based on value

The following profiles provide a summary of that analysis.

4.2 ROLE OF TMFN IN ADVANCED MANUFACTURING FOR AUTOMOTIVE AND AEROSPACE SUPPLY CHAINS

Advanced Manufacturing in automobiles and aerospace is a key industrial sector in Texas. Texas enjoys several competitive advantages with access to abundant energy, a pool of skilled workers and access to trade gateways on the border with Mexico and the Gulf Coast. Recent investments by Samsung and Tesla in production facilities in Texas are the highest-profile examples of the rapid growth and expansion of manufacturing in Texas, particularly in the production of high-value goods, such as aircraft, motor vehicles and electronics.

DID YOU KNOW?

A single car has about **30,000 PARTS,** counting every part down to the smallest screws.

Source: Amtech.

The following sectors were identified in coordination with TxFAC and represent the major freight activities and movements of the TMFN analyzed for the advanced manufacturing industry:

Vehicle Parts — includes the production of a wide range of materials and components used as inputs to make finished automobiles, buses and trucks.

Vehicle Manufacturing — includes the receipt of manufactured inputs, assembly of components into finished automobiles and buses and trucks and shipment of finished products through distribution channels to customers.

Aircraft and Aerospace — includes the receipt of some manufacturing inputs that are shared with vehicle manufacturing, plus specialized inputs, such as engines that are unique to aircraft and aerospace, and assembly of components into finished aircraft and space vehicles and shipment of finished products through distribution channels to customers.

Economic Importance of Automotive and Aerospace Manufacturing in Texas is Significant

865 firms with **969** establishment locations

100,748 employees with **$9.0** billion in direct wages
(11% of all Texas manufacturing)

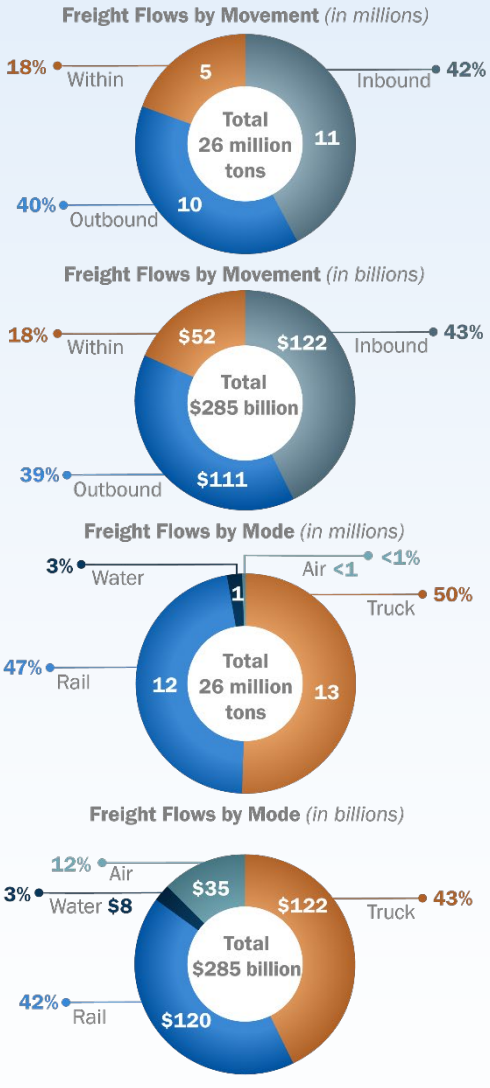
$30.5 billion in direct value added
(14% of all Texas manufacturing)

Source: Texas Workforce Commission and IMPLAN input-output multipliers.

Texas' automotive and aerospace sector commodities account for nearly **$37 billion or 10% of total U.S. export value** and over **$61 billion or 13% of total U.S. import value**, showing a very significant share of the nation's international trade.

Freight Generated by Automotive and Aerospace Manufacturing

The industry generated 26 million tons of freight, with a value of $281 billion that originated in, was destined for or moved within Texas. Inbound freight represents imports into the state; outbound freight represents exports from the state; and within movements represent freight that originate and terminate in the state. Nearly half of the freight (49%) was transported by truck.



Source: Transearch, Waybill, USA Trade Online, Enverus. Analysis by Cambridge Systematics.

TOP COMMODITIES

- Vehicle manufacturing generated freight with a value of **$186 BILLION**, representing two-thirds of the total for the automotive and aerospace sector.
- Exports of vehicle parts were valued at **$19 BILLION** or **56%** of sector exports.
- Imports of manufactured vehicles were valued at $**34 BILLION** or **55%** of sector imports.

TOP TRADING PARTNERS

MICHIGAN, ILLINOIS and **CALIFORNIA** are Texas' top trading partners for vehicle parts. These moves presumably continue across the border as US trade with Mexico.

ILLINOIS, LOUISIANA and **CALIFORNIA** are Texas' top trading partners for manufactured vehicles.

OHIO, OKLAHOMA, ALABAMA and **QUEBEC** are Texas' top trading partners for aircraft and aerospace products and parts.

WEBB, TARRANT, HARRIS, DALLAS and **BEXAR** counties are key origins and destinations for freight tonnage.

DID YOU KNOW?

The import of transportation equipment into Texas is between 10% and 13% of total exports/ imports for the United States, respectively.

The highways, multimodal facilities and trade gateways on the TMFN function as an integrated system that facilitates the seamless delivery of commodities and products. To serve the transportation needs of the supply chains in this industry cluster, **Texas will need to ensure sufficient capacity and reliability** for the following elements on the TMFN:

- **Higher-tonnage,** critical corridors (I-10, I-20, I-35, I-40, I-45, I-69, US77, US83 and US281).
- **Texas-Mexico border crossings** for truck and rail, particularly Laredo, Eagle Pass and El Paso. The crossings facilitate trade with Mexico for imports and exports of vehicle parts and manufactured vehicles.
- **Intermodal rail ramps,** automobile ramps, intermodal/auto rail mainline corridors and plant connecting service tracks.
- **Texas Seaports,** particularly Port Houston, Port Freeport and Port of Galveston, which are the key gateways for imports and exports of manufactured vehicles.
- **Airports,** particularly George Bush Intercontinental Airport, Dallas/Ft. Worth International Airport and Ft. Worth Alliance Airport.
- **Last-mile truck delivery routes,** particularly in urban areas.
- **Warehouse and distribution facilities** serving manufacturers and parts suppliers, including facilities used for cross-docking operations, which minimizes the time that freight is stored before distribution to retailers.

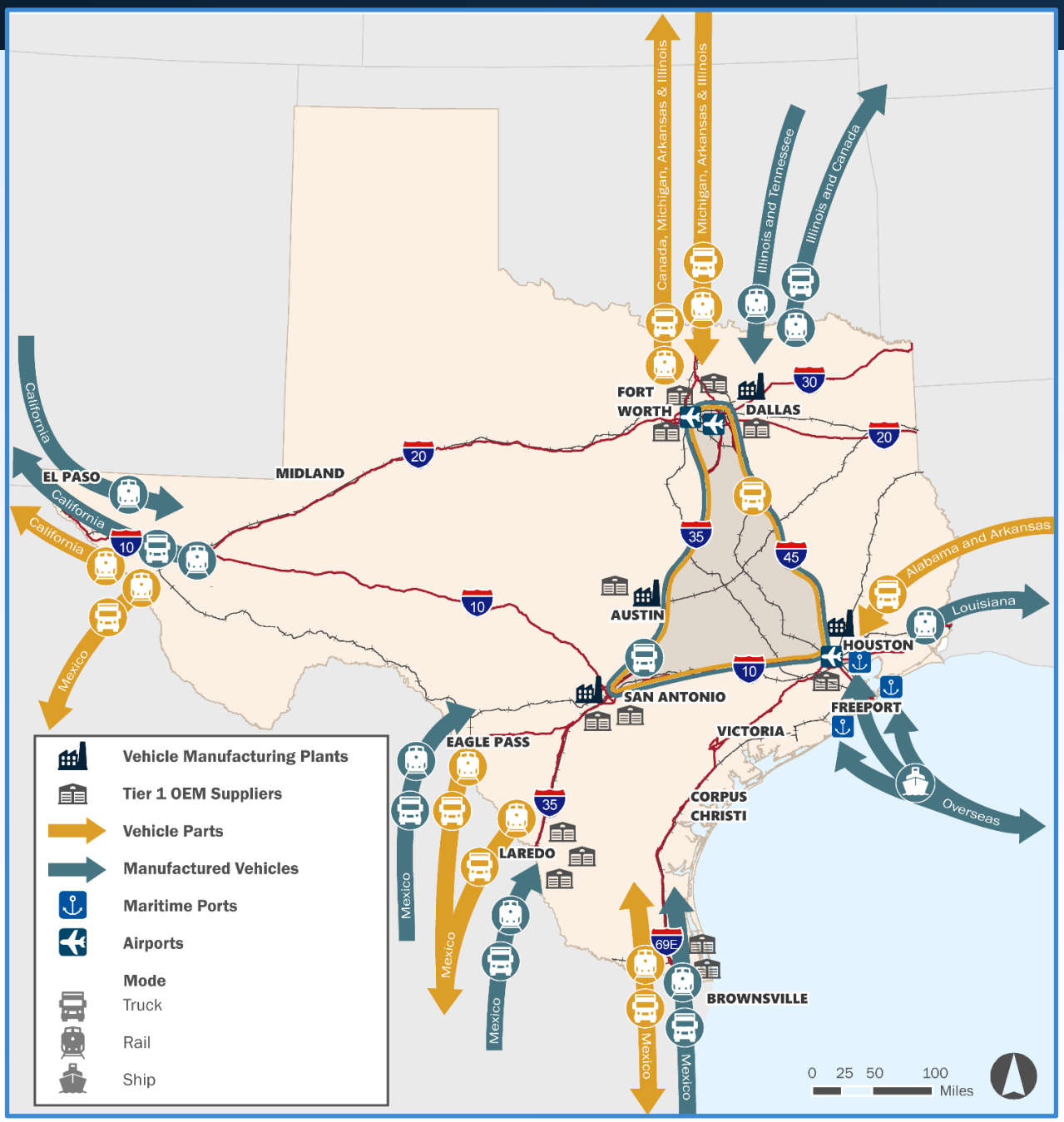
KEY TRENDS IMPACTING INDUSTRY

There are numerous trends driving growth in the automotive and aerospace sectors that will lead to increased demand for freight transportation on the TMFN. Some of the key trends include:

- Growing interest and investment in the commercialization of space.
- Push to vehicle electrification and production of advanced batteries and other required systems.
- Increasing Texas and U.S. demand for transportation sector commodities.
- Supply chain disruptions from the COVID-19 pandemic that highlighted the need for domestic production of advanced production inputs (some of which will be in Texas).

Automotive and Aerospace Manufacturing Relies on a Multimodal Global Supply Chain

Texas' advanced manufacturing industry is largely clustered around the Texas Triangle and depends on international land borders and seaport gateways to move parts and finished products to and from markets. It also relies on truck and rail service providers for movements throughout North America. The map below illustrates major freight movements that provide a high-level representation of how the supply chain interfaces with the trade gateways and modal networks on the TMFN.



Source: Cambridge Systematics.

4.3 ROLE OF TMFN IN ADVANCED MANUFACTURING FOR ELECTRONICS SUPPLY CHAINS

Advanced manufacturing in semiconductors and computer components are a significant and expanding sector of the Texas economy. Dell, National Instruments and Texas Instruments are home grown examples of companies in Texas that make significant contributions to semiconductors, consumer electronics, telecommunications and computing. Today, technology clusters in Texas feature companies from around the world that have design centers and fabrication facilities in the state. Texas' large pool of skilled and educated workers, access to international trade, and low-cost basis are among the competitive advantages attracting innovative companies and talent.

DID YOU KNOW?

The first integrated circuit was invented by engineers at Texas Instruments in 1958. That breakthrough paved the way for microprocessors today that are used in everyday applications from the smallest handheld devices to the world's most power supercomputers.

Source: Texas Instruments

The following sectors were identified in coordination with TxFAC and represent the major freight activities and movements on the TMFN analyzed for the electronics and electrical equipment industry:

Semiconductors — comprises a broad set of intermediate products including diodes, computer logic modules and transistors which are essential components of most electronic circuits. All items in this category are critical building blocks of the components for computers, cell phones, automobiles and many other products.

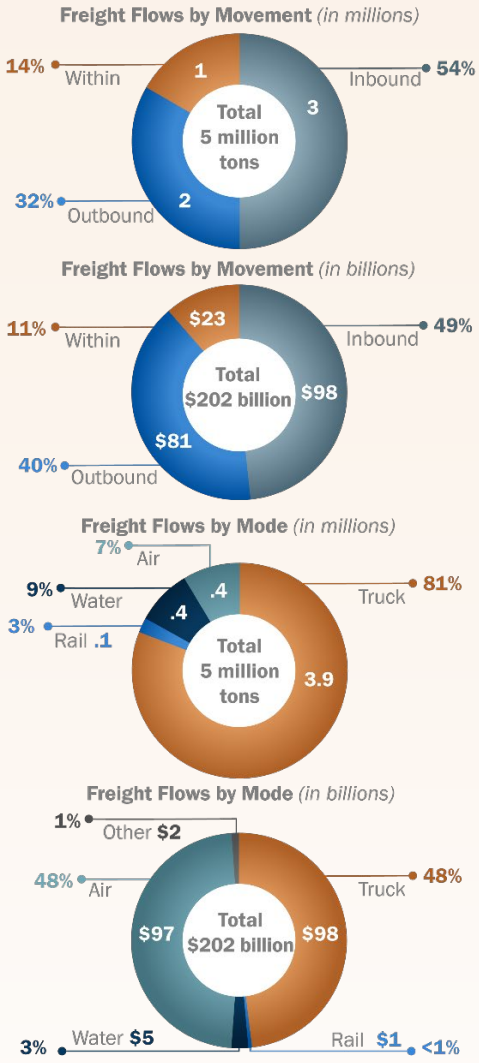
Computer Components — includes the actual parts that compose the end product of a computer, laptop, tablet, etc. These components include intermediate products, such as motherboards, processors, memory, graphics cards and solid-state storage.

Economic Importance of the Electronics and Electrical Equipment Industry in Texas is Significant

Source: Texas Workforce Commission and IMPLAN input-output multipliers.

Freight Generated by Electronics and Electrical Equipment

The industry generated 4.7 million tons of freight, with a value of $198 billion that originated in, was destined for or moved within Texas. Over 80% of tonnage for semiconductors and computer components was transported by truck, and these moves connect manufacturers to the airports and seaports that are essential to this highly global supply chain. Air movements are particularly important for these high-value, low-weight products that move between continents several times during the production and eventual assembly into final products.



TOP COMMODITIES

- The top three commodities by tonnage and value in the electrical equipment sector are various product types used for industrial and commercial applications and equipment used in healthcare. These freight flows had a combined value of **$100.5 BILLION** in 2019.
- The top three commodities by tonnage in the electronics sector are miscellaneous electrical components, electronic data processing equipment and storage batteries or plates. These freight flows had a combined value of $**15.9 BILLION** in 2019.
- Among electronic commodities, parts and accessories for computers is top in Texas export value (**$9.8 BILLION**) and accounts for **61%** of total U.S. exports. For imports, digital processing units had the highest value (**$18.8 BILLION**).
- Electrical Equipment includes a range of commodities from electrical conductors (i.e., wiring), to appliances, and medical/scientific equipment. Texas shipped **$16 BILLION** worth of exports in 2019 and imported **$20.2 BILLION** of imports.

Source: Transearch, Waybill, USA Trade Online, Enverus. Analysis by Cambridge Systematics.

TOP TRADING PARTNERS

Inbound flows of semiconductors from CALIFORNIA, OREGON and COLORADO that are manufactured in those states or imported through the Ports of Los Angeles and Long Beach, the nation's leading import ports for electronics.

Predominant inbound flows of computer components from MEXICO and CENTRAL AMERICA. There are also significant flows from CALIFORNIA, ALASKA and CANADA.

Outbound flows of semiconductors from Texas to ILLINOIS, FLORIDA and NEW YORK. Internationally, there are large flows which go to MEXICO and CENTRAL AMERICA, as well as considerable flows to EUROPE.

Inbound computer parts are coming from MEXICO and CENTRAL AMERICA. There are also significant flows from CALIFORNIA, ALASKA and CANADA. Outbound flows are going to CENTRAL AMERICA and EUROPE where there is substantial manufacturing.

The highways, multimodal facilities and trade gateways on the TMFN function as an integrated system that facilitates the seamless delivery of commodities and products. To serve the transportation needs of the supply chains in this industry cluster, **Texas will need to ensure sufficient capacity and reliability** for the following elements on the TMFN:

- Highways - I-10 between Houston and San Antonio, between Laredo and Houston via I-35 and I-10, I-45 between Houston and Dallas, and Interstates 35 and 35E between Laredo, San Antonio and Dallas.
- Airports - Airport and landside access to Dallas Fort Worth Airport (DFW) along I-635, along with TX 121 and TX 114 and local access roads to the airport. Austin-Bergstrom International Airport (AUS) and associated landside access are critical to manufacturers in Austin and San Antonio. In the Houston area, landside improvements to George Bush Intercontinental Airport (IAH) and Port Houston, including I-69 and TX 8 to IAH, and I-10, TX 146 and TX 330 to Port Houston along with local access roads.
- Ports- In addition, a growing volume of the containerized imports from Asia is being handled in Freeport, which is expected to increase its capacity in the near-term, with the expected completion of a new container berth in 2023 and channel deepening improvements in 2025.

KEY TRENDS IMPACTING INDUSTRY

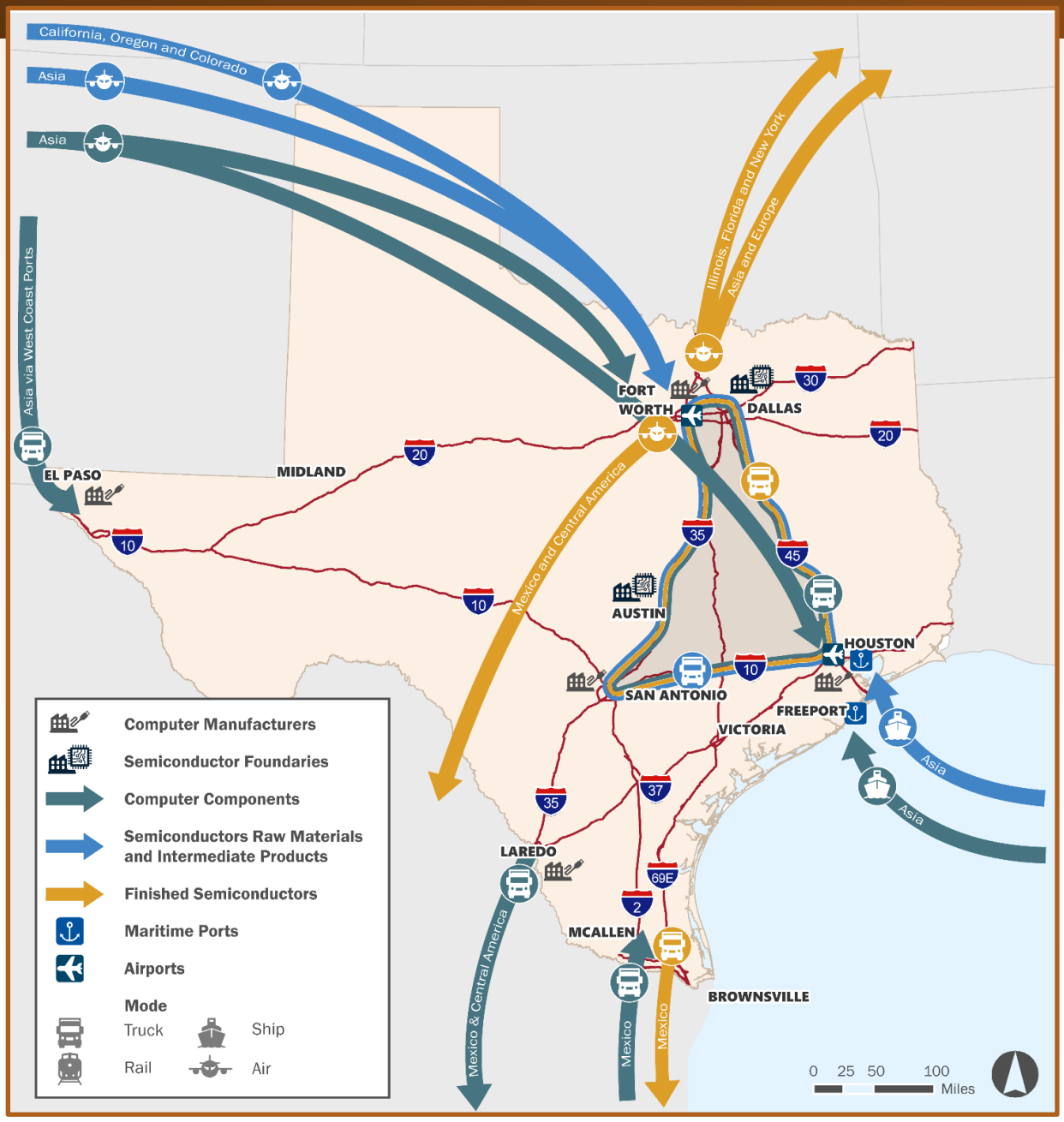
There are numerous trends driving growth for the warehousing and distribution industry that will lead to increased demand for freight transportation on the TMFN. Some of the key trends include:

- Changes in the way people live and work shaped by the COVID-19 pandemic. With more employees working from home, supply chains face challenges with the additional demand for laptops, monitors and other electronic and electrical equipment devices.
- Use of online video conferencing and cloud services has grown since the pandemic. These services require infrastructure that is reliant on semiconductors and computer components.
- The shortage of semiconductors and computer components during the pandemic highlighted the lack of resiliency in the supply chain. Additionally, many of these products go into sensitive defense applications. Legislation such as the CHIPS ACT enacted in response are incentivizing potential onshoring of semiconductor manufacturing facilities in states, such as Texas.[1]

1 https://www.congress.gov/116/plaws/publ283/PLAW-116publ283.pdf

Texas' Electronics Industry is a Global Supplier of Semiconductors and Other Key Components for the Technology Sector

Texas' high-tech manufacturing sector is concentrated in the Texas Triangle region. The state's trade gateways provide supply chains in the United States and Asia with vital semiconductors and components to assemble computers and electronics. Manufacturers require expedited shipments of high-value inputs, making air cargo an important mode to this industry. The map below illustrates major freight movements to provide a high-level representation of how the supply chain interfaces with the trade gateways and modal networks on the TMFN.



Source: Cambridge Systematics.

4.4 ROLE OF TMFN IN AGRICULTURE SUPPLY CHAINS

Throughout the state's history, agriculture has been a critical industry for Texas. Today, Texas leads the nation in number of farms and ranches, with 247,000 farms and ranches covering 126 million acres.[34] Primary crop production includes cotton, cottonseed, hay, grains, oilseed, sorghum, watermelons, pecans, peanuts, oats, sunflower, wheat, rice, and corn. Texas is also the leading state in the country for cotton production, which is produced mainly in the Western and Panhandle regions of the state. Primary livestock commodity groups in Texas are cattle and calves, sheep, goats, poultry, and eggs and dairy.

DID YOU KNOW?

Texas leads the nation in cash receipts for animals and products ($14.3 billion in 2019) and ranks 10th in cash receipts for crops ($6.3 billion in 2019).

Source: United States Department of Agriculture (USDA), Economic Research Service (ERS).

The following sectors were identified in coordination with TxFAC and represent the major freight activities and movements on the TMFN analyzed for the food and agriculture industry:

Agriculture Crops — includes agricultural crops that are farmed, harvested and sent to market.

Animal Livestock — includes livestock breeding, farming/ranching and processing.

Food Manufacturing — includes food manufacturing associated with the production of food products.

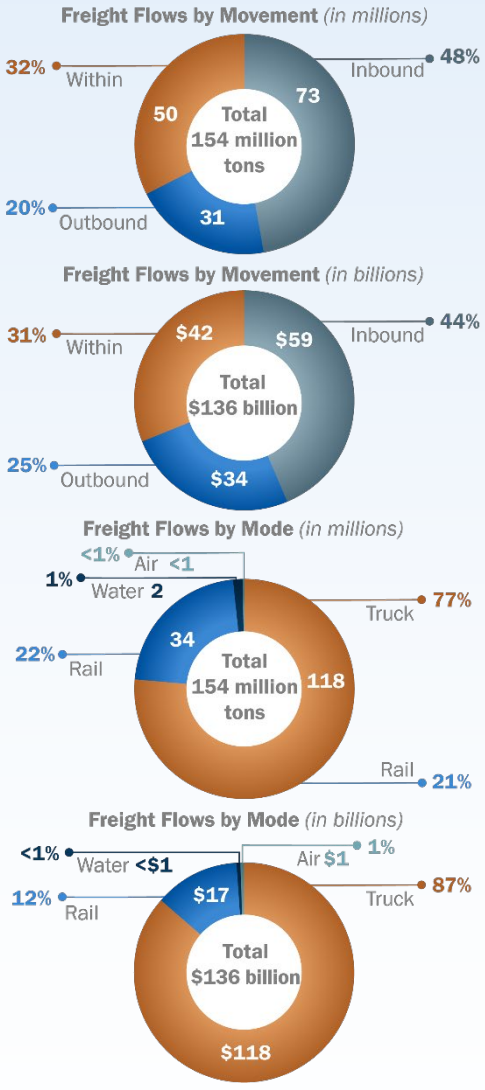
Economic Importance of Agriculture in Texas is Significant

Source: 2020 – Fact Sheet-Feeding the Economy, 2019.

[34] U.S. Department of Agriculture (USDA). 2021 State Agriculture Overview.

Freight Generated by Agriculture and Food Manufacturing

The industry generated **154 million tons** of freight that originated in, was destined for or moved within Texas. Inbound freight represents imports into the state; outbound freight represents exports from the state; and within movements represent freight that originate and terminate in the state. Most of the freight was transported by truck.



Source: Transearch, Waybill, USA Trade Online, Enverus. Analysis by Cambridge Systematics.

TOP COMMODITIES

- Texas is the leading state in the country for cotton production, which is produced mainly in the Western and Panhandle region. The **6.3 MILLION** bales produced in 2019 represented nearly a third of the U.S. total.
- Among U.S. states, Texas is the largest cotton exporter (**$2 BILLION**), second in beef exports (**$1 BILLION**) and fifth in dairy products exports (**$386 MILLION**).
- Agriculture is a high-value export industry in Texas. Among U.S. states, Texas is second in animal product exports (**$2.1 BILLION**), sixth in plant product exports (**$4.2 BILLION**) and fifth in agricultural (combined animal and plant products) exports.
- Port Freeport has the **largest on-dock rice parboiling facility in the world** and handles most of the green fruits imported into Texas and the middle US.

TOP TRADING PARTNERS

MEXICO is Texas' top trading partner of agricultural commodities consisting of imports of fresh vegetables and bulk agricultural commodities.

Significant amount of cattle is trucked in from MEXICO to feed yards across the Texas Panhandle.

VIETNAM, CANADA, CHINA and NIGERIA are other top trading partners for imports of bulk grain and grain products from Texas.

The highways, multimodal facilities and trade gateways on the TMFN function as an integrated system that facilitates the seamless delivery of commodities and products. To serve the transportation needs of the supply chains in this industry cluster, **Texas will need to ensure sufficient capacity and reliability** for the following elements on the TMFN:

- Highway's transport significant tonnage of agricultural and food manufacturing. Critical links on the THFN include I-10, I-20, I-27, I-35, I-37, I-40, I-45, US 60, US 84, US 281 and US 287.
- Texas Freight Rail Network lines connecting Texas with neighboring Oklahoma and Louisiana and various lines within Texas reaching major cities in the north (Amarillo); Gulf Coast (Houston, Beaumont and Corpus Christi); and in the central part of the state (San Marcos, Lockhart, Bastrop and Georgetown).
- Texas Seaports - Port Houston, Port of Galveston, Port of Corpus Christi, Port Freeport, Port of Beaumont and Port of Brownsville are key gateways to export agricultural commodities to trade partners in South America, Africa and Asia.
- Texas-Mexico border crossings at El Paso, Presidio, Pharr, Eagle Pass and Laredo play a significant role in transporting agricultural products to Mexico.

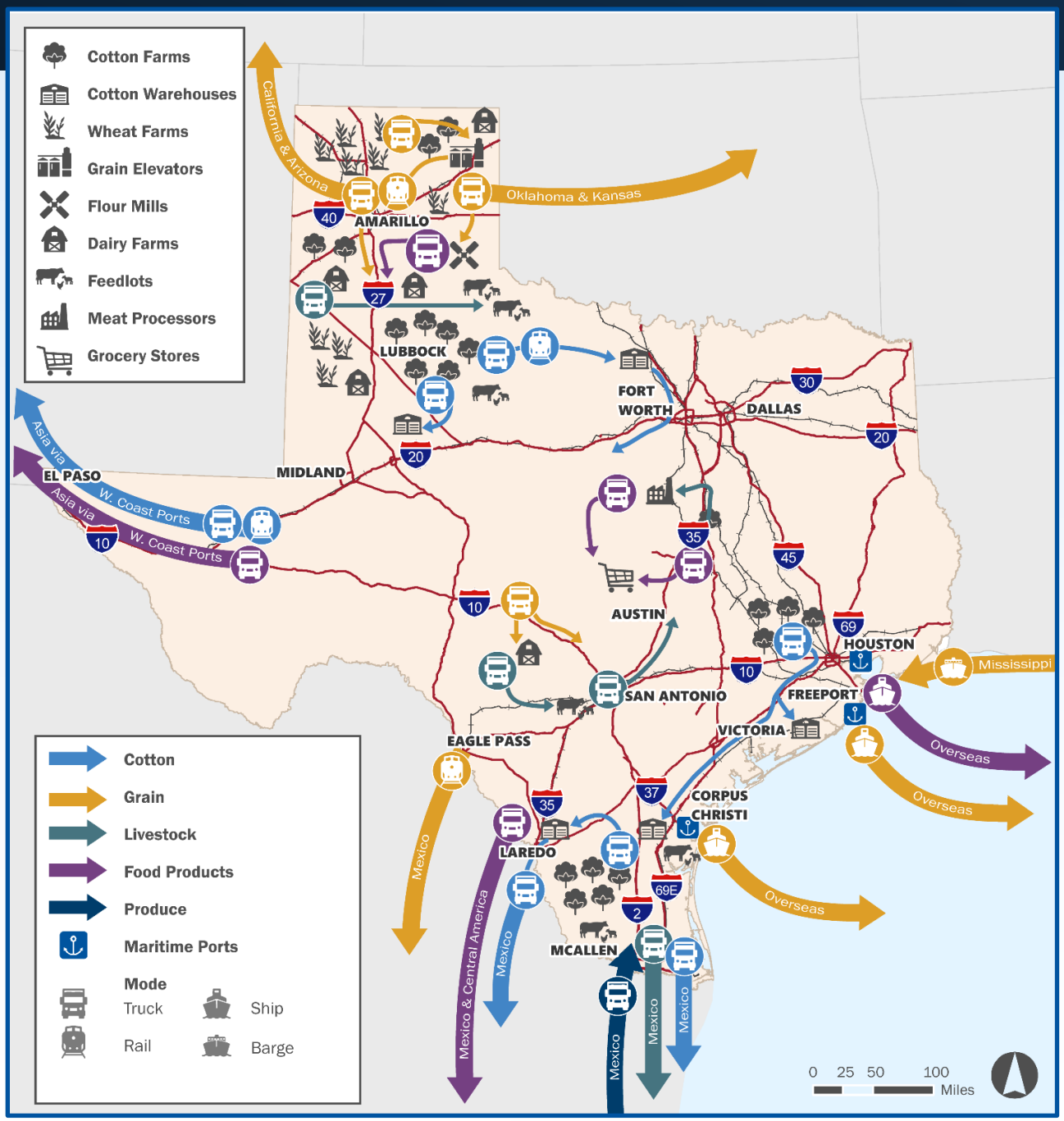
KEY TRENDS IMPACTING INDUSTRY

There are numerous trends driving growth for the food and agriculture industry that will lead to increased demand for freight transportation on the TMFN. Some of the key trends include:

- Loss of arable land in counties because of the growing population in the state, resulting in increased urbanization, rural development and land fragmentation.
- Increasing droughts and higher temperatures will impact the productivity of Texas' farms and cattle ranches.
- In the coming decades, storms are forecasted to become more severe, and summers are forecasted to become increasingly hot and dry, creating problems for agriculture. Increasing droughts and higher temperatures are likely to interfere with Texas' farms and cattle ranches, as well as farmers who irrigate crops.
- Environmental concerns linked to meat production in other countries could create opportunities for domestic industry growth.

Texas' Agriculture Supply Chains Keeps Grocery Stores Stocked

The agriculture industry in Texas is a leading producer of crops and livestock. Highways and rail transport commodities from farms and ranches to food processing facilities. These agriculture products ultimately make their way to grocery stores in Texas and to the rest of the country. Texas' trade gateways send agriculture exports abroad that feeds people around the world. The map below illustrates major freight movements to provide a high-level representation of how the supply chain interfaces with the trade gateways and modal networks on the TMFN.



Source: Cambridge Systematics.

4.5 ROLE OF TMFN IN CONSTRUCTION SUPPLY CHAINS

Over the past decade, Texas has experienced large influxes of new residents and businesses drawn to the robust economy and quality of life. Since 2010, Texas saw an addition of nearly 4 million people, a 15.9% increase in population, which ranks third in the nation for population growth.[35] The construction industry is a key sector that provides housing and supporting infrastructure that grows the state's population and industries.

The following sectors coordinate with TxFAC and represent the major freight activities and movements on the TMFN analyzed for the construction industry:

DID YOU KNOW?

Within the construction industry, the highest employment is in Heavy and Civil Engineering Construction, which employs about 418,000 Texans.

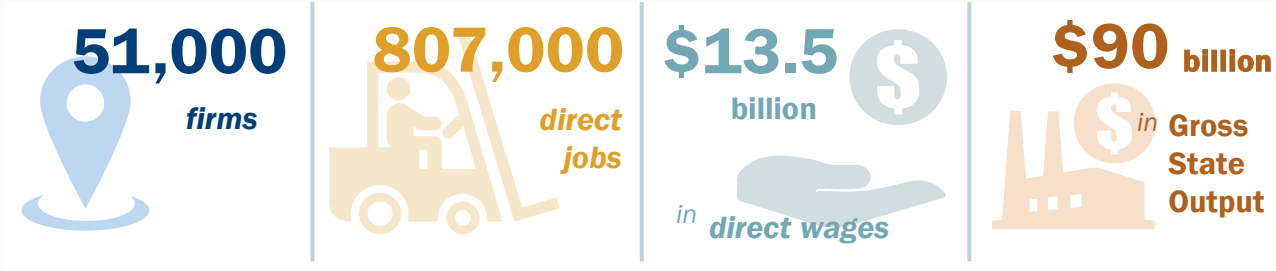
Source: Texas Workforce Commission, 2020

Lumber and Wood Products — includes raw materials transported to Texas from forests outside the state or harvested from the state's forests, as well as finished lumber/wood products that are either manufactured in or brought to Texas.

Metallic Building Supplies — includes primary steel products manufactured at Texas steel mills or transported to the state from outside suppliers and finished metal products manufactured in or brought to Texas for use by the construction industry.

Nonmetallic Mineral Products — includes raw materials such as aggregates and limestone originating from quarries and mines and finished materials, such as cement and concrete, either brought to or manufactured in Texas.

Economic Importance of Construction in Texas is Significant

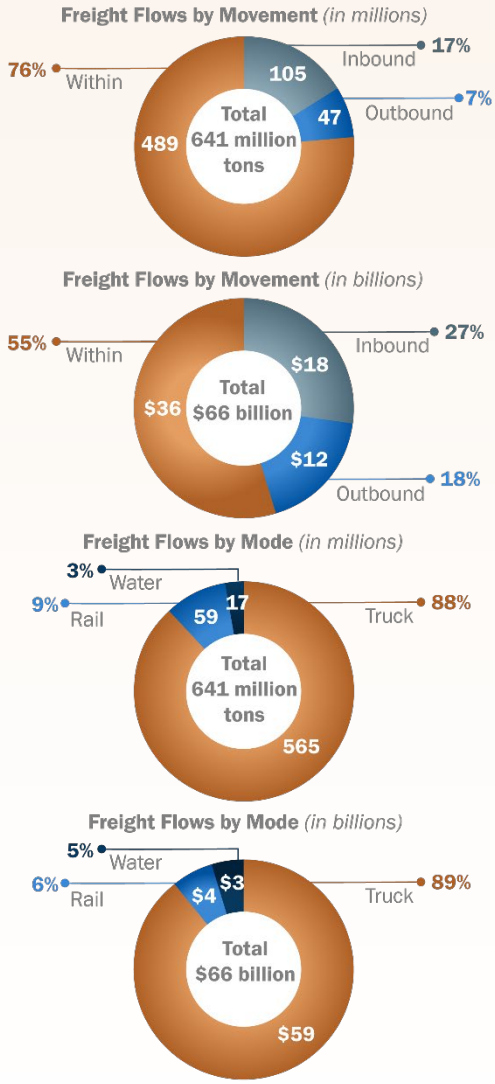


Source: Texas Workforce Commission, Quarterly Census of Employment and Wages (QCEW) Report, 2020. U.S. Bureau of Economic Analysis, Table SAGDP2N Gross domestic product (GDP), https://apps.bea.gov/itable/iTable.cfm?ReqID=70&step=1.

[35] U.S. Census Bureau. Texas: 2020 Census. *Texas Added Almost 4 Million People in Last Decade*. August 25, 2021. Available at: https://www.census.gov/library/stories/state-by-state/texas-population-change-between-census-decade.html.

Freight Generated by Construction

The industry generated 641 million tons of freight, with a value of $66 billion that originated in, was destined for or moved within Texas. Inbound freight represents imports into the state; outbound freight represents exports from the state; and within movements represent freight that originate and terminate in the state. Most of the freight was transported by truck.



Source: Transearch, Waybill, USA Trade Online, Enverus. Analysis by Cambridge Systematics.

TOP COMMODITIES

- Aggregates are the highest volume non-metallic mineral commodities shipped. Most movements occur within the state, as Texas has resources suitable for production. Crushed stone, gravel and sand account for **430 MILLION TONS**, or over three quarters, of the total for the subsector. Inbound flows of non-metallic materials come from Mexico.
- The largest share of metallic building supplies is shipped intrastate within Texas, including fabricated structural metal products, metal doors and architectural metal work. Over **5.2 MILLION TONS** were shipped in 2019.
- Primary forest materials are the largest subsector of lumber and wood products, with shipments in Texas valued at **$1.3 BILLION** in 2019.
- Texas is a net importer of construction materials. In 2019, imports were valued at **$4.9 BILLION** and represented **12%** of the U.S. total.

TOP TRADING PARTNERS

High volume flows of lumber and wood products from the adjoining states of LOUISIANA, ARKANSAS AND OKLAHOMA or the PACIFIC NORTHWEST, as well as South America.

Steel comes from a variety of sources in TEXAS, MEXICO and OVERSEAS. Steel mills in Texas mostly supply a specific product used by the construction industry (i.e., rebar).

The DALLAS/FORT WORTH metropolitan area receives a significant volume of non-metallic mineral products from OKLAHOMA consisting of broken stone/rip rap and gravel/sand.

The highways, multimodal facilities and trade gateways on the TMFN function as an integrated system that facilitates the seamless delivery of commodities and products. To serve the transportation needs of the supply chains in this industry cluster, **Texas will need to ensure sufficient capacity and reliability** for the following elements on the TMFN:

- Highways connecting lumber producing regions in the woodlands of East Texas and adjacent states. Connections into Louisiana, Arkansas and Oklahoma take place over I-10, I-20, I-30, I-35 and US 75 in the eastern part of Texas.
- Texas Freight Rail Lines - Lumber products such as hardwood from Canada and the Pacific Northwest come into Texas by rail on UP and BNSF lines, though some lumber and pulp come from overseas.
- The Texas Triangle contains the largest population centers of the state, and I-10, I-45, I-35 and US 290 connect them. US 287 and the western portions of I-10 and I-20 link the Texas Triangle highways to urban centers further west. I-35 travels through the major limestone deposits of Texas, and most of the state's cement plants are in this corridor for proximity to supply. Some crushed limestone is sourced from Mexico, entering through Texas through Freeport.
- Texas Seaports - The full length of the Gulf Intracoastal Waterway is critical infrastructure, with key points at Port Arthur, Port Houston, Port Freeport and Port of Corpus Christi. Steel comes in by barge from Arkansas. Texas steel mills are either near the waterway or within the Texas Triangle. A great deal of aggregate is shipped by barge. In 2019 alone, the Port of Victoria shipped over a half million tons of sand and gravel.[36] Port Houston and the surrounding port district is the leading gateway for wood products, primary metal products and non-metallic minerals.

KEY TRENDS IMPACTING INDUSTRY

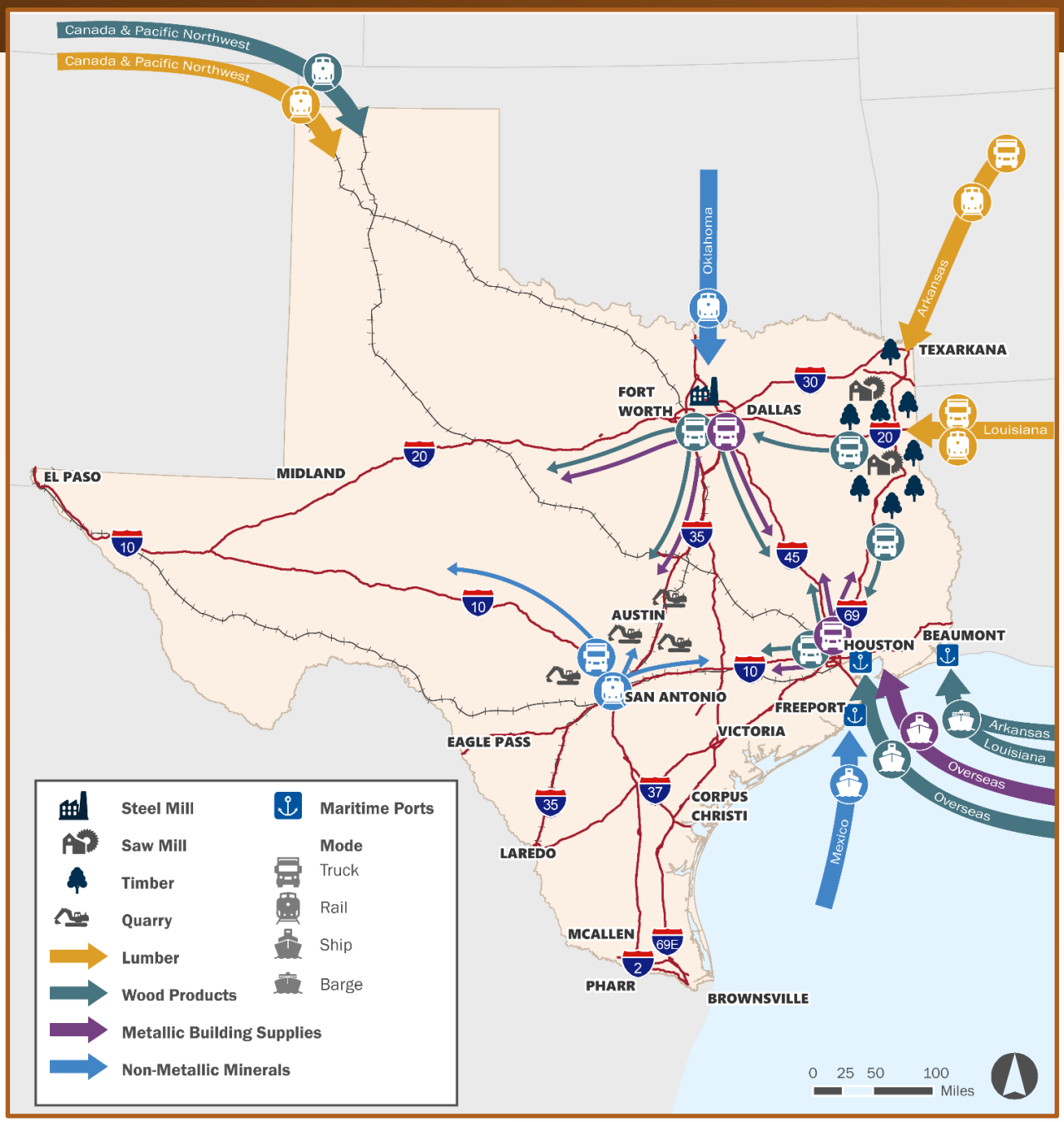
There are numerous trends driving growth for the construction industry that will lead to increased demand for freight transportation on the TMFN. Some of the key trends include:

- Texas is among the highest population growth states in the country, and the Texas construction industry will need to meet the demand for housing and all other structures and infrastructure that these additional residents will require.
- Building supplies may need to come from locations farther away as development expands outward in metropolitan areas. Quarries and mines that operate on the periphery may find themselves in conflict with new, adjacent residential and commercial land uses.
- Construction companies are considering greater usage of prefabrication/modular building to shorten construction time. Building components are constructed offsite and then transported to the construction site and assembled.

[36] Supply Chain Working Group (SCWG) discussion.

The Construction Industry Provides Infrastructure Vital to the Growth of Texas' Economy and Population

Texas' construction industry depends on materials sourced from the mining and forestry sectors within the state and around the country. Trucks deliver wood, gravel and steel rebar to construction sites in metropolitan areas. Texas ports are gateways to materials from global suppliers. The map below illustrates major freight movements that provide a high-level representation of how the supply chain interfaces with the trade gateways and modal networks on the TMFN.



Source: Cambridge Systematics.

4.6 ROLE OF TMFN IN PETROLEUM SUPPLY CHAINS

With abundant sources of fossil fuels and renewables, **Texas is the leading producer of energy** in the U.S. In 2019, Texas accounted for 23% of the total energy produced in the U.S., and oil and natural gas were the leading sources of energy representing 93% of the total produced in the state. [37] The **petroleum** industry includes oil and natural gas drilling, extraction, support services, refining, pipeline transport, petroleum product manufacturing and retail distribution. Texas is also a key supplier of petrochemicals derived from oil and natural gas used to create plastics, rubber, fertilizers, cleaners, lubricants, pharmaceuticals, adhesives and many other products and materials that are essential to everyday life.

DID YOU KNOW?

The Permian Basin produces **15%** of all natural gas in the nation and is also the number one producer of wind energy.

Source: U.S. Energy Information Administration

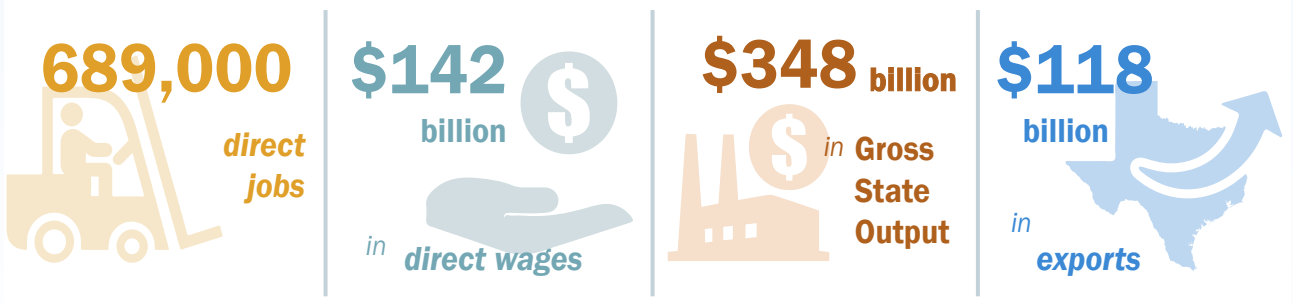
The following supply chain sectors were identified in coordination with TxFAC and represent the major freight activities and movements on the TMFN analyzed for the petroleum industry:

Oil and Gas Production — includes crude oil and natural gas that is extracted, refined/processed and distributed in Texas.

Petrochemical Manufacturing — includes petrochemicals produced from refining oil and gas and distributed through pipeline and intermodal transfer networks.

Rubber and Plastics Manufacturing — includes the production of plastic resins and synthetic rubber that are supplied to end users as key materials and inputs for manufacturing.

Economic Importance of the Petroleum Industry in Texas is Significant

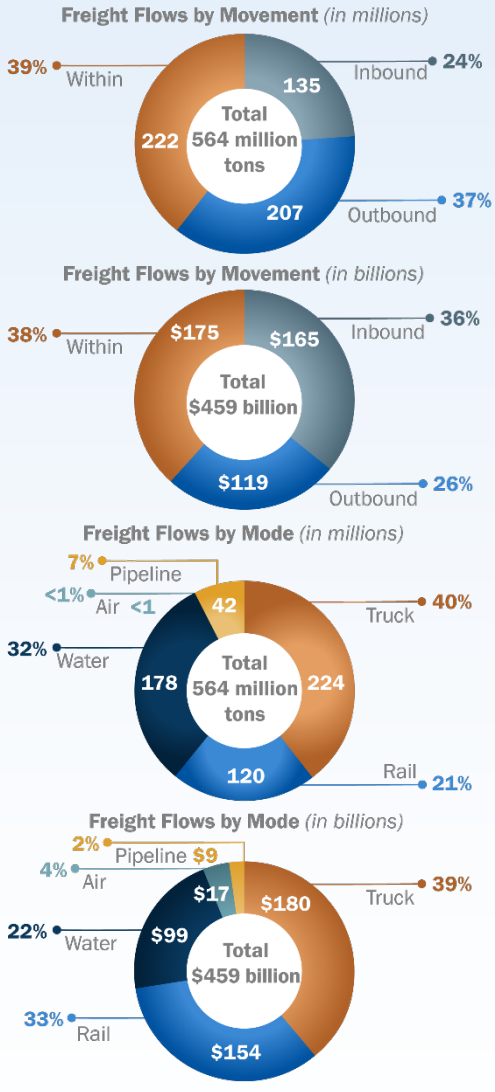


Sources: (1) American Petroleum Institute. Impacts of the Oil and Natural Gas Industry on the US Economy in 2019. July 2021. Prepared by PricewaterhouseCoopers (PwC). (2) American Chemistry Council. 2019 Guide to the Business of Chemistry; 2020 Guide to the Business of Chemistry; 2021 Guide to the Business of Chemistry.

[37] U.S. Energy Information Agency (EIA). State Profile and Energy Estimates, 2019 Texas Profile Data. Available at: https://www.eia.gov/state/data.php?sid=TX#SupplyDistribution

Freight Generated by Petroleum Manufacturing

The industry generated 564 million tons of freight that originated in, was destined for or moved within Texas. Inbound freight represents imports into the state; outbound freight represents exports from the state; and within movements represent freight that originate and terminate in the state. Nearly three-quarters of freight was transported by truck.



Source: Transearch, Waybill, USA Trade Online, Enverus. Analysis by Cambridge Systematics.

TOP COMMODITIES

- Texas produced **1.9 BILLION** barrels of crude oil in 2019, the most of any state, accounting for **42%** of domestic production.
- Finished motor gasoline and diesel fuel oil were the leading petroleum product commodities with a combined production of **1.1 BILLION** barrels in 2019.
- Exports oil and gas commodities had the highest value **($74.9 BILLION),** followed by exports for the chemical sector **($42.6 BILLION).**
- Propane/propylene was the top petrochemical commodity exported from the Gulf Coast region with a total volume of nearly **350 MILLION** barrels in 2019.

TOP TRADING PARTNERS

LOUISIANA was Texas' top domestic trading partner for oil and natural gas imports and exports.

LOUISIANA was also the top domestic trading partner for petrochemicals, representing 28% and 33% of Texas' imports and exports with the rest of the country.

MEXICO was the top destination for natural gas, with over 1.8 trillion cubic feet of natural gas exported from Texas or 40% of total U.S. natural gas exports.

MEXICO was the top North American trading partner for petrochemicals, importing 3.4 million tons, or 26% of total tonnage.

The highways, multimodal facilities and trade gateways on the TMFN function as an integrated system that facilitates the seamless delivery of commodities and products. To serve the transportation needs of the supply chains in this industry cluster, **Texas will need to ensure sufficient capacity and reliability** for the following elements on the TMFN:

- **Rural highway networks** transport production inputs and waste byproducts involved in oil and gas production. SH 302, US 385, SH 349 and US 285 on the THFN are some of the main highways in the Permian Basin region that facilitates these truck movements.
- **Interstate routes** such as I-10, I-20, I-35 and I-45 are used to transport heavy machinery and drilling inputs from suppliers and distributors to the shale plays in the state (Permian Basin, Barnett, and Eagle Ford). Many of these companies are based in the Houston metro area.
- **Pipeline intermodal facilities** along the border at Laredo, Brownsville and El Paso transfer fuels and refined products to trucks and trains bound for Mexico.
- **Pipelines** on the TMFN includes intrastate networks that serve users within Texas and interstate networks that supplies bulk products to other major metropolitan areas of the country.
- **Texas seaports** serve as gateways for exporting petroleum products to domestic and international markets. Port Houston, Port of Corpus Christi, Port of Beaumont, Port Freeport and Port Arthur are located near the refinery complexes on the Texas Gulf Coast and provide maritime access to the GIWW.

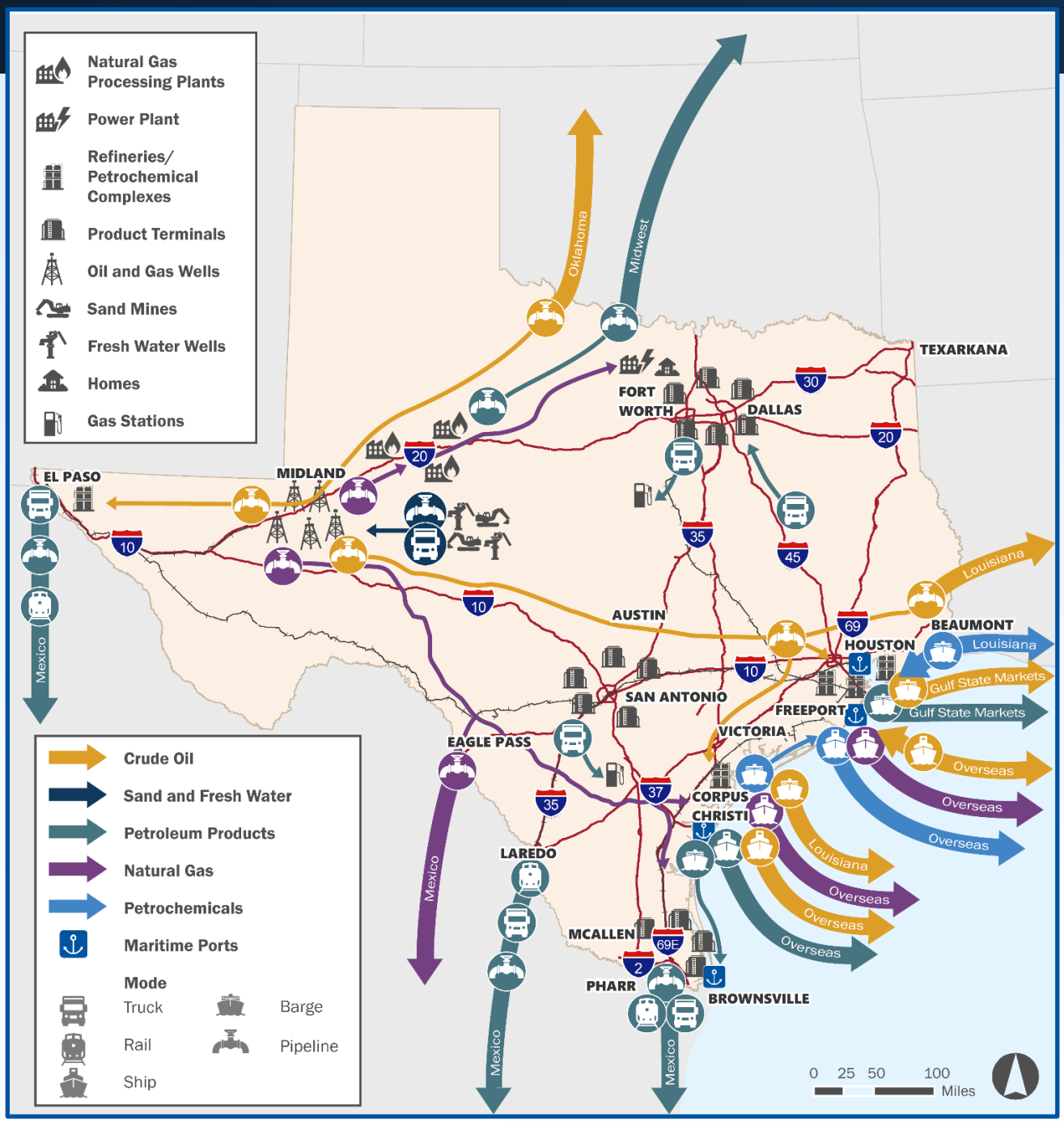
KEY TRENDS IMPACTING INDUSTRY

There are numerous trends driving growth for the petroleum industry that will lead to increased demand for freight transportation on the TMFN. Some of the key trends include:

- Changes in global energy prices for crude oil and natural gas can influence production activity and output in the state. If the effect on prices continues over time, companies will adjust their operations and production levels according to market conditions. The ongoing war in Ukraine and many nations' response to sanction, boycott, or embargo Russian oil may continue upward pressure on prices that results in greater petroleum production in Texas.
- Extreme weather conditions such as flooding and freezing temperatures can shut down production, and pipelines and processing facilities. The oil production and petrochemical manufacturing sectors are vulnerable to hurricanes, with the large concentration of refinery complexes located near Houston, Corpus Christi, Freeport, Port Arthur, Beaumont and Galveston Bay.
- This shift in consumer preferences towards sustainable and reusable products could impact the petrochemical manufacturing sector that produces the feedstocks for plastic manufacturing.

Texas' Petroleum Supply Chains are Interconnected with Global Energy Markets

The petroleum industry touches nearly every facet of the freight network — highways, rail, seaports and pipelines. Texas' energy exports reach domestic markets and the rest of North America and abroad through pipelines, land border crossings and seaports. Last-mile delivery relies on trucking to distribute commodities and products, such gasoline, fuels and chemicals to end users. The map below illustrates major freight movements that provide a high-level representation of how the supply chain interfaces with the trade gateways and modal networks on the TMFN.



Source: Cambridge Systematics.

4.7 ROLE OF TMFN IN WAREHOUSING AND DISTRIBUTION SUPPLY CHAINS

The warehousing and distribution sector is an integral part of any supply chain. Key industries in Texas such as automobile and electronics manufacturing rely on these logistical networks to manage inbound and outbound shipments of commodities and goods. The state's businesses and households also rely on the sector to access consumer goods and commercial products. A combination of growth in e-commerce and consumer preferences for online shopping is driving the demand for warehousing and distribution center capacity, especially to serve markets in the major urban regions of the state.

GROWTH OF E-COMMERCE

The COVID-19 pandemic accelerated the growth of e-commerce in Texas and around the nation. The Census Bureau shows e-commerce accounted for about 12% of all sales in the nation at the start of 2020 and increased to **14.5%** by the second quarter of 2022, increasing the importance of distribution centers.

Source: U.S. Census Bureau, 2022

The following sectors were identified in coordination with TxFAC and represent the major freight activities and movements on the TMFN analyzed for the warehousing and distribution industry:

Warehousing — includes facilities dedicated to the storage of raw materials prior to production, the maintenance of work in progress through the production cycle and the collection of finished goods ready for delivery to the point of final consumption by business or consumers. Warehouse establishments are considered an intermediate stage in the consumer goods supply chain.

Retail Distribution — includes facilities primarily engaged in the selling of goods or services to consumers or end users. Retail distribution establishments are considered the final stage of the consumer goods supply chain.

Economic Importance of the Warehousing and Distribution Industry in Texas is Significant

685,000 *direct jobs*

$24.8 billion *in direct wages*

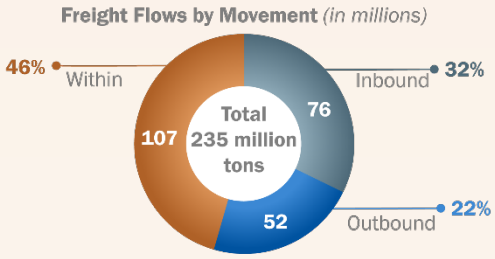
$73.2 billion *in* **Gross State Output**

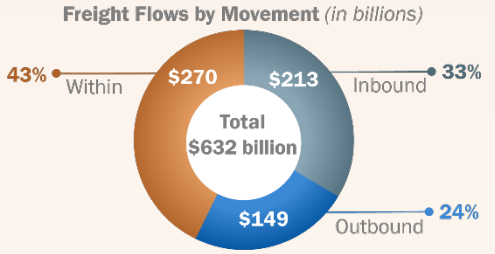
$40 billion *in* **value added to the state economy**

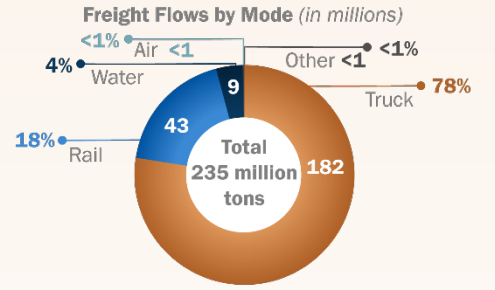
Source: Texas Workforce Commission and IMPLAN input-output multipliers.

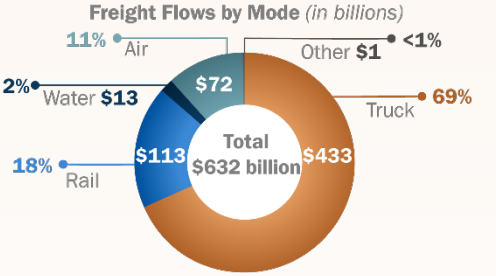
Freight Generated by Warehousing and Distribution

The industry generated 235 million tons of freight, with a value of $632 billion that originated in, was destined for or moved within Texas. Inbound freight represents imports into the state; outbound freight represents exports from the state; and within movements represent freight that originate and terminate in the state. Nearly three-quarters of freight was transported by truck.









TOP COMMODITIES

- Most of the inbound cargo by tonnage was for grocery which included dry goods and perishables. Inbound shipments in 2019 amounted to **47.3 MILLION TONS**, valued at **$61.9 BILLION.**
- Grocery also accounted for most of the outbound cargo by tonnage at **54%** of the **20.3 MILLION TONS.**
- General retail and personal health represented about **6%** combined of the total **235 MILLION TONS** overall for the sector, but **29%** of the total value of **$632 BILLION**, suggesting that these commodities are more valuable on a per-ton basis.
- The value of imports for the general retail and grocery sector was greater than exports by a ratio greater than 2:1 in 2019. General retail imports were valued at **$26.3 BILLION**, nearly twice the value of grocery imports (**$11.9 BILLION**).

Source: Transearch, Waybill, USA Trade Online, Enverus. Analysis by Cambridge Systematics.

TOP TRADING PARTNERS

Significant warehouse distribution cargo moves between Texas, CALIFORNIA and ILLINOIS and between NEW MEXICO and El Paso.

Retail commodities flow into Texas from CALIFORNIA, ILLINOIS, OHIO and GEORGIA. Some retail commodities from CALIFORNIA involve imports to be distributed throughout the United States from Texas.

Large inbound grocery commodity flows between CALIFORNIA and Houston, as well as ARKANSAS and Houston; MEXICO and the border crossing at Hidalgo; NEBRASKA and ILLINOIS and the border crossing at Eagle Pass; and IOWA and the Texas Triangle, as well as the northwest corner of Texas.

The highways, multimodal facilities and trade gateways on the TMFN function as an integrated system that facilitates the seamless delivery of commodities and products. To serve the transportation needs of the supply chains in this industry cluster, **Texas will need to ensure sufficient capacity and reliability** for the following elements on the TMFN:

- **Containerized intermodal rail freight** for Asian imports entering the U.S. via West Coast ports and international border crossings. The West Coast rail freight are destined to rail intermodal facilities across the state and to major logistics hubs (i.e., inland ports), such as AllianceTexas and the Dallas Intermodal Terminal.
- **Texas seaports** are a major gateway for retail distribution goods that enter the state. Port Houston plays a major role in the transport and distribution of retail commodities into the state.
- **Trucking** is an essential mode for all retail cargo. The largest cargo flows move through the major urban areas (particularly within the Texas Triangle). There is also a large volume of tonnage coming from the border at Laredo, El Paso and Pharr.

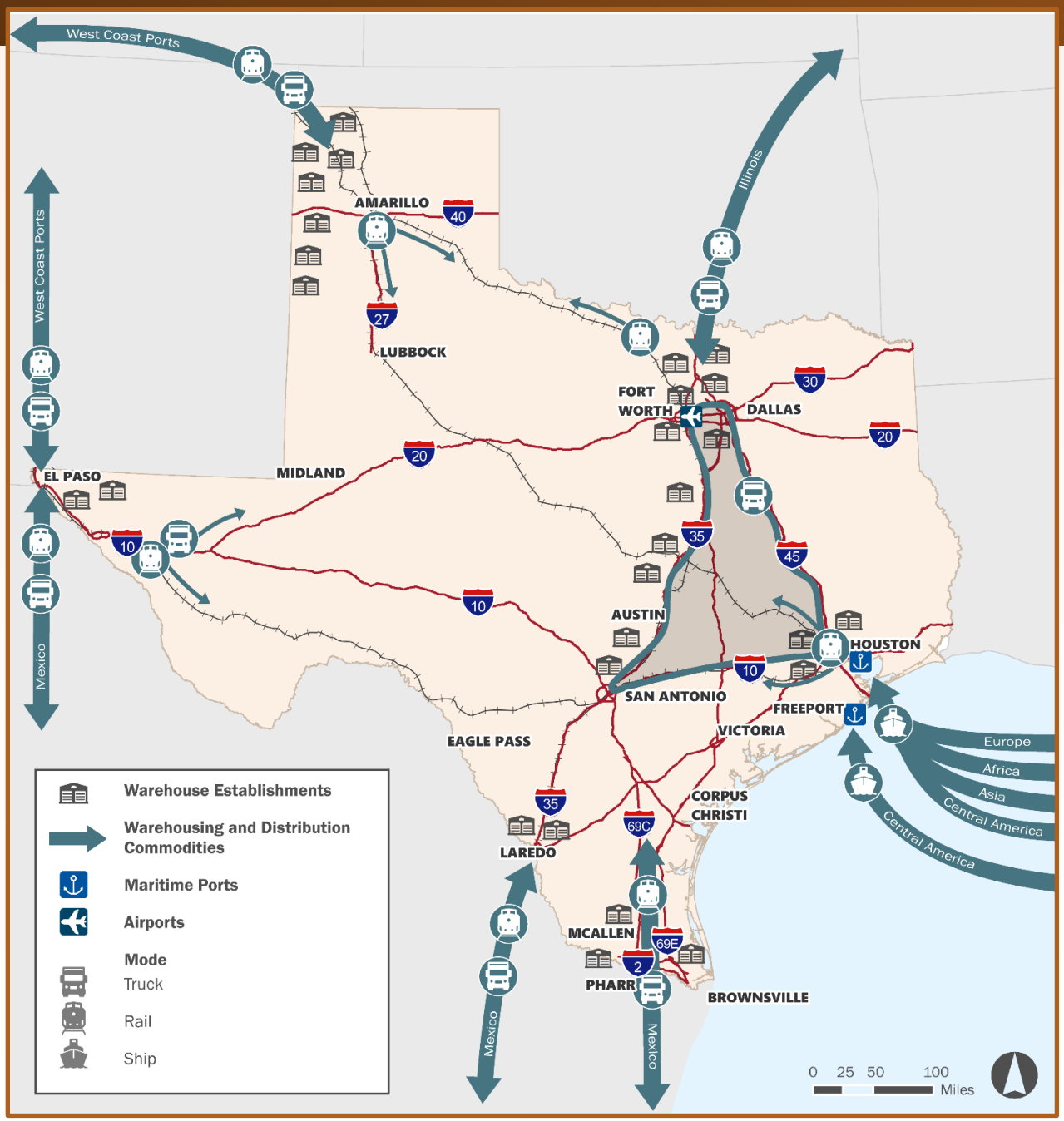
KEY TRENDS IMPACTING INDUSTRY

There are numerous trends driving growth for the warehousing and distribution industry that will lead to increased demand for freight transportation on the TMFN. Some of the key trends include:

- Growth in e-commerce is likely to result in more goods moving inbound into the state, arriving via truck, rail and ship, headed for large warehouses and distribution centers. This growth could lead to more traffic on local roads, as these goods are distributed to smaller warehouses, businesses and residences.
- U.S. companies that were previously offshoring some of their production to Asia have considered moving production closer to domestic markets (nearshoring) or to lower cost areas in the southern and southeastern United States (onshoring). Texas is an attractive location for domestic manufacturing with its central, geographic location and advantages in lower cost of labor and land.
- The push for sustainability may result in the use of smaller, more efficient vans in place of larger trucks (a trend also seen in e-commerce). Since these vans are more efficient on shorter routes than longer ones, the result is more trips on local roads which are often not suitable for high levels of traffic.

Warehouse and Distribution Supply Chains Connect Businesses with Their Customers

Centrally located, Texas is well linked to global supply chains. The speed and efficiency of e-commerce depends on an expansive multimodal network that brings goods from around the world to Texas households and businesses. Imports arrive from the West Coast by truck and rail or directly to Texas markets through its land ports of entry, seaports and airports. The map below illustrates major freight movements that provide a high-level representation of how the supply chain interfaces with the trade gateways and modal networks on the TMFN.



Source: Cambridge Systematics.

4.8 KEY SUPPLY CHAIN TAKE AWAYS

The supply chain analysis helps give a comprehensive understanding of how the key industries in Texas are using and relying on the TMFN. This understanding is critical to help identify and prioritize needs across all modes to ensure the right capacity and operational efficiencies are in place in the right markets at the right time. The six industry clusters presented above helped create several key points that inform the strategies and recommendations discussed in Chapters 8 and 9. Key highlights include:

- **Texas' key industry clusters all rely on a global supply chain.** Texas' industry clusters are integrated into the global economy, with raw materials and finished products moving through land, and air and sea gateways. These movements rely on intermodal connectivity, foreign trade zones and customs services.

- **The Texas Triangle is integral to most industry clusters.** The Texas Triangle, bound by I-35 (San Antonio to Dallas/Fort Worth), I-10 (San Antonio to Houston) and I-45 (Houston to Dallas/Fort Worth), is prominent in almost all the industry cluster supply chain illustrations. As the economic and population center of the state, this region is crucial for some part of the operation for each of the six industry clusters.

- **Industry clusters span rural and urban geographies.** Each of the industry clusters impacts rural and urban communities. For some clusters such as agriculture, petroleum and construction, key operations occur in rural locations (growing/harvesting, mining). For other clusters such as advanced manufacturing and warehousing, key operations tend to be more concentrated in urban locations. For all industries, raw materials and finished goods travel throughout the state.

- **Clusters rely on local connections to access key TMFN corridors and gateway.** Finally, it is important to acknowledge that while there are key corridors and gateways driving the success of these industries, local connections to and from the farms, factories and distribution centers are critical to an efficient supply chain. While these local connections are not visible on the supply chain illustrations or lists of key modal links, they are a critical component that must be planned and invested.

- **Key industry clusters rely on common elements of the TMFN.** Industry clusters are located throughout Texas and rely on all parts of the TMFN. Many of the key corridors and gateways are used by multiple industry clusters, clearly indicating the importance and accurate designation of the TMFN.

- **Each industry cluster has its own unique set of needs.** While there is much overlap in the facilities used, each industry cluster has aspects that are unique to its operation. This

includes service requirements, time of day operations, first/last mile connectivity and markets/trading partners.

- **All key industry clusters rely on multiple modes of transportation.** Texas' key industry clusters discussed in Texas Delivers 2050 reflect industries that use more than one mode of transportation. This mode varies by supplier, commodity characteristics, market proximity, and service requirements. Therefore, the success of the Texas economy will be based on the continued investment in all modes.

These key highlights illustrate the vast importance of all parts of the TMFN and connections to this network for the industries based in benefitting Texas.

Chapter 4 presented and discussed how the TMFN is used by six key industry supply chains. Chapter 5 presents an overview of the multimodal needs assessment for each mode.

Chapter 5 Assessing TMFN Infrastructure Needs and Challenges

The TMFN designation process discussed in Chapter 3 identified the most important freight assets on the multimodal network. This chapter provides a high-level evaluation of the conditions and performance of the modes and key assets on the network — highways, rail, ports and waterways, air cargo and pipelines.

The issues and challenges affecting the current efficiency and safety of freight movements on the TMFN are discussed based on infrastructure needs affecting the performance and asset conditions on the statewide network. The freight infrastructure needs and challenges along the highway component of the TMFN are highlighted in the areas of **mobility, safety, asset management** and **design**. Addressing these critical freight areas support the goals of Texas Delivers 2050 by creating an environment for the safe and reliable movement of freight. Freight investments that increase mobility, safety and preservation in turn support economic competitiveness, multimodal connectivity, stewardship and customer service.

The overview of needs and challenges presented in this chapter draw from the Multimodal Freight Needs Assessment technical memorandum.

Freight infrastructure needs are organized and discussed by mode in this chapter.

Highlights

Highway congestion in Texas resulted in $1.5 billion in trucking costs in 2019 from lost time and excess fuel consumption.

About 80% of the mileage on the THFN has a Good or Fair pavement condition rating.

In 2021, 95% of bridges on the THFN are in Good or Satisfactory condition, and 14% of bridges meets the current clearance vertical standard of 18.5 feet.

Truck-involved crashes increased 8% between 2015 and 2019. Despite a 12% decrease in truck-involved crashes between 2019 and 2020, fatal truck-involved crashes only decreased by 5%.

Class I railroad corridors support 286,000 pound weights, while many short line branches still require an upgrade to this standard.

Dredging on the Gulf Intracoastal Waterway and ship channels presents a persistent asset management challenge due to funding and institutional challenges.

Seven of 10 airports on the TMFN have sufficient runway lengths to support large, international cargo planes.

Source: TxDOT, FAA, TTI.

However, it is important to recognize the modes on the TMFN function as an integrated system. Manufacturing and logistics supply chains in Texas rely on intermodal freight to move commodities and finished goods seamlessly from the point of production to the end user. The efficiency in which freight moves from one mode to another contributes to the competitiveness of Texas supply chains by shortening delivery times, increasing areas of service and reducing operating costs. Chapter 5 discusses multimodal needs across the TMFN, looking at access between the highway network and trade gateways with the rest of the TMFN, as well as multimodal challenges and supply chain impacts.

5.1 HIGHWAY NEEDS

Texas has a vast highway network of over 80,000 miles, and approximately 23,000 of those miles are designated as the THFN. The **THFN is TxDOT's basis for highway freight planning**, and it serves as a significant component of the multimodal freight network. Highways play a critical role in linking all modes, supply chains and commodity types. Trucking and highways play a particularly important role in distribution and goods movement, which requires access to a wide range of possible destinations, flexibility, and rapid service.

Highway needs discussed in this section highlight key modal challenges and issues related to Mobility and Reliability, Safety, Asset Management, and Design and Truck Parking.

5.1.1 HIGHWAY MOBILITY AND RELIABILITY

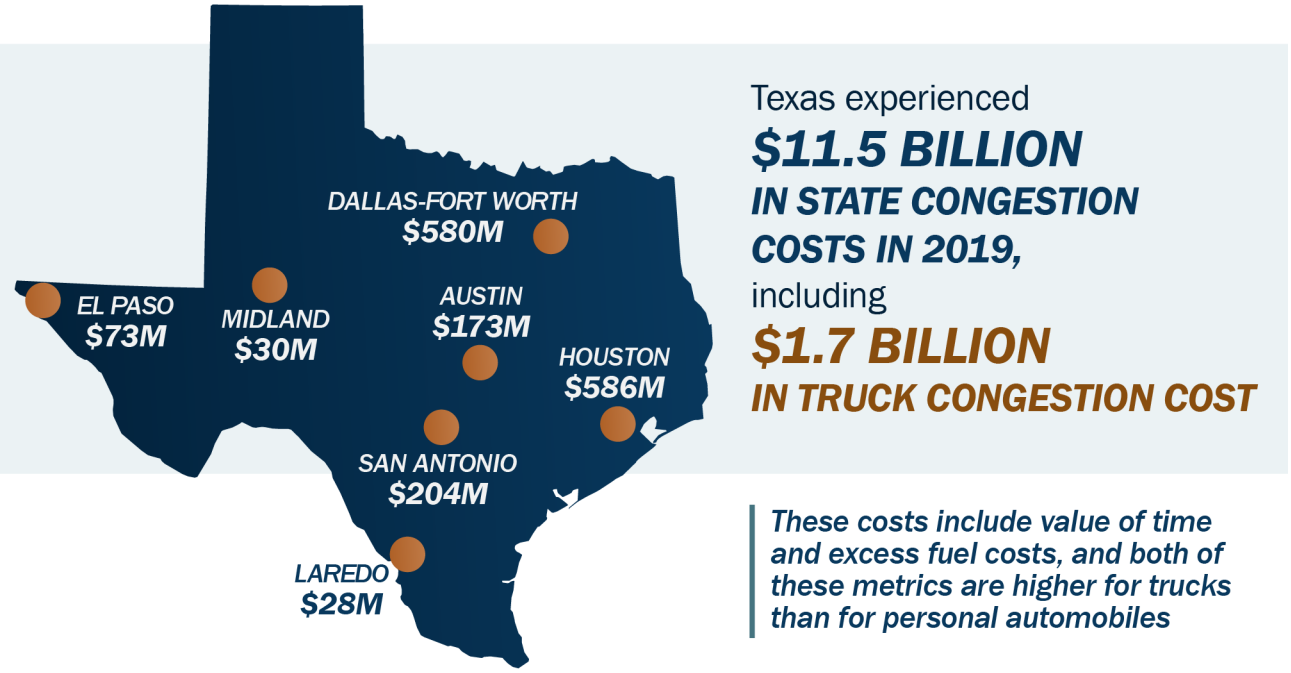
Efficient freight movement depends on uncongested and reliable travel times. Congestion and delay increase costs to private businesses and consumers while also increasing societal and environmental costs. Reliability is critical to freight movement because carriers associated with all modes must plan to meet customer expectations, while balancing labor and equipment availability. Unreliable travel times result in longer planning periods and delayed deliveries, which increase the amount of time people and equipment are required to complete a shipment. In addition, this creates delays in transporting goods to market. This section elaborates on three topics related to freight mobility and reliability:

- **Highway Delay, Reliability and Bottlenecks.**
- **Commercial Vehicle International Border Crossings.**
- **Impacts of Mobility and Reliability on Key Supply Chains.**

HIGHWAY DELAY, RELIABILITY AND BOTTLENECKS

Performance data for highways and trucking are readily available from public and proprietary data sources purchased by TxDOT. Most truck delay occurs in urbanized areas, especially the largest metropolitan areas (**Exhibit 22**).

EXHIBIT 22: COST OF TRUCK DELAY IN TEXAS

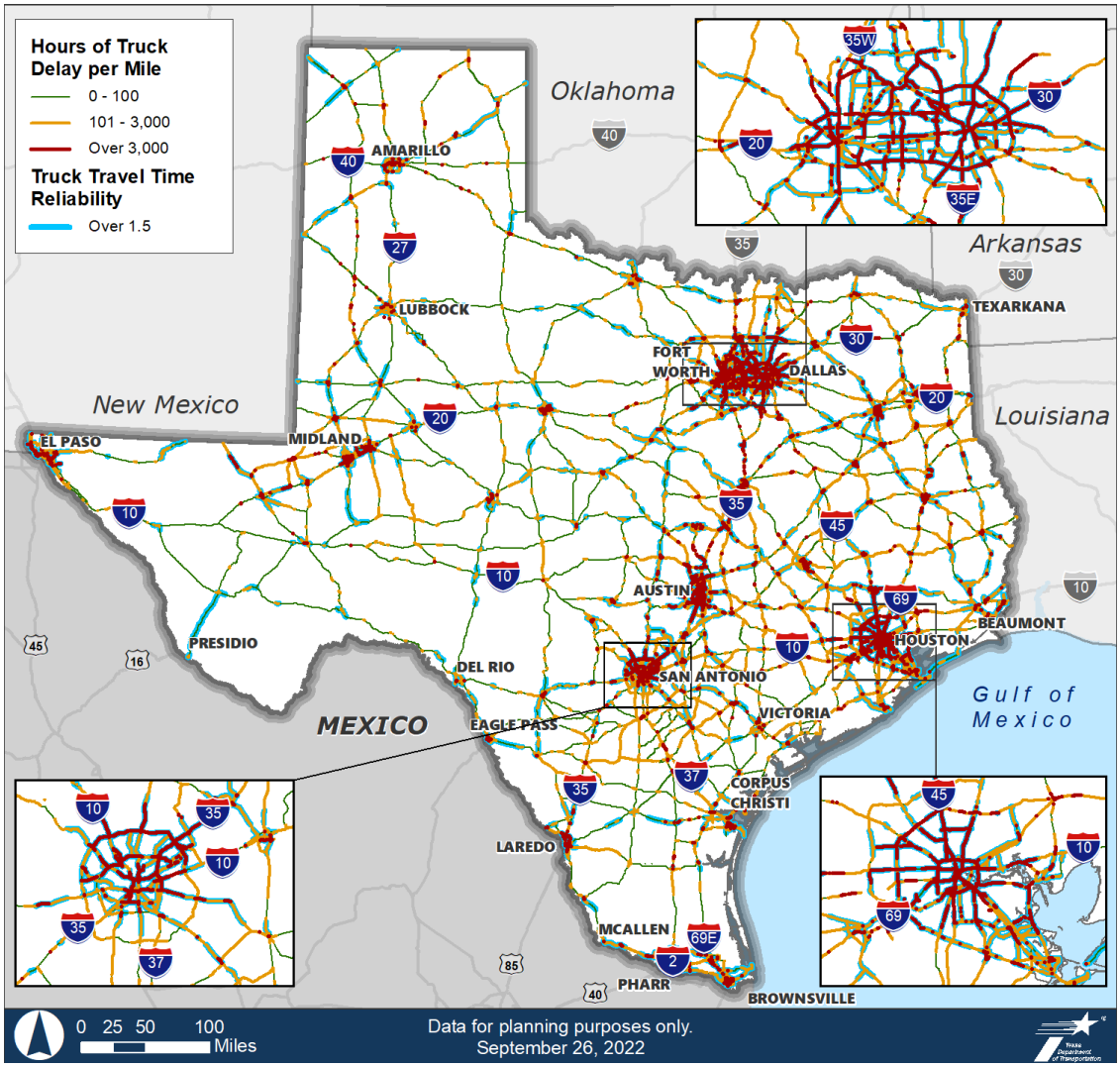


Source: Texas A&M Transportation Institute, Urban Mobility Report. 2021.

Truck Travel Time Reliability (TTTR) is defined by comparing travel times for trucks between a free-flow period with no congestion against normal travel times (95th percentile). A lower TTTR represents a more reliable segment, and **the statewide reliability index in Texas was 1.32 in 2019.**[38] For example, if a trip takes 20 minutes when the driver can drive the speed limit, but has a TTTR of 1.5, a driver would need to plan 30 minutes for the trip to arrive on time 95% of the time. **Exhibit 23** displays truck delay on the THFN, including locations with a maximum TTTR greater than 1.5. These segments require an additional 50% of planned travel time during at least one time of day to reliably arrive on time. Unlike delay, which measures total time lost, reliability concerns over consistent travel times are present in different contexts throughout Texas: urban and rural settings; interchange and corridor locations; and high and low volume roadways. The 10 segments with the greatest truck delay in Texas are identified below the exhibit.

[38] TTTR is calculated for morning, midday, afternoon, and overnight periods during the week, as well as for weekends. The greatest of these five periods is used here and in federal performance measure reporting.

EXHIBIT 23: TRUCK TRAVEL TIME RELIABILITY AND DELAY



Source: INRIX and National Performance Management Research Data Set (NPMRDS), 2019.

TTI'S TOP TRUCK DELAY SEGMENTS IN TEXAS

- **#1** I-35 in Austin — US 290 to SH71
- **#2** I-69 in Houston — SH 288 to I-10
- **#3** I-610 in Houston — I-10 to SW Freeway
- **#4** I-10 in Houston — I-45 to US 59
- **#5** I-45 in Houston — I-10 to South Loop
- **#6** N. Loop in Houston — I-45 to I-10
- **#7** I-35E in Dallas — SH 183 to I-30
- **#8** I35W in Fort Worth — SH 183 to I-30
- **#9** Loop 20 in Laredo — US-Mexico Border to I-35
- **#10** I-69 in Houston — I-610 to SH 288

Source: Texas A&M Transportation Institute, Top 10 Congested Truck Locations, 2020.

ATRI TOP TRUCK BOTTLENECK INTERCHANGES IN TEXAS BY NATIONAL RANKING

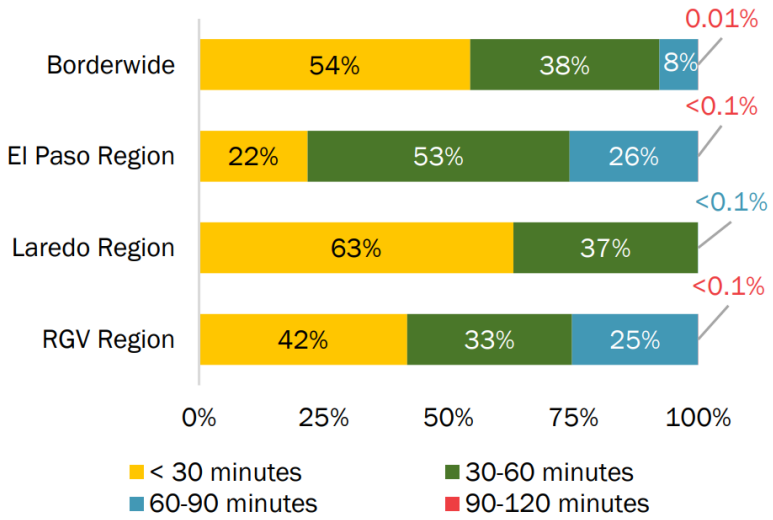
- **#3** Houston — I-45 at 1-69/ US 59
- **#8** Dallas — I-45 at I-30
- **#13** Houston — I-10 at I-45
- **#15** Houston — I-45 at I-610N
- **#27** Austin — I-35
- **#30** Houston — I-10 at I-610W
- **#34** Houston — I-610 at US 290
- **#41** Houston — I-10 at I-610E
- **#54** Dallas — US 75 at I-635
- **#60** Ft. Worth — I-35W at I-30

Source: American Transportation Research Institute, 2022.

COMMERCIAL VEHICLE INTERNATIONAL BORDER CROSSINGS

TxDOT completed its **Texas-Mexico Border Transportation Master Plan** (BTMP) in 2021 and found delays at bridge crossings are currently longer for commercial motor vehicles (about 1 hour) than privately owned passenger vehicles (about 30 minutes). Northbound crossing times vary by region within the state, and crossing times are typically lowest in the Laredo region, the central portion of the Texas-Mexico border (**Exhibit 24**). The El Paso region comprising the western portion of the border had the highest crossing times with 78% of northbound crossings taking more than 30 minutes. The nature of international border crossings requires federal cooperation across state and local jurisdictions, with delays across borders impacting all modes.

EXHIBIT 24: NORTHBOUND COMMERCIAL VEHICLE BORDER CROSSING TIME DISTRIBUTION BY REGION, 2019



Source: TxDOT, Border Transportation Master Plan. 2021.

The value of goods moved by CMV across the Texas-Mexico border is forecast to surpass $1.2 trillion by 2050, a 257% increase from $342 billion in 2019. Fourteen of the 28 border crossings currently process CMVs.[39] Based on the substantial growth in economic activity, the 90th percentile crossing times for commercial vehicles at some bridges could reach more than 18 hours by 2050 under a "no build" future. This is likely because of limited hours of operation for CMV crossings, limited staffing and physical capacity of

Economic Losses from Border Delays

If improvements are not made between now and 2050, the negative impact of Texas-Mexico border delays on the GDP of the U.S. and Mexico will increase from $2.3B in 2019 to $116B in 2050. This is a growth of over 50 times.

Source: TxDOT, Border Transportation Master Plan. 2021

[39] TxDOT, *Border Transportation Master Plan*. 2021. https://www.txdot.gov/government/partnerships/trade-border/btmp.html.

crossing facilities, and the unequal utilization of border crossing locations. Small crossings are generally underutilized, while all large crossings are overutilized. The Pharr Reynosa International bridge, for example, is at 114% current utilization rate and is expected to increase to 356% by 2050.[40] Thus, improving the travel time reliability and capacity of the overall border crossing system will be especially important for the international movement of goods via CMVs in the future.

MOBILITY AND RELIABILITY IMPACTS ON KEY SUPPLY CHAINS

Combined mobility and reliability needs on the THFN were categorized as high, medium or low based on **truck delay, TTTR, and daily truck traffic at at-grade highway-rail crossings**. **Exhibit 25** displays mobility and reliability needs compared to key supply chain corridor locations. Corridors associated with one or more supply chains generally had better mobility and reliability than the THFN as a whole: 27% of the THFN was rated as having high mobility needs, while only 24% of corridors on one or more supply chain networks rated high.

Mobility and Reliability Impacts to Key Supply Chains

Mobility and reliability impact the strength and efficiency of every supply chain incorporated in Texas Delivers 2050.

- Electronics are more impacted by mobility and reliability concerns than any other supply chain, with 44% of key corridor mileage rated high.
- Petroleum is the least impacted, with more than 55% of key corridor mileage rated low.
- In general, highway corridors associated with one or more supply chains had a slightly smaller share of high needs compared to the THFN.
- The mobility and reliability of water, rail and air and pipeline movements depend on first-/last-mile connectivity to key intermodal transfer points for every supply chain. Each mode operates based on set schedules that can impact the reliable movement of specific shipments, including scheduled cut-off times for scheduled flights, sailings, intermodal rail and even commodity specific time slots for pipelines.

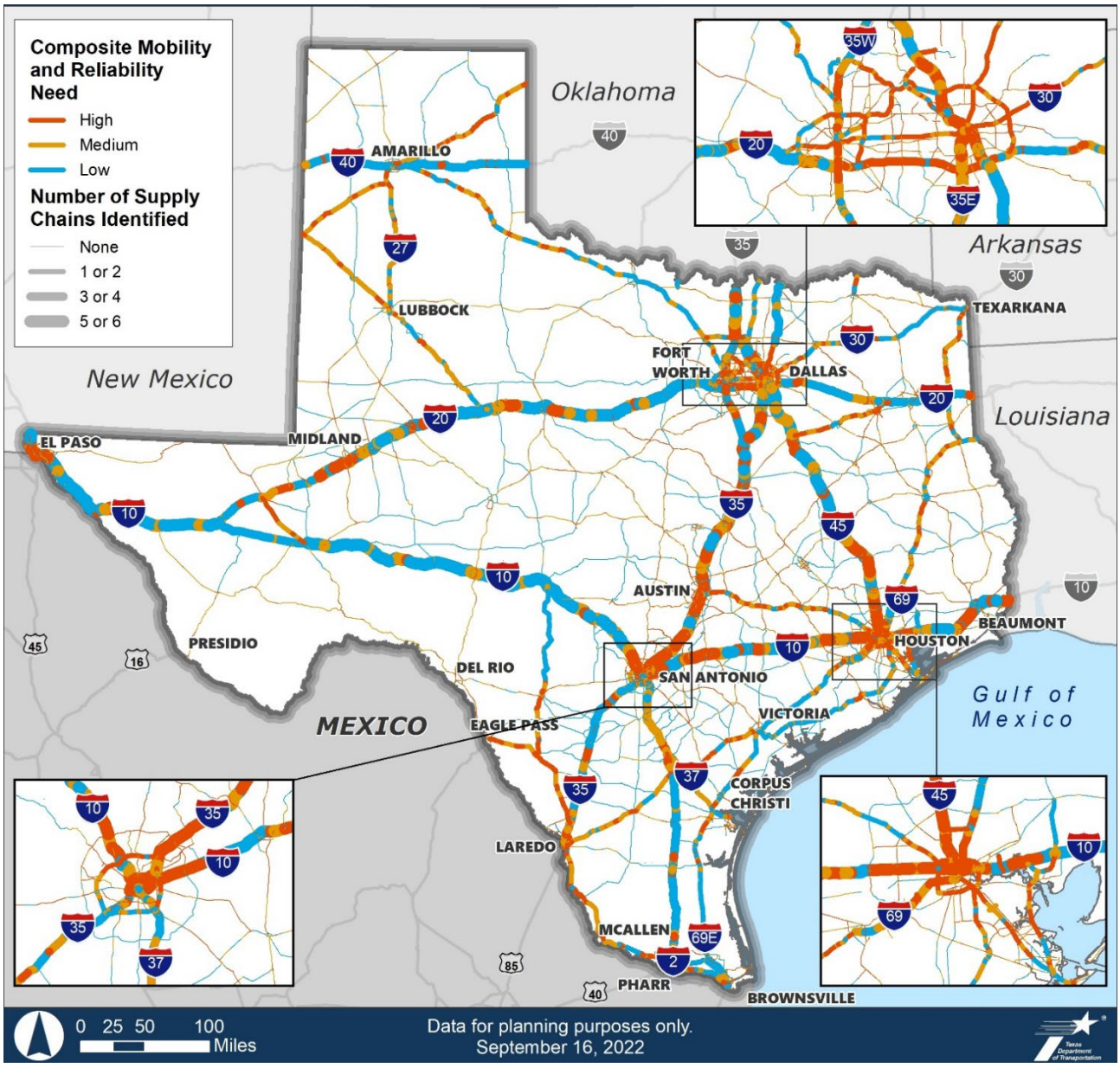
Source: TxDOT.

I-35, I-45, and I-10 in the eastern half of Texas have the greatest concentration of high needs and critically important corridors coinciding. The regional highway networks of Dallas-Fort Worth and Houston also have high mobility needs, reflective of the congestion in Texas' largest metropolitan areas. However, these are not the only areas of concern for freight mobility and reliability. I-20 in West Texas, the US 83/I-2 corridor along the Texas-Mexico border and the US 60 and US 84 corridors in the Panhandle all exhibit high mobility and reliability needs from a freight perspective.

[40] Ibid.

TxDOT has less influence over the mobility and reliability of other modes, but it must respond to changes in volume and throughput at intermodal facilities interfacing with the highway network. All of Texas' key supply chains rely on an integrated, reliable multimodal network to ship goods cost effectively.

EXHIBIT 25: MOBILITY AND RELIABILITY NEEDS ON KEY MULTIMODAL SUPPLY CHAIN CORRIDORS



Source: Cambridge Systematics Analysis, 2022.

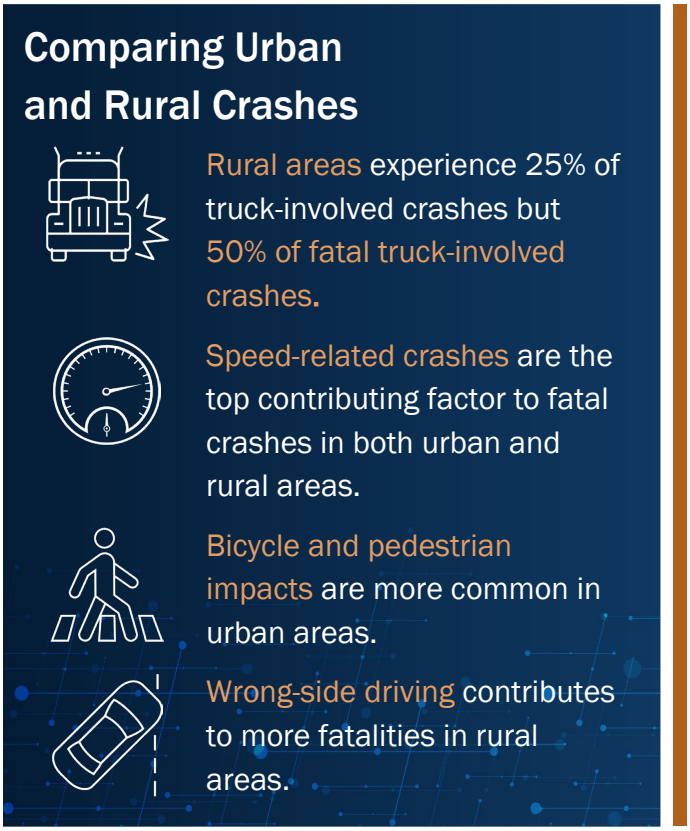
5.1.2 HIGHWAY SAFETY

Along with being a major goal of TxDOT, enhancing multimodal safety is one of the goals of Texas Delivers 2050 and ranked consistently by TFMP stakeholders as critically important. Overall crash reduction on all Texas roadways is critical to safety throughout the state. A subset of this goal is to reduce the number of truck-involved crashes and the severity of those crashes in terms of the number of fatalities and serious injuries. In addition to saving lives, increasing highway freight safety reduces disruptions to the efficient flow of goods and people across Texas' transportation system. This section elaborates on two topics related to freight safety:

- Truck-Involved Crashes.
- Safety Impacts to Key Supply Chains.

TRUCK-INVOLVED CRASHES

Between 2015 and 2020, 25,000 to 28,000 truck-involved crashes occurred per year in Texas. These crashes are not necessarily caused by a truck driver and include over 400 fatal truck-involved crashes per year. Despite a 20% reduction of annual average daily traffic (AADT) on Texas highways during the pandemic, annual crashes only reduced by 12% between 2019 and 2020, and fatal truck-involved crashes only reduced by 5%.[41]



Overall, truck-involved crashes are concentrated in the urban areas, especially in Houston, Dallas, and San Antonio. I-35, I-10, I-20, I-45, and I-30 have a high number of truck-involved crashes, while urbanized areas have the highest rate of truck-involved crashes per 100 million vehicle miles traveled (**Exhibit 26**). Notably, hotspots in West Texas, particularly Midland-Odessa, exhibit a smaller but equally dense concentration of truck-involved crashes as the larger urban areas of Dallas-Fort Worth and Houston.

On average, about 25% of truck-involved crashes happen within rural areas; however, approximately half of truck-involved fatalities occur in rural areas. The top contributing factors to fatal truck-involved crashes are different in urban and rural contexts as well:

41 TxDOT. Crash Records Information System (CRIS), 2019.

Urban

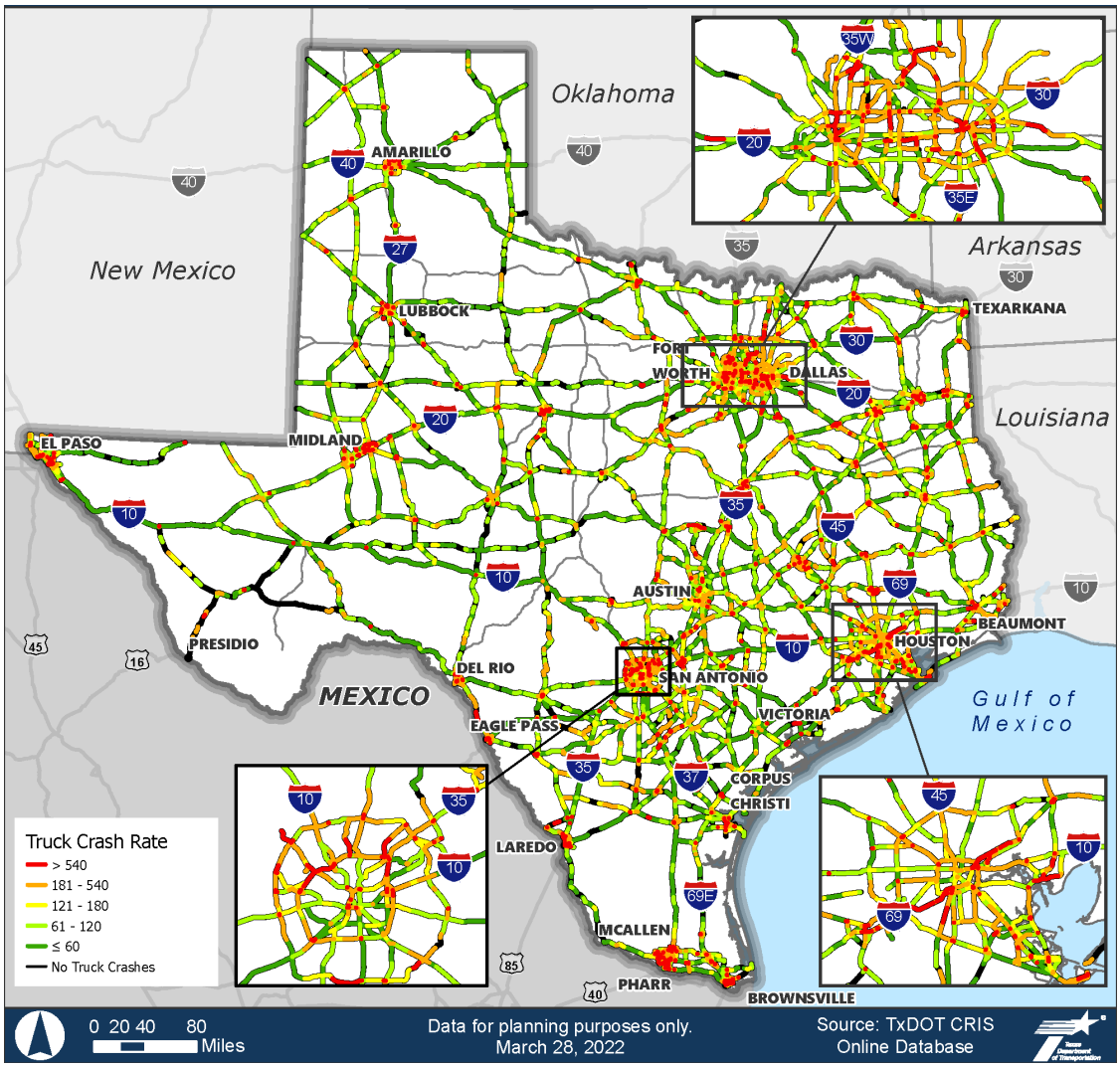
- Failed to control speed
- Failed to drive in single lane
- Pedestrian failure to yield
- Driver distraction
- Unsafe speed

Rural

- Failed to control speed
- Failed to drive in single lane
- Wrong side, not passing
- Unsafe speed
- Failed to yield at stop sign

More information about contributing factors, truck-involved crashes in each of TxDOT's Strategic Highway Safety Plan focus areas[42] and impacts to other modes can be found in the **Crash Analysis Memorandum.**

EXHIBIT 26: TRUCK-INVOLVED CRASH RATE, 2015-2020



Source: TxDOT Crash Records Information System (CRIS). CY2015 to CY2020. Rate is represented as crashes per 100 million vehicle miles traveled.

42 TxDOT, Strategic Highway Safety Plan, https://www.texasshsp.com/.

SAFETY IMPACTS TO KEY SUPPLY CHAINS

Safety needs on the THFN were categorized as high, medium, or low based on **truck-involved crash rates, truck-involved severe injuries and fatalities, and at-grade crossings**. **Exhibit 27** displays safety needs compared to key supply chain corridor locations. Corridors associated with one or more supply chains generally had similar needs compared to the THFN as a whole: 12% of mileage was rated high need in both cases. Supply chain corridors had a slightly higher ratio of medium needs.

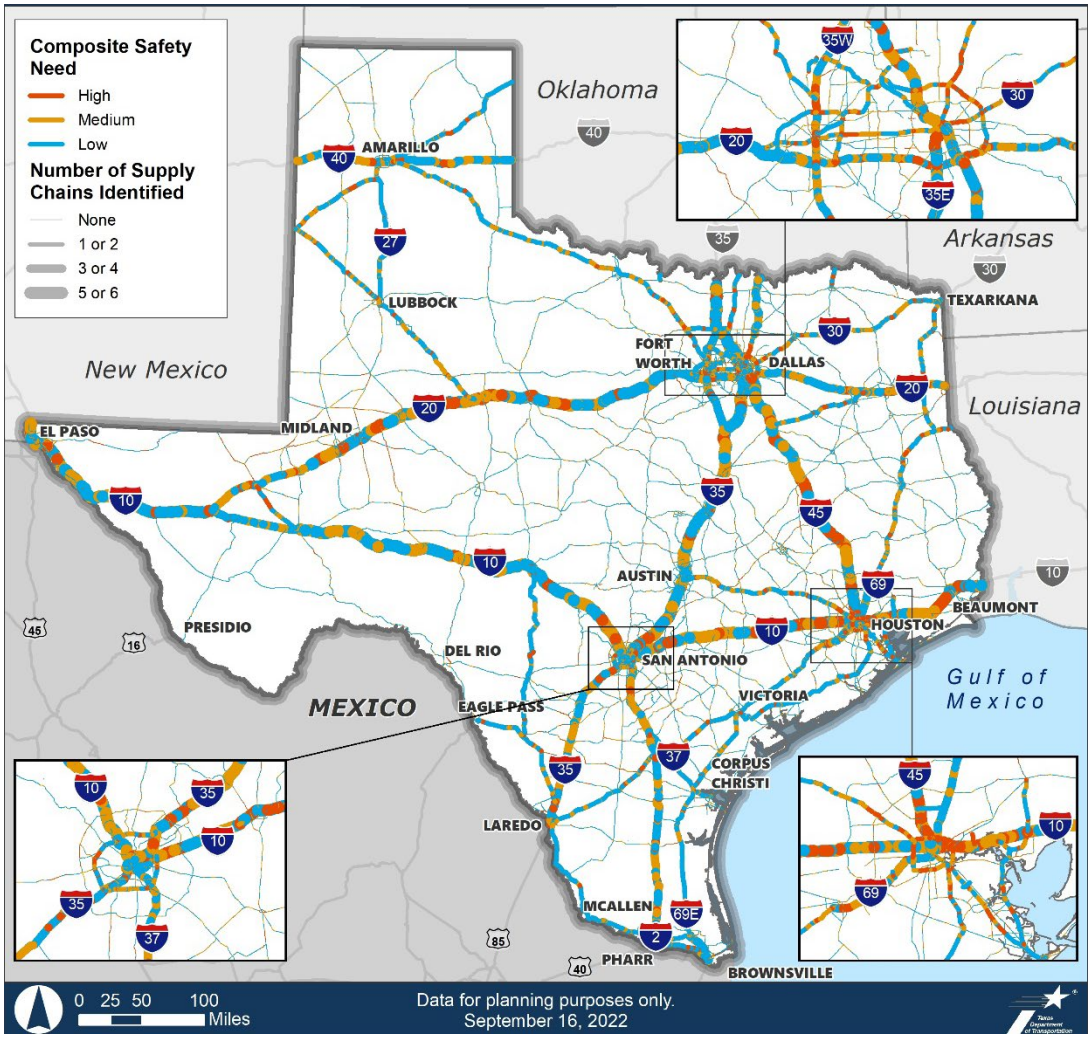
I-45, I-20 in the Permian Basin and I-10 between San Antonio and Houston had the highest safety needs alongside the greatest supply chain focus. Urban and rural areas both exhibited a range of low to high needs, reflecting the balance between higher incidence in urban areas and higher severity in rural areas.

Safety Impacts to Key Supply Chains

- Higher crash rates result in loss of life, reduction in quality of life, and property damage. Crashes and safety also impact the safety and reliability of goods movement for every supply chain considered in Texas Delivers 2050.
- Corridors associated with the electronics supply chain had the highest share of high need segments at 16%, followed by construction with 14%. No supply chain had a higher share of low needs than the THFN average (58%).
- In general, highway corridors associated with one or more supply chains had moderately higher safety need ratings. These corridors carry the greatest truck traffic and have the most exposure to crashes.

Source: TxDOT.

EXHIBIT 27: SAFETY NEEDS ON KEY SUPPLY CHAIN CORRIDORS



Source: Cambridge Systematics Analysis, 2022.

5.1.3 HIGHWAY ASSET MANAGEMENT

Asset management and utilization is critical to ensure continued competitiveness of Texas. TxDOT and its partners aim to protect their investments in infrastructure and goods movement to improve safety, reliability, and quality of life. This section elaborates on highway asset condition and impacts to key supply chains.

HIGHWAY ASSET CONDITION

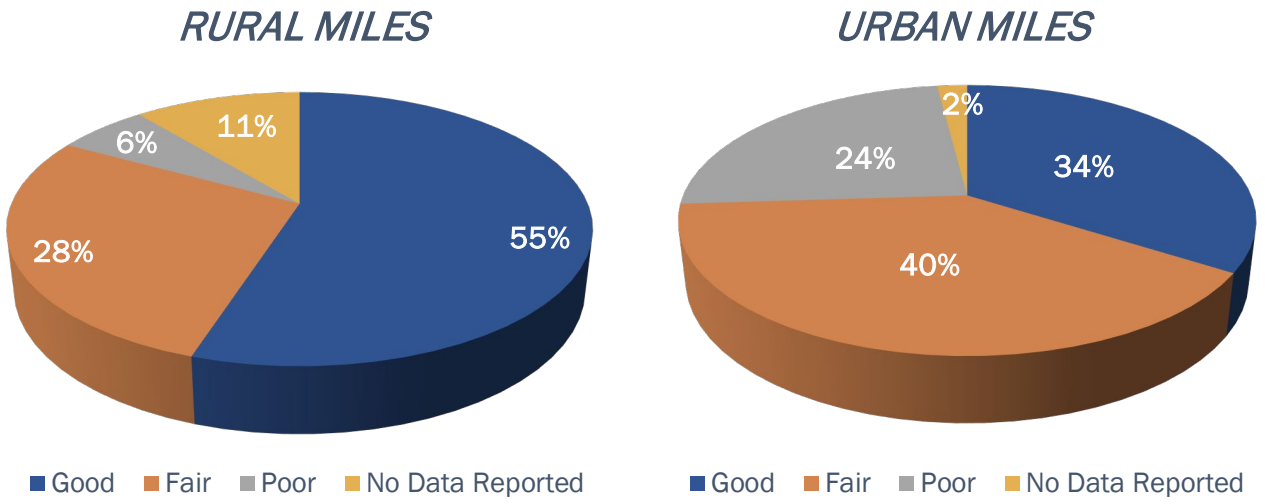
TxDOT invests an average of $1.4 billion per year on pavement repairs and rehabilitation to provide high quality transportation to all roadway users[43]. Pavement in poor condition reduces the speed vehicles could safely travel and results in lost productivity. Contact with pavement cracks and potholes accelerates vehicle wear and tear, causes damage to cargo, and increases the risk of crashes. These conditions lead to higher operating costs for the freight industry and longer shipping times for customers.

Pavement Condition Ratings Based on International Roughness Index (IRI) Thresholds

- Good = IRI value is less than 95
- Fair = IRI value is between 95 and 170
- Poor = IRI value is greater than 170

TxDOT evaluates pavement ride quality according to the International Roughness Index (IRI), published in the Highway Performance Monitoring System (HPMS), which is then translated to qualitative condition ratings. In general, pavement ride condition on the THFN is worse in urban areas than in rural areas, likely due to high traffic volumes moving people and goods (**Exhibit 28**). There are several contexts in Texas that can result in accelerated pavement deterioration because of frequent, heavy truck volumes, such as local roads used by heavy-haul vehicles transporting sand, water, lumber, and machinery.

EXHIBIT 28: TEXAS HIGHWAY FREIGHT NETWORK PAVEMENT CONDITION BY MILEAGE, 2019



Source: Highway Performance Monitoring System, 2019.

[43] TxDOT, 4-Year Pavement Management Plan Work Group. https://ftp.dot.state.tx.us/pub/txdot-info/tpp/ters/pavement-management-plan.pdf.

Depending on network density and detour lengths, restricted bridges can add significant time, cost, and community impact to a trip because of additional miles traveled.

Bridge conditions and load restrictions affect the overall efficiency of freight operations by limiting the route options for certain trucks, particularly those transporting oversized and overweight loads. This requires vehicles to travel on alternate routes with longer distances to avoid conflicting with a low clearance bridge or a bridge with a load restriction. Truck drivers are not always aware of bridge condition issues and traveling on them accelerates the rate of deterioration to the deck and structure. While bridge condition is important to monitor and improve, the majority of TxDOT bridges are in good or satisfactory condition, and load restrictions on the THFN are relatively low. **Of the 38 bridges that qualify as having load restrictions, three are rated as being in poor condition and one is rated as being in serious condition.** Bridge prioritization is presented later in this section.

ASSET MANAGEMENT IMPACTS TO KEY SUPPLY CHAINS

Pavement asset needs were prioritized based on **pavement condition** and **oversize/overweight vehicle permits** on a segment. Bridge asset needs were prioritized based on **bridge condition, load restrictions** and **oversize/overweight vehicle permits**. The results of this analysis are shown in **Exhibit 29.**

Pavement issues on the THFN are most concentrated in urban areas, but rural corridors carrying much of Texas' agricultural and energy products also exhibit high needs. Beyond the major corridors identified as key supply chain corridors, regional rural networks supporting connectivity may also be impacted by pavement deterioration, especially on local roads not designed for heavy freight vehicle traffic. Bridge restrictions and conditions have the potential to disrupt freight movement

Asset Management Impacts to Key Supply Chains

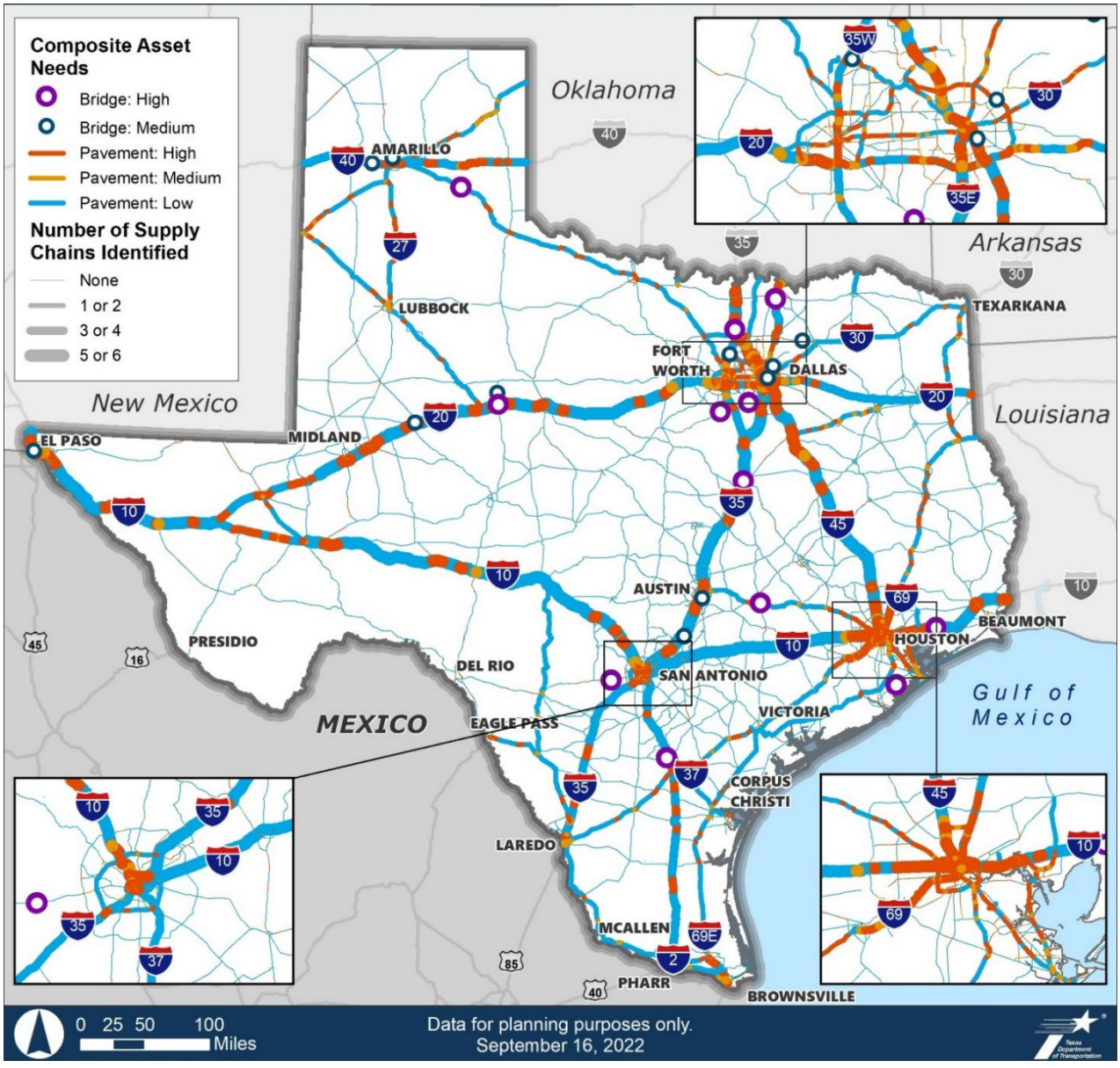
Asset management and preservation are essential for protecting the infrastructure investments TxDOT and its modal partners have made.

- Corridors associated with the Electronics supply chain are most concentrated in urban areas and have the highest share of high pavement needs as a result (19% of mileage rated high).
- In addition to major corridors, regional rural networks connecting agriculture and energy production are negatively affected by cumulative impacts of trucks.
- All supply chains can rely on 286,000-pound rated rail lines on all long-distance rail corridors. Local connections may be more limited.
- Inadequate dredging of the GIWW results in less than 10-foot channel depths, leading to underutilized barge capacity.
- High priority bridge needs are generally located away from corridors supporting multiple key supply chains.

significantly, especially where long detours are required. Most of the high priority bridge needs do not impact corridors flagged as critical to multiple supply chains.

Asset management constraints on other modes are generally determined by industry standards but may limit the ability of the TMFN to handle larger volumes of freight efficiently in the future as vehicle, equipment, or vessel sizes increase. TxDOT can continue to coordinate with modal partners regarding current and emerging needs of key supply chains in Texas to create an optimal, multimodal freight environment as technology, equipment, and commodity mix evolve.

EXHIBIT 29: ASSET NEEDS ON KEY SUPPLY CHAIN CORRIDORS



Source: Cambridge Systematics Analysis, 2022. Bridges with weight limits under 80,000 lbs. or in poor condition were prioritized by Freight System Designation Score.

5.1.4 HIGHWAY DESIGN

Infrastructure should be designed with freight vehicle or equipment size, cargo types, and volumes in mind. TxDOT has the greatest influence over the design of highway facilities. Freight-focused infrastructure is an important design consideration for roadway standards because cargo and goods are typically shipped in larger, heavier vehicles. Key freight concerns include narrow shoulders, lane width, turning radii, low clearance bridges, and shorter merging lanes. Each of these topics is explored in depth in TxDOT's **Freight Infrastructure Design Considerations** study that was completed in April of 2021.[44]

Five considerations were incorporated into the updated Texas Delivers 2050 assessment:

- Bridge vertical clearance over the THFN.
- Two-lane undivided highways.
- Interstates without frontage roads.
- Lane widths fewer than 12 feet.
- Interstate outside shoulders fewer than 12 feet.

In general, **most of the THFN is built with lane widths of12 feet or greater** (92%). Most freeways are built with 12-foot outside shoulders, but arterials on the THFN do not commonly meet this recommendation. Together, over 60% of THFN mileage has shoulders less than 12 feet wide (71% of urban segments and 54% of rural segments).

TxDOT continues to address and modernize bridge vertical clearance following the **implementation of its 18'6" clearance policy over the THFN in 2018.** Existing lower clearance bridges remain in place and will be raised as feasible when replaced, and new bridges require exemption by TxDOT Bridge Division for lower clearance.

DESIGN IMPACTS TO KEY SUPPLY CHAINS

Design needs on the THFN were evaluated based on attributes that are available in TxDOT's statewide roadway inventory and are not temporary work zone conditions: **bridge vertical clearance, two-lane undivided highways, interstates without frontage roads, lane width** and **interstate outside shoulder width**. **Exhibit 30** compares the findings to key supply chain corridors. Two sections of I-10 exhibit high and medium needs and impact many supply chains: between El Paso and the I-20 junction and between San Antonio and Houston. I-40 in the Panhandle also rated highly, and segments of I-45 between Houston and Dallas included medium or high priority design needs.

[44] TxDOT, Freight Infrastructure Design Considerations. https://www.txdot.gov/projects/planning/freight-planning.html.

Highway dimensions are particularly limited for oversize/overweight cargo. Permits are available for movement of several key supply chain commodities, including crop and animal agriculture, equipment, timber, wind energy, drilling and well servicing equipment, intermodal shipping containers and many other scenarios.[45] Key supply chain corridors are typically rated as higher need than the THFN as a whole because of the inclusion of factors specific to interstates. These corridors are currently supporting large volumes of freight traffic, but improvements could improve mobility and safety.

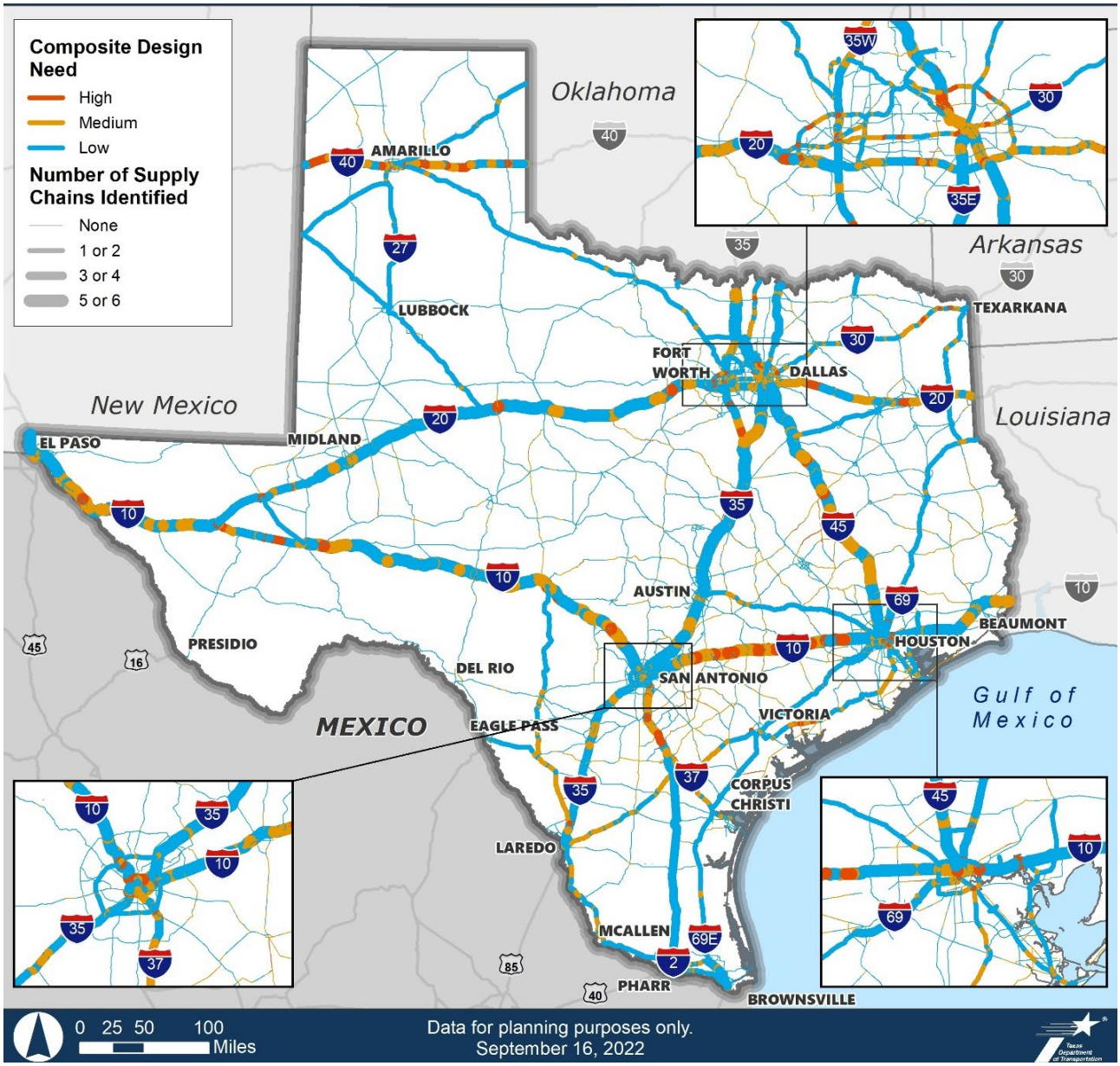
Design Impacts to Key Supply Chains

Design limitations can occur on any mode and have the potential to restrict where certain cargo or vehicle types. However, the most important portions of the TMFN are designed to accommodate most freight moving today. Additional improvements are planned and institutionalized through policy to ensure efficiency in the future.

- All key supply chains had an above average percentage of high design need ratings when considering ideal design parameters: only 2% of the THFN mileage rated high, while over 5% of each supply chain network rated high.
- Critical supply chain corridors are generally designed to accommodate most freight traffic, but improvements could increase safety and efficiency.
- Design criteria that optimize rural highway infrastructure would benefit supply chains such as agriculture and petroleum that transports oversize and overweight loads on roadways not designed initially to handle that type of freight.

[45] Texas Department of Motor Vehicles, Oversize/Overweight Permits. https://www.txdmv.gov/motor-carriers/oversize-overweight-permits.

EXHIBIT 30: DESIGN NEEDS ON KEY SUPPLY CHAIN CORRIDORS



Source: Cambridge Systematics Analysis, 2022.

5.1.5 TRUCK PARKING

TxDOT completed a comprehensive **Statewide Truck Parking Study** in 2020.[46] The study evaluated supply and demand of truck parking capacity (including publicly and privately owned parking areas), crashes involving parked trucks and recommendations to increase parking capacity and efficiency. Since the completion of the Statewide Truck Parking Study, TxDOT has

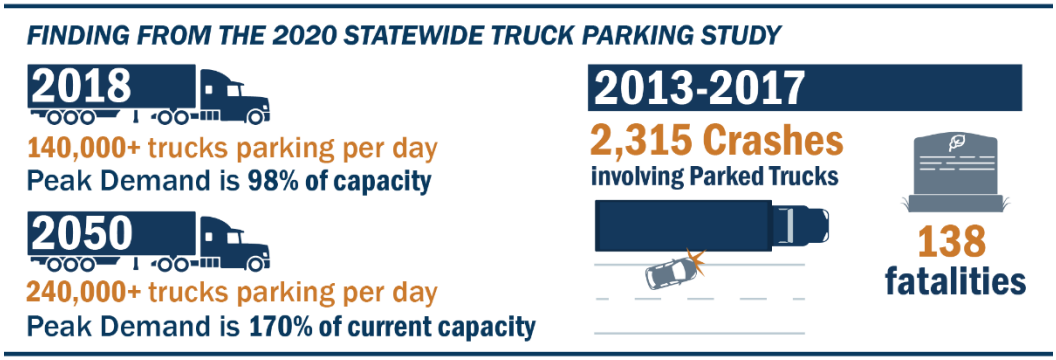
[46] TxDOT, Statewide Truck Parking Study. https://www.txdot.gov/projects/planning/freight-planning.html.

established a truck parking implementation program for ongoing development of capacity, technology, and programmatic truck parking solutions. **The TxDOT Maintenance Division manages a truck parking capacity expansion program that invests $30 million per year into additional safety rest area capacity. Even with the states additional investment in truck parking, it is critical that TxDOT support private investment in additional truck parking.** These programs address several areas of the state that were found to have conditions leading to unauthorized parking and inadequate capacity (shown on **Exhibit 31**):

Truck Parking Capacity will be Driven by Private and Public Investments.

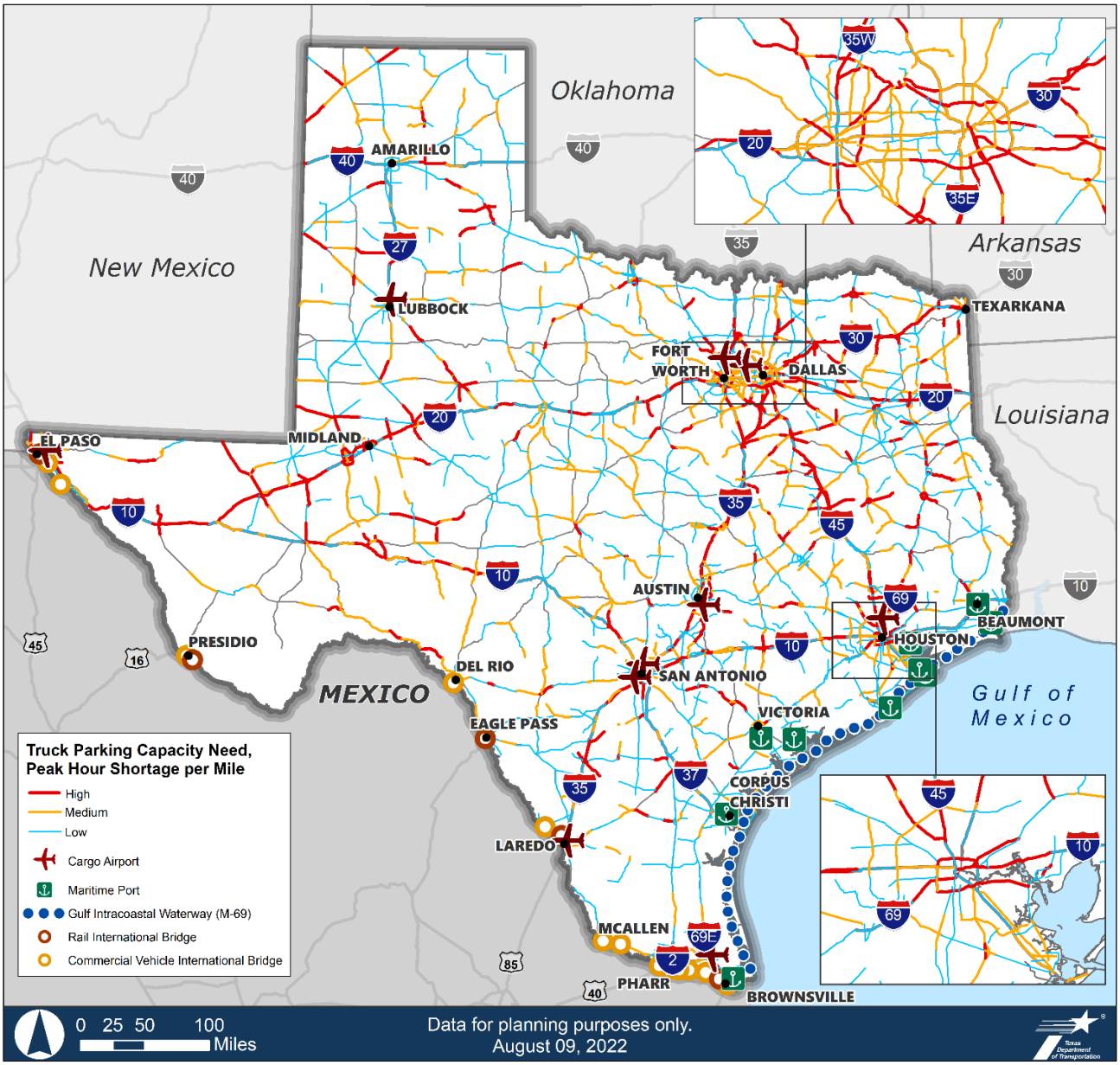
Private investments in truck parking facilities are on a scale of ten to one to public sector investments, and the industry is actively expanding private truck parking capacity. The trucking industry is encouraged by the state's progress in addressing truck parking needs at state-owned facilities, acknowledging the initial allocation of $30 million in funding, however, with a need far exceeding $100 million the state's program will take years to complete.

- **The Permian Basin** in West Texas has an extremely high volume of truck traffic associated with oil and gas production. The truck volumes are spread across a large rural area, making sufficient consolidated truck parking difficult to provide in the right areas.
- **The Texas Triangle** bounded by I-10, I-35, and I-45 includes some of the largest truck volume corridors in the state, and demand for truck parking is concentrated and high. Parking demand is generated by local, regional, and long-haul truck trips within the same corridors. In addition, different types of truck parking including staging, short-term and overnight parking are needed.
- **The Texas-Mexico Border** region generates an elevated demand for truck parking associated with staging and border crossings. Many trips bound for Mexico generate an additional parking stop while drivers wait for customs clearance, exacerbating parking demand resulting in unauthorized truck parking.



Source: TxDOT. Statewide Truck Parking Study, 2020.

EXHIBIT 31: PEAK HOUR (1 A.M.–2 A.M.) TRUCK PARKING SHORTAGE PER MILE, 2020



Source: TxDOT Texas Statewide Truck Parking Study, April 2020.

5.2 RAIL NEEDS

The rail network in Texas is a critical component of a thriving economy, safely connecting industries, ports, and people without congesting highways. **Railroads make significant investments as private entities to strengthen their systems.** In 2021, the Class I railroads invested about one billion dollars in Texas on capital expenditures. Short line railroads also make annual investments in expanding capacity and upgrading track.

Railroads are a key component of the TMFN, connecting with the other modes and providing access to trade gateways. Each of the three Class I railroads have state-of-the-art intermodal facilities which connect Texas to international gateways and markets, as well as the domestic hinterland. There is a strong automotive distribution network via the rail system in Texas with nine facilities located throughout the state. Five of the eight rail border crossing cities between the U.S. and Mexico are in Texas, allowing the state to lead the nation in rail traffic between the two countries. The reopening of the Presidio crossing is pending final implementation of inspection facilities.

Rail needs are discussed further in this section to highlight key modal challenges and issues related to Mobility and Reliability, Safety, Asset Management and Design.

5.2.1 RAIL MOBILITY AND RELIABILITY

Occupied Rail Crossings: TxDOT recently completed its **Highway-Rail Grade Crossing State Action Plan (SAP)** which identifies specific solutions for improving safety at at-grade highway-rail crossings. The SAP found that between January 2020 and July 2021, there were 2,825 occupied crossing reports at 915 unique crossings. The top 10 locations each had between 433 to 10,005 hours of reported occupied time, and **six of the 10 were in Harris County.**

Border Crossings: Railroads in Texas operate on six rail only international border crossings between the U.S. and Mexico. Trains interchanged at the Mexico border are required to stop to change crews. Crew changes at the Mexican border decrease efficiency of railroad operations; limit mobility of the community at occupied crossings; and introduce safety and security concerns for train cargo and people and vehicles around these trains.

Beginning in 2018, the Federal Railroad Administration (FRA) and Customs and Border Protection (CBP) along with other state and federal agencies authorized KCS international crews to move trains seamlessly across the border through a pilot waiver process. Efficiencies derived from international crew operations include an increase of 12% in the average number of cars per train crossing over the Laredo bridge from 2018 to 2022. The total number of trains per day operating through Laredo from 2018 to 2022 increased by four. **The throughput/border train velocity improved from 2018 to 2022 by 25%.**

A comprehensive international crew initiative at all Texas border crossings would allow trains to bring their crew into the opposite border without stopping to provide greater mobility, improve railroad operations and enhance safety.

5.2.2 RAIL SAFETY

At-Grade Crossings: The SAP includes a full analysis of highway-rail grade crossing collisions between 2016 and 2020. **Exhibit 32** displays the breakdown of collisions, including fatality, injury-only and non-casualty collisions between 2016 and 2020. Within the previous five years, there were 1,154 collisions. Of these collisions, 92 were fatal and 322 were injury only. Two collisions (one casualty and one property damage only) occurred at public pathway (sidewalk or trail) crossings. Nearly 82% of collisions occurred at public highway-rail grade crossings.

EXHIBIT 32: TOTAL HIGHWAY-RAIL GRADE CROSSING COLLISIONS BY TYPE, 2016–2020

Grade Crossing Type	Fatal	Injury-only	Non-casualty (Property only)	Total	Percent of Incidents
Public	74	271	597	942	81.6%
Private	17	50	143	210	18.2%
Pathway (Public)	1	1	0	2	0.2%
Total	**92**	**322**	**740**	**1,154**	**100%**

Source: 2022 Highway-Rail Grade Crossing State Action Plan, TxDOT.

Security and Occupational Safety at Intermodal Facilities: All cargo-handling facilities manage occupational safety and security at their facilities. Rail terminals **monitor personnel safety and inspect cargo** to ensure the security of people and infrastructure assets at their facilities. Specific occupational hazards and mode-specific security concerns are beyond the scope of Texas Delivers 2050 but are recognized as an important component of Texas' competitiveness and quality of life in supporting key supply chains.

5.2.3 RAIL ASSET CONDITION

Like highways, railroad infrastructure conditions can either enable or inhibit freight movement. Track class and weight limits are a function of both asset condition and initial design: while some limitations are because of design standards at the time and context of installation and other locations may change.

Track class governs the maximum speed limit on railroads. Over 95% of mileage on all three Class I railroads in Texas is rated as Class III track or better (**Exhibit 33**). Weight restrictions can provide a barrier to more efficient freight movement if they are inconsistent within the network. **Most of the Texas Class I rail network can accommodate industry standard 286,000-pound (286k) loads** (**Exhibit 34**). KCS routes within Texas allow 286k loads. Generally, all BNSF routes in Texas allow 286k loads, but a few routes are still restricted to 268k maximum loads. UP has

268k, 286k and 315k weight restrictions. Overall, 9% of Class I rail network miles are restricted to 268,000-pound allowable gross weight.

EXHIBIT 33: TRACK CLASS OF CLASS I RAILROADS IN TEXAS, PERCENT OF MILES, 2019

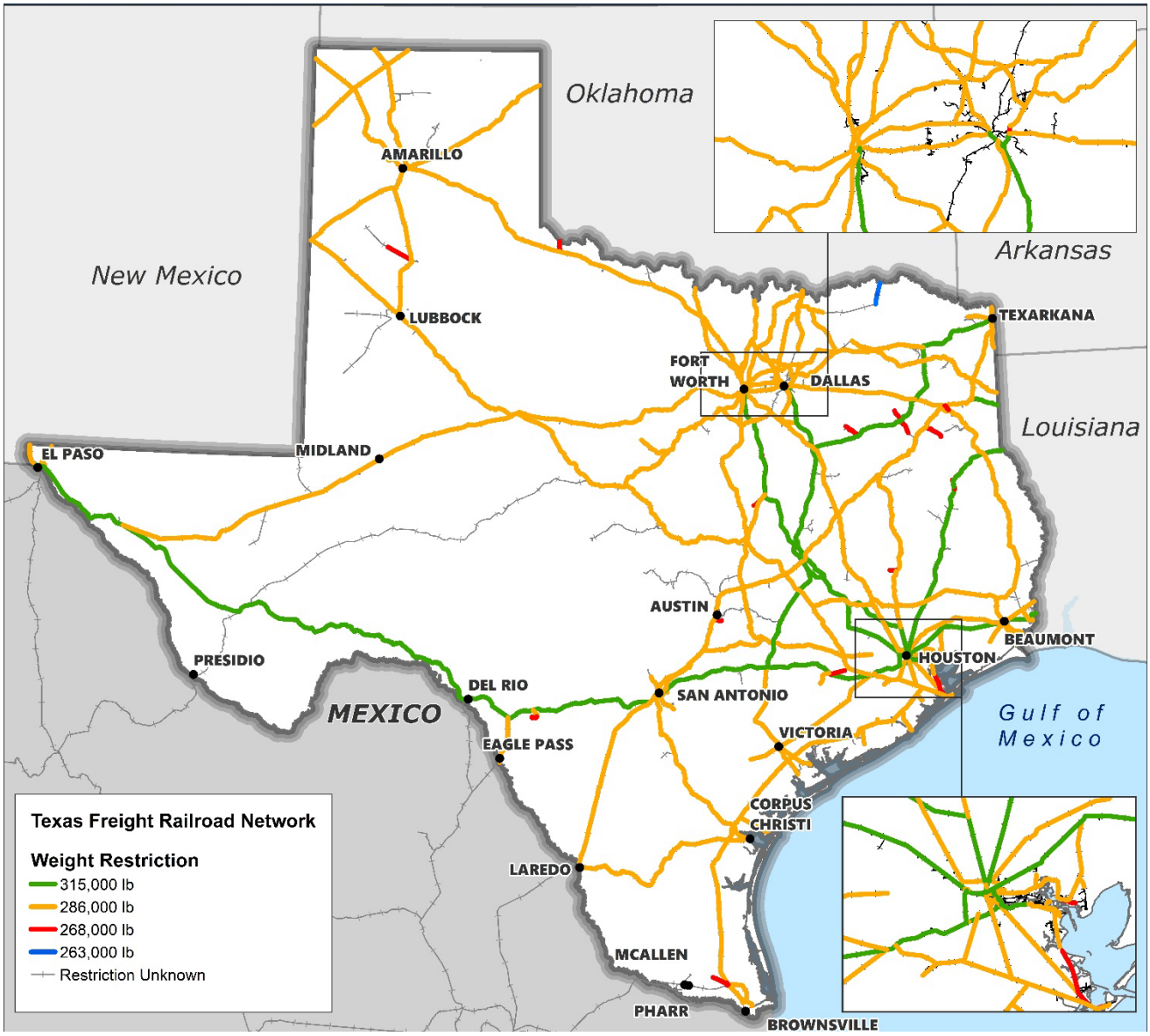
Railroad	Class 1 (10 mph)	Class 2 (25 mph)	Class 3 (40 mph)	Class 4 (60 mph)	Class 5 (80 mph)
BNSF	1%	3%	19%	64%	13%
KCS	--	2%	12%	86%	--
UP	<1%	4%	8%	55%	33%

Source: TxDOT Texas Rail Plan, 2019.

While Class I railroads are generally in good condition, short lines inherited track that experienced years of deferred maintenance by their previous owners. Investing in the state of good repair for this infrastructure is critical for first-mile/last-mile transportation in the supply chain for shippers and manufacturers. Investments in track expansion, yard capacity and improved interchange connections with Class I carriers are critical to creating a seamless rail network. When short lines operate at a lower weight restriction than their Class I partners, there is a fundamental service breakdown with impacts to velocity and rail car dwell time.

Over the past few decades, many larger railroads have discontinued service on short-haul routes for more profitable long-distance routes. All railroads, including short lines, require high levels of capital investment for safe and reliable operations and devote a substantial portion of revenue to rehabilitate their infrastructure to maintain carload volumes necessary for continued operation. Short line operations are vital to rural regions and small towns, as they support economic activity and improve quality of life in many of Texas' smaller communities.

EXHIBIT 34: FREIGHT RAIL WEIGHT RESTRICTIONS, 2021



Source: TxDOT Texas Rail Plan, 2019.

5.2.4 RAIL DESIGN

Railroad track design incorporates standards that ensure safe and efficient operation of trains. Trains can reduce the load and improve efficiency from truck trips, as by design track infrastructure has the capability to carry higher weight with fewer stops.

Track Capacity: Texas has seen a population growth of approximately 16% since 2010. This high growth in population requires more goods and places more demand on the transportation network to carry the goods. This growth has resulted in longer trains. As trains get longer, rail sidings are not always able to store the entire train. An insufficient number and length of sidings on the Texas

rail system leads to more occupied crossings and less efficient rail operations. To address capacity concerns, railroads in Texas are working on extending sidings with a length of 8 to 10 thousand feet to 15 to 16 thousand feet.

A transition of certain goods from truck freight to rail would be beneficial for Texas highways to reduce maintenance needs. Additionally, delays at occupied crossings will decrease as train operations improve through efficient use of sidings and double track segments.

Track Clearance: Track design standards require specific clearance envelopes to move trains safely along rail corridors. These clearance envelopes also allow for double-stack trains. There are only limited locations in Texas where double-stack clearance is not available. However, there are other locations where highway infrastructure encroaches on railroad right-of-way and railroad bridges provide insufficient clearance over roadways. Locations with horizontal or vertical clearance restrictions increase the potential for bridge strikes and corrections would benefit safety and system reliability.

5.3 PORT AND WATERWAY NEEDS

Texas ports and waterways handle a large and growing share of waterborne freight cargo. The TMFN contains seven of the 50 largest ports ranked by waterborne tonnage. The GIWW provides access to inland waterways that reaches most of the major parts of the U.S. Key sectors important to the Texas economy such as advanced manufacturing, petrochemicals, construction, and agriculture depend on ports and waterways to obtain raw materials and parts and deliver exports to customers in domestic and international markets. Ports are also managing growth from supply chain shifts because of the disruptions of the COVID-19 pandemic; 2021 broke records in the number of containerized imports U.S. ports handled that year.[47] The experience with COVID-19 highlights the limited options to quickly expand capacity at ports and the impacts of labor shortages on operations. The trend towards near-shoring of U.S. manufacturing from China to Mexico and Latin America could also lead to long-term shifts in maritime traffic to Texas ports.

Port and waterway needs are discussed further in this section to highlight key modal challenges and issues related to Mobility and Reliability, Safety, Asset Management and Waterway Design.

5.3.1 PORT AND WATERWAY MOBILITY AND RELIABILITY

- Port and Waterway Congestion: Ports throughout the world experienced increased congestion during the COVID-19 pandemic. Labor shortages at ports and in drayage companies, container availability and disrupted global supply chains all contributed to congestion at

[47] The White House. National Economic Council Briefing Room. "A Record Year for America's Ports and a Look to the Year Ahead". January 20, 2022. Available at: https://www.whitehouse.gov/nec/briefing-room/2022/01/20/a-record-year-for-americas-ports-and-a-look-to-the-year-ahead/.

ports impacting supporting waterways. One example project combating waterway congestion is the **widening of the Houston Ship Channel by 170 feet**. "Project 11" will allow large vessels to pass each other traveling opposite directions, reducing emissions and delay at port terminals. Container growth at Port Houston is expected to continue at a level higher than the national average as channel improvements are completed in 2025.

- **Supply Chain Bottlenecks:** The COVID-19 pandemic caused widespread disruptions to warehousing and logistics supply chains. Shortages of chassis and containers, coupled with an industry wide labor shortage of drivers and workers at warehouses and ports, constrained the amount of cargo that could move in and out of Texas ports. As a result, dwell times increased for containers and berthed vessels. Commodities that usually took hours to transload from ship to truck, rail, or pipeline and vice versa, could now take days, causing delays to compound across supply chains. In 2020 and 2021, ports on the West Coast and in Texas experienced unprecedented surges in traffic as consumer behaviors changed as more people worked at home and bought goods online. Bottlenecks at the Ports of Los Angeles and Long Beach led some shippers to turn to Texas ports to fulfill critical supply chain orders.

Port Congestion Extends Beyond the Gate.

Congestion along port access routes can often delay truck trips as much or more than terminal delays. "Total" turn time is what truckers care about. Truckers have access to information on terminal turn times but do not always have the necessary information on port connector performance.

- **Oversize and Overweight Cargo:** Texas ports are handling increasing volumes of oversized and overweight cargo such as wind turbine components and other specialized loads, such as industrial boilers and heavy machinery for the energy sector. Currently, there are no heavy haul trucking corridors to designate where trucks transporting OSOW loads could safely navigate the roadways connecting the TMFN with the ports. These routes should be free of obstacles such as restricted bridges and roadway pavement that are not designed to accommodate heavier and more frequent loads. Investments in port connectivity improvements are needed to ensure specialized freight can safely and efficiently navigate between the ports and the rest of the TMFN. Inside the gate improvements are also needed to expand storge yards and install handling equipment to accommodate oversized loads.

5.3.2 PORT AND WATERWAY SAFETY

- **Security and Occupational Safety at Intermodal Facilities:** All cargo-handling facilities manage occupational safety and security at their facilities. Seaports **monitor personnel safety and inspect cargo** to ensure the security of people and infrastructure assets at their facilities. Specific occupational hazards and mode-specific security concerns are beyond the scope of

Texas Delivers 2050 but are recognized as an important component of Texas' competitiveness and quality of life in supporting key supply chains. Coordination with the federal government is needed to ensure that CBP and US. Coast Guard operations are adequately staffed to keep pace with cargo inspections and to prevent unauthorized access to ports and waterways.

- **Channel Widths:** Channel widening is needed to maintain a safe and navigable waterway system for ships accessing Texas ports. A wider channel allows ships in opposing directions to safely pass each other. This measure of safety is especially important for ports that handle hazardous materials, such as petrochemicals or handle the largest vessels. Currently, Texas ports would not be able to handle the largest New Panamax ships, which have a maximum beam width of 168 feet, which is 58% wider than current Panamax ships.[48]

- **Channel Depths**: Overtime, sedimentation can cause channels to fill up with sand and silt. The reduced depths as a result can reduce the ability of ships and barges to safely navigate the waterway. This increases the chance of a vessel running making contact with the bottom of the waterway and running aground. The impact can cause a vessel to break apart and release hazardous materials. A grounded vessel can also block a waterway and pose a safety hazard for ships navigating nearby.

- **Resiliency:** Texas ports are susceptible to impacts from hurricanes with high winds, flooding, and storm surges — some of the key threats to maritime operations and infrastructure. Extreme weather events are expected to be more frequent and intensive within decades. Investments in coastal resiliency are needed in coordination with the federal government to prepare ports and waterway facilities for future events. The Coastal Spine is a project that highlights the intergovernmental coordination and investments needed to protect the Texas Gulf Coast from the effects of extreme weather. The proposed project aims to increase coastal resiliency by restoring shoreline ecosystems and building storm barriers. The centerpiece of the project is the Ike Dike, a system of barriers and gates that would protect Galveston Bay from a massive storm surge.[49] Recent hurricanes such as Harvey and Ike have hit the Texas Coast and underscores the need for coordinated federal and state funding to increase the resiliency of Texas ports and waterways to mitigate the effects of extreme weather on freight.

5.3.3 PORT AND WATERWAY ASSET MANAGEMENT

- **Waterway Dredging:** Maintenance of the GIWW, Texas' primary shallow draft waterway, has been a persistent challenge. Dredging projects on the GIWW have deferred or downsized

48 2024-2025 Port Mission Plan, TxDOT Maritime Division. 2024-2025 Texas Port Mission Plan (txdot.gov).

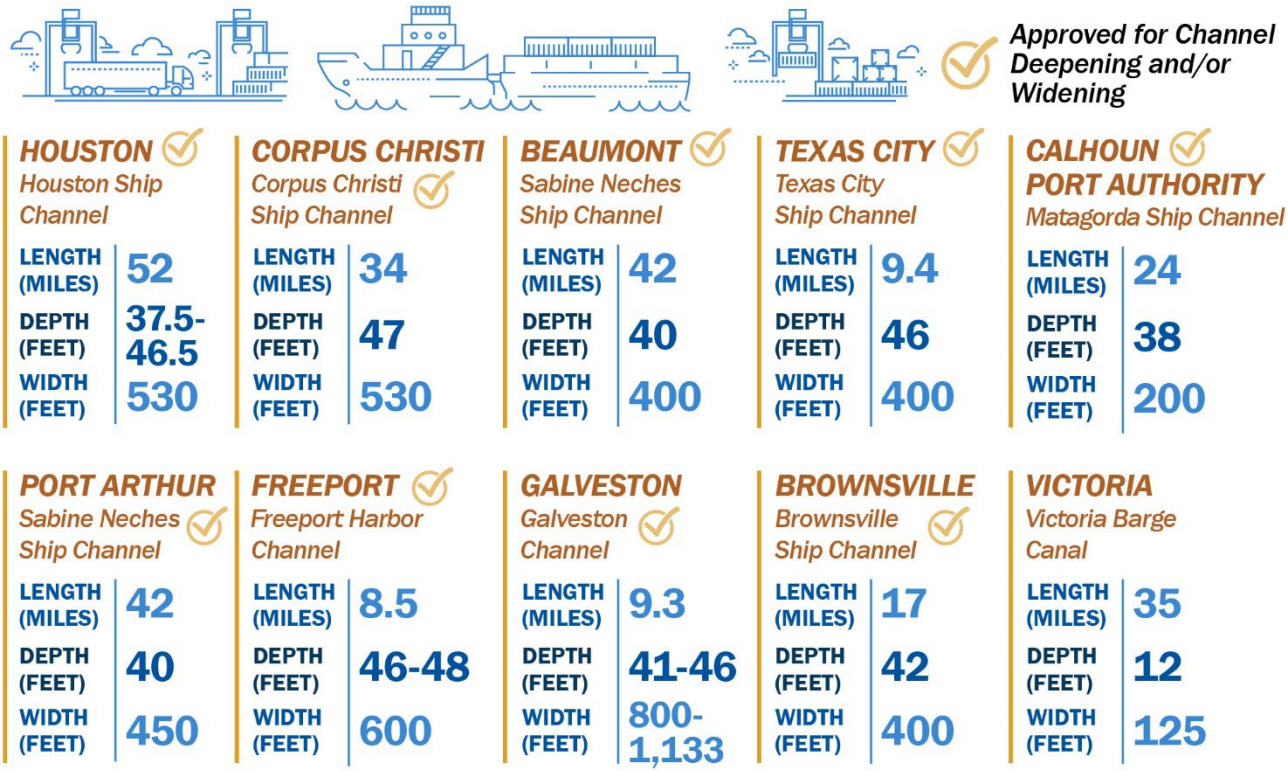
49 Douglas, Erin. "U.S. Senate approves bill containing Texas' "Ike Dike" coastal protection project". The Texas Tribune. July 28, 2022. Retrieved October 21, 2022, from https://www.texastribune.org/2022/07/28/texas-ike-dike-senate/

when federal appropriations for maintenance have been insufficient. Some vessels are "light loaded," or loaded to less than capacity, in response to these conditions to ensure sufficient under keel clearance. These constraints, and similar limitations and funding challenges on ship channels, **reduce the ability of waterways to reliably and efficiently support Texas supply chains** and freight movement. Texas' Ship Channel Improvement Revolving Fund (SCIRF) created a funding mechanism for financing federally authorized channel improvement projects in 2017; however, as of 2022 it has never been funded. Today, the GIWW is active but could be more highly utilized in the future to respond to growing freight demand. **The investments that maintain the GIWW at its depth levels will be more important in the future to provide alternatives to highway transportation**. Compared to trucks, barges and ships can transport bulk quantities of goods more cost effectively and safely with fewer accidents; waterways are also less congested and more reliable. Waterborne transport uses less fuel on a per-ton basis, emits fewer emissions and have fewer direct impacts on communities. For Texas to handle the volume of freight expected in 2050, multimodal freight investments are needed, and waterways have an important role to play in alleviating some of the demand and congestion on the state's major freight corridors. This requires the appropriation of federal and state funding to maintain the GIWW and the ship channels for deep draft ports at their authorized depths.

5.3.4 WATERWAY DESIGN

Channel depth is the primary design attribute impacting vessel size, and therefore, cargo capacity in Texas. Nine of the top 10 ports in the state are accessed by deep-draft channels capable of handling large vessels, and only Port of Victoria's main channel is a shallow-draft (**Exhibit 35**). As denoted in the exhibit, eight of the 10 ports have approval to further deepen. The approvals include four ports with drafts of 50 feet or greater that will support large, fully loaded post-Panamax vessels.

EXHIBIT 35: PORT CHANNEL CHARACTERISTICS FOR THE TOP 10 TEXAS PORTS



Note: Channel depths listed are in reference to Mean Lower Low Water (MLLW). Source: Port Mission Plan 2024-2025.

On the GIWW, the antiquated design of the floodgates at the Brazos River crossing and the locks at the Colorado River crossing impact the safety, efficiency, and resiliency of the waterway. Congress has authorized the replacement of these structures with new facilities that will meet the needs of modern commerce and design work is ongoing, but appropriations for FY-2023 and beyond are necessary to commence construction of the new structures.

It is important that ship channel improvement projects receive federal appropriations to maintain the channels to its authorized depths. At the state level, the Ship Channel Improvement Revolving Fund needs its funding allocated from the Texas Legislature. This level of funding coordination between federal and state is needed to ensure that Texas ports and waterways remain safe to navigate and can compete with the ports on the East and West Coast.

5.4 AIR CARGO NEEDS

Despite the relatively low volume of total tonnage moved via air, air cargo's role in freight transportation and economic development is unique and critical. Air cargo access is a major challenge for the movement of air cargo to and from the airport. Airports can construct airside infrastructure to support larger aircraft and to move higher volumes of air cargo, but if the

connections to transfer the cargo to trucks and rail facilities are lacking or congested, it will not matter. There is a need to provide adequate connections to transfer this often time-sensitive cargo from the air cargo apron to the highway distribution network and then to Texas homes and businesses.

The major air cargo airports are located within or near the state's congested metropolitan areas, which leads to issues with travel time efficiency and reliability on the infrastructure accessing the airports. Infrastructure improvements to the interstate system and major state highway corridors is moving forward, but distribution of federal and state highway funds should consider the importance of certain corridors to the movement of freight from airports, especially as e-commerce volume grows. Not all the air cargo needs are access-related; increased air cargo volumes combined with staffing shortages are creating congestion at many airports. There is a significant need for new cargo facilities that can handle larger aircraft and specialized cargo requirements, such as cold-storage.

Air cargo needs discussed in this section highlight key modal challenges and issues related to Mobility and Reliability, Safety, Asset Management and Design.

5.4.1 AIR CARGO MOBILITY AND RELIABILITY

- **Airport On-Time Performance and Departure Delay:** Four Texas airports report performance data: AUS, DFW, IAH, and SAT. Performance information includes passenger flights with belly cargo, dedicated cargo flights, and dedicated passenger flights. **On-time departure percentages held steady from 2015-2019** and improved in 2020 due to reduced flight volume. DFW reported the lowest on-time percentage at approximately 65-70% on-time departure, while other major airports range between 75-85% on-time.[50] Average delay time is highest at DFW and SAT, but delay time for all major airports ranged between only 13–21 minutes each non-pandemic year. These statistics include passenger and dedicated cargo flights, both of which are relevant to freight movement due to significant freight carried as belly cargo in passenger flights.

5.4.2 AIR CARGO SAFETY

- **Aviation Incidents:** **Commercial aircraft crashes are rare**, and most incidents occur in smaller, general aviation airports and are equipment-related incidents. The National Transportation Safety Board (NTSB) investigates crashes and causes and reported only 14 incidents between 2015 and 2020.[51] Causes of crashes impacting cargo are similar to passenger

50 FAA Aviation System Performance Metrics, 2015-2020. Data only available for four TX airports.

51 National Surface Transportation Board, Aviation Accident Database & Synopses. https://www.ntsb.gov/Pages/AviationQuery.aspx, includes commercial carriers with a part 121 certificate.

aircraft, especially considering significant volume of air cargo transported on passenger flights, with these notable additions: cargo weight balance, overweight aircraft, and unsecured loads leading to cargo shift and crew error or fatigue.

- **Security and Occupational Safety at Intermodal Facilities:** All cargo-handling facilities manage occupational safety and security at their facilities. Airports **monitor personnel safety and inspect cargo** to ensure the security of people and infrastructure assets at their facilities. Specific occupational hazards and mode-specific security concerns are beyond the scope of Texas Delivers 2050 but are recognized as an important component of Texas' competitiveness and quality of life in supporting key supply chains.

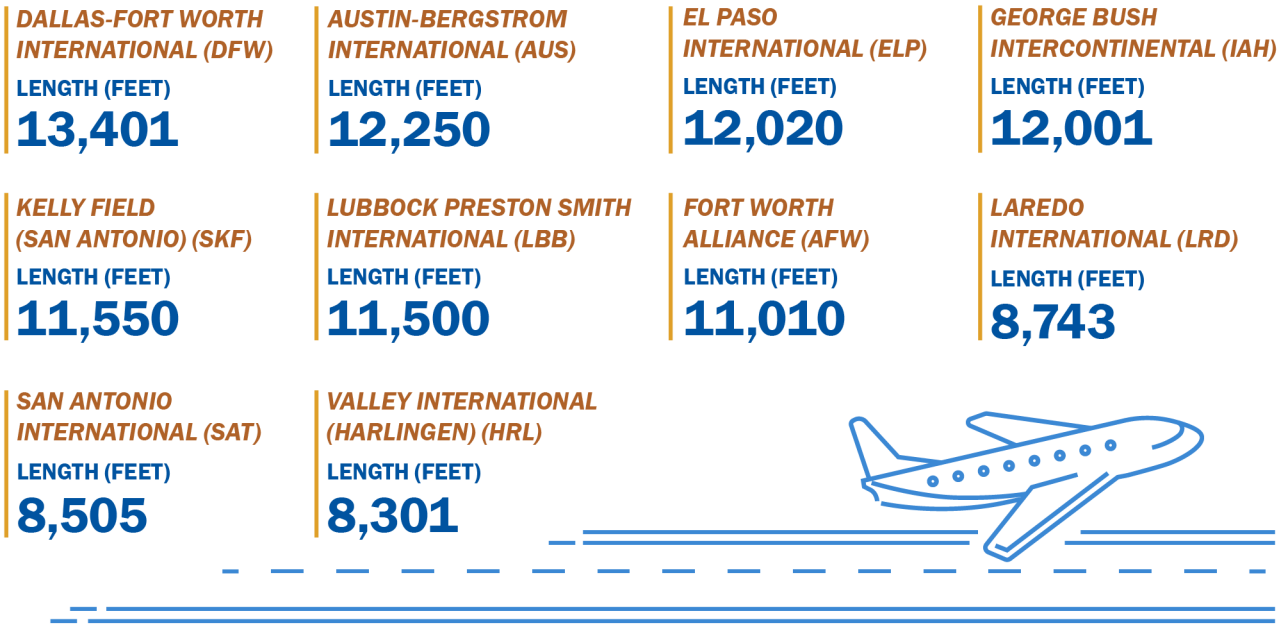
5.4.3 AIR CARGO ASSET MANAGEMENT

Air cargo-operations rely on standard airport asset management practices. Airports define key metrics and maintenance standards as part of asset management plans. Runway, taxi way, and ramp conditions are critical for all aircraft operations. For airports handling the jumbo, heavy lift aircraft, runway condition will be a critical factor as any down time will impact airline schedules and on time performance. Maintenance activities are led by airport authorities (public and private) with grants from the Federal Aviation Administration (FAA), airport revenues, and private tenant investments.

5.4.4 RUNWAY DESIGN

Runway lengths of 8,000 feet are required for most domestic cargo planes, while 10,000 feet is generally required for most international operations. Runway length is most critical for takeoff for air cargo aircraft because of the heavy weight of the aircraft caused by a full fuel load and cargo. All cargo airports on the TMFN have sufficient runway lengths to accommodate domestic cargo planes, while DFW, IAH, ELP, Fort Worth Alliance (AFW), AUS, LBB, and SKF can accommodate the larger international aircraft (**Exhibit 36**). In addition to all cargo operations, approximately one-quarter of air cargo in Texas moves as belly freight in the belly of passenger aircraft. Large airports with frequent flights to many locations are critical for this cargo market.

EXHIBIT 36: RUNWAY LENGTH FOR AIRPORTS ON THE TMFN, 2019



Source: Texas Airport Directory, 2019.

5.5 PIPELINE NEEDS

Texas has the most extensive pipeline network in the United States, comprised primarily of natural gas and petroleum liquid pipelines. Pipelines on the TMFN play an important role in transporting raw inputs, intermediates, and finished products for petroleum supply chains in Texas. The industry utilizes pipelines to transport bulk quantities of natural gas and crude oil from production areas located in West Texas. Texas also has the most oil refineries and natural gas processing plants in the United States, many of which are concentrated in large complexes along the Gulf Coast and connected by pipeline. These facilities produce consumer grade natural gas, petrochemical feedstocks, and finished products, such as motor gasoline, fuels, and lubricants.

Pipeline needs are discussed further detail in this section to highlight key modal challenges and issues related to Mobility and Reliability, Safety, Asset Management and Design.

5.5.1 PIPELINE MOBILITY AND RELIABILITY

- Pipeline Connectivity: The physical connection of a generating site to the pipeline system is a critical factor for product mobility. High volume wells typically have a direct connection to the system. This requires new pipeline infrastructure as new wells come online. For sites without a direction pipeline connection, products are transferred to truck for movement to the closest pipeline transfer point. Landowner concerns and government permitting requirements often impact the efficiency of new pipeline connections. For large transfer points, like at major

refineries or transfer points at ports to load vessels, the efficiency of the connections drives mobility and reliability of the system. In addition, electrical service is required for pipelines to operate, so any power outage shuts the system down.

- **Pipeline Reliability:** Gathering pipelines in the Permian Basin froze during Winter Storm Uri in 2021 shutting down natural gas production and supplies to power generation plants. The effects of the winter storm pointed to the need to increase the resiliency of the pipeline network. Disruptions could also include man-made events, such as the ransomware attack on the Colonial Pipeline System in May 2021. The shutdown of the Colonial Pipeline disrupted the delivery of fuels and other vital petroleum products in the northeastern U.S. The Rio Grande Valley Freight and Trade Transportation Plan also discussed the impacts of pipeline disruptions in Mexico and how they can limit Texas' ability to export gasoline and other fuel products from the Port of Brownsville to markets in Mexico, resulting in a shift to truck transportation. These events underscore the importance of the pipeline network to the energy security of the country, and the need for coordination with federal agencies to secure the infrastructure from potential threats.

5.5.2 PIPELINE SAFETY

- **Pipeline Incidents:** Reporting and regulation of pipeline safety is carried out by the Pipeline and Hazardous Material Safety Administration (PHMSA) per federal regulation. The number of pipeline incidents has generally been increasing alongside increasing oil and gas production since a low point in 2008 (114 incidents) to a high point in 2015 (232 incidents). Most incidents occur in liquid pipeline facilities, which accounted for 79% of all incidents from 2005 to 2021. Gas distribution facilities account for 60% of all incidents resulting in a fatality or injury during the same period. While the number of incidents has increased, it should also be noted that during this same time period there was a significant increase in both the total mileage of pipeline and the number of audits conducted. Further, pipeline safety is highly federally regulated through 49 CFR Parts 192 and 195, as well as by the Texas Railroad Commission.

- **Emergency Preparedness:** Pipeline companies are monitored and regulated by PHMSA, the Texas Railroad Commission and they also actively regulate and monitor themselves. The worst possible incident would be a leak in a highly populated area and/or a large volume release. Safety is the key focus of these companies to prevent and prepare for an incident. Each company has emergency response plans in place to effectively prevent and/or mitigate any type of event.

- **Security and Occupational Safety at Transfer Facilities:** All pipeline product transfer terminals manage occupational safety and security at their facilities. Operation of the pipeline system includes monitoring personnel safety to ensure that hazardous liquids are handled properly and routine inspections to ensure the safety and security of people and infrastructure. Specific occupational hazards and mode-specific security concerns are beyond the scope of Texas Delivers 2050 but are recognized as an important component of Texas' competitiveness and quality of life in supporting key supply chains.

PHMSA's 49 Parts 192 and 195 Regulate All Aspects of Pipeline Design, Construction, and Operation for Gas and Liquids

- Pipe Design
- Materials
- Construction
- Testing
- Operations
- Maintenance
- Safety and Accident Reporting

Source: PHMSA, 2017.

5.5.3 PIPELINE ASSET MANAGEMENT

- **Inspection and Maintenance:** Asset management practices for pipeline companies are regulated by PHMSA through 49 CFR Parts 192 and 195. Maintenance is continuous and ongoing every day. Integrity testing tools are used to inspect and test pipe condition. The regulations dictate repair timelines. Treatments like cathodic protection are used to keep pipe in "like new" condition at all times. The ability to maintain pipe in this condition is critical as 40 percent of Texas' pipeline infrastructure is over 50 years old.

5.5.4 PIPELINE DESIGN

- **Pipeline Design.** In general, pipelines have gotten bigger over time. Design is regulated by 49 CFR Parts 192 and 195. All pipelines must be built at least to standards outlined in these regulations, and often the pipeline companies exceed these standards.

This Chapter presented and discussed multimodal transportation needs across five areas including mobility and reliability, asset management, design, and truck parking. Chapter 6 discusses multimodal connectivity and resiliency needs impacting the TMFN and key supply chains.

Chapter 6 Ensuring a Connected and Resilient Freight Network

Chapter 5 identified infrastructure needs. Freight movement will also be safer, more efficient and more reliable when the multimodal network is connected and resilient at a systemwide level.

Connectivity is a measure of a transportation network's ability to efficiently route users to destinations. From a freight perspective, a well-connected multimodal network offers route or mode choices that are direct and minimize travel time. Greater connectivity increases economic competitiveness for Texas industries and supply chains by shortening delivery times, increasing areas of service and reducing operating costs.

Resiliency and connectivity are related: a freight network with robust multimodal connectivity can better sustain and recover from disruptions caused by natural or manmade disasters, workforce issues or institutional barriers. Resiliency is also closely related to infrastructure design and organizational capacity, which impacts the ability to respond to and recover from events.

The needs and challenges presented in this chapter draw from the Multimodal Freight Needs Assessment and Resiliency Case Studies that were developed to inform Texas Delivers 2050.

Highlights

Connectivity and resiliency go hand-in-hand when assessing system-level needs related to supporting the safe, efficient movement of freight.

Highway connectivity – the ability to efficiently reach destinations without additional mileage traveled - is lowest in rural parts of East, South and West Texas.

Intermodal facilities in Texas provide interfaces between modes of the TMFN, including linking:

Crude energy products from oil fields to refineries and seaports on the Gulf Coast.

Containerized freight from seaports and border ports-of-entry to population centers.

Agricultural production to processing and export facilities.

E-commerce between producers, airports, and consumers.

Texas has been impacted by a pandemic, weather events, policy and labor disruptions and cyber-attacks over the last several years. **Six case studies** exemplify opportunities to improve the TMFN.

Almost half of the THFN is located in counties at higher risk for natural disasters

6.1 IMPORTANCE OF CONNECTIVITY

Several aspects of connectivity are relevant to freight movement and supply chain efficiency:

- Connectivity between urban and rural areas.
- Connectivity to trade gateways.
- Connectivity to other transportation modes.
- Connectivity to input and final goods markets.

Supply chains rely on Connectivity between urban and rural areas, especially highway connectivity, is essential in Texas to ensure efficient and seamless supply chains for the oil and gas and agriculture industries. Many of the production facilities for these industries are in rural areas while the international gateways and downstream activities are located in or near more urban areas.

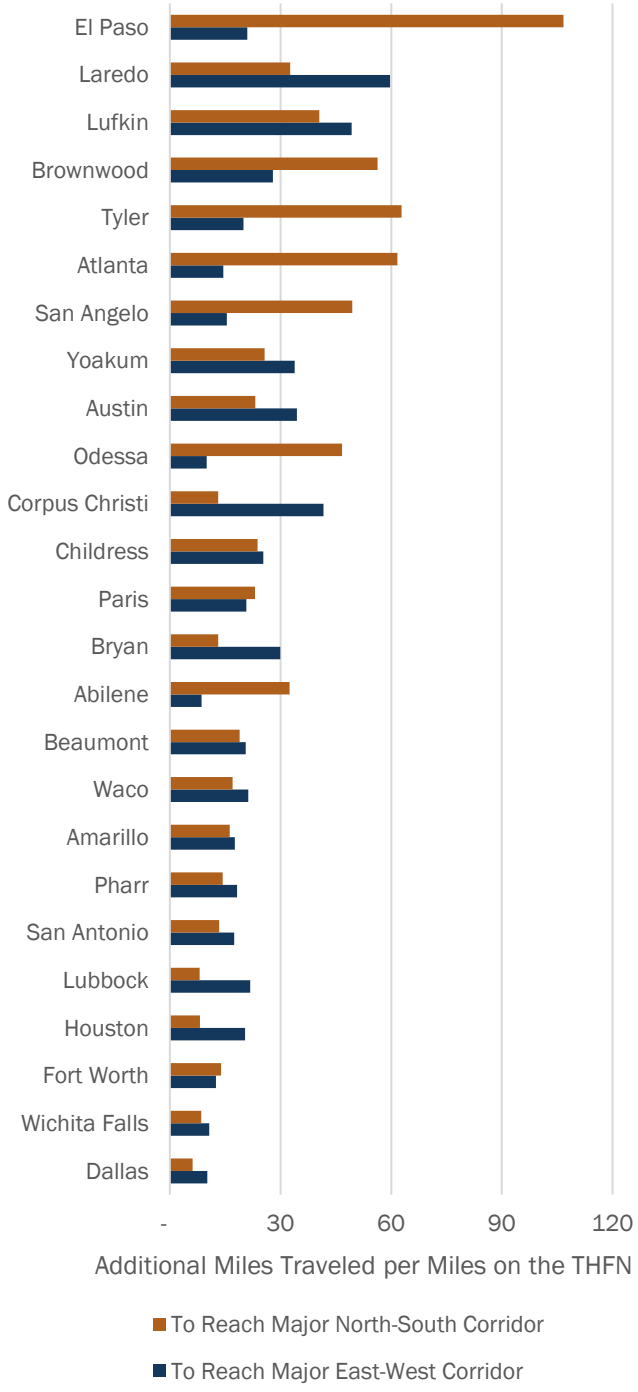
Connectivity to trade gateways and other modes of transportation is critical for all of the state's goods producing industries as they rely on a variety of commodities being transported to and from a variety of domestic and global destinations, including significant international cross-border trade. Finally, connectivity to input and final goods markets impacts business location and expansion decision and the overall cost of doing business for every industry in Texas.

6.1.1 HIGHWAY NETWORK CONNECTIVITY

Freight in Texas travels through all parts of the state, accessing origins and destinations related to raw materials production, manufacturing, assembly, packaging and distribution. As shown in **Chapter 4**, these steps within supply chains occur at different locations, and goods are often moved to many intermediate destinations before reaching an individual or commercial consumer. For this reason, the highway network connectivity needs assessment in Texas Delivers 2050 focuses on how efficiently truck drivers can reach a high-capacity facility that could efficiently take them to any number of destinations.[52]

Network connectivity analysis answers the question: **how far out of the way do drivers have to travel to reach their destination?** The difference between routed travel distance and straight-line distance is the additional mileage drivers travel due to imperfect network connectivity. Rural areas in the Panhandle, West, East and South Texas require the greatest additional travel distance to reach high-capacity, high-quality highways (**Exhibit 37,** normalized by mileage on the THFN). Connectivity to major corridors is essential for linking rural areas to urban commerce and population centers where much of Texas freight is consumed or forwarded. East-west connectivity is poorer than north-south connectivity in 16 districts, indicating less direct routes available.

EXHIBIT 37: ADDITIONAL MILEAGE TRAVELED TO MAJOR CORRIDORS PER MILES ON THE THFN



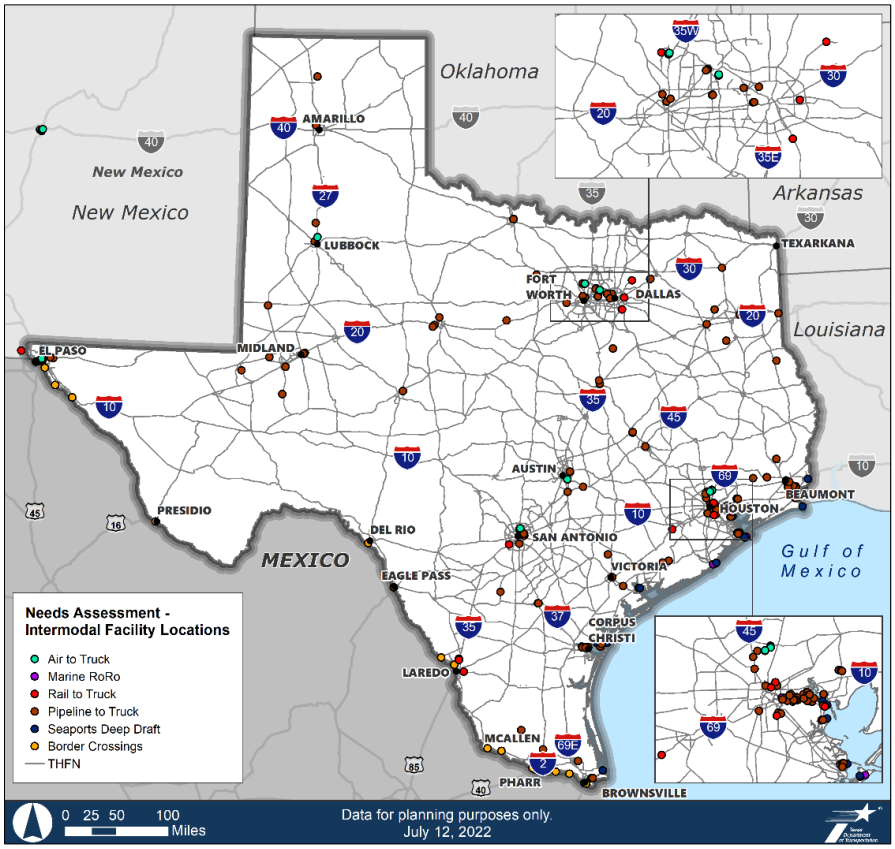
Source: Cambridge Systematics analysis, 2022. Major corridors are defined as Functional Class 1 or 2, Interstates and Other Freeways.

[52] Defined as Functional Classification 1, which includes Interstates, and Functional Classification 2, which includes non-Interstate freeways.

6.1.2 ACCESS TO TRADE GATEWAYS AND BETWEEN MODES

Supply chains in Texas depend on the ability to move freight to and from trade gateways and between transportation modes to efficiently reach markets throughout the state, nation, and world. International trade gateways on the TMFN include airports, seaports, and Texas-Mexico border crossings by truck, rail or pipeline.

EXHIBIT 38: MULTIMODAL CONNECTIVITY THROUGH INTERMODAL TRUCK FACILITIES, BORDER CROSSINGS, AND SEAPORTS



Source: 1. Bureau of Transportation Statistics (BTS): Intermodal Freight Facilities. TxDOT: Seaports. Texas Border Crossings.

Major exporting airports are in large urban areas that generate sufficient freight demand to load dedicated cargo planes or large international passenger planes with belly cargo: Houston, Dallas-Fort Worth, San Antonio and Austin (**Exhibit 38**). Seaports and land ports are located at the periphery of the state in both large urban areas and relatively isolated rural areas. While these trade gateways are in relatively few geographic regions of Texas, the statewide TMFN ties together supply chains, linking freight generation throughout the state to import-export points.

Intermodal facilities provide a critical interface supporting this interconnected system. Truck-to-pipeline facilities in Texas' oil and gas producing regions provide efficient, reliable pipeline transportation to refineries and maritime export facilities on the Gulf Coast. Rail-to-truck intermodal facilities are similarly located at critical points in agricultural, construction, and distribution supply chains. These facilities provide modal options linking ports-of-entry, freight production areas, and population centers. In particular, the rail-to-truck (trailer-on-flatcar and container-on-flatcar) facilities shown in **Exhibit 38** link urbanized areas with import-export points for consumer goods and other commonly containerized products.

6.1.3 MULTIMODAL CONNECTIVITY

Connectivity within and between modal networks is also critical for goods movement and access to markets. For example, freight may travel by train to a transload facility and moved to truck for distribution, or energy products may move by pipeline to the Gulf Coast for refining and export. Intermodal and transload facilities can be specialized to accommodate many niche freight types in Texas supply chains, resulting in few available options and limited ability to access other markets:

- Marine roll on/roll off facilities supporting military, automotive or project cargo.
- Intermodal container transfer between ships, barges, rail and trucks.
- Dry bulk facilities for grain, sand and gravel, coal and others between all surface modes.
- Break bulk cargo on racks or pallets such as steel rolls, wind turbines or wood.
- Tanker vessels, railcars and truck trailers for bulk liquids.
- Pipelines and terminals dedicated to specific product types, differentiating between crude and refined products.

Shippers of specialized freight requiring specific capabilities have more limited options among Texas terminals and gateways. Insufficient air draft for rail or road bridges over waterways can be a hinderance for some ports. In addition to improving network connectivity on the highway, and rail and waterway systems, freight connectivity can also be increased by expanding capabilities at existing ports-of-entry and intermodal facilities. TxDOT's **Port Mission Plan** and **BTMP** include specific capabilities and projects for seaports and land ports respectively, including typologies of cargo types served at each Texas seaport and planned infrastructure improvements.[53,54] TxDOT is not directly engaged in facility planning at airports, rail terminals or pipeline terminals. **However, coordination with these partners is critical to ensure the highway network provides adequate access and flexibility for the markets and commodities served by intermodal facilities.**

6.1.4 IMPACT TO KEY SUPPLY CHAINS

Connectivity to gateways will be essential to the continued economic strength of Texas' export market as well as quality of life received from ready access to imports. Improvements at and connecting to international **border crossings** will be needed to handle the increasing amounts of

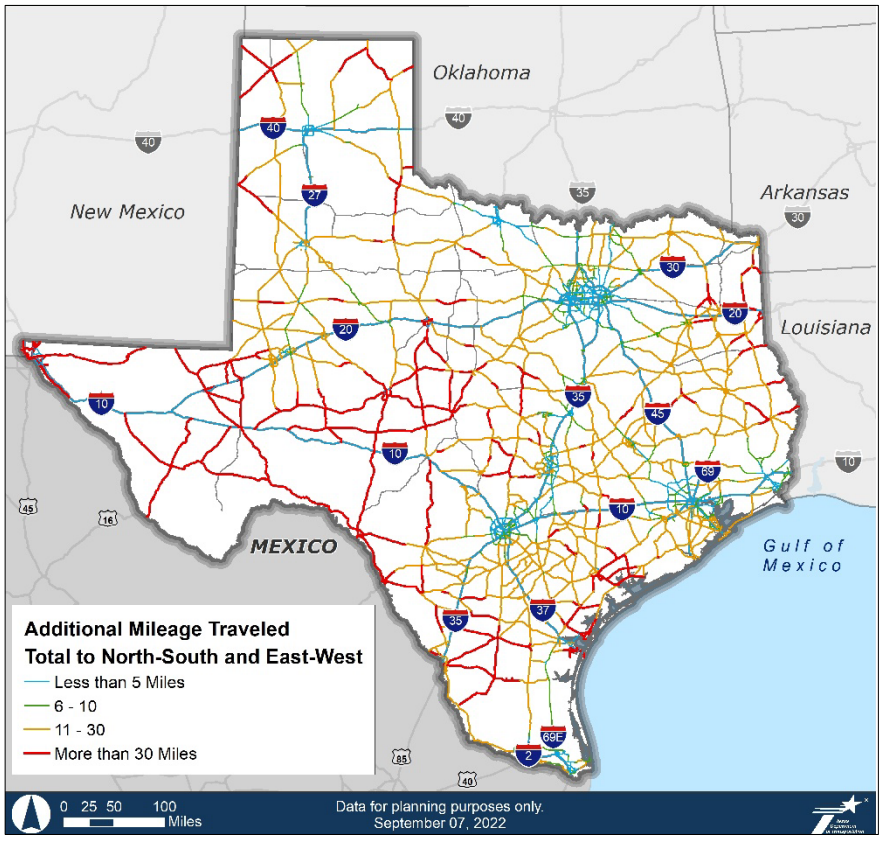
53 2024-2025 Port Mission Plan, TxDOT Maritime Division. 2024-2025 Texas Port Mission Plan (txdot.gov).

54 TxDOT, https://www.txdot.gov/projects/planning/international-trade-border-planning/btmp.html.

freight moving to and from the border with Mexico. The **BTMP** highlighted issues related to border crossing delay, roadway congestion and rail infrastructure constraints that create bottlenecks and reduce throughout of people and goods. Supply chains for industries such as advanced manufacturing depend on the flow of raw materials, automobile parts and electronic components moving between plants on both sides of the border.

Connectivity is also critical along the Texas Gulf Coast **connecting ports and intermodal facilities**. Beaumont, Corpus Christi, Houston and Brownsville have significant energy sector activity and the ports provide key access for inbound and outbound shipments of petroleum-based commodities and finished products. Development of I-69 from the Texas-Mexico border to Texarkana will improve connectivity to these facilities within and beyond Texas. **Coordination with ports, railroads and other planning partners with jurisdictions over local roads could help accelerate the planning and implementation of port access and inland connectivity investments so that cargo unloaded at the port can quickly access the multimodal network.**

EXHIBIT 39: ADDITIONAL MILEAGE TRAVELED TO EAST-WEST AND NORTH-SOUTH CORRIDORS



Source: Cambridge Systematics anlaysis, 2022. See Section 6.1.1.

Highway connectivity is essential in both urban and rural contexts. The highway network supports distribution throughout urban areas and often completes the first- and last-mile of cargo carried by other modes to manufacturers and consumers. In rural areas, **vast regional networks connect farms, ranches, timber fields and oil and gas fields** spread over wide areas. These individual facilities, fields and wells have access to highways which connect to the interstate system and terminals accessing rail, pipeline and maritime terminals. The Panhandle, South, East and West Texas experience the greatest detour lengths to access major highways facilitating these movements (**Exhibit 39**).

6.2 NEED FOR RESILIENCY ON THE TMFN

Supply chain disruptions come in all shapes and sizes, from localized congestion on a key port access road, to a blocked global trade route like the Suez Canal. The ability of industry to plan for and mitigate the impacts of these disruptions is critical for supply chain resiliency and ultimately for the on-time, efficient delivery of raw materials and finished products. When these disruptions cannot successfully be mitigated, businesses and consumers are faced with materials shortage and production shutdowns. These events create economic hardships that ripple throughout the entire supply chain, and can create life threatening conditions when food, water, medicine, and energy producing fuel deliveries are blocked or delayed.

6.2.1 FREIGHT SYSTEM RESILIENCY

Supply chain disruptions make it difficult for raw materials to be transported to factories, forcing manufacturers to shut down due to lack of power or raw materials, creating dangerous travel conditions that prevent workers from getting to their jobs, and generating shifts in demand/consumer preferences. In order to prevent and minimize disruptions to supply chains it is vital to maintain a resilient freight network.

In order to better plan for disruptive events, it is critical to understand and incorporate freight system resiliency into Texas' freight program and the TMFN. Resiliency refers to the ability of a system to **absorb or withstand** an event, **operate or maintain** continuously, and **recover or adapt** following a disruption. In the context of the TMFN, a resilient system involves infrastructure design and maintenance to maximize asset availability and quality; connectivity within and between modal networks to provide alternatives; and institutional capacity for communication and coordination across jurisdictions or between public and private sectors.

TxDOT and its partners must prepare for and respond to a wide variety of disruptions, or sudden changes, impacting the TMFN. Public organizations and private companies have emergency preparedness plans in place to help guide mitigation efforts before, during and after events.

Emergency preparedness plans developed and maintained by government and industry provide a critical opportunity to establish pre-event preparation protocols, during event management activities, and post-event recovery actions. For government, this includes infrastructure hardening, emergency response, and infrastructure clearance and inspection. For business, this can go even further to shifting business activities to alternate facilities to avoid the impacted areas; this practice will become more common as companies invest in supply chain redundancy.

With the increased frequency of events over the last few years, many responders are finding that existing response protocols need to more comprehensively consider the role of freight in

preparing for, responding to, and recovering from disruptions. In addition, in some regions, atypical events are occurring for which existing plans are inadequate.

Supply chain disruptions can be categorized in many ways and include:

- **Physical:** natural and manmade impediments to use of transportation infrastructure.
- **Economic:** changes in the state, national or global economy impacting freight flows in Texas.
- **Institutional:** changes in policy that facilitate or hinder efficient freight movement.

Each of the key industry supply chains discussed in Chapter 4 relies on multiple modes of transportation. These modal decisions are based on level of service, commodity characteristics, available options, shipper preferences, and cost. Disruptions to one or more modes can have significant impacts on how or if products can move.

Freight stakeholders in Texas agree that disruptions from a variety of sources are not only likely to occur in the future, but also likely to impact freight volumes and patterns in Texas (**Exhibit 40**).

Freight resiliency plays a vital role in the economy and reduces disruptions to supply chains. With natural hazards increasing in frequency and severity, it is crucial that freight resiliency is incorporated into the planning process in order to minimize potential disruptions and reduce the time required to return to normal operations.

EXHIBIT 40: STAKEHOLDER INPUT ON LIKELIHOOD AND IMPACT OF DISRUPTIONS TO FREIGHT MOVEMENT IN TEXAS

Source: Fall 2021 TFMP Workshop Combined Results.

6.2.2 LESSONS LEARNED FROM CASE STUDIES

In an effort to examine the resiliency of the Texas Multimodal Freight Network (TMFN), six case studies were identified to explore the freight impacts of specific events and identify what worked well, as well as areas of weakness and how the freight system might respond to a similar event in the future. The case studies were identified to cover the unique geographies of Texas as well as a cross-section of events, both natural and manmade. Detailed summaries of each case study can be found in the **Resiliency Case Study Technical Memorandum**. The six case studies helped identify key freight resiliency needs across five categories summarized below:

Infrastructure – this includes hardening of facilities including maintenance, system redundancy, capacity, and connectivity.

- Many types of infrastructure hardening could reduce impacts of a future event, including maintenance of tree limbs, vegetation and other objects that could result in debris on the TMFN (e.g., winter storm, hurricane).
- Increased pavement monitoring could reduce maintenance costs associate with pavement issues associated with specific events (e.g., droughts).
- Proactive vegetation management inside TxDOT ROW to thin and remove potential wildfire fuel during droughts could help reduce the impacts from wildfires (e.g., droughts).
- System redundancy and identification of alternative routes for THFN corridors that are vulnerable could help keep freight moving in case of road closures (e.g., wildfires, flooding).

WINTER STORM URI

- Timeline: February 7 through February 20, 2021
- The prolonged duration of the subfreezing temperatures coupled with the widespread coverage of winter weather placed a strain on TxDOT resources.
- The lack of reliable power across much of the state worsened the impacts to freight movements.
- Clearance of debris including tree limbs and other vegetation from the TMFN was a significant effort.
- Modal partners reported difficulty getting crews to work to clear or operate other modes, which could have relieved freight movement from the icy highway system.
- Materials and supplies storage at TxDOT districts was inadequate for preparing large quantities of brine, salt and other de-icing materials.
- The winter storm was a different kind of event from what Texans' have experienced in the past and revealed where we need to create system redundancies.

- Prioritization of critical energy facilities to receive fuel and energy could help keep power generation systems online.
- Adjacent roadway and freight rail corridors should be identified that could provide a modal alternative in the absence of pipeline access or availability.
- Increased connectivity could reduce the impacts of border disruptions by facilitating rerouting.

Materials/ Supplies – this includes procurement of and staging of personal protective equipment (PPE), generators, materials and storage (e.g., de-icing).

- TxDOT is investing in power generators to ensure its facilities maintain power in the event of prolonged outages.
- Supplies such as food, water, personal protective equipment, radios, and other equipment based on type of event (e.g., waders, mosquito repellent and flotation devices for flooding events) should be procured with enough lead time to accommodate distribution to districts, maintenance offices, and emergency operations centers in advance of an event.

Communication/Collaboration – this includes communication and collaboration between agencies regarding response and operations, with the public regarding dangerous conditions and status, and with shippers regarding status and routing instructions.

HURRICANE HARVEY

- Timeline: three landfalls between August 25 and August 30, 2017
- Flooding was the main issue with some areas near Houston receiving over 60 inches of rain.
- Most roadways in the Gulf Coast between Corpus Christi and Beaumont were inundated at some point, halting the Gulf Coast economy as businesses were closed and workers were not able to get to ports and other economic generators.
- The vast majority of THFN segment closures lasted up to two days. An estimated 20% of segments were closed three to seven days, and some were closed for more than one week.
- Harvey caused unprecedented shoaling in the GIWW. The waterway was closed completely from August 25 until September 23, at which time it opened with an 8-foot draft restriction.
- Key supplies such as food, water, personal protective equipment, radios, waders, mosquito repellent and flotation devices were not purchased and positioned pre-event.
- Additional supplies received or distributed immediately following the event are impacted by available routes.
- The current corridor prioritization and evaluation process utilized by TxDOT includes pavement, bridge, mobility, safety and connectivity.
- Identifying alternative routes is critical when roads are closed due to flooding.

- Emergency planning and response requires regular communication to manage all activities and communicate conditions to impacted communities and businesses.
- Providing real-time traffic and border crossing information would allow truck drivers and dispatchers to make more informed decisions during a disruption.
- Partnerships are essential for addressing border disruptions due to the complex binational policy environment.

Technology – this includes CAV policies, non-intrusive CMV inspections, and alignment and coordination among system users.

- Advancements in technology and technology applications can impact key parts of the supply chain, whether it be border screening and clearance activities or roadside commercial vehicle enforcement activities associated with ELDs and/or autonomous trucks.

Policies – this includes oversize/overweight permits, hours of service requirements, and project and corridor prioritization and evaluation processes.

- Flexibility in oversize/overweight permitting for equipment positioning before, during and after events could improve both initial mitigation and event response.
- Critical infrastructure prioritized for clearance should include freight considerations.

2011 DROUGHT AND WILDFIRES

- **Duration**: beginning with below average rainfall in Fall 2010 through Summer 2013, with short periods of temporary relief in between.
- Droughts and wildfires can impact freight movements across a variety of modes. Higher temperatures that often coexist with drought can affect road pavement performance and airport runways, as well as cause rail line buckling, which can lead to delays in freight shipments and increase maintenance costs.
- When water supplies are depleted in droughts, increased use of groundwater can cause the ground to sink (called land subsidence). Subsidence damages infrastructure and can cause sinkholes leading to road closures.
- The main impact of wildland fires on the freight transportation system is roadway closure due to emergency operations, poor visibility or fire damage, which can force trucks to seek alternate routes that often require additional travel time and travel distance equating to higher costs for shippers and creating delays.
- The 2011 Texas drought caused over $7.62 billion in crop and livestock losses, pushed power grids to the limit, impacted tourism, and reduced rivers, lakes, and reservoirs to dangerously low levels.

The six case studies also helped identify the need for further study in some areas. The state should continue expanding their mitigation strategies, actions, and infrastructure to prepare for and manage future events impacting key freight corridors.

TxDOT's ongoing statewide resiliency plan will provide the framework for these actions and the freight resiliency plan scheduled to commence in early 2023 will provide the platform to further expand on this topic as part of Texas Delivers 2050 implementation.

CYBER SECURITY: PIPELINE DISRUPTION

- A hypothetical pipeline cyber security attack similar to the one on the Colonial American Pipeline in May 2021 that impact pipelines in the Permian Basin could have devastating economic and supply chain impacts.
- A cyberattack impacting pipelines in the Permian Basin and throughout Texas could cause multi-level disruptions that would not only be felt in the state but across the nation due to Texas' status as the leading domestic producer of oil and gas.
- In 2019 alone, the Permian Basin region supported nearly 766,000 jobs, $52 billion in labor income, $90 billion in GSP and $10 million in combined federal, state and local taxes generated by the freight and energy sector.
- Depending on the severity of the attack and the length of pipeline shutdowns, a disruption to petroleum and natural gas supply chains could take days or months to recover from associated economic losses.
- A pipeline cyberattack would likely cause a modal shift to trucks, rail and oil tankers, which would impact the operations of other modes.

INTERNATIONAL BRIDGE DISRUPTION

- Disruptions at border crossings can cause freight to be rerouted to other border crossings resulting in increased border wait times, longer trips and increased travel times. If the disruptions are long lasting or occur at large border crossings with a significant amount of commercial vehicle traffic, shippers may resort to modal shifts to ensure their cargo makes it to the destination on time.
- No matter the cause for border disruptions, carriers and infrastructure operators need to respond and shift to other border crossings or to other modes as a result of increased wait times or closures.
- Mexico is among the U.S.'s largest trading partners and Texas' largest trading partner. The total trade between the two countries amounted to $56.25 billion in February 2022, according to recent government data. Disruptions at the border can create long wait times at border crossings and wreak havoc on supply chains.

COVID-19

- Duration: Most transportation impacts felt from March 2020 through March 2021, with lingering supply chain issues
- Traffic on most of the TMFN suddenly declined, but demand for goods and services surged, straining a freight ecosystem that was not fully prepared for the transportation and workforce challenges of a pandemic.
- The uncertainty of the nature of the global pandemic, the unprecedented global response to combat the spread of infection, volatility of demand and supply, along with shortages and delays of critical items severely impacted the operational and personnel capacity of supply chains.
- State and national truck driver availability was limited as individuals became ill, and lockdown measures closed or limited access to workplaces.
- E-commerce growth has led to increased freight activity throughout Texas, especially in the urban areas. Consumers spent less on services and travel, shifting more disposable income to buying goods and increasing demand for consumer products.
- Texas ports experienced lack of equipment, material and labor to address the increased demand for commodities leading to major supply chain bottlenecks.

6.2.3 RISK ASSESSMENT AND COMPARISON TO KEY SUPPLY CHAINS

Resiliency needs at a system-wide level were assessed by overlaying the areas of the state that showed a higher risk of natural disasters with the needs assessment scoring on the THFN. The intersection between the needs and areas of the state with a high risk of natural hazards point to areas with potential vulnerabilities on the system. Areas of the network that already experience high needs could be more susceptible to disruptions in freight movement during an event, such as a hurricane.

Resiliency needs on the THFN were evaluated using a risk index calculated by the Federal Emergency Management Agency (FEMA): the National Risk Index (NRI), which scores the level of likely impacts for 18 natural disaster risks. The score is based

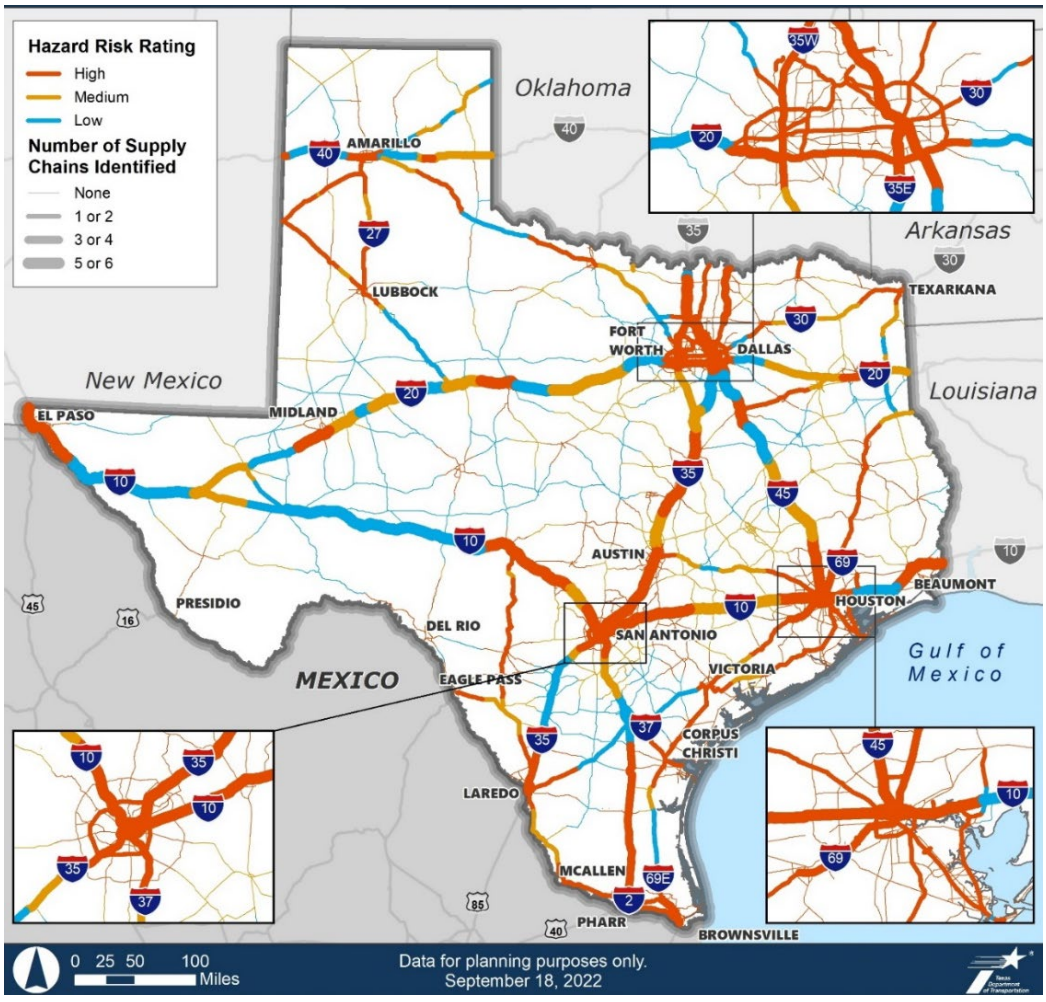
- **Expected Annual Loss (EAL)** - the average economic loss in dollars resulting from natural hazards each year. It is calculated for each hazard type and quantifies loss for relevant consequence types: buildings, people and agriculture.
- **Social Vulnerability** - the susceptibility of social groups to the adverse impacts of natural hazards, including disproportionate death, injury, loss or disruption of livelihood.
- **Community Resilience** - the ability of a community to prepare for anticipated natural hazards, adapt to changing conditions and withstand and recover rapidly from disruptions.

on three components that evaluate the consequences of an event, including both vulnerabilities and mitigating factors within communities.[55]

Nearly half of the mileage on the THFN is located in counties with risk scores in the top third of Texas counties (47%), and more than half of mileage supporting one or more key supply chains is within those counties (52%, **Exhibit 41**).

- Electronics has a higher ratio of high-risk mileage than any other supply chain (72%).
- Transportation and construction supply chains also have above average mileage in high-risk counties (53% and 50%).
- Natural and manmade disruptions impact all freight modes, including closure of facilities, damage to infrastructure, workforce challenges, trade policies and cybersecurity.

EXHIBIT 41: NATURAL HAZARD RISK AND KEY SUPPLY CHAINS



Source: Transystems analysis of FEMA NRI data.

55 Federal Emergency Management Agency, https://hazards.fema.gov/nri/determining-risk.

In addition to the analysis of the number of supply chains associated with areas of natural hazard risk, the high risk areas were also overlayed with five key needs categories including mobility and reliability, safety, design, connectivity and asset management. Forty-two to sixty-five percent of the high priority infrastructure needs in each of these categories are in locations at higher risk for natural disasters (**Exhibit 42**). The six case studies provided further discussion of the specific impacts that a range of events can have on supply chain efficiency and reliability. Additional study is needed to determine the ability of specific infrastructure assets in high risk, high priority locations to withstand the disasters relevant to the risks at their location.

EXHIBIT 42: NATURAL HAZARD RISK AND HIGH-PRIORITY FREIGHT INFRASTRUCTURE NEEDS

46% of high-priority Safety Needs	**46%** of high-priority Bridge Needs
58% of high-priority Mobility and Reliability Needs	**44%** of high- priority Design Needs
65% of high-prioirty Pavement Needs	**42%** of high-priority Connectivity Needs

Source: Transystems analysis of FEMA NRI data. See topic-specific sections in Chapters 5 and 6 for individual analysis sources.

This Chapter discussed multimodal connectivity and resiliency needs impacting the TMFN and key supply chains in Texas. Chapter 7 discusses needs and challenges critical to developing a freight system that achieves the best possible outcomes for all Texans: technology, equity and institutional challenges.

Chapter 7 Preparing for the Next Generation of Goods Movement

TxDOT's planning considerations for the future of the TMFN continue to evolve and become more comprehensive. Texas Delivers 2050 recognizes critical opportunities to create a freight system that is efficient and benefits all Texans: technology, equity and policy environment.

Infrastructure and vehicle technology are rapidly changing, and TxDOT and its partners can harness these advancements to better leverage both new and existing infrastructure. Derived from the 2018 TFMP, TxDOT completed the Freight Network Technology Operations Plan (FNTOP) in 2020. The FNTOP explored infrastructure and data management technologies to improve freight movement. Chapter 7 focuses on comparison of needs to existing infrastructure, with the goal of identifying key technology opportunities on the THFN.

This chapter also presents needs related to a topic that has long impacted Texans but has only recently been studied at the long-range freight planning level: equity and impacts to historically marginalized communities. In addition to comparing needs and supply chains to equity focus areas, this chapter presents findings of a 2021 screening of freight impacts to communities throughout the state.

Finally, this chapter concludes with key institutional challenges facing infrastructure providers and freight stakeholders.

Highlights

In recent years, TxDOT has broadened the scope of its freight planning considerations to address changing technology, equity implications of freight movement, and policy or institutional opportunities.

- Most existing technology infrastructure is in urban areas where congestion and organizational capacity to operate traffic management centers are both located.
- Rural areas also contain corridors with safety, asset condition, or mobility needs that could benefit from technology strategies.
  - Interstates present the biggest opportunity.
  - A statewide management approach may be needed to support these operations in rural contexts.
- High priority safety, mobility, asset management, and design needs are present in equity focus areas at a slightly elevated rate.
- Local safety and air quality impacts of freight transportation disproportionately impact communities with higher concentration of non-white, impoverished, or limited-English proficiency populations.
- Texas benefits from an innovation-friendly regulatory environment, but additional coordination opportunities exist.

7.1 TECHNOLOGY AND OPERATIONS

Technology strategies, often collectively called ITS, are essential tools for managing and improving safety, asset condition, mobility and reliability on the TMFN. ITS applications involve the collection, processing and dissemination of information that enables transportation users to utilize the existing infrastructure more efficiently. Access to information enables freight users to make informed travel choices and for operating agencies, awareness of travel conditions enables traffic management to be more responsive and effective.

Intelligent Transportation Systems (ITS)

Compared to traditional infrastructure and capacity projects, ITS and operational solutions are:

- Cost effective.
- Better at leveraging TxDOT's existing infrastructure investments.
- Minimize negative environmental and community impacts with smaller changes to the transportation footprint.

7.1.1 FREIGHT NEEDS AND TECHNOLOGY OPPORTUNITIES

Existing needs and technology were assessed to identify technology gaps and determine locations where technology strategies could improve safety, asset condition and reliability. Four multi-faceted considerations were incorporated into this assessment:

- Weigh-in-Motion need, derived from TxDOT's Weigh-in-Motion Strategic Plan.
- Existing Traffic Management Center (TMC) coverage compared to truck volume.
- Existing Dynamic Message Sign (DMS) coverage compared to TTTR.
- Existing Closed-Circuit Television (CCTV) coverage compared to truck-involved crash rate.

EXHIBIT 43: RURAL AND URBAN ITS DEVICE SUMMARY

ITS Asset	Urban Counties	Rural Counties
CCTV Cameras	2,607 (96%)	110 (4%)
Dynamic Message Signs (DMS)	904 (91%)	85 (9%)
Vehicle Detectors	2,441 (97%)	84 (3%)
Weigh-In-Motion (WIM)	22 (54%)	19 (46%)
Permanent Count Sites	265 (66%)	137 (34%)

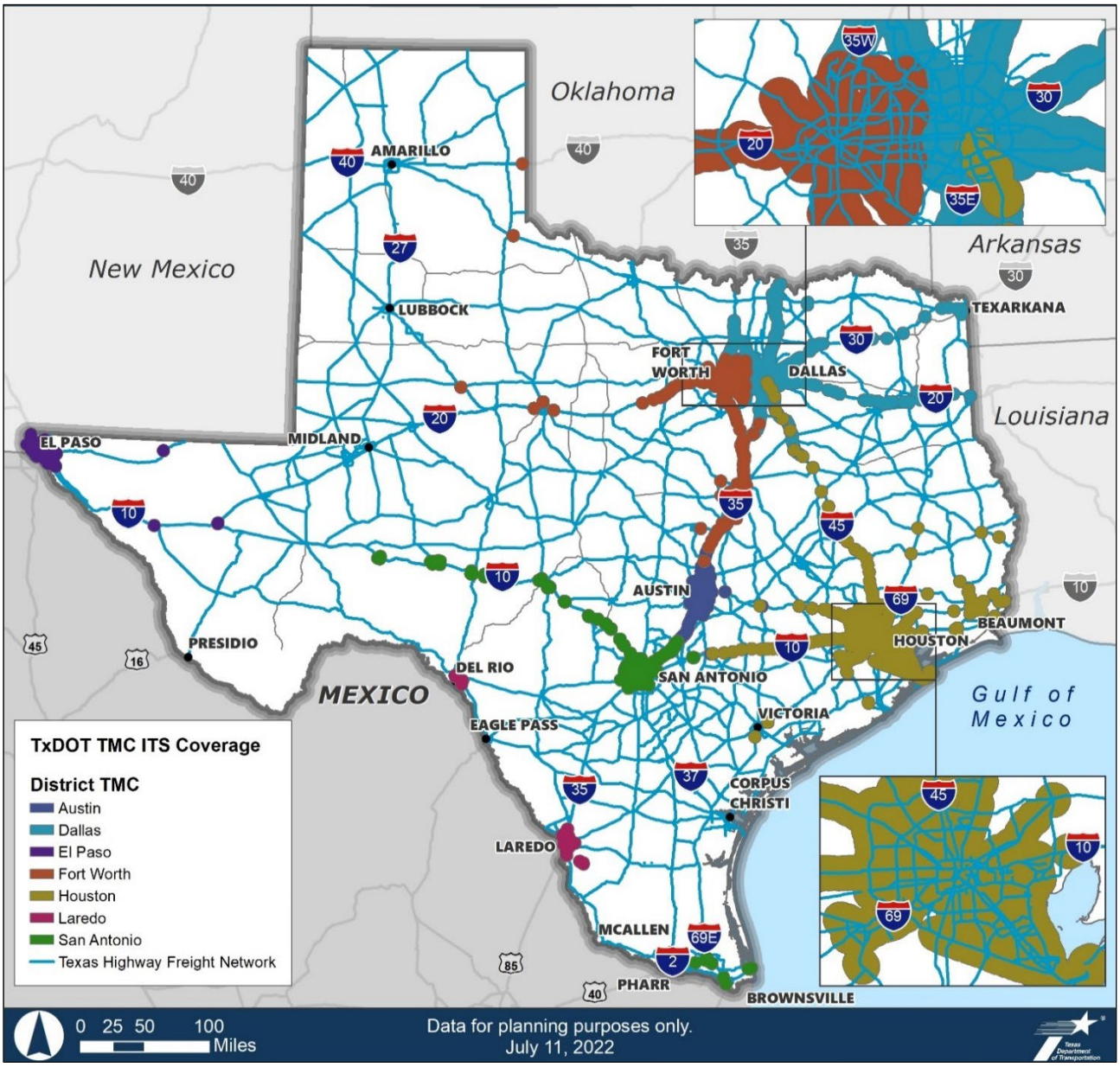
Source: TxDOT Traffic Safety Division, 2021.

These represent opportunities for TxDOT to prioritize technology improvements associated with existing freight conditions and performance. The approximately 6,000 ITS devices in Texas consist of a variety of types of devices used for different traffic management purposes. These include 2,526 CCTV cameras, 885 DMS and 2,509 traffic detectors. The San Antonio District also has 30 flood detection stations used by the district's TMC. Most of TxDOT's ITS assets for real-time traffic management are in urban counties, with these counties containing about 96% of CCTV cameras, 91% of DMS and 97% of vehicle detectors, as shown in **Exhibit 43**.

TRAFFIC MANAGEMENT CENTERS

These devices are associated with TxDOT TMCs and are aligned with facilities and contexts with high traffic volumes. TMCs serve as central hubs for collection and distribution of information about highway conditions and enable rapid response to traffic incidents by personnel or via automated systems. Seven TxDOT districts have TMCs, and other districts coordinate with established centers in more populous districts (**Exhibit 44**). However, the majority of the THFN is not monitored or managed by a TMC and rely on field observations from law enforcement and emergency calls. These gaps include hundreds of miles of the interstate system. Expansion of monitoring and integration into a statewide system could improve incident response and operational efficiency.

EXHIBIT 44: TXDOT TRAFFIC MANAGEMENT CENTER COVERAGE



Source: Prepared by Cambridge Systematics using data provided by the TxDOT Traffic Safety Division, 2021.

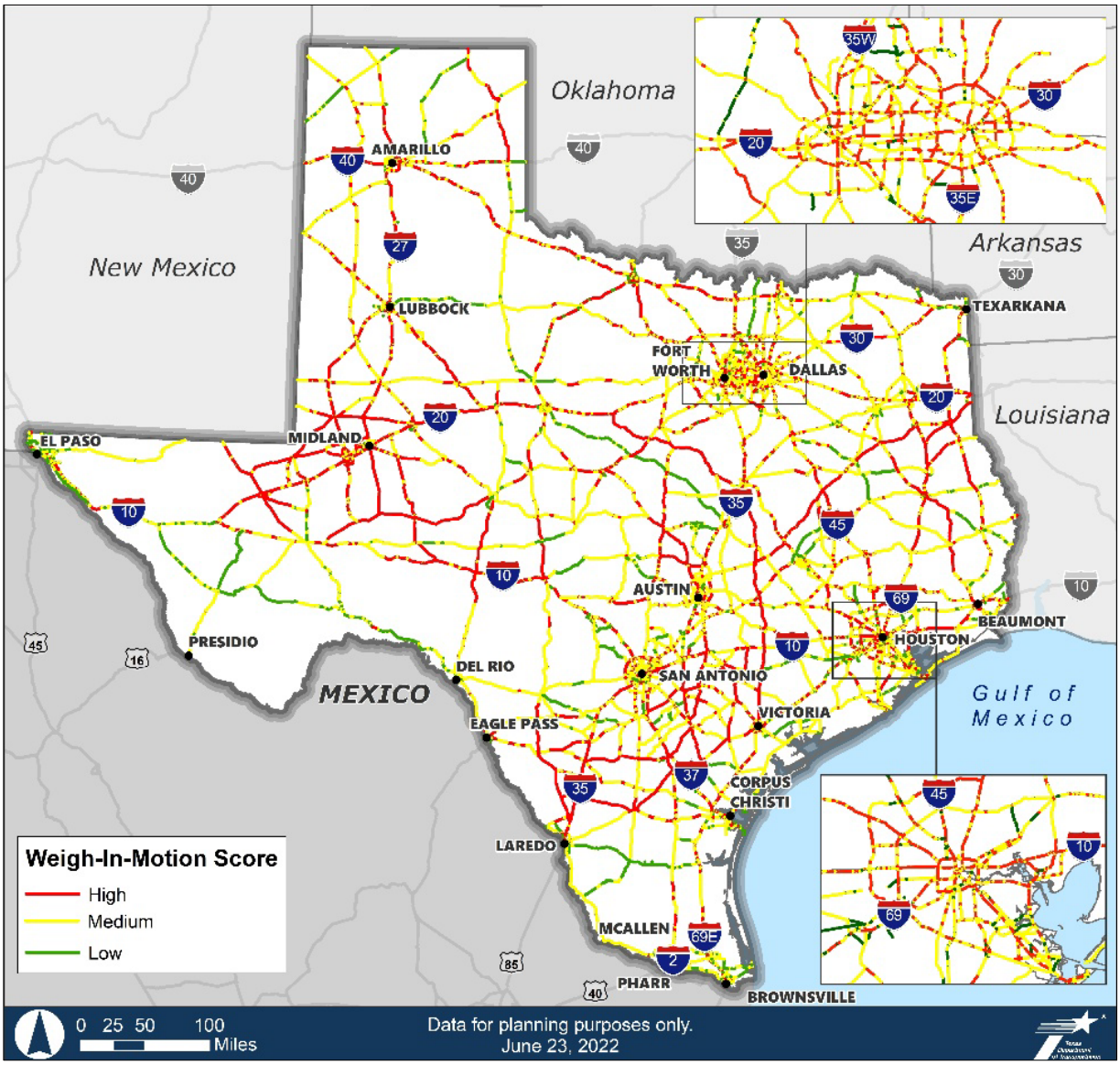
WEIGH-IN-MOTION

Weigh-in-motion and vehicle classification (WIM/VC) stations improve TxDOT's ability to monitor and manage vehicle weights and types on the highway network to improve planning related to pavement quality and capacity. Truck drivers also benefit from operational improvements and fuel savings because drivers do not have to come to a stop at weigh stations. There are 41 permanent WIM/VC stations in Texas, and the **WIM/VC Strategic Plan** prioritized locations for additional sites. Prioritization was based on asset condition, freight movement, mobility, and

safety. The highest need areas were in rural regions with significant heavy load traffic (**Exhibit 45**):

- Oil and gas producing regions of the Permian Basin and Eagle Ford Shale.
- Timber-producing regions in East Texas.
- Mineral-producing region of Central Texas west of the I-35 corridor.
- Agriculture-producing regions of West Texas and the Panhandle.

EXHIBIT 45: WIM/VC NEEDS COMPOSITE SCORE



Source: Prepared by Cambridge Systematics using data provided by the TxDOT Traffic Safety Division, 2021.

TRUCK PARKING AVAILABILITY SYSTEMS (TPAS)

The I-10 Corridor Coalition, a volunteer coalition of state Departments of Transportation for California, Arizona, New Mexico, and Texas, was awarded a $6.85 million U.S. Department of Transportation (USDOT) Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) grant in April 2019 to implement a Truck Parking Availability System (TPAS) along the I-10 corridor. In addition to the grant, the Coalition states are matching the funds 1:1, allowing the Coalition to leverage $13.7 million for the TPAS project.[56]

TPAS is a technology system that will detect, monitor, and disseminate truck parking availability information at 37 public truck parking locations along I-10 in California, Arizona, New Mexico, and Texas. The system will assist truck drivers and dispatchers in making informed parking decisions by providing real-time truck parking information through dynamic message signs, smartphone, and in-cab applications and via website and traveler information sites. In Texas, this includes 16 Safety Rest Areas and 2 Traveler Information Centers along I-10 between the New Mexico and Louisiana state lines.

The implementation of TPAS may also serve as the foundation for future technology implementation along the I-10 Corridor, including integration of weather or other alert systems, a truck parking reservation system and automated and connected vehicle and infrastructure technology. It will also help support potential statewide expansion of TPAS to other key freight routes outside of I-10.

Trucking Industry Prioritizes Investments in Proven Technologies.

The trucking industry typically invests in technology once there is a solid business case or value add. Most carriers wait until performance is proven to increase efficiency, improve safety, and cut costs. However, shipper requirements have accelerated carrier investments in some technologies like electric vehicles and alternative fuels based "green" initiatives and environmentally conscious corporate culture.

OTHER MODAL TECHNOLOGY APPLICATIONS AND ADVANCEMENTS

Technology programs exist in other modes, but often with less visibility than the highway mode's transportation programs because other modes are regulated by national governmental standards for broad technology advancements and involve private-sector organizations with finer, more specific technology advancements that are not publicly available due to concerns of economic competitiveness.

56 I-10 Connects TPAS, I-10 Corridor Coalition Truck Parking Availability System (TPAS). https://i10connects.com/sites/default/files/TPAS%20Fact%20Sheet%20-%202022.05.pdf.

In the context of the **rail mode**, most technology programs fall between both categories, with many technology applications and advancements focused on locomotive fuel efficiency and/or alternative fuel programs, rail signals and operations management, and back-office scheduling and routing systems. Nationally, the concept of Positive Train Control (PTC) is one high-profile safety and operational program that has been discussed extensively in the industry. PTC systems use communication-based and processor-based train control technology to prevent train-to-train collisions reliably and functionally, overspeed derailments, incursions into established work zone limits, and movements of trains through switches in the wrong position. In 2020, this technology recently reached full deployment, where the FRA reported that PTC is operating on all required freight and passenger railroad routes.[57]

In 2021, FRA issued a Final Rule on the use of ultrasonic inspection technology, augmented with global positioning system (GPS) technology, to employ continuous rail testing. Continuous rail testing involves rail cars outfitted with ultrasonic and GPS technologies to examine rail internally without stopping. Rail cars traveling along the track collect images and transmit information to monitoring sites. Data is processed, and if potential defects are identified, railroad inspectors are dispatched to the site for more thorough inspection and appropriate remedial action is taken. FRA estimates that one continuous rail car could replace three to five stop-and-verify test cars. This equates to fewer test cars stopping on tracks and reducing the number of trains that slow to accommodate them. Fewer trains slowing decreases the likelihood of crews exceeding maximum allowable work hours; thus, decreasing the expense of unscheduled replacement crews.[58]

The Texas A&M Transportation Institute (TTI) initiated research on the Freight Shuttle System (FSS) to develop a suitable short-haul and high-volume mode that segregates freight from passenger traffic. The most suitable application would be at seaports, landside ports-of-entry and congested transportation corridors. Integrating this system with rail and trucking could ease congestion and provide secure movement of goods at the border. This system would use linear induction motors, autonomous transporters and have redundant safety systems. A prototype system is complete and in pilot testing. Future development for design and planning for an actual system is in process.[59] Freight Shuttle Xpress (FSX) is the result of this research and is working to advance the concept in an operational environment.[60]

In the context of the **maritime mode**, many infrastructure owner operators and fleet managers have implemented key technology programs as part of their infrastructure or operations.

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57 United States Department of Transportation, Federal Railroad Administration. Positive Train Control. Visited on October 17, 2022. https://railroads.dot.gov/train-control/ptc/positive-train-control-ptc.

58 https://railroads.dot.gov/newsroom/press-releases/federal-railroad-administration-announces-rail-inspection-technology-rule.

59 https://tti.tamu.edu/freight-shuttle/.

60 https://www.freightshuttle.com/.

Specifically, ports have been focused on: 1.) improving load matching between vehicles, and 2.) improving operations in and around facilities. The Port Authority of New York and New Jersey operates a web portal that consolidates information regarding six container terminals in the region, providing insights on operational constraints, container availability, and vessel schedules.[61] The Los Angeles Metropolitan Transportation Authority is conducting a USDOT-funded pilot project to build upon that concept called Drayage, Freight and Logistics Exchange (DrayFLEX) which aims to deploy systems that support the two goals identified above. Similarly, the Port of Oakland — in coordination with the Alameda County Transportation Commission — undertook its Global Opportunities at the Port of Oakland (GoPort) program to improve transportation efficiencies by streamlining traffic management and operations around the facility. More complex systems have been deployed at certain key ports — particularly, Port of Hamburg and Port of Rotterdam in Europe — to create a smart port environment that facilitates information exchanges between various on-site operators.[62,63] Similarly, the Port of Qingdao and Port of Shanghai in Asia; the Port of Rotterdam in Europe; and the Port of Long Beach have adopted automation for container movement applications, cranes, and automated, guided vehicles.[64]

Fleet operators have particularly focused on technology programs that can aid in targeting zero emissions, which can be challenging for widespread adoption due to the lengthy lifecycle turnover of cargo vessels; limitations on alternative fuels that are appropriate for an ocean voyage; and the mismatch of policies and interests among various international destinations. Most alternative fuel demonstrations have been smaller scale, but several industry proposals are seeking out the next level in deployment. One concept is a proposal to establish "green corridors," which include key strategic shipping routes that allow policy makers to establish regulatory measures, financial incentives, technology hardware and safety regulations to facilitate operation of a zero-emission shipping lane.[65]

In the context of the **aviation mode**, most technology advancements are governed closely by national aviation agencies in various countries, so most operational procedures, associated technology programs and techniques of air navigation are directed by the United Nation's International Civil Aviation Organization (ICAO). Technologies used for intermodal operations at airports mirror those found in other industries for shipment scheduling, routing, and tracking. Like other modes, the aviation industry is looking to identify means and methods for achieving

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61 Port of NY and NJ Inaugurates TIPS System, 2015, https://www.panynj.gov/port/pdf/JoC_WP-NYNJ0915-v3.pdf.

62 Smart Ports—Hamburg/Rotterdam https://www.governmenteuropa.eu/smart-initiatives-smartport-hamburg/85944/.

63 PortBase Port of Rotterdam https://www.portofrotterdam.com/en/doing-business/services/service-range/port-community-system.

64 iContainers, The future of automation and terminals and ports: https://www.icontainers.com/us/2018/10/09/the-future-of-automation-at-terminals-and-ports/.

65 McKinsey and Company. Green corridors: A lane for zero-carbon shipping. December 21, 2021. https://www.mckinsey.com/business-functions/sustainability/our-insights/green-corridors-a-lane-for-zero-carbon-shipping.

net-zero emission goals with their vehicle fleets; however, rather than electrification or hydrogen, this industry looks more toward use of biofuels, development of new aircraft technologies, operational efficiencies (i.e., using national airspace more efficiently), and infrastructure improvements at airports to help reduce the trip time required to move freight.[66]

Technology advancements that are less mainstream than traditional long-haul freight focus on direct transit or last-mile applications. Electric Vertical Takeoff and Landing (eVTOL) vehicles are a new type of passenger or cargo vehicle that aims to provide local air service to destinations not typically served by aviation; use cases in this field, include point-to-point delivery of small freight or emergency shipments of critical supplies. Similarly, the unmanned aerial system (UAS), or drone, market remains a topic of great interest, where small, automated drones would aerially deliver packages and have many use cases in the last-mile delivery concept. Several research organizations are examining the many potential use cases for these technologies, including Lone Star UAS at the Texas A&M University Corpus Christi campus and the Ohio UAS Center as part of the Ohio Department of Transportation's DriveOhio initiative.

In the context of the **pipeline mode**, most technology advancements are more industrial for system operation, and thus, tend to be less obvious than other technology that directly impacts traffic operations. Most technology programs for pipelines involve using data to provide better system monitoring and maintenance. Cybersecurity, in particular, has been a critical consideration following the 2021 ransomware attack that occurred with Colonial Pipeline.

7.1.2 IMPACT TO KEY SUPPLY CHAINS

Technology priorities were evaluated based on **Weigh-in-Motion need,** areas without **TMCs** compared to **truck volume,** areas without **dynamic message signs** compared to **TTTR** and areas without **CCTVs** compared to **truck-involved crash rate.** Corridors supporting several supply chains on the eastern half of the state are generally covered by TMCs and have existing technology solutions in place. The future I-69 corridor in East Texas; I-10, I-20 and I-40 in West Texas; and I-35 and I-69C/US 281 in South Texas support many supply chains with limited technology management in place today. These locations all have significant truck volume and stand to benefit from more robust real-time data collection and distribution.

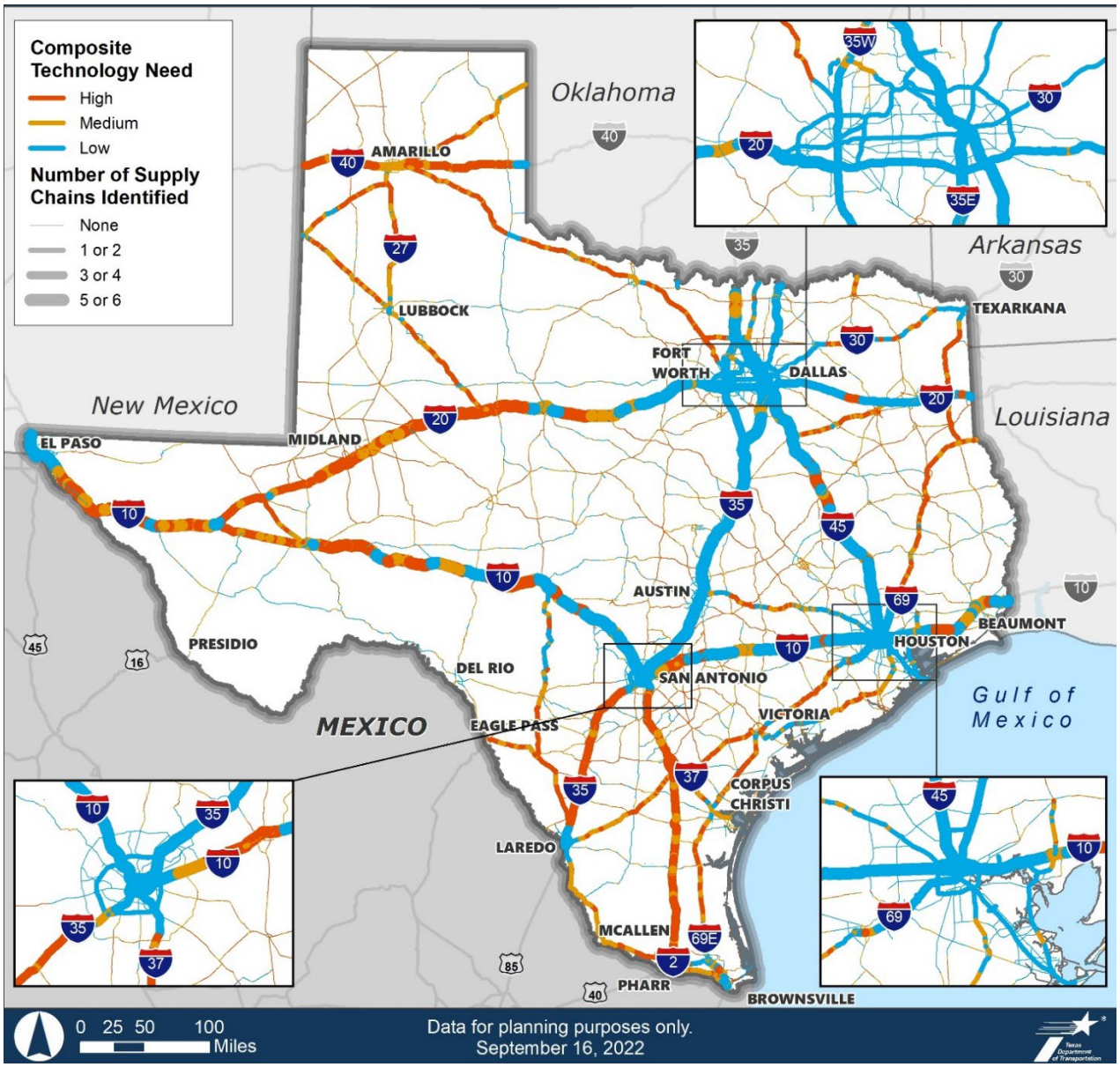
- Electronics and construction supply chain corridors included significant mileage of existing technology applications and rated below average in terms of high technology priorities.

[66] International Air Transport Association. Our Commitment to Fly Net Zero by 2050. Accessed on March 29, 2022. https://www.iata.org/en/programs/environment/flynetzero/.

- Advance manufacturing (automotive and aerospace) and agriculture supply chain corridors had the least existing technology, and the highest share of high priority technology needs as a result.

- Transportation operators within all supply chains use available information to optimize cost, reliability, and travel time. Similarly, operators of the state's rail, maritime, air and pipeline infrastructure implement technology strategies to increase competitiveness and safety. Regardless of existing infrastructure, increased data sharing and granularity across modes and organizations would benefit decision-making by public- and private-sector partners.

EXHIBIT 46: TECHNOLOGY PRIORITIES AND KEY SUPPLY CHAIN CORRIDORS



Source: Cambridge Systematics Analysis, 2022.

Freight Network Technology Operations Plan (FNTOP)

In addition to the technologies and needs discussed here, the FNTOP recommended 10 strategies and developed Concepts of Operations for implementing six. These recommendations are discussed more in **Chapter 9.**

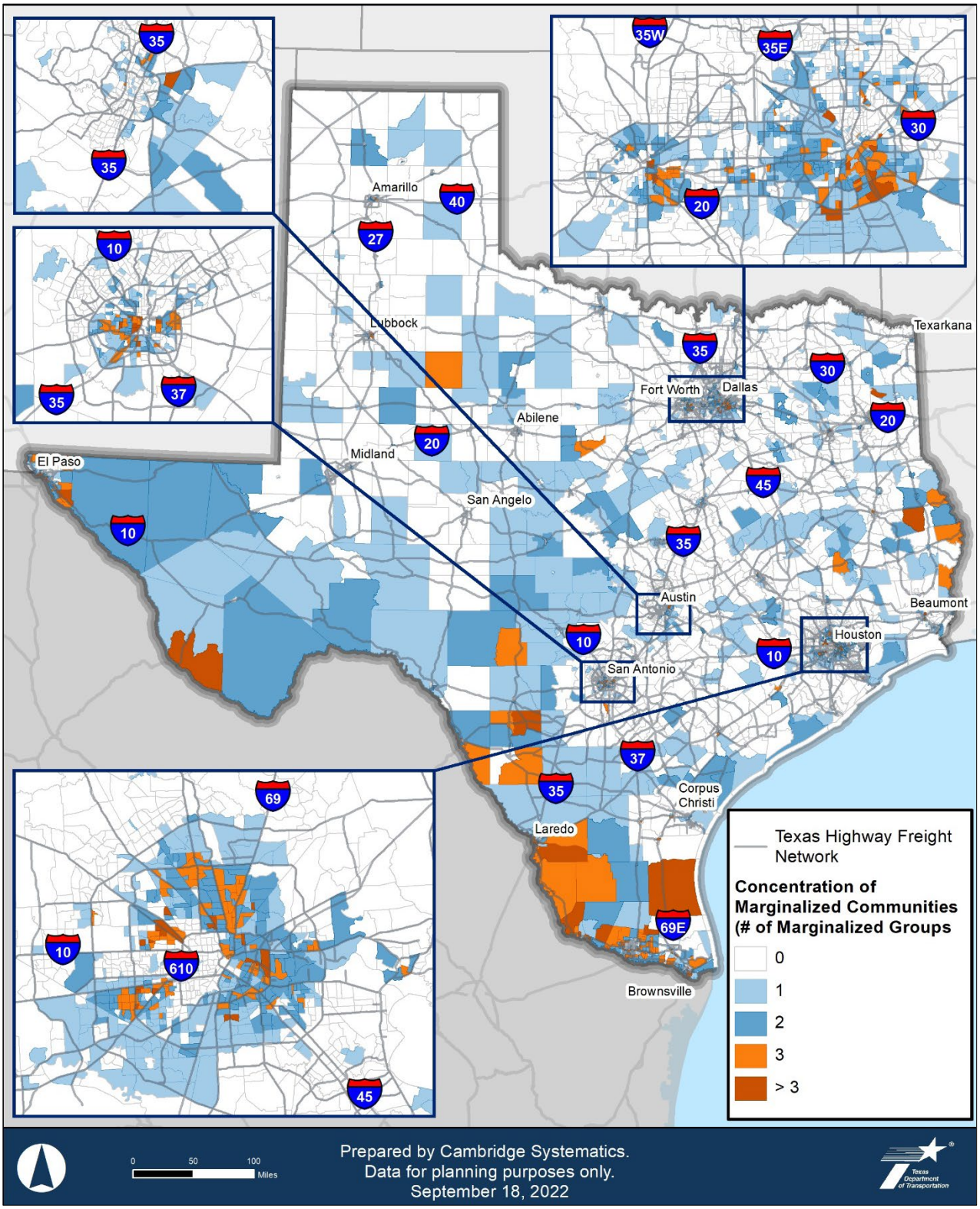
Source: TxDOT. Texas Freight Network Technology and Operations Plan (FNTOP), 2020.

7.2 EQUITY CHALLENGES AND NEEDS

Freight activity can bring both positive and negative impacts to communities. Neighborhoods adjacent to freight activity face greater negative externalities in terms of environmental, quality of life, and public health outcomes — impacts that could have a disproportionate effect on historically underrepresented communities and disadvantaged populations. In contrast, freight activity and infrastructure investments could benefit the community by increasing opportunities from a workforce development standpoint.

Exhibit 47 displays identified equity focus areas based on concentration of populations: under 18 years of age, over 65 years of age, with a disability, non-white, educational attainment, poverty level, limited English proficiency, and unemployment. These attributes were selected because of historical disenfranchisement of people within these groups in the United States. Urbanized areas exhibit sub-areas with concentrated equity focus areas, and rural census tracts were also identified with above average populations of one or more historically marginalized communities.

EXHIBIT 47: IDENTIFIED EQUITY FOCUS AREAS BY CENSUS TRACT



Source: Cambridge Systematics analysis of U.S. Census American Community Survey data, 2014-2018 5-year Estimates.

Equity Focus Areas

The following metrics were analyzed using U.S. Census American Community Survey (ACS) data to identify equity focus census tracts:

- Under 18 years of age.
- 65 years of age and older.
- People with a disability.
- Non-white population.
- No High School diploma.
- Poverty level.
- Limited English proficiency.
- High Unemployment.

Each factor was compared to the statewide average to determine relative impacts.

These locations were compared to the THFN, supply chain corridors, and high priority infrastructure needs to identify areas of potential concern. Specific mitigations or interventions need to be evaluated on a location-specific level to confirm both current impacts to communities and opportunities to address or mitigate negative impacts.

Approximately 13% of the THFN is in high-priority equity focus areas. Four of the six infrastructure need categories exhibit above-average high needs located within high-priority equity focus areas:

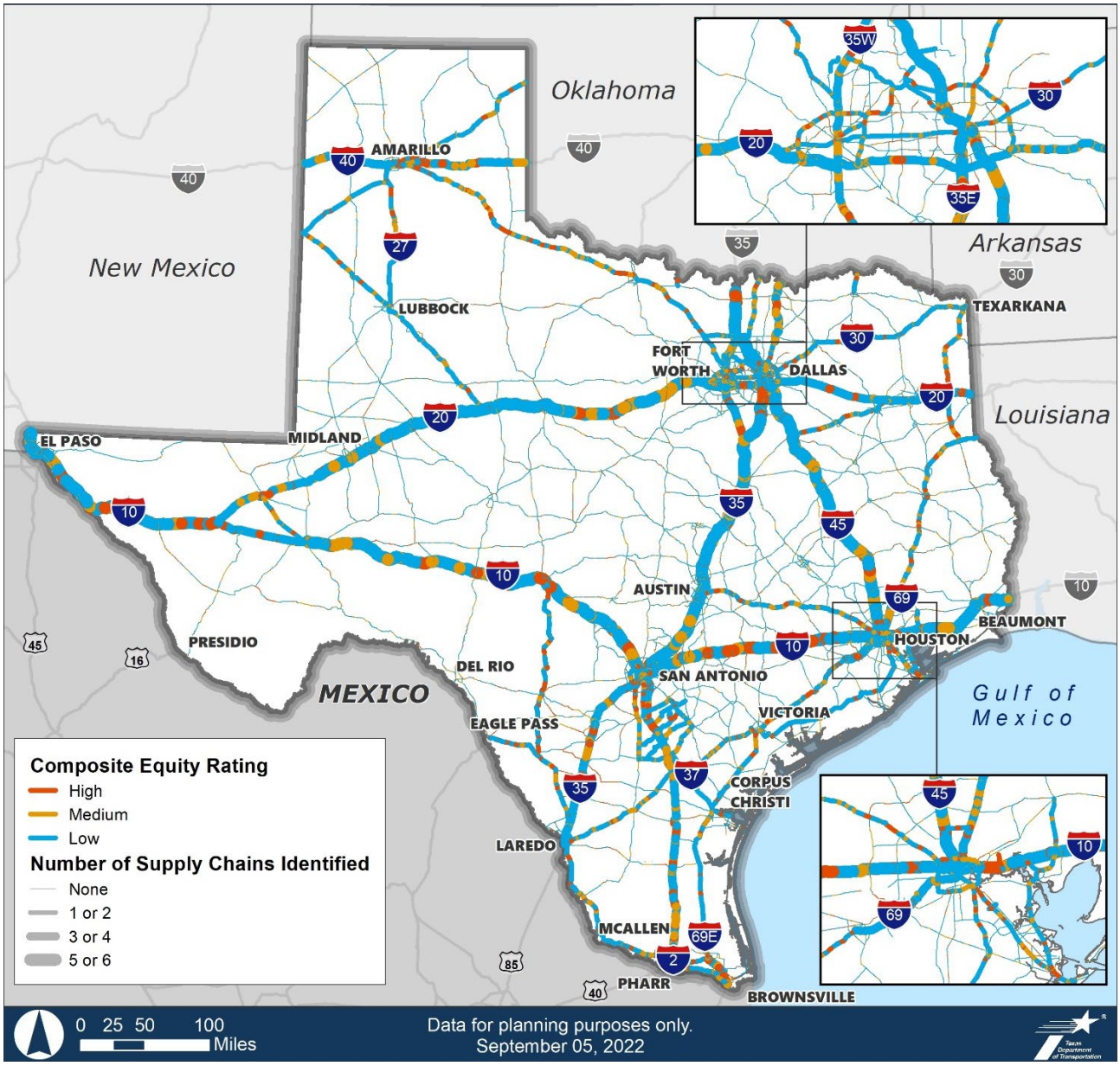
- 14.5% of high priority Safety Needs.
- 14.3% of high priority Connectivity Needs.
- 14.2% of high priority Design Needs.
- 13.7% of high priority Pavement Needs.

When looking at local impacts from freight transportation, several factors warrant additional consideration because of increased impact to communities with multiple marginalized identities (when normalized per 1,000 miles of on-system roadway). Each of these factors could impact local residents and transportation users:

- At-grade crossings impact mobility, and elevated incidents indicate higher occurrence of or exposure to safety risks.
- Truck-involved crashes with bicycles or pedestrians focus on incidents involving the most vulnerable roadway users, particularly significant for those who do not own a motor vehicle.
- Truck-involved crashes on local roads focus on incidents more likely to impact local residents rather than those on high-capacity through routes.
- Peak hour truck parking is an indicator of noise and air quality emissions received by communities because of recurring truck idling.
- Pounds of annual excess CO_2 from truck delay is a measure of emissions received by local communities because of adjacent congestion.

Unlike other needs and prioritization analyses in Texas Delivers 2050, high priority equity focus areas are small, localized areas rather than spanning long corridors (**Exhibit 48**). Freight transportation and freight-dependent industries also provide access to jobs and goods, and these locations could be assessed to enhance workforce development opportunities.

EXHIBIT 48: EQUITY PRIORITIES AND KEY SUPPLY CHAIN CORRIDORS



Source: Cambridge Systematics Analysis, 2022.

7.3 INSTITUTIONAL AND REGULATORY CONDITIONS

Institutional and regulatory conditions influence how freight moves, how TxDOT plans for freight, and how strategies are implemented. These conditions can facilitate, impede, or simply change TxDOT's ability to respond to a dynamic freight environment. Critical regulatory topics relevant to freight planning in Texas include:

- CAV regulations and partnerships.
- Growth of oversize/overweight traffic and permitting, routing and coordination.
- CMV operations at international bridges.
- Freight project funding and prioritization practices.

7.3.1 CONNECTED AND AUTONOMOUS TECHNOLOGY

Demonstrations of CAV 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 automated vehicle (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 are currently testing CAV systems for heavy duty trucking use on Texas roads, and small delivery vehicles are also deployed in urban contexts.

In Texas, the regulatory environment is very industry friendly, enabling these deployments and TxDOT continues to coordinate with private industry through its Cooperative Automated Transportation (CAT) Strategic Plan, Texas Connected Freight Corridors program, and CAV Task Force. Continuation of these partnerships will be essential for TxDOT to continue its support of the safe deployment of CAV technology and to anticipate evolving physical and digital infrastructure needs.

7.3.2 OVERSIZE/OVERWEIGHT PERMITTING AND ROUTING

The Texas Department of Motor Vehicles (TxDMV) issues OS/OW permits, and Texas Transportation Code authorizes certain cities, port authorities, and regional mobility authorities (RMAs) to issue permits on designated highway segments.[67] Provided routes take infrastructure constraints, construction, and other disruptions into account. However, OS/OW users of the THFN report routing issues, coordination challenges when traveling through multiple TxDOT districts, unanticipated construction and detours, and delays in permit or route adjustments.

[67] Transportation Code, Title 7, Subtitle E, Chapter 623. https://statutes.capitol.texas.gov/Docs/TN/htm/TN.623.htm.

Better coordination between TxDMV, TxDOT districts and TxDOT divisions would improve the efficiency of freight movement. Additionally, drivers and escort vehicles may have to pull to the shoulder or onto local roadways while waiting for a revised route during unanticipated conditions resulting in damage to local roadways and shoulders. Better coordination would improve safety and asset preservation during these incidents by reducing the number and duration of such stops.

7.3.3 COMMERCIAL MOTOR VEHICLE OPERATIONS AT INTERNATIONAL BORDER BRIDGES

TxDOT, the Texas Department of Public Safety (TxDPS), CBP and their respective counterparts in Mexico all play distinct roles in ensuring both efficiency and security at the Texas-Mexico border. Coordination between these entities has resulted in innovative and streamlined practices, such as **Unified Cargo Processing (UCP)** at the Laredo port of entry. UCP is a joint program between the U.S. and Mexican governments to conduct joint vehicle inspections, reducing delay at the port of entry without compromising inspection requirements.

Despite extensive coordination and efforts to improve border operations, most recently through the BTMP[68], the complex regulatory environment and criticality of security on the border lead to continued delays and congestion. It is also important to recognize that enabling policy may not have an immediate, significant impact. For example, Free and Secure Trade (FAST) Lanes provide expedited inspection processes for pre-cleared vehicles. However, the manufacturer, carrier, and importer must all be certified for a driver to take advantage of these lanes at border crossings, limiting utilization of lanes even when drivers are certified.

TxDOT can continue its role as a leader in coordination between the public and private sectors, the binational transportation community, and all levels of government responsible for infrastructure provision, policy, and enforcement. With border trade volumes experiencing significant growth, it is critical that border policies and plans continue to help minimize events that result in border closures.

7.3.4 FREIGHT PROJECT FUNDING AND PRIORITIZATION PRACTICES

TxDOT uses a performance-based planning approach to prioritize projects for advancement and funding. The Performance Metrics: Data Integration System (PM-DIS) compiles data from multiple TxDOT sources and compares conditions to project impacts. Then, projects are prioritized by standardized criteria which consider the ability of an individual project to impact core performance measures. Currently, this scoring process includes limited consideration of freight: location on the NHFN. Future iterations of TxDOT's suite of project planning and prioritization resources could expand freight considerations to incorporate more elements from

[68] TxDOT, Border Transportation Master Plan, https://ftp.dot.state.tx.us/pub/txdot/tpp/btmp/btmp-final-report.pdf.

Texas Delivers 2050. These changes would increase likelihood that projects impacting high freight needs are funded and delivered quickly. More in-depth consideration of freight needs during project prioritization and funding programming could also enhance TxDOT's existing process for allocating NHFP funds.

While TxDOT continually coordinates with its modal partners, TxDOT has no dedicated funding sources to support improvements on other modes that would relieve stress on the THFN. TxDOT can and has used state highway fund revenues not constitutionally dedicated to highway purposes for other functions, including public transportation, rail, aviation, ports, and bridges. Examples of opportunities to fund other modes include the Texas Rail Relocation and Improvement Fund (TRRIF), the Ship Channel Improvement Revolving Fund, and projects included in the Port Capital Improvement Report. However, both programs are currently unfunded by the Texas Legislature. TxDOT has requested $150 million in its 2024-2025 Legislative Appropriations Request (LAR). Budget riders have biannually funded port access projects through the Port Access Improvement Program, but sustained funding is not guaranteed from cycle to cycle. TxDOT makes Legislative Appropriations Requests to request and justify funding for these programs and continues to publish planning documents characterizing the importance of all modes to freight transportation.

Five Funding Programs Exist to Advance Port Projects

The Infrastructure Investment and Jobs Act (IIJA). The IIJA is expected to invest $17.4 billion in port infrastructure and waterways to address maintenance needs, reduce congestion, and cut emissions.

Port Access Improvement Program. This program provides grants for ports for projects that "improve connectivity, enhance safety and relieve congestion." This program has funded 47 projects for almost $140 million since 2015.

Ship Channel Improvement Revolving Fund and Loan Program. This program helps "finance congressionally authorized ship channel deepening and widening projects." **Port Capital Report.** The TxDOT Maritime Division submits a port capital report on behalf of the Port Authority Advisory Committee (PAAC) to the Texas Legislature every biennium.

These programs provide a mechanism for the state to fund port improvement projects, but do not guarantee an ongoing dedicated funding source.

7.4 FREIGHT AND THE ENVIRONMENT

Environmental impacts from transportation, including freight, are influenced by miles of travel, congestion, vehicle technology, infrastructure design, land development patterns, and other factors. Externalities from freight transportation impact both the natural and human environment, at times resulting in environmental justice concerns such as in the equity focus

areas presented in **Section 7.2**. TxDOT integrates environmental mitigations into every stage of project development based on guidance in its Environmental Toolkits and other resources available through the Environmental Affairs Division.[69,70] Four environmental topics were explored in greater detail for Texas Delivers 2050.

7.4.1 FREIGHT RESILIENCY

Freight resiliency, response to disruptions, and recovery from disruptions have been a recent focus of TxDOT. **Chapter 6** includes resiliency case studies and recommended actions to improve response and recovery specific to freight transportation. At the agency level, Research Project 0-7079 – "Establish TxDOT Transportation Resilience Planning Scorecard and Best Practices" looked at assessing impacts of extreme weather events on Texas' transportation network to lessen the effects of such events.[71] This study resulted in a framework for incorporating infrastructure resiliency into the project planning process and is available to the Statewide Resiliency Plan team to further integrate with other technical, social, and security attributes along with other TxDOT initiatives and programs. Both a statewide resiliency plan and a freight-specific resiliency plan will be completed within the next two years to deepen TxDOT's ability to prepare for, respond to, and recover from extreme weather and other disruptions.

7.4.2 EMISSIONS REDUCTIONS

TTI is conducting a study in partnership with the Texas Commission on Environmental Quality (TCEQ) to estimate transportation emissions in Texas. The study estimated on-road emissions in 1990 and 1999 through 2060 by vehicle type, pollutant type, location, and other attributes. The analysis found that most of the analyzed pollutants are forecast to decrease due to emissions regulations and the resulting enhancements in vehicle technology (**Exhibit 49**). One exception is CO_2-equivalent emissions, which are forecast to increase 3.6% between 2019-2050. This group of pollutants is correlated to the number of vehicle-miles traveled, and the modest increase is anticipated alongside a doubling in population and freight movement. This analysis used the Motor Vehicle Emission Simulator (MOVES3) model published by the Environmental Protection Agency (EPA).

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69 TxDOT, Environmental Compliance Toolkits. https://www.txdot.gov/business/resources/environmental/compliance-toolkits.html.

70 TxDOT, Environmental Resources and Programs. https://www.txdot.gov/business/resources/environmental.html.

71 TTI and TxDOT, Establish TxDOT Transportation Resilience Planning Scorecard and Best Practices. https://library.ctr.utexas.edu/Presto/project=7079.

EXHIBIT 49: ANNUAL STATEWIDE EMISSIONS FOR TRUCKS, IN TONS

Year	CO	NO_x	VOC	PM_{10}	$PM_{2.5}$	CO_2-EQ
2019	144,613	142,377	10,561	7,037	3,952	57,179,845
2020	120,606	118,558	8,272	5,719	2,970	50,914,971
2050	97,991	91,813	4,438	5,681	1,417	59,293,237
Percent Change (2019–2050)	**-47.6%**	**-55.1%**	**-138.0%**	**-23.9%**	**-178.9%**	**3.6%**

Source: TCEQ and TTI study using version 3.0.3 version of MOVES and default MOVES3 database, movesdb20220105.

TxDOT reports several emissions reductions performance measures to FHWA.[72] All measures are related to projects funded by the Congestion Mitigation and Air Quality (CMAQ) program, which is focused on reducing emissions in areas where air pollutants exceed National Ambient Air Quality Standards (also called non-attainment areas). TxDOT reports two- and four-year targets and progress for the following pollutants:

- Particulate matter less than 10 microns in diameter (PM_{10}),
- Oxides of nitrogen (NO_X),
- Carbon dioxide (CO), and
- Volatile organic compounds (VOC).

2- and 4-Year Texas Emission Reduction Targets

- **PM_{10} (kg/day reduced):** 4.73 (2 yr), 21.96 (4 yr)
- **NO_X (kg/day reduced):** 4,312.39 (2 yr), 8,833.03 (4 yr)
- **CO (kg/day reduced):** 434.93 (2 yr), 841.62 (4 yr)
- **VOC (kg/day reduced):** 768.97 (2 yr), 2,048.62 (4 yr)

7.4.3 WILDLIFE IMPACT MITIGATION

Infrastructure projects can divide natural habitats and reduce the amount of contiguous land available for wildlife. TxDOT addresses impacts to the natural environment in each project as part of compliance with the National Environmental Policy Act (NEPA) and conducts research to improve the efficacy of mitigations. TxDOT's Research and Technology Implementation Office sponsored a project on incorporating wildlife crossings into TxDOT's project development, design, and operations processes.[73] The study by the Center for Transportation Research (CTR) included observations of installed wildlife crossings in the TxDOT Pharr District. Researchers observed a highly endangered ocelot species, bobcats, and alligators using the facilities and used observation findings to recommend design best practices (**Exhibit 50**). The Pharr District has developed 12 wildlife crossing structures along one highway corridor (SH 100).

72 Federal Highway Administration. *https://www.fhwa.dot.gov/tpm/reporting/state/emissions.cfm?state=Texas*.

73 Center for Transportation Research, Project Summary, 0-6971: Incorporating Wildlife Crossings into TxDOT's Project Development, Design and Operations Processes. https://library.ctr.utexas.edu/ctr-publications/psr/0-6971-s.pdf.

EXHIBIT 50: OCELOT AND BOBCAT PRESENCE NEAR CROSSING STRUCTURES IN TXDOT PHARR DISTRICT

(a) Ocelot looking into a crossing on SH 100

(b) Bobcat using a underpass on SH 100

Source: Center for Transportation Research, Project Summary, 0-6971: Incorporating Wildlife Crossings into TxDOT's Project Development, Design and Operations Processes. https://library.ctr.utexas.edu/ctr-publications/psr/0-6971-s.pdf

7.4.4 STORMWATER RUNOFF MITIGATION

Stormwater runoff quantity and quality are coordinated with TCEQ to minimize environmental impacts from infrastructure development. TxDOT considers hydrology and hydraulic activity at every stage of project development, proliferating guidance in its Hydraulic Design Manual.[74] At the project planning stage, the District Hydraulics Engineer is consulted to confirm whether significant drainage issues are anticipated. During preliminary engineering, drainage agreements, locations and sizes of bridges and culverts, and Federal Emergency Management Administration (FEMA) Special Flood Hazard Areas are all considered. Preliminary hydraulic studies are conducted during the environmental stage. This stage estimates the impacts of a specific project on waterways and floodplains and identifies mitigation measures. Finally, the Plans, Specifications, and Estimates (PS&E) phase results in refined design, geotechnical review of bridge design, drain and pump sizing, and development of Stormwater Pollution Prevention Plans (SW3Ps).

Chapter 7 discussed conditions and challenges that have emerged to the forefront of freight transportation practices. Issues related to technology, equity, institutional challenges, and the environment have always been present. TxDOT recognizes its opportunity in Texas Delivers 2050 to advance these key areas. Chapter 8 discusses policy and program recommendations.

74 TxDOT Hydraulic Design Manual. September 2019. http://onlinemanuals.txdot.gov/txdotmanuals/hyd/design_activities_by_project_phase.htm.

Chapter 8 Developing a Freight Forward Framework- Policy and Programmatic Freight Recommendations

The 2018 TFMP served as a critical building block in developing the policy and program recommendations for Texas Delivers 2050. Since the adoption of the TFMP in March of 2018, TxDOT has continued with implementation by advancing key recommendations by conducting the Texas Statewide Truck Parking Study, two Regional Freight Studies, the Freight Network Technology and Operations Plan; developing Freight Infrastructure Design Considerations; and documenting the Economic Role of Freight in Texas.

Continuing to address goods movement needs and opportunities in Texas requires an environment conducive to freight mobility. A first step is to ensure an adequate regulatory and institutional underpinning for advancement of freight recommendations. Broad policy recommendations help change the way Texas approaches freight mobility through adopting a specific course of action. Programs are a collection of initiatives or activities that can be undertaken to achieve a desired outcome. **Together, the policy and program recommendations advance the Texas Delivers 2050 goals to deliver Texas' freight vision.**

Texas Delivers 2050 Recommendations

POLICIES

Specific courses of action that, if adopted, will shape the way Texas approaches freight mobility

PROGRAMS

Collection of initiatives or activities to achieve desired outcomes

TECHNOLOGY AND OPERATIONS

Investments that improve safety and efficiency of existing systems and prepares Texas for the future of freight mobility

PROJECTS

Capital investments under development, proposed, and strategic

Chapter 8 presents policy and program recommendations, **Chapter 9** presents technology and operations recommendations, and **Chapter 10** presents multimodal projects included in the Freight Investment Plan (FIP).

Not all recommendations fall under the jurisdiction of TxDOT and can require TxDOT to take on a supportive role. Implementation of many of the recommendations is the responsibility of other state and federal agencies, MPOs, local governments, private-sector entities, and other organizations. Some will require Legislative action. Together, policy and program recommendations will create a freight forward planning framework that will:

- **Strengthen the freight and logistics industry in Texas.**
- **Support Texas' growing population and economy while preserving the quality of life.**
- **Preserve, enhance, and further evolve the TMFN.**

8.1 POLICY RECOMMENDATIONS

The policy recommendations address freight transportation challenges confronting Texas by providing an overall framework for freight transportation investment decision-making. The policies provide the basis for aligning this investment with the state's economic goals to enhance economic competitiveness. The adoption and implementation of these policies will ensure the continued efficient and safe movement of people and goods. The policies also are consistent with the multi-institutional and multimodal nature of freight transportation.

These policy recommendations are informed by the 2018 Texas Freight Mobility Plan, extensive technical analysis of existing needs, stakeholder and TxFAC input, and both TxDOT and national goals. The policy strategies are outlined below.

TXDOT FREIGHT PLANNING CAPACITY AND ACTIVITIES

The state should continue to support and expand freight planning capacity and activities.

Objectives of this policy include:

- Continue to expand and administer a comprehensive and multimodal freight-planning program that integrates freight considerations and needs within TxDOT's performance- based project selection process.
- Ensure effective implementation of Texas Delivers 2050 through a commitment to appropriate staffing and resources, subject to legislative appropriations.
- Support TxDOT's long-term freight planning efforts through internal and external outreach efforts with an emphasis on a multimodal approach, including expanded partnership with the freight industry and businesses.

- Further the understanding of the role of the TMFN in supporting the state's key supply chains.
- Coordinate with partners administering environmental programs to address wildlife impacts, air pollution, and greenhouse gas emissions to continually enhance the incorporation of freight considerations in all stages of project planning and development.[75]

FREIGHT NETWORK DESIGNATION AND INVESTMENT

TxDOT should continue to use the adopted Texas Multimodal Freight Network as the strategic framework for statewide transportation investment decisions.

Objectives of this policy include:

- Provide analysts, managers, and policymakers with a clear understanding of the areas of critical need for improving multimodal goods movement and supply chain efficiency throughout the state.
- Comply with federal requirements for freight planning and future project funding eligibility.
- Target investment in the Texas Multimodal Freight Network as a critical component of the state's economy and to enhance supply chain fluidity.
- Designate an Automated Freight Vehicle Network (AFVN) in coordination with the private sector to prepare for the future of freight mobility by identifying and investing in the most promising facilities on the TMFN for early technology deployment.

TEXAS HIGHWAY FREIGHT NETWORK DESIGN GUIDELINES AND IMPLEMENTATION

TxDOT should implement the Freight Infrastructure Design Considerations on the Texas Highway Freight Network.

Objectives of this policy include:

- Evaluate feasibility of incorporating freight infrastructure design standards with respect to commercial vehicle movement on the Texas Highway Freight Network.

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[75] TxDOT guides environmental consideration of project planning, development, and construction in its Environmental Toolkits, especially its Natural Resources Toolkit. The Texas Council on Environmental Quality is TxDOT's primary partner regarding stormwater and runoff management. TxDOT recently funded research on reducing wildlife impacts by incorporating wildlife crossings in project development. TxDOT also funds annual assessment of excess emissions from freight delay through TTI's Most Congested Roadways reporting. Additionally, TxDOT partners with MPOs to administer Congestion Mitigation and Air Quality (CMAQ) funding to reduce greenhouse gas emissions from freight and passenger transportation.

- Continue implementing the new vertical clearance standard of 18 feet 6 inches on the Texas Highway Freight Network.
- Implement freight infrastructure design policies by incorporating them into TxDOT's design manuals.

MULTIMODAL FREIGHT PLANNING, PROGRAMMING, AND IMPLEMENTATION

TxDOT should implement multimodal freight planning, programming, and implementation guidelines for integrating freight into the TxDOT investment decision-making process.

Objectives of this policy include:

- Develop public- and private-sector partnerships that target the various modes and users of the freight transportation network.
- Integrate freight considerations into TxDOT district and MPO planning, project development, programming, and implementation efforts.
- Ensure freight considerations are included in the UTP project development and prioritization process.
- Identify opportunities to advance high priority multimodal projects based on the increased availability of NHFP funds for intermodal projects.

MULTIMODAL CONNECTIVITY

The state should invest in multimodal strategies and solutions that link the different freight transportation modes.

Objectives of this policy include:

- Identify multimodal opportunities, in coordination with private sector, to address current and projected freight flows.
- Identify, preserve, protect, and invest in the Texas Multimodal Freight Network across the state.
- Enhance intermodal connectivity efficiency between railroads, seaports, airports, and highways.
- Support development of rail connections to the international border to alleviate congestion at key freight gateways, freight generators and ports of entry.

URBAN FREIGHT MOVEMENT

The state should continue to address freight transportation issues critical to the urban areas in Texas that support mobility and economic growth.

Objectives of this policy include:

- Encourage and support MPO freight planning efforts.
- Partner with local planning partners on strategies to address urban freight congestion and bottlenecks.
- Support growing e-commerce and urban freight deliveries such as drones and delivery robots, to meet the freight delivery demands arising from growing urban populations.
- Continue to invest in the state's Critical Urban Freight Corridors.
- Develop guidance for MPOs and local planners on how to update complete streets policies to include the full range of passenger and freight modes.

RURAL CONNECTIVITY

The state should continue to address multimodal freight transportation issues critical to the rural areas in Texas that support the states critical agricultural, oil and gas and construction supply chains.

Objectives of this policy include:

- Continue to invest in the state's Critical Rural Freight Corridors.
- Continue to invest in the Texas Trunk system to enable the transport of energy, food, and other critical raw materials.
- Support rural economic development opportunities through alternative modal options and connectivity.
- Increase access for rural populations to e-commerce.

ECONOMIC DEVELOPMENT AND ECONOMIC COMPETITIVENESS

The state should continue to align investments in the multimodal transportation system with the state's vision for economic growth, key industry supply chain requirements, and global competitiveness.

Objectives of this policy include:

- Support strategic initiatives of the Governor's Office of Economic Development & Tourism.
- Support industry efforts to enhance workforce training, recruitment and retention in the transportation and logistics industries.
- Prioritize multimodal investments that align with the projected freight growth, population growth, and increasing global trade.
- Partner with emerging technology leaders and the private sector to ensure Texas is a leader for freight mobility technology.

TEXAS AS A GLOBAL TRADE AND LOGISTICS HUB AND GATEWAY

The state should invest in strategic multimodal transportation solutions to ensure Texas is supportive of cross-border trade, a leader in North American trade and a top international trade gateway and national logistics hub.

Objectives of this policy include:

- Encourage multimodal solutions for strategic freight hubs and trade gateways.
- Foster collaboration between the Texas Freight Advisory Committee, Border Trade Advisory Committee, Port Association Advisory Board, Texas Trucking Association, and the Texas Technology Task Force.
- Advance a Texas Global Gateway concept of a one-stop, unified, coordinated, and comprehensive information portal for all transportation modes.
- Establish a Third Coast Global Gateway task force.

SAFETY, SECURITY AND RESILIENCY OF THE FREIGHT TRANSPORTATION SYSTEM

TxDOT should identify and implement strategies that will improve safety, security, and resiliency on the Texas Multimodal Freight Network.

Objectives of this policy include:

- Address freight movement safety "hot spots" (locations with high truck-related crashes) and identify potential crash remediation strategies.

- Partner with modal partners to develop strategies to address non-highway freight movement safety hotspots.
- Improve safety and security along high-volume hazardous material routes.
- Develop and incorporate resiliency measures in transportation planning, policy, and infrastructure investment decisions to mitigate impacts of extreme weather and natural disasters on freight movement.
- Facilitate the development of new or expanded truck rest stops and related parking availability communications systems along the Texas Highway Freight Network.
- Support the establishment of a statewide Supply Chain Council consisting of industry representatives to advise various state agencies on a variety of supply chain challenges and opportunities.
- Develop a THFN cyber security policy.

FREIGHT TRANSPORTATION ASSET PRESERVATION

TxDOT should continue to invest and pursue innovative strategies in ServiceNow, the existing asset preservation policy, on the Texas Highway Freight Network. TxDOT should also work closely with the private sector to identify and implement highway and multi-modal preservation strategies.

Objectives of this policy include:

- Maintain roadways and services to preserve function, extend useful life, eliminate maintenance backlogs, improve bridge ratings, and improve pavement condition.
- Identify asset-related constraints that lead to increased congestion, longer trip times and higher costs for businesses, which all impact industry productivity and competitiveness.
- Continue the advancement of recommendations from the Statewide Truck Parking Study.
- Advance the Weigh-in-Motion (WIM) and Vehicle Classification (VC) strategic plan.

FREIGHT-BASED TECHNOLOGY SOLUTIONS AND INNOVATION

TxDOT should develop and implement innovative multimodal transportation technologies, techniques, research, and methods.

Objectives of this policy include:

- Monitor and support appropriate policies that encourage technology deployment while ensuring public interests are protected.
- Expand the development of sophisticated real-time information systems and increase the dissemination of dynamic travel information.
- Establish a statewide traffic management system by integrating data provided by existing traffic management centers to provide comprehensive traveler information, such as weather-related information, construction, incident management, emergency management coordination and identification of alternative routes.
- Develop digital infrastructure and integration policies necessary to enable the development of digital twins and implementation of emerging freight mobility technologies.
- Expand cooperation with public- and private-sector stakeholders to implement multimodal freight-based technology solutions and foster emerging transportation technologies across all modes.

STEWARDSHIP AND PROJECT DELIVERY

TxDOT should continue to identify and adopt strategies to improve the management of multimodal freight transportation resources and advance accountable, transparent decision-making.

Objectives of this policy include:

- Incorporate freight performance measurements into the TxDOT performance-based project selection process.
- Advance the highest priority projects on the Texas Multimodal Freight Network by ensuring they are fully funded.
- Ensure resilient supply chain for cargo necessary to ensure efficient delivery of TxDOT's investment program.

INTERNATIONAL BORDER CROSSINGS

The state should invest in transportation strategies to improve freight mobility across international border crossings by implementing the Border Trade Master Plan recommendations.

Objectives of this policy include:

- Strengthen coordination between federal, state, regional and local agencies, stakeholders, and the private sector on border management.
- Encourage integrated cargo security strategies, such as the single-window program that enables inspections to occur prior to the cargo reaching the border, thus reducing congestion at the crossings.
- Improve binational coordination and planning to expedite the delivery of border crossing projects.
- Harmonize and streamline commercial vehicle regulations to increase operational efficiency.
- Support technology and operational strategies and deployment of integrated border-crossing management solutions.

ENERGY SECTOR DEVELOPMENT TRANSPORTATION

TxDOT, in coordination with state leadership should continue to identify and address current and future energy sector freight transportation needs and impacts.

Objectives of this policy include:

- Strengthen partnerships with state and local agencies, and industry to identify and invest in the multimodal transportation system that supports the energy sector.
- Identify and invest in infrastructure needed to support new and increasing energy sector production including oil and gas and alternative energy sources.
- Streamline OS/OW regulation and permitting by improving data collection, data sharing/exchange, and communications.
- Monitor the development of the policies, programs, and infrastructures necessary to accommodate fuel diversification by freight network users.

RAIL FREIGHT TRANSPORTATION

TxDOT should continue to work with the private-sector rail industry and other stakeholders to identify strategies that expand rail capacity, improve rail fluidity and ease traffic congestion to accommodate projected growth in imports and exports.

Objectives of this policy include:

- Highlight the importance of the rail industry to the Texas economy and its role in moving freight efficiently.
- Support strategies that reduce the number of at-grade highway/rail crossings, improve the efficient movement of freight, and increase the quality of life through reduced congestion and improved safety.
- Foster rail freight movements as a practical modal option that relieves freight congestion on Texas highways.
- Support partnerships for public-private funding and financing opportunities that expand rail capacity and connectivity.

PORT AND WATERWAY FREIGHT TRANSPORTATION

TxDOT should continue to work with the Texas ports through the Texas Port Authority Advisory Committee, Texas Port Association, the U.S. Army Corps of Engineers, and other stakeholders to pursue strategies to strengthen and improve maritime freight operations and efficiencies.

Objectives of this policy include:

- Foster the significance of Texas ports and waterways and the maritime industry to the state and national economies.
- Support the significance, awareness, and use of the GIWW as a key component of the Texas Multimodal Freight Network.
- Support public-private partnership opportunities that expand port capacity and connectivity.
- Develop and present a coordinated and unified approach for state and federal funding for port-related projects.

AIR CARGO TRANSPORTATION

TxDOT should integrate air cargo needs, into state planning activities, initiatives, and project development.

Objectives of this policy include:

- Highlight the significance of air cargo transportation to the Texas economy and quality of life through its role in transporting high-value and time-sensitive goods.

- Incorporate air cargo needs, issues, and recommendations in future updates of the TxDOT Texas Airport System Plan and other planning activities.
- Partner with airports and local, regional, and other statewide agencies to identify critical airport landside access improvements.
- Encourage development of advanced air mobility options in Texas.

PIPELINE INFRASTRUCTURE

TxDOT and the Texas Railroad Commission should work with the public and private sectors in support of strategies that address pipeline needs.

Objectives of this policy include:

- Encourage multimodal collaboration for commodities that can be shipped by pipelines.
- Support upgrading and expanding the Texas pipeline system with safe, equitable solutions.

FUNDING AND FINANCING

The state should investigate additional options for funding and financing flexibility for transportation projects that impact freight movement.

Objectives of this policy include:

- Explore funding for existing freight programs, such as the Texas Rail Relocation Fund, Port Access Account Fund, and the Ship Channel Improvement Fund.
- Encourage the full return of Harbor Maintenance Tax fees to Texas.
- Pursue federally available funds through discretionary grants for multimodal freight projects.
- Collaborate with the private sector to encourage investment in multimodal freight infrastructure.
- Examine alternative public funding sources that provide adequate, stable, and equitable revenue streams given the trends impacting future freight transportation demand and operations.

INSTITUTIONAL COORDINATION AND COLLABORATION

TxDOT should coordinate with international, national, state, regional and local agencies, and private sector stakeholders.

Objectives of this policy include:

- Enhance coordination with MPOs and local governments to identify freight infrastructure needs of statewide importance.
- Improve communication between public agencies to streamline project delivery and build consistency among various jurisdictions in regulations, permitting, planning and preservation of the freight network.

PUBLIC AWARENESS AND ENGAGEMENT

In partnership with the public and private sectors, TxDOT should lead education and communication efforts that build awareness of the importance of efficient freight movement to the state's economy and quality of life.

Objectives of this policy include:

- Educate local jurisdictions, businesses, communities, TxDOT districts and decision- makers about the economic importance of moving freight efficiently.
- Educate the public about safety issues related to multimodal freight transportation.
- Expand stakeholder outreach for freight planning efforts to include community and public outreach using high- and low-tech techniques.
- Include measures to account for freight transportation impacts on communities into the project development process, especially for historically disadvantaged communities, along the TMFN.
- Encourage a robust community impact assessment and outreach program related to freight movement that includes examining community impacts such as emissions and air pollution and evaluating and communicating the equity considerations of those impacts.

8.2 PROGRAM RECOMMENDATIONS

The program recommendations support the policies outlined above and address the freight transportation challenges identified in Texas delivers 2050. These challenges include system

capacity constraints, system operations, safety issues, rural connectivity, congestion and bottlenecks, border-crossing issues, institutional coordination, education, public awareness, equity, resiliency, and funding.

The recommendations include several initiatives requiring public- and private-sector coordination and partnerships to effectively address identified freight transportation challenges to enhance freight mobility and support the state's economic development goals and competitiveness. The program categories are:

- Strategic Freight Planning Initiatives and Studies.
- Education and Public Awareness.
- Technology and Operations.
- Border/Ports-of-Entry.
- Highway.
- Rail.
- Ports and Waterways.
- Aviation.

TXDOT MULTIMODAL FREIGHT PLANNING

The state should continue to develop, integrate, and administer a comprehensive and multimodal TxDOT Freight Planning Program, focused both on developing strategies, policies, and methodologies for improving the multimodal freight transportation system and linking transportation investments to the state's economic development goals.

Objectives of this program include:

- Develop a Texas Delivers 2050 roll-out plan to include TxDOT Divisions and Districts, MPOs and other planning partners, and the private sector.
- Develop a statewide supply chain and multimodal freight network resiliency enhancement plan to address implications of disruptions on the TMFN and to key industries and improve the resiliency of the TMFN.
- Deliver freight planning training on incorporating freight into planning and operations for TxDOT Divisions, Districts, MPOs, and regional and local planning staff.

- Develop industrial access and freight supportive land use and development guidance in coordination with private sector industrial developers.
- Develop a TMFN grant program targeting federal discretionary grants for high priority multimodal freight projects.

FREIGHT MOVEMENT EDUCATION AND PUBLIC AWARENESS

The state should develop a public awareness campaign to roll out Texas delivers 2050 to inform the public, elected officials, policymakers, and other stakeholders on the economic benefits of freight and safety-related issues.

Objectives of this program include:

- Support the economic role of freight.
- Identify existing programs to integrate workforce development opportunities into public outreach programs, especially along the TMFN.

FREIGHT-BASED TECHNOLOGY AND OPERATIONS

The state should implement a statewide Freight Technology-Based Solutions Program based on the findings from the Texas Freight Network technology and Operations Plan (FNTOP). While this recommendation focuses on the programmatic aspect of ensuring the TMFN is technology ready, **Chapter 9** presents specific technology and operation recommendations that should be part of a technology program.

Objectives of this program include:

- Implement a WIM/VC program to oversee the implementation of the strategic plan.
- Initiate a Truck Parking Availability System (TPAS) program with the goal of expanding TPAS to all interstates in Texas.
- Implement the safety warning device program.
- Explore demand management strategies aimed at freight trips and logistics service providers as well as consumers and shippers who generate the demand for the freight trips.

TEXAS BORDER-CROSSING TRANSPORTATION AND TRADE

The state should continue to work with the Border Trade Advisory Committee to enhance international border coordination strategies to improve freight transportation safety, mobility, and

efficiency and to facilitate trade and travel without compromising security, through the implementation of the Border Master Plan.

Objectives of this program include:

- Advance the BTMP implementation program.
- Continue to facilitate the binational collaboration through the BTAC, Binational regional steering committees, and dialogue with the Mexican entities.

HIGHWAY DEVELOPMENT AND IMPROVEMENT

The state should continue to advance safety and mobility on the Texas Highway Freight Network.

Objectives of this program include:

- Create a rural freight connectivity program focused on development and implementation of corridor master plans.
- Create a Texas Highway Freight Network Safety Program to improve safety and mobility on the THFN.
- Develop a first and last mile connectivity program to identify and address the current needs and to enhance the technology readiness of these corridors.
- Explore “bypass” routes, usage incentives, technology enhancements, and the role of land use in freight bottlenecks relief.
- Develop an Automated Freight Vehicle Network program to assess and ensure the technology readiness of the state’s key trade and commerce routes.

RAIL DEVELOPMENT AND IMPROVEMENT

The state should continue to update its Texas State Rail Plan, prepared in accordance with federal regulations and through the involvement of passenger and freight railroad stakeholders.

Objectives of this program include:

- Continue coordination with our private sector rail partners to identify funding programs to implement railroad improvements and technology advancements on the TMFN.

PORT AND WATERWAY DEVELOPMENT AND IMPROVEMENT

The state should continue working with Texas ports and other stakeholders to identify strategies that expand port and waterway capacity and improve waterway infrastructure through the Texas Port Authority Advisory Committee, through its Maritime Ports Strategic Mission Plan and biennial Texas Ports Capital Program.

Objectives of this program include:

- Partner with Texas ports and other private sector stakeholders to identify and implement technology solutions to improve mobility and reliability at Texas ports.
- Elevate the "3rd Coast" concept as a key gateway of North America.

AVIATION-AIR CARGO DEVELOPMENT AND IMPROVEMENT

The state should develop a comprehensive Air Cargo Development and Improvement Program focused on working with Texas airports and other stakeholders to identify strategies that expand air cargo capacity and improve air cargo transportation infrastructure.

Objectives of this program include:

- Partner with airports, the business community, and host communities to help implement recommendations developed by the Texas Aviation System Plan.

8.3 SUMMARY

Texas Delivers 2050 puts forth 22 policy and 8 program recommendations to achieve the Texas freight vision. The specific objections provided for each of the policy and program recommendations support implementation actions described in Chapter 12 that will ensure TxDOT is maintaining current freight mobility while continuing to improve and enhance the TMFN for future freight transportation needs and evolution.

This Chapter presented policy and program recommendations. Chapter 9 presents technology and operational recommendations designed to modernize the TMFN.

Chapter 9 Modernizing the Texas Multimodal Freight Network — Technology and Operations Recommendations

Infrastructure investments alone will not be able to fully meet the freight system needs related to safety, economic competitiveness, asset preservation and utilization, mobility and reliability, and multimodal connectivity. New technology and operation applications can improve freight system efficiency, improve logistics reliability, reduce freight industry costs, and improve safety.

This chapter builds on the technology policy and program recommendations presented in **Chapter 8** by putting forth technology and operation project investments. These recommendations position TxDOT to make investments that address the current and future needs and challenges of the TMFN. The recommendations were developed based on review of the state of the practice on existing and emerging freight technologies, an assessment of existing freight technology systems and infrastructure in Texas, and public and private stakeholder outreach to understand Texas freight operational needs, gaps, and opportunities.

Highlights

Technology and operations strategies have largely been identified and developed by key TxDOT initiatives such as:

- Texas FNTOP
- Texas WIM/VC Strategic Plan
- Texas Truck Parking Study

Incorporation of existing and emerging technology and operational strategies into the freight program helps maximize the efficiency of existing capacity and aligns with private sector investments.

In addition, the strategies aligned with emerging technologies play a key role in establishing and maintaining Texas' reputation as an innovator and leader in preparing for the future.




9.1 TECHNOLOGY AND OPERATIONS RECOMMENDATIONS

Technology and operational solutions can have a significant impact on the overall performance of the existing TMFN. Not only does deploying technology and operational solutions allow TxDOT to get more mobility out of the existing network for existing users, but it also positions the state to continue to attract new users through improving economic competitiveness of the TMFN. Technology also promises to transform the way freight moves globally. Texas is currently a leader in freight technology deployments and maintaining that leadership role requires ongoing investments. Thirteen recommendations are discussed below that will advance freight mobility in Texas, allowing the state to retain its leadership role in innovation and economic growth while ensuring equitable transportation and community solutions.

Assess the feasibility of integrating statewide traffic management information into existing TMCs

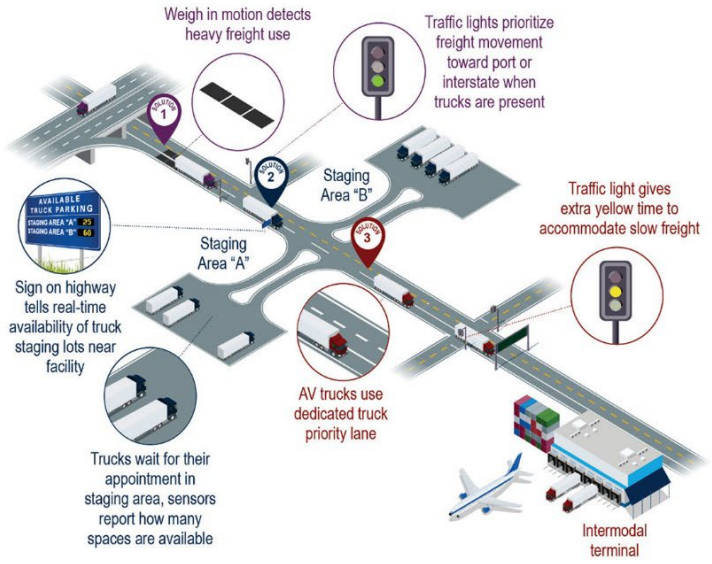
A high-resolution, real-time traffic data system for the THFN would provide information through the web and mobile apps, which allows trucking companies and drivers to make informed pre-trip and on-the-road routing decisions. TxDOT should conduct a feasibility study for integrating statewide traffic management information for the THFN into existing TMCs.

Continue to test and deploy the Texas Connected Freight Corridors (TCFC) System

The TCFC system is a connected vehicle (CV) environment that seeks to improve safety and mobility for the Texas Triangle. The TCFC project was the recipient of $6.09M in 2018 Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) Program Funds from the Federal Highway Administration (FHWA). Its purpose is to successfully test the deployment of Vehicle-to-Infrastructure (V2I) equipment to transmit traffic data and to share the data with Connected Vehicle (VC) software applications. The resulting data from the applications will improve commercial freight carriers' operations through more efficient scheduling and routing. The Program is currently 20 months in to a 36-month testing schedule. TxDOT should continue to test and deploy the TCFC.

Deploy smart freight connector technology on the TMFN to enhance connectivity between modes and expand modal options

TxDOT, in coordination with local agencies, should develop smart freight corridors to improve connectivity between modes and facilitate alternative delivery modes such as by enhancing the first- and last-mile connectivity, investing in technology and integration of information across modes, and funding multimodal projects and programs. Additionally, TxDOT should examine the costs and benefits of providing infrastructure, technology, and funding for additional existing modal options such as drone delivery, cargo bikes, and automated electric delivery vehicles.



OVERVIEW: Deploy freight-specific ITS technology (truck priority signals, etc.) on critical freight routes to provide efficient operations and staging, such as on last-mile routes from interstate to ports.

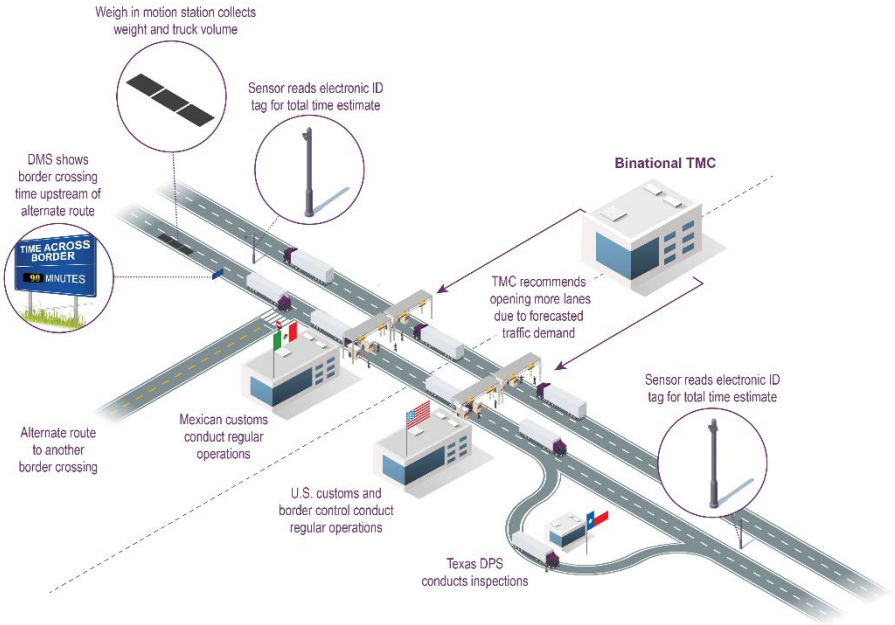
NEEDS: Need to improve mobility, safety, and efficiency for trucks on last-mile connections to intermodal facilities.

CHALLENGES: TxDOT maintenance of ITS assets that are off the freeway network.

Develop a binational freight traffic operations center

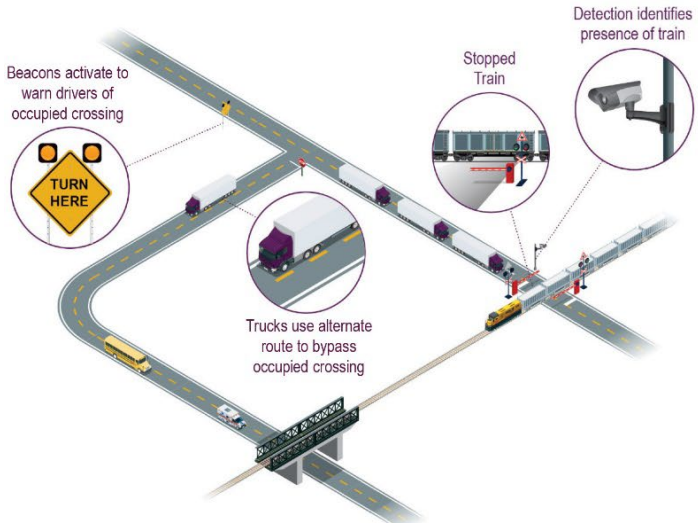
At international borders, multiple agencies operate to serve various mobility, safety, and security needs. Due to jurisdictional differences, a comprehensive binational freight operation across the border can be challenging due to lack of coordination between participating agencies in Mexico and the United States.

TxDOT should work with border officials from Mexico and the United States to develop a binational border freight traffic operations center (TOC) that works in collaboration with U.S. CBP and Servicio de Administración Tributaria (SAT) to monitor all CMV traffic operations at the border with a goal of reducing delays and improving mobility while preserving security. This TOC would support interagency staff to help collaborate on roadway traffic operations and potentially explore opportunities to assist with improving rail efficiency.



Develop a rail crossing traffic management system

Advanced notification of slow moving or stopped trains would allow freight operators and emergency response personnel and other roadway users to select alternative routes to minimize delays. TxDOT should coordinate with the railroads to install occupied rail crossing detection systems (cameras, sensors, etc.) and advance notification equipment at high-profile freight routes with frequent rail activity.



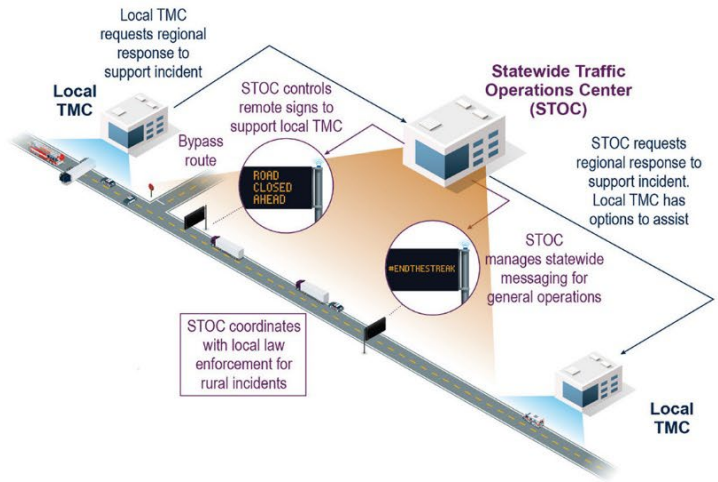
OVERVIEW: Install occupied rail crossing detection systems and advance notification equipment at high-profile routes with frequent rail activity.

NEEDS: Need to improve mobility near rail crossings by providing route options and advanced notification of delays.

CHALLENGES: Freight rail handles commercially sensitive material that does not allow for tracking trains through the network.

Develop integrated traffic management and operations and data exchange platforms

TxDOT should develop a Freight Operation Exchange platform which integrates various TxDOT freight data such as weigh- in-motion, vehicle classification, TPAS, and location-based data with private sector sources such as automated and connected vehicles and electronic logging devices to develop a robust and integrated platform that will assist in future freight planning efforts.



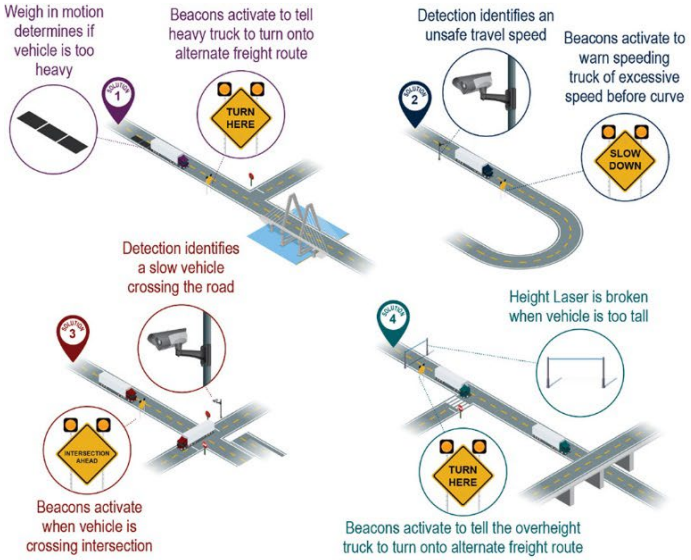
OVERVIEW: Implement a statewide TOC for overseeing statewide freight initiatives and large scale traffic management activities.

NEEDS: Need to improve statewide traffic operations, particularly along rural routes, by providing a consistent strategy and improved coverage.

CHALLENGES: Difficulties with upgrading the Advanced Traffic Management System.

Expand and deploy a safety warning detection system

In some instances, a freight vehicle may be operating outside of desirable parameters (e.g., too fast, too big, too heavy) without awareness of a potential hazard, such as a low overpass, a sharp curve, or a blind intersection. Failing to be aware of these hazards can result in crashes or other safety issues caused by damaged infrastructure, as well as the costs associated with damaged infrastructure (e.g., bridge strike repairs). TxDOT should expand and deploy a network-wide safety warning detection system on the TMFN to improve safety, mobility, and efficiency.



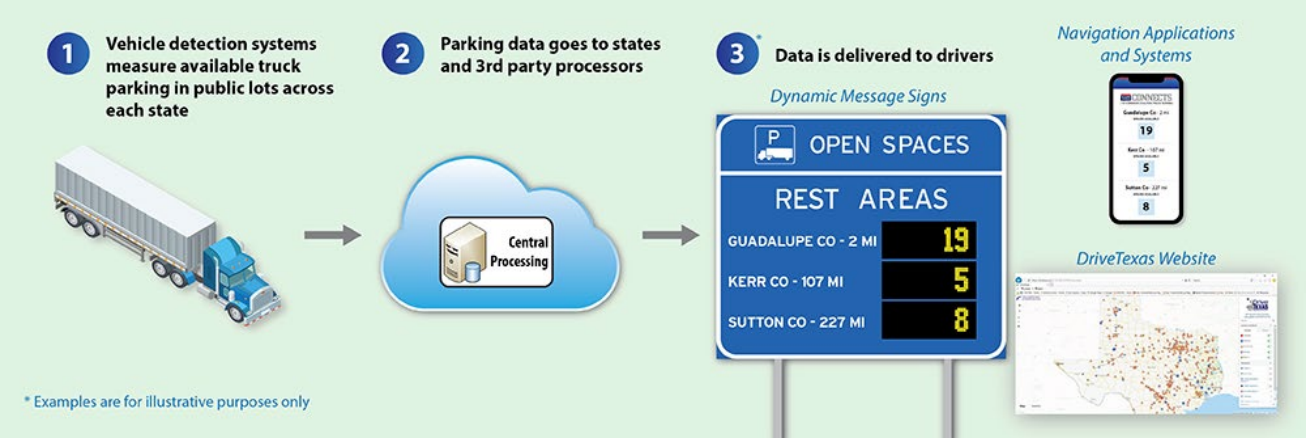
OVERVIEW: Install spot-treatment overheight, overweight, and/or overspeed detection equipment and notification systems at locations with a high-incidence of crashes or mission-critical infrastructure (bridges, etc.).

NEEDS: Need to provide real-time notifications of safety issues to prevent safety incidents and preserve infrastructure for future freight operations.

CHALLENGES: Freight rail handles commercially sensitive material that does not allow for tracking trains through the network.

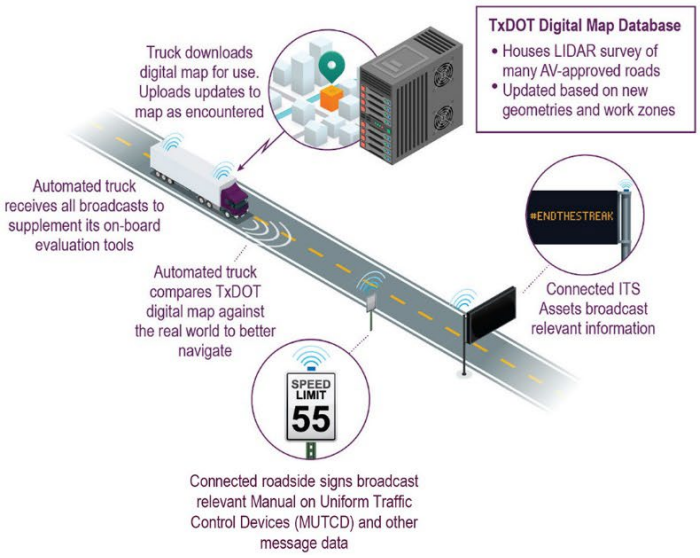
Expand the statewide Truck Parking Availability System (TPAS)

TPAS is a technology system that will detect, monitor, and provide real-time truck parking availability information to truck drivers, dispatchers and other interested stakeholders through roadside dynamic message signs, smartphone applications, in-cab applications and online via websites, and traveler information sites. TxDOT is currently implementing TPAS along I-10. TxDOT should expand TPAS to the remaining interstate corridors and examine the feasibility of extending to other key THFN facilities.



Implement a Freight Automation Program to invest in the AFVN

Following designation of an AFVN and development of the AFVN program, TxDOT should invest in developing and operating the network in coordination with private sector modal partners, innovators, industrial developers, and communities. This includes identifying, prioritizing, and encouraging public and private-sector investments.



OVERVIEW: Implement AV-specific infrastructure requirements for "smart" roadside signs and repository for digitized infrastructure data ("digital map").

NEEDS: Need to offer better information on the roadway environment to improve efficiency and safety of automated freight vehicles.

CHALLENGES: Achieving a consolidated and consistent basemap of the roadway environment will require a strong public-private-partnership between TxDOT and its private sector partners.

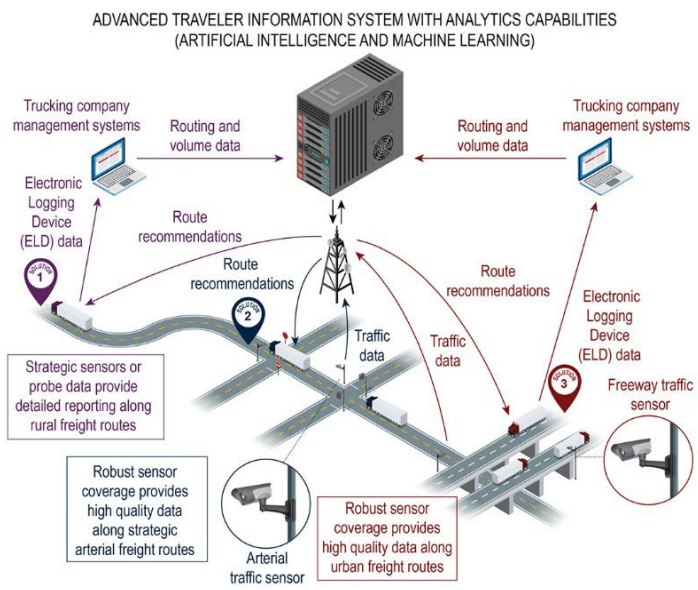
Implement the WIM/VC Strategic Plan

TxDOT completed the development of a WIM/VC Strategic Plan in 2022 that identified the needs, gaps, and strategies moving forward. TxDOT should implement the strategic plan and develop a WIM/VC program for ongoing operations of the system.

Incorporate machine learning and predictive analytics into technology solutions

Implementing many of the technology and operations strategies will result in significant amounts of data that facilitates machine learning and predictive analysis. Machine learning (ML) and predictive analysis (PA) can further enhance operations, mobility, safety, and resiliency of the TMFN. TxDOT should develop a ML and PA program that includes:

- Investment in high-resolution traffic data services for the THFN, utilizing state-owned sensors and/or private sector probe data services.
- Establishment of mechanisms to accept freight-related location-based data that preserves anonymity to help refine freight data, with established data use guidelines to encourage the private sector to contribute.
- Development of artificial intelligence-enabled tools to support incident management, event screening, and forecasting of future traffic conditions.
- Consolidation of multiple data sources into a consistent format for each data type, such as road closure information, traffic data, incidents, and recent route performance, to allow easy data sharing with other stakeholders.
- In coordination with the Information Technology Division, TxDOT should establish specific data access and distribution protocols for freight data users to encourage use of the data.
- Incorporation of machine learning and predictive analysis to actively manage the THFN.



OVERVIEW: Develop a statewide data collection program to provide high-resolution real-time traffic data for all freight network routes to provide for freight industry use in making informed routing decisions.

NEEDS: Need to improve the quality of traveler information to dramatically improve routing and freight efficiency.

CHALLENGES: Data processing power needed to generate predictive analytics for the entire statewide roadway system.

Integrate freight considerations into the Transportation Management and Operations (TSMO) Plan

TxDOT currently is working to address roadway bottlenecks and operational challenges such as recurring delay, safety hotspots and design challenges through the implementation of TSMO and has developed a statewide TSMO Strategic Plan.[76] TSMO is a strategic approach to proactively improve mobility for all modes of transportation by integrating planning and design with operations and maintenance to holistically manage the transportation network and optimize existing infrastructure. Examples include signal timing, access management, use of ITS, and pricing. TxDOT should explicitly integrate freight into the TSMO strategic plan.

Support private sector development of innovative freight mobility hubs

TxDOT should support the advancement and deployment of alternative freight delivery concepts such as the freight shuttle, drone/urban air mobility, freight mobility zones, automated and connected commercial vehicles at border crossings, and others by partnering with the private sector to create and/or expand incubator programs.

[76] TxDOT. Transportation Systems Management & Operations (TSMO) Strategic Plan. https://www.txdot.gov/safety/tsmo.html.

Support the expansion of broadband and 5G capabilities along the THFN

Broadband access is essential for the deployment of transportation technologies including TPAS, Weigh-in-Motion, CAVs, and others. The IIJA, along with numerous Texas Legislative bills, have provisions for expanding broadband and 5G capabilities in coordination with transportation infrastructure. Given the early adoption of technology by the freight industry and resulting public benefits, TxDOT should support expansion of these capabilities along the THFN.

9.2 SUMMARY

Based on the estimated coverage gaps identified in the needs assessment, **71% of the THFN is not currently covered by TxDOT's ITS program** (**Exhibit 44**). This means that freight users outside of these coverage areas are less likely to have assistance from TxDOT when a disruption occurs or witness rapid incident response. The 14 technology and operations recommendations presented above allow TxDOT to maintain, enhance, and transform freight mobility now and in the future.

This Chapter presented and discussed technology and operational strategies. Chapter 10 presents project needs for each mode and identifies key gaps along the THFN where needs exist, but no projects have been identified.

Chapter 10 Investing in the Texas Multimodal Freight Network — The Freight Investment Plan

The Freight Investment Plan (FIP) is a critical element to Texas Delivers 2050. The FIP aligns high and medium needs with available funding for the constrained plan and presents the overall unconstrained plan for highway and non-highway projects. This combined list identifies comprehensive needs on the TMFN regardless of ownership or funding program eligibility. As the FIP moves to a four-year cycle with up to 30% of NHFP funding available for intermodal projects, it is important to have a multimodal needs list.

The prioritization methodology for this FIP goes beyond what was used for the 2018 TMFP FIP, incorporating a new Freight Investment and Optimization (FIO) tool developed as part of ongoing freight program implementation activities. This new tool compares the freight needs documented by the freight plan with the priorities established by TxDOT as part of the UTP development to determine final freight project priorities to support the FIP. This evolution is discussed below.

10.1 BUILDING THE FREIGHT INVESTMENT PLAN

The Texas Delivers 2050 process for prioritizing freight projects builds on the

Highlights

The Texas Freight Investment Plan (FIP) provides fiscally constrained and unconstrained funding priorities for the TMFN. The FIP incorporates the project priorities identified and prioritized by TxDOT's 10-year Unified Transportation Plan (UTP) for all projects determined to be freight-centric or freight-supportive. Further, the FIP assigns freight priority scores to each project based on TxDOT's Freight Investment and Optimization Tool.

The unconstrained component of the FIP allows TxDOT to document all needs identified by its non-highway modal partners, as well as additional highway projects currently unfunded and/or outside the eight-year window of the fiscally constrained plan.

The Texas FIP presents key priority freight projects for highways, railroads, ports and waterways, airports, and border crossings.

The FAST Act requires state freight plans to include a FIP with a priority list of projects and the supporting funding strategy. The IIJA made several key changes to FIP requirements:

- Increased the frequency of the FIP updates from five to four years.
- Changed the funding period from five to eight years.
- Broadened the funding flexibility by increasing the percentage of NHFP funds that can be invested in intermodal projects from 10% to 30%.

process used during the 2018 TFMP. Consistent with the approach used for prior plan, the FIP is the result of a data-driven approach to support the identification of projects that meet the greatest freight needs on the transportation system. Enhancing the previous process, the Texas Delivers 2050 freight investment assessment and prioritization process uses the FIO tool to pair freight needs with predicted project benefits for each project considered.

TxDOT uses several tools to support the decision-making process for developing its investment programs. Predicted project benefits are derived from PM-DIS, the TxDOT system for evaluating and scoring projects. PM-DIS uses performance metrics for project scoring and provides a predicted project benefit for each project. TxDOT publishes its key performance measures on its online dashboard, and these include:[77]

- Urban and rural congestion and reliability indices, including TTTR,
- Vehicle miles traveled,
- Annual delay per person,
- Number and rate of fatalities,
- Number and rate of serious injuries,
- Fatalities in safety emphasis areas,
- Bridge condition score,
- Lane-miles in good or better condition, and
- Additional measures related to project delivery, customer service, employee experience, and fiscal stewardship.

Starting with the freight needs identified along the TMFN, as described in Chapter 5, the FIO tool pairs needs with predicted project benefits along the THFN to establish a freight priority score to help inform funding decisions. The portfolio of projects along the THFN is ranked based on each project's potential impact on critical freight needs by type, as detailed in the **Needs Assessment Memorandum**. More than 20 factors were assessed, including:

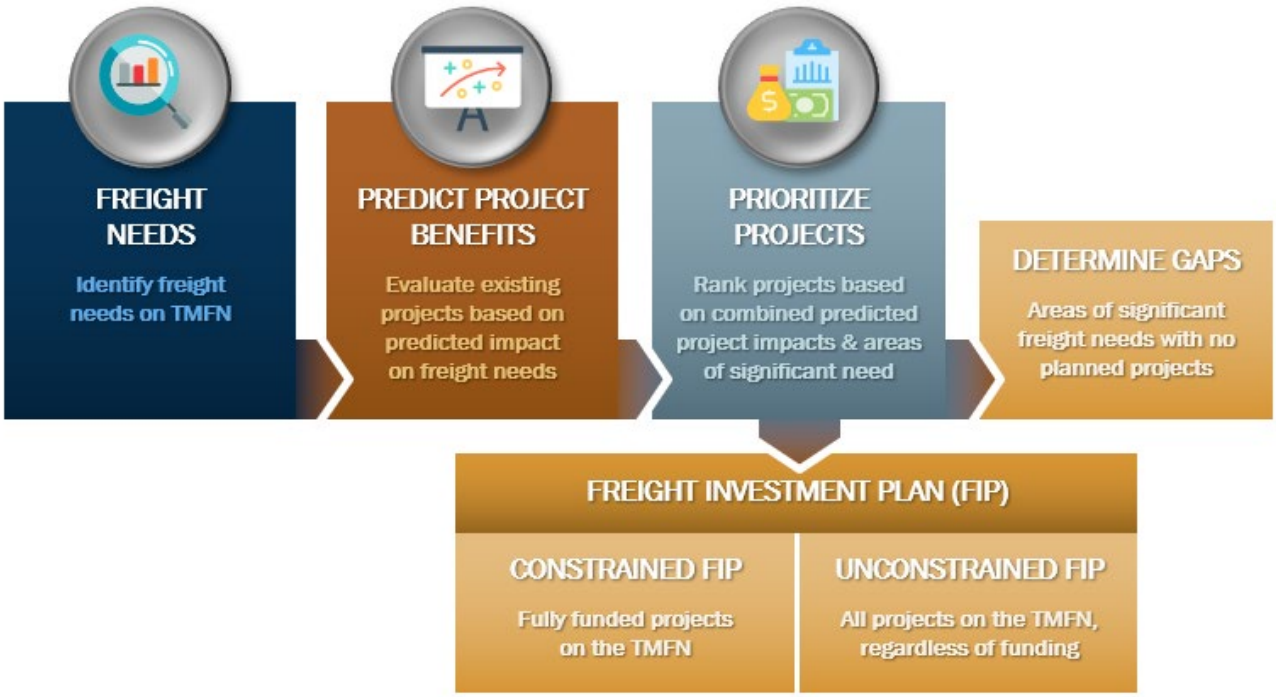
- Truck-involved crashes and fatalities,
- Truck delay per mile,

[77] TxDOT Performance Dashboard. 2022. https://www.txdot.gov/data-maps/performance-dashboard.html

- Oversize/overweight routing,
- Bridge and pavement condition,
- Roadway design,
- At-grade crossings,
- Presence of ITS technology, and
- Many other factors discussed in Chapter 5 and the technical memorandum.

The process results in three key outcomes: a constrained FIP, an unconstrained FIP, and a gap analysis. The constrained FIP represents fully funded projects along the THFN over an 8-year period. The unconstrained FIP represents unfunded, partially funded, and fully funded projects incorporating all modal projects. The gap analysis highlights areas of the THFN with a significant freight need with no project identified. **Exhibit 51** provides an overview of the FIP process.

EXHIBIT 51: OVERVIEW OF FREIGHT INVESTMENT PRIORITIZATION PROCESS



10.2 THE 8-YEAR FISCALLY CONSTRAINED FIP

The 8-year fiscally constrained FIP projects address key freight needs across the THFN. Fully funded projects programmed over the next 8 years along the THFN represent a $29.7 billion investment of 1,800 projects including asset management, connectivity, mobility, and safety project types. A breakdown of the category of within the fiscally constrained FIP is shown in **Exhibit 52**.

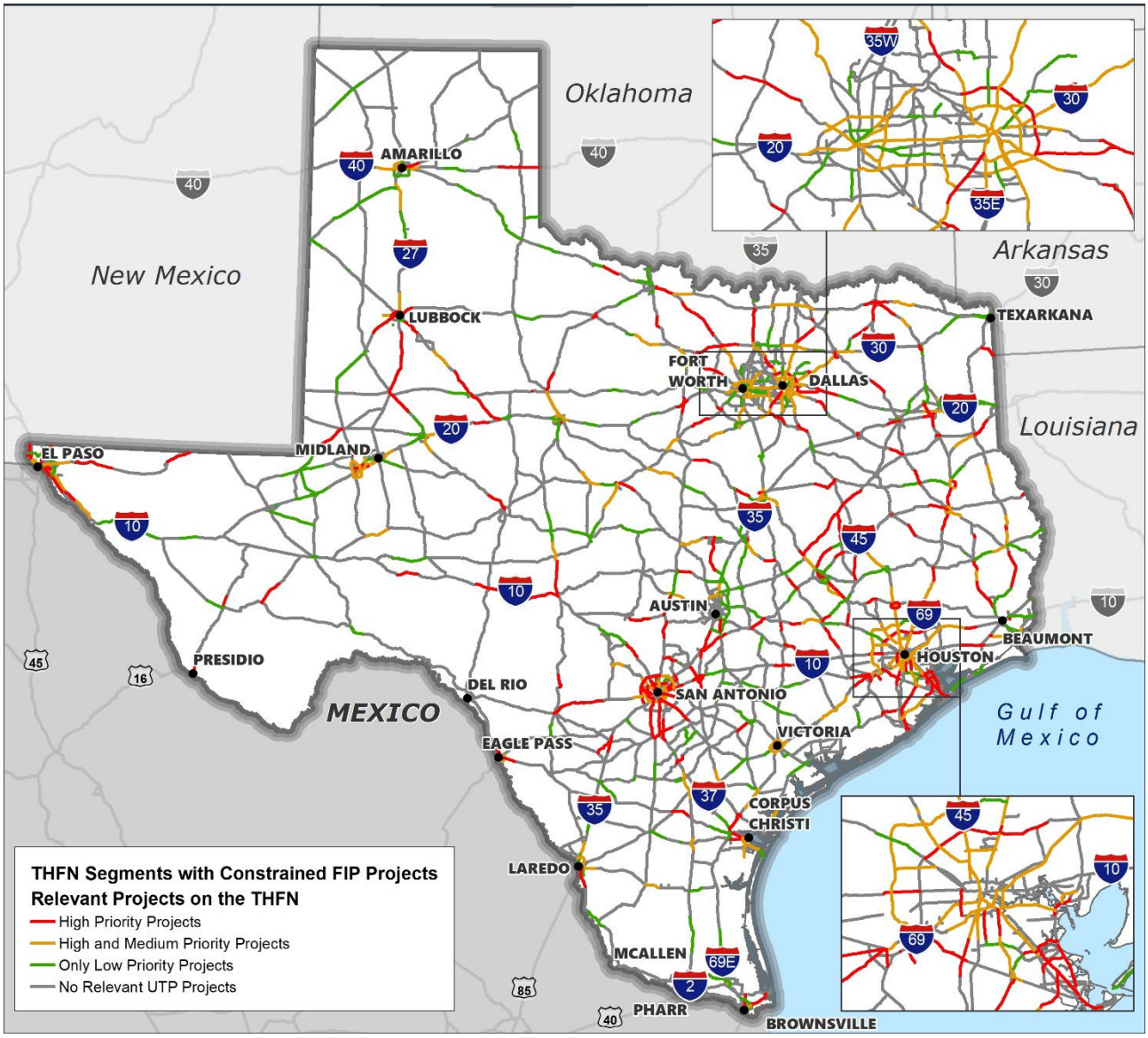
EXHIBIT 52: CONSTRAINED FIP BY PROJECT CATEGORY

Project Category	Number of Projects	% of Projects	Cost (Millions)	% of Cost
Asset Management	597	32%	$3,627.2	12%
Connectivity	25	1%	$837.1	3%
Mobility	472	26%	$23,866.5	80%
Safety	750	41%	$1,360.2	5%
Total	**1,844**	**100%**	**$29,691.0**	**100%**

Source: TxDOT, 2023 Unified Transportation Program

The Texas Delivers 2050 freight investment assessment and prioritization process, supported by the FIO tool identified high, medium, and low priority freight projects in the next 8-year period. This rating is determined both on the predicted benefits of the project and the severity of freight needs addressed by the project. This set of fully funded projects represent the fiscally constrained FIP and is shown in **Exhibit 53**.

EXHIBIT 53: CONSTRAINED FREIGHT INVESTMENT PLAN BY PROJECT PRIORITY



Source: TxDOT, 2023 Unified Transportation Program

Exhibit 54 summarizes the fiscally constrained FIP based on funding and priority. The fiscally constrained FIP contains almost $15 billion in high priority freight projects, as evaluated through the freight investment assessment and prioritization process. This represents over 640 projects.

EXHIBIT 54: PROJECTS BY FREIGHT PRIORITY

Priority	Number of Projects	Cost (Millions)
High	648	$14,906.1
Medium	590	$10,540.3
Low	606	$4,244.6
Total	**1,844**	**$29,691.0**

Source: TxDOT, 2023 Unified Transportation Program

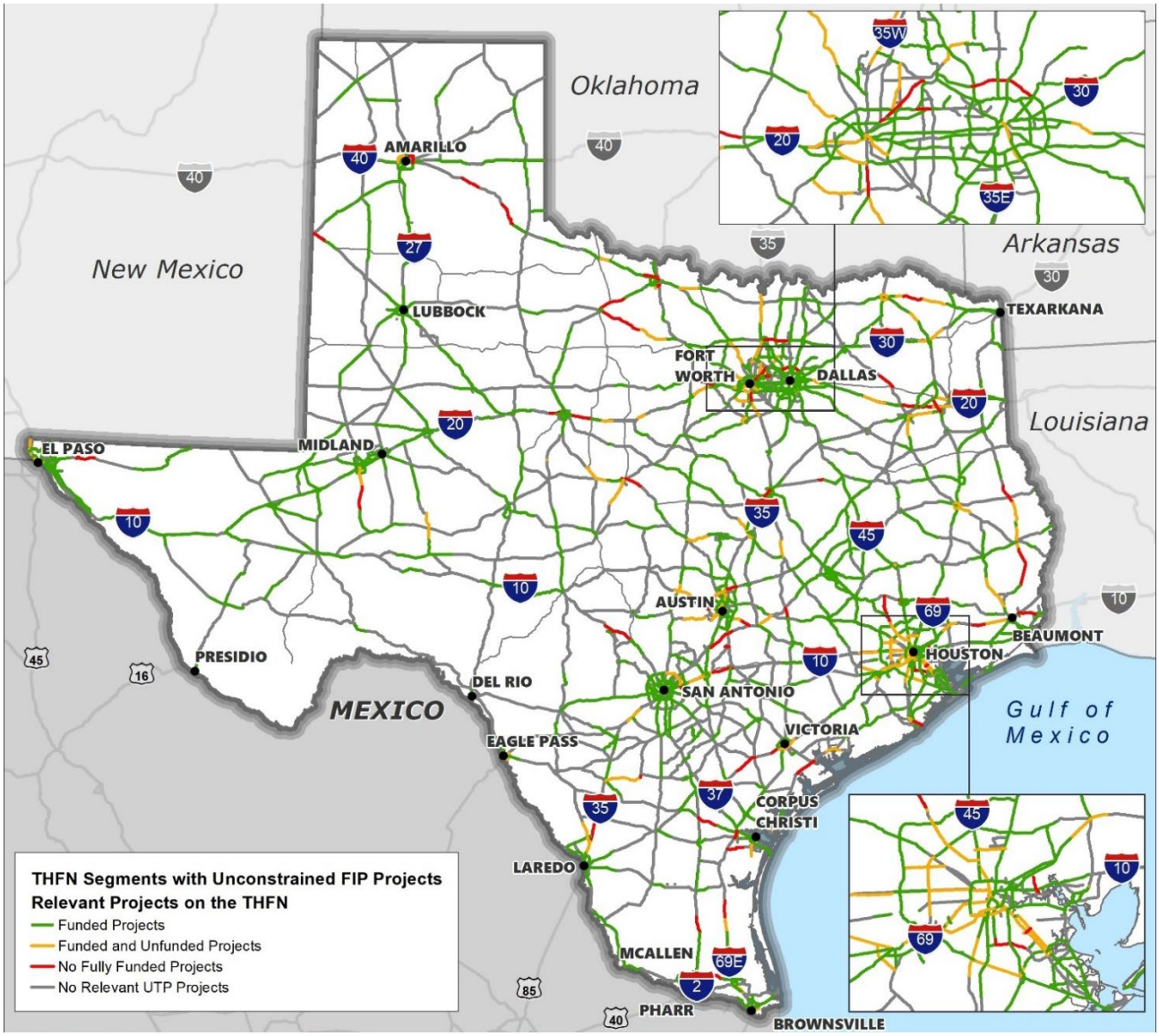
10.3 THE UNCONSTRAINED FREIGHT INVESTMENT PLAN

The unconstrained FIP consists of all roadway projects in the UTP that fall on the THFN and represent freight-related investments, as well as all modal project needs identified by port, waterway, rail, border, and airport stakeholders.

10.3.1 UNCONSTRAINED HIGHWAY FIP

The full set of projects in the unconstrained FIP represents funded projects and partially funded projects on the THFN. This represents the full range of project priorities regardless of the level of financial commitment identified to develop and deliver the project. **Exhibit 55** depicts the segments of the THFN that intersect with a project in the unconstrained FIP.

EXHIBIT 55: THFN SEGMENTS WITH UNCONSTRAINED PROJECTS BY PROJECT FUNDING



Source: TxDOT, 2023 Unified Transportation Program.

FREIGHT INVESTMENT PLAN

The **unconstrained FIP** along the THFN represents a **total investment need of over $47 billion through 2,200 projects** of varying types including asset management, connectivity, mobility, safety and other project types.

A breakdown of the category of highway projects and investment level of the unconstrained FIP is shown in **Exhibit 56**.

EXHIBIT 56: UNCONSTRAINED HIGHWAY PROJECTS BY FUNDING STATUS AND PROJECT CATEGORY

Project Category	Number of Projects	% of Projects	Cost (Millions)	% of Cost
Asset Management	708	32%	$5,009	11%
Connectivity	37	2%	$1,778	4%
Mobility	663	30%	$38,703	82%
Safety	816	37%	$1,835	4%
Total	**2,224**	**100%**	**$47,001.9**	**100%**

Source: TxDOT, 2023 Unified Transportation Program

Exhibit 57 provides a breakdown of the unconstrained FIP projects in terms of funding status and freight priority. Of the 1,481 high and medium priority freight projects, 16% are partially funded. **The total funding gap is over $11 billion.**

EXHIBIT 57: UNCONSTRAINED HIGHWAY PROJECTS BY FUNDING STATUS AND PRIORITY

	Unfunded or Partially Funded			Fully Funded		Total	
Priority	Number of Projects	Cost (Millions)	Funding Gap (Millions)	Number of Projects	Cost (Millions)	Number of Projects	Cost (Millions)
High	87	$5,916.0	$3,467.6	654	$15,725.0	741	$21,641.0
Medium	136	$7,684.3	$5,658.6	604	$11,305.8	740	$18,990.0
Low	134	$2,346.0	$1,920.9	609	$4,348.6	743	$6,694.6
Total	**357**	**$15,946.3**	**$11,047.0**	**1,867**	**$31,379.4**	**2,224**	**$47,325.7**

Source: TxDOT, 2023 Unified Transportation Program. Projects without location data are not prioritized.

10.3.2 NON-HIGHWAY MULTIMODAL FREIGHT PROJECTS

Needs for TxDOT's modal partners were collected using surveys and interviews. While many of these modal projects fall outside the normal funding ability of TxDOT, it is important that these projects are documented in Texas Delivers 2050 to provide a complete picture of necessary investment in the TMFN. Highlights of Texas' modal projects are presented below based on input and direction for TxDOT's modal divisions and modal partners including seaports, airports, and railroads.

Importance of Including Non-Highway Projects in Texas Delivers 2050

The TMFN is the backbone of the Texas economy. The health and capacity of each modal system and the key points of intermodal connectivity must be managed. The Texas Delivers 2050 documents the projects for all modes for three key reasons:

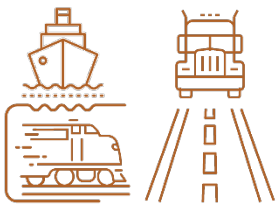
- It is important to understand the full breadth of freight projects and investments being made in Texas regardless of ownership.
- The IIJA increases the percentage of NHFP funds that can be allocated to non-highway intermodal projects from 10% to 30%.
- The inclusion of modal projects in the state's adopted freight plan should increase the competitiveness of discretionary federal grants; the IIJA increased funding levels of established grant programs and created new programs.

PORT AND WATERWAY PROJECTS

Texas is home to a diverse network of seaports which play a critical role in the domestic and global supply chains of the industries operating in Texas. Continued investment in access to and capacity of these critical trade gateways is necessary to support growth in the Texas economy. To help support and facilitate the necessary investments, Texas Delivers 2050 captures and summarizes the connectivity and infrastructure projects identified in the 2024-2025 Texas Port Mission Plan, which represents a 2-year period of shovel-ready, needed projects that are unfunded or partially funded. Priorities within the Port Mission Plan change in real-time based on business opportunities. Highlights of each project list are summarized below.

PORT CONNECTIVITY PROJECTS

Port connectivity projects address access to ports, consisting of roadway and rail improvements.



The **Port Mission Plan** documents **142 projects** across 18 ports representing an **investment need of $4.3 billion.**

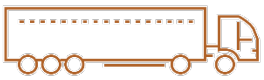


Exhibit 58 summarizes the number of port connectivity projects by port. The detailed project list is provided in **Appendix D**.

EXHIBIT 58: SUMMARY OF PORT CONNECTIVITY PROJECTS

Port Connectivity Report Project Summary		
Port	**Number of Projects**	**Cost ($M)**
Port of Orange	9	$27.3
Port of Beaumont	9	$13.6
Port of Port Arthur	15	$72.2
Sabine Pass Authority	3	$0.6
Port Houston	30	$2,912.0
Cedar Bayou Navigation District	2	$96.5
Port of Galveston	14	$107.5
Port Freeport	8	$27.8
Port of Bay City	4	$36.2
Port of Palacios	4	$10.1
Calhoun Port Authority	5	$117.8
Port of West Calhoun	5	$14.6
Port of Victoria	6	$123.3

Port Connectivity Report Project Summary		
Port	**Number of Projects**	**Cost ($M)**
Port of Corpus Christi	12	$384.9
Port of Port Mansfield	4	$236.5
Port of Harlingen	4	$22.1
Port of Isabel	1	$8.8
Port of Brownsville	7	$132.2
	142	**$4,344.0**

Source: TxDOT, 2024–2025 Port Mission Plan.

ON-PORT INFRASTRUCTURE PROJECTS

On-port capital improvements include:

- *Terminal expansion*
- *Berth maintenance and expansion*
- *Truck staging*
- *Rail terminal expansion*
- *and more...*

These projects address **on-port capacity and operational efficiency.** The **Port Mission Plan** summarizes the **top 51 projects** at fifteen ports representing **$1.7 billion in capital need.**

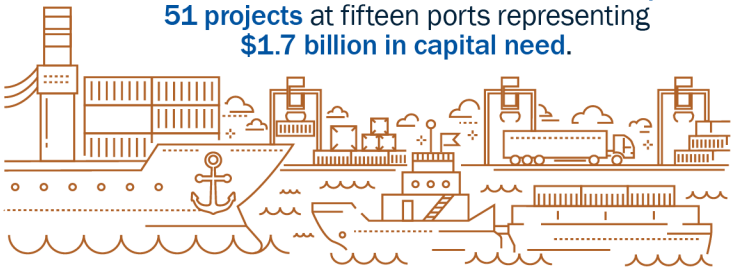


Exhibit 59 summarizes the number of projects by port. The detailed project list is provided in **Appendix D.**

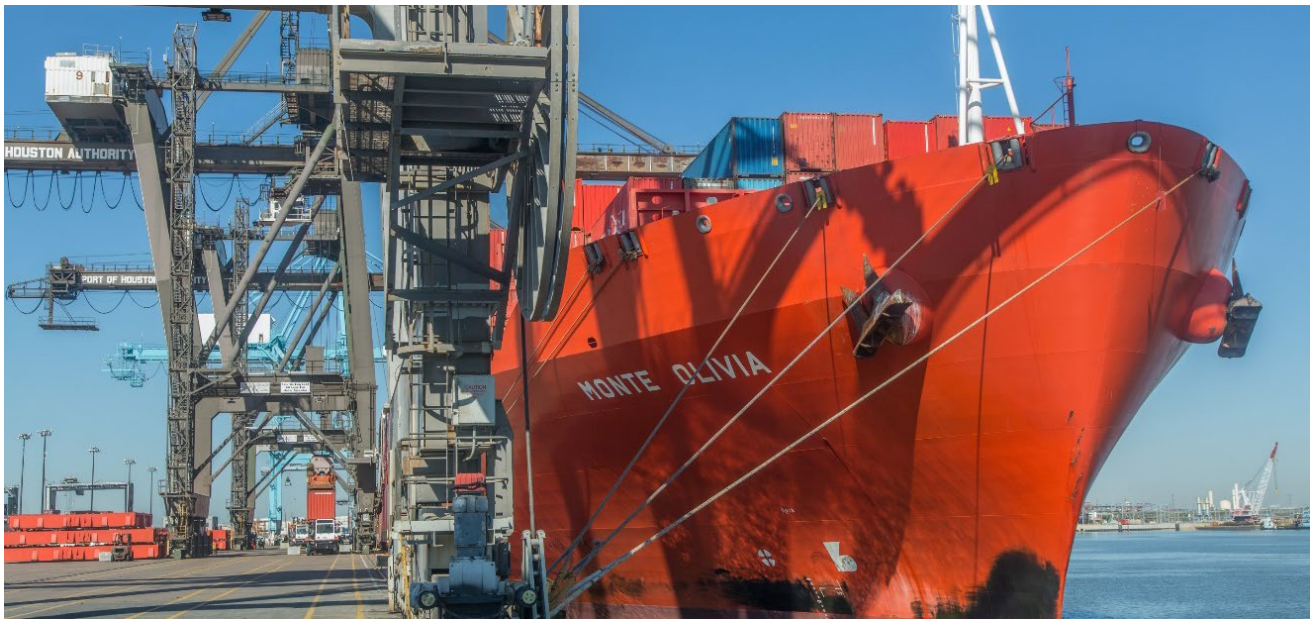


EXHIBIT 59: SUMMARY OF ON-PORT PROJECTS

Port Capital Investment Report Projects		
Port	**Number of Projects**	**Cost ($M)**
Port of Orange	5	$40.0
Port of Beaumont	2	$179.0
Port of Port Arthur	7	$97.6
Sabine Pass Authority	1	$6.0
Port Houston	4	$260.3
Port of Galveston	8	$301.2
Port Freeport	3	$31.0
Port of Palacios	2	$14.0
Calhoun Port Authority	3	$175.4
Port of West Calhoun	1	$18.6
Port of Victoria	3	$34.0
Port of Corpus Christi	3	$415.9
Port of Port Mansfield	2	$23.3
Port of Harlingen	4	$47.2
Port of Brownsville	3	$24.0
	51	**$1,667.5**

Source: TxDOT, 2024-2025 Port Mission Plan.

Example Port Projects

- **Port Houston / Bayport Terminal Yard Expansion /** $95M Total Cost / Adds 46 acres of new container capacity to port, building on recent 56-acre expansion necessary to manage high growth / Port Facilities and Inland Connectivity
- **Port of Brownsville / Bulk Cargo No. 3 Rehabilitation and Expansion /** $15M Total Cost / Plans for phased dock improvements and expansions to handle increased cargo throughput / Port Facilities
- **Port of Victoria / General Cargo Dock Development /** $5M Total Cost / Constructs additional cargo dock to accommodate additional vessel traffic and enable future on-dock rail connections / Port Facilities

GULF INTRACOASTAL WATERWAY

In addition to port improvements, the GIWW also has several key projects. The GIWW Legislative Report (88th Session) identifies several projects to maintain and improve the waterway. One of the key challenges facing the waterway is fully funding the annual maintenance dredging program, which results in waterway restrictions. **Exhibit 60** summarizes the key projects identified in the legislative report.

Texas has marine highways as designated by U.S. DOT's Maritime Administration. Designation as "marine highways" creates funding eligibility that should be monitored and pursued by TxDOT as available. Securing funding will be key to maximizing the potential of Texas' waterway system. The three designated marine highways include:

- M-146 – while not part of the GIWW, consists of commercially navigable waterways that provide a direct connection from the Houston Ship channel to the Cedar Crossing Industrial Park -- provides a barge alternative to truck and rail for container movement.
- M-69 and M-10 – which, in Texas, consist of the Gulf of Mexico and the GIWW and its commercial navigation channels and ports within Texas – provide alternative waterborne options for containers, roll on/roll off facilities, and hazardous materials.

Source: https://cms.marad.dot.gov/sites/marad.dot.gov/files/2021-08/Route%20Designation%20one-pagers%20Aug%202021.pdf

EXHIBIT 60: GULF INTRACOASTAL WATERWAY PROJECTS

GIWW Projects	Project Costs
Modify the Brazos River floodgates ▶ Removal of gates east and west of river ▶ New 125-foot wide east-sector gate structure south of existing alignment ▶ Minimum 125-foot channel on west side of river	Approximately $320 million
Modify the Colorado River locks ▶ Removal of riverside structures while retaining outer gates, creating wider and much longer forebay	Approximately $252 million
Maintain authorized depth and width of the GIWW	$54 million annually
Add additional mooring facilities along the channel	Project cost not available

Source: TxDOT's Gulf Intracoastal Waterway Legislative Report, 88th Texas Legislature, and USACE presentation, December 1, 2022.

RAILROAD PROJECTS

Texas is home to the largest number of railroad miles in the country, providing intermodal, carload/general merchandise, and specialized unit train services supporting a variety of key industries. Rail service is critical to the success of key industries and to the efficiency of the TMFN. Railroad projects were identified based on input from railroads operating in Texas as well as from the TxDOT Rail Division.

The list in **Appendix C** reflects **56 rail projects including corridor track improvements, at-grade crossing improvements, and grade separations representing almost $1.4B in investments.** While this list does not reflect a complete overview of rail capital improvements, it does highlight key projects shared with TxDOT that demonstrate rail projects with a public benefit.

Exhibit 61 provides a summary of the 56 projects.

EXHIBIT 61: SUMMARY OF RAIL FREIGHT PROJECTS

Source/Sponsor	# of Projects	Estimated Cost (in millions)**
Class I Railroads	34	$1,164.5
Short line Railroads	21	$192.9
Rail Freight/Port Projects	1	$30.0
Total	**56**	**$1,387.4**

*** Cost estimates were provided for 31 of the 56 projects.*

Example Railway Projects

- **Rehabilitation of the NETEX rail line from Greenville to Mount Pleasant (66 miles).** Track speeds on the NETEX line are limited to 10 mph due to defective crossties and bridge deficiencies. The rail line must be rehabilitated to continue providing service to existing customers and attract new business to the line and the region.
- **The Metroplex Freight Mobility Study Phase I & II** (TxDOT, 2021) identified projects which enhance mobility for passenger and freight operations in the Dallas-Fort Worth Metroplex. One specific investment at Control Point (CP) 217 near downtown Dallas aims to alleviate capacity constraints which result from commuter train schedules, multiple railroad interactions, and limited track capacity.
- **The Houston-Beaumont Freight Rail Study** (TxDOT, 2021) identified projects that enhance mobility for passenger and freight operations in the Houston railroad network. The high number of trains using mainline tracks are often blocked due to trains departing and arriving, traveling between yards, and receiving crews. Improvements to the Houston Belt and Terminal Railway Company (HB&T) West Belt, HB&T East Belt, and UPRR Strang Subdivisions in the area include additional mainlines, switching leads, and wye connections.

BORDER PROJECTS

The Texas-Mexico border has 28 border crossings, 15 of which handle commercial vehicles. These international gateways handle significant trade and traffic is forecast to growth significantly over the next few decades. To help mitigate this growth, the BTMP was developed by TxDOT to help identify needed projects. This plan identifies 661 border crossing and corridor projects costing $37.4 billion. Only $5.5 billion or 15% of these projects were fully funded in 2021. **Fifty-three (53) of the BTMP projects are on the THFN and are included in UTP, with 42 fully funded ($1.6B), 4 partially funded ($819M), and 7 unfunded ($315M).** The fully funded projects are included in the constrained FIP, with the remaining projects included in the unconstrained FIP.

Exhibit 62 provides a summary of the border crossing projects from the BTPM that are on the THFN and included in the FIP.

EXHIBIT 62: SUMMARY OF TEXAS-MEXICO BORDER PROJECTS ON THE THFN

Funding Status	Border Crossing Projects on the THFN	Costs ($M)
BTMP	**53**	**$2,745.1**
▶ Fully Funded	42	$1,610.9
▶ Partially Funded	4	$819.5
▶ Unfunded	7	$314.7

Source: Texas-Mexico Border Transportation Master Plan, 2021, and TxDOT 2023 UTP.

Example Border Projects

- **Rio Grande Valley Region / Pharr Bridge Commercial Staging** / $7.5M Project Cost / Pharr Commercial Vehicle Staging Area
- **Laredo Region / World Trade Bridge Fast Lane Construction** / $10.3M Project Cost / Construct inspection booths
- **El Paso Region / Texas Pacifico Railroad Mainline Improvements** / $8.4M Project Cost / Privately funded projects to improve mainline connection to new border rail crossing

AIRPORT PROJECTS

Ten international airports are included on the TMFN. Several of these airports handle significant air cargo volumes. On- and off-airport projects were identified for eight of these airports via surveys, interviews, and review of available capital improvement programs. For many airports, the air cargo support projects represent overall airfield improvements that benefit all air service. With that said, there are examples of air cargo specific improvements, specifically in Austin, Dallas, Lubbock, and Laredo. **Eight Texas airports have 39 fully funded air cargo projects – two of which are off-airport connector projects – representing $754 million in investments.**

Exhibit 63 provides a summary of 39 fully funded airport projects representing an $754 million investment.

EXHIBIT 63: SUMMARY OF FUNDED AIR CARGO PROJECTS

Airport	Inside the Gate Projects	Connector Projects	Total Costs ($ M)
AFW	14	0	$108.7
AUS	1	0	$11.4
DFW	2	0	$151.0
ELP	11	2	$128.9
HRL	1	0	$25.0
IAH	2	0	$237.0
LBB	2	0	$29.0
LRD	4	0	$63.0
Total	**37**	**2**	**$754.0**

Example Air Cargo Projects

- DFW / Relocation/Updating the Fumigation Facility / $11M
- LRD / Rehabilitate Northeast Cargo Apron / $12M
- AUS / Cargo Development East / $11M

Source: Airport surveys, master plans and capital improvement programs.

In addition to the fully funded projects, there are airport projects that are longer-term projects identified in airport master plans which generally don't have a dedicated funding source attached to them. Examples of these projects include: a relocated belly freight facility at AUS and widening of Glade Road between Hwy 360 and West Airfield Drive at DFW.

PIPELINE PROJECTS

The pipeline industry invests significantly in the maintenance and expansion of the state's privately held pipeline network. While capital investment numbers or specific projects are not readily available, construction of pipeline in 2019 generated 29,000 direct constructions jobs and almost $5.5B in in gross output and pipeline capacity increased over 13% from 2013 to 2019.[78] These numbers demonstrate a significant number of funded expansion projects. Given these investments serve a competitive oil and gas mining industry, detailed projects and need are not publicly shared by individual pipeline companies.

[78] https://texaspipelines.com/wp-content/uploads/2020/10/Update-to-the-Economic-Impacts-of-Texas-Oil-and-Gas-Pipeline-September-2020-FINAL.pdf.

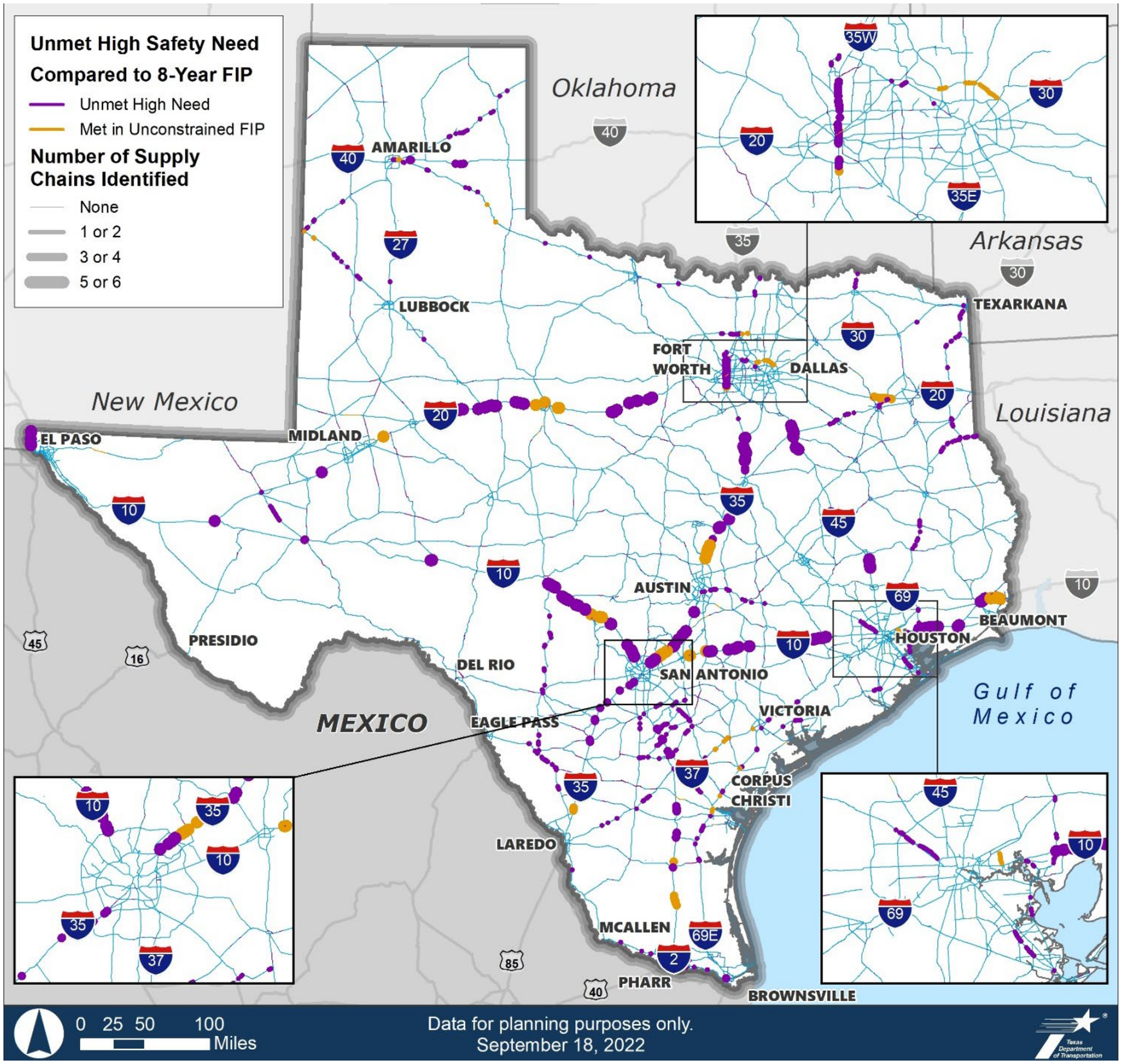
10.4 UNMET NEEDS ON THE TEXAS HIGHWAY FREIGHT NETWORK

There are over 5,000 miles on the THFN with high priority infrastructure needs from **Chapter 5** and no related project in the 8-year FIP.[79] Some of these needs have projects in the unconstrained FIP which could be accelerated to address high priority freight needs sooner, while others have no projects in the TxDOT's 10-year project funding program. Locations with no projects may have early-stage projects under consideration by TxDOT districts or local partners that could be accelerated. This section presents the locations of high needs without projects in the 8-Year FIP and their relationship to other freight topics from **Chapters 6 and 7** as well as key supply chains.

Exhibit 64 displays high priority safety needs compared to the 8-Year FIP. Unmet needs are located on interstate corridors, the future I-69 corridor, and rural US and state highways. Most unmet safety needs are in rural areas, and few are located on the most critical corridors for key supply chains: only 20% of unmet safety needs are on key supply chain corridors.

[79] Analysis assumes all projects are will positively impact safety, asset condition, and design. Mobility needs are only considered addressed by capacity or operational improvements.

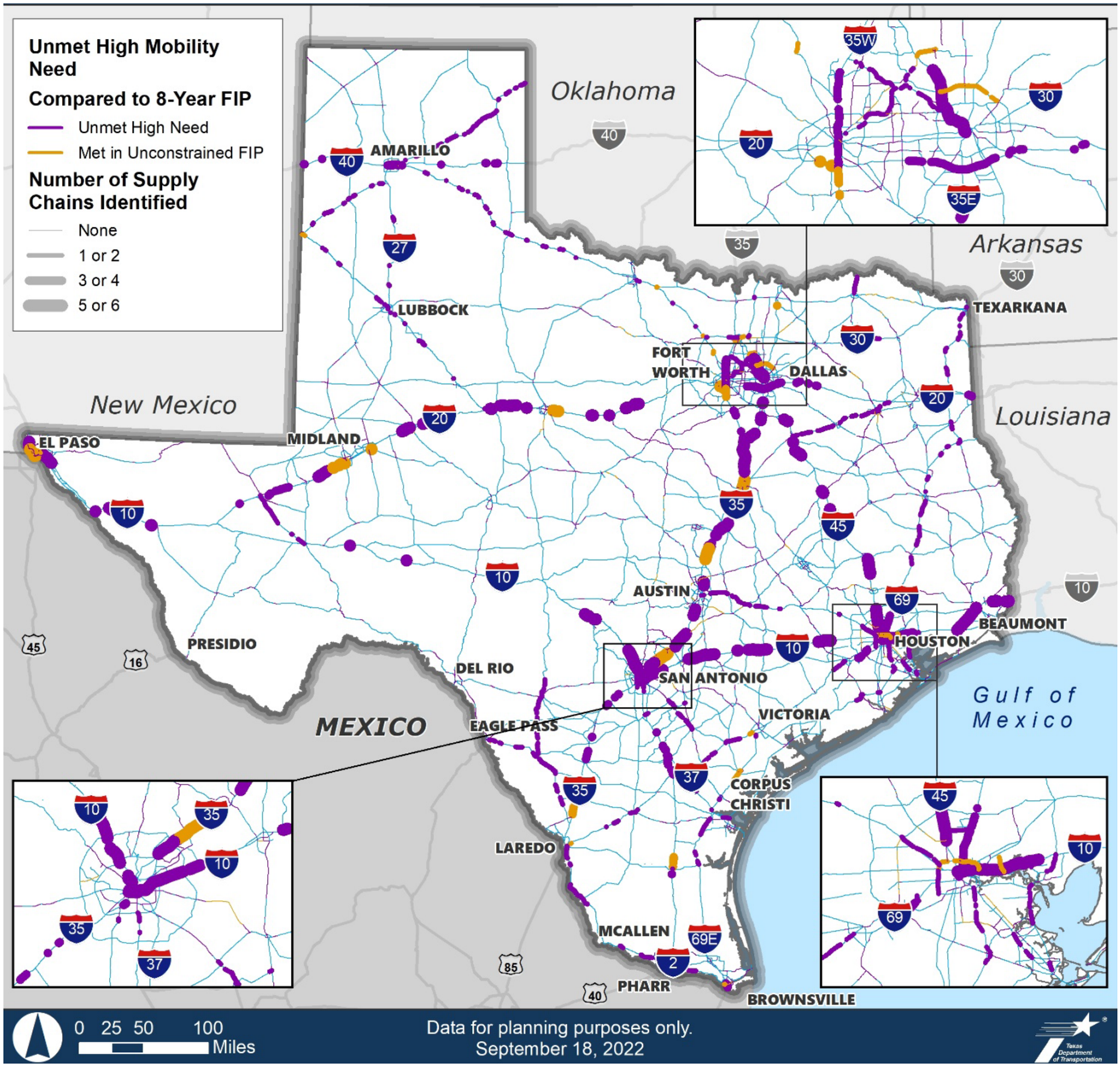
EXHIBIT 64: UNMET SAFETY NEEDS ON THE THFN



Source: TxDOT, 2023 Unified Transportation Program.

Unmet mobility and reliability needs are in urban and rural areas, though these high needs derive from different sources depending upon the level of congestion, availability of alternatives, and causes of unreliability if present (**Exhibit 65**). Less than a quarter of unmet mobility and reliability needs are on key supply chain corridors, reflecting both existing mobility, and investment in these critical routes. Over half of unmet mobility and reliability needs are collocated with high priority resiliency risk, indicating potential for additional risk during disruptive events.

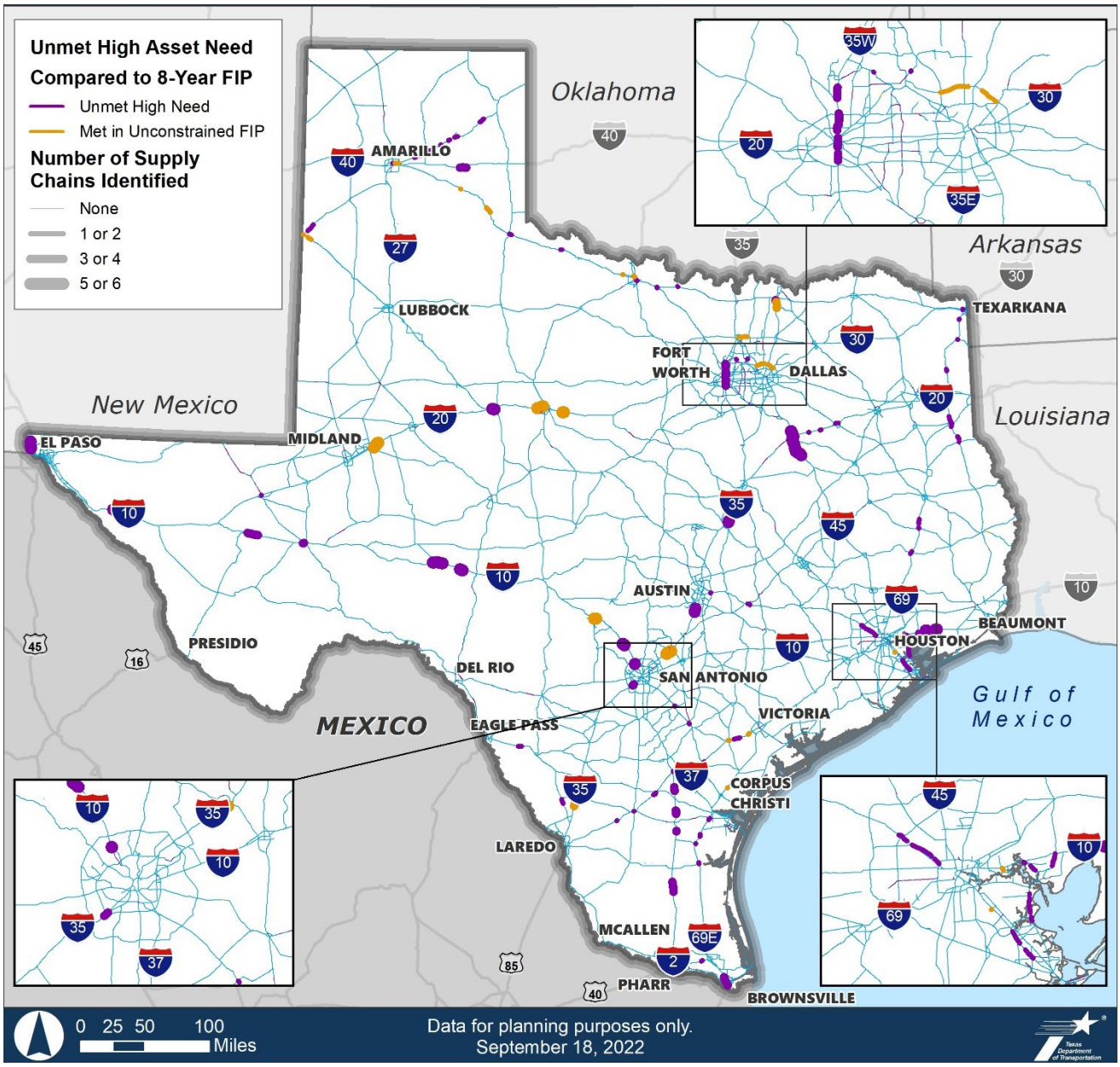
EXHIBIT 65: UNMET MOBILITY AND RELIABILITY NEEDS ON THE THFN



Source: TxDOT, 2023 Unified Transportation Program.

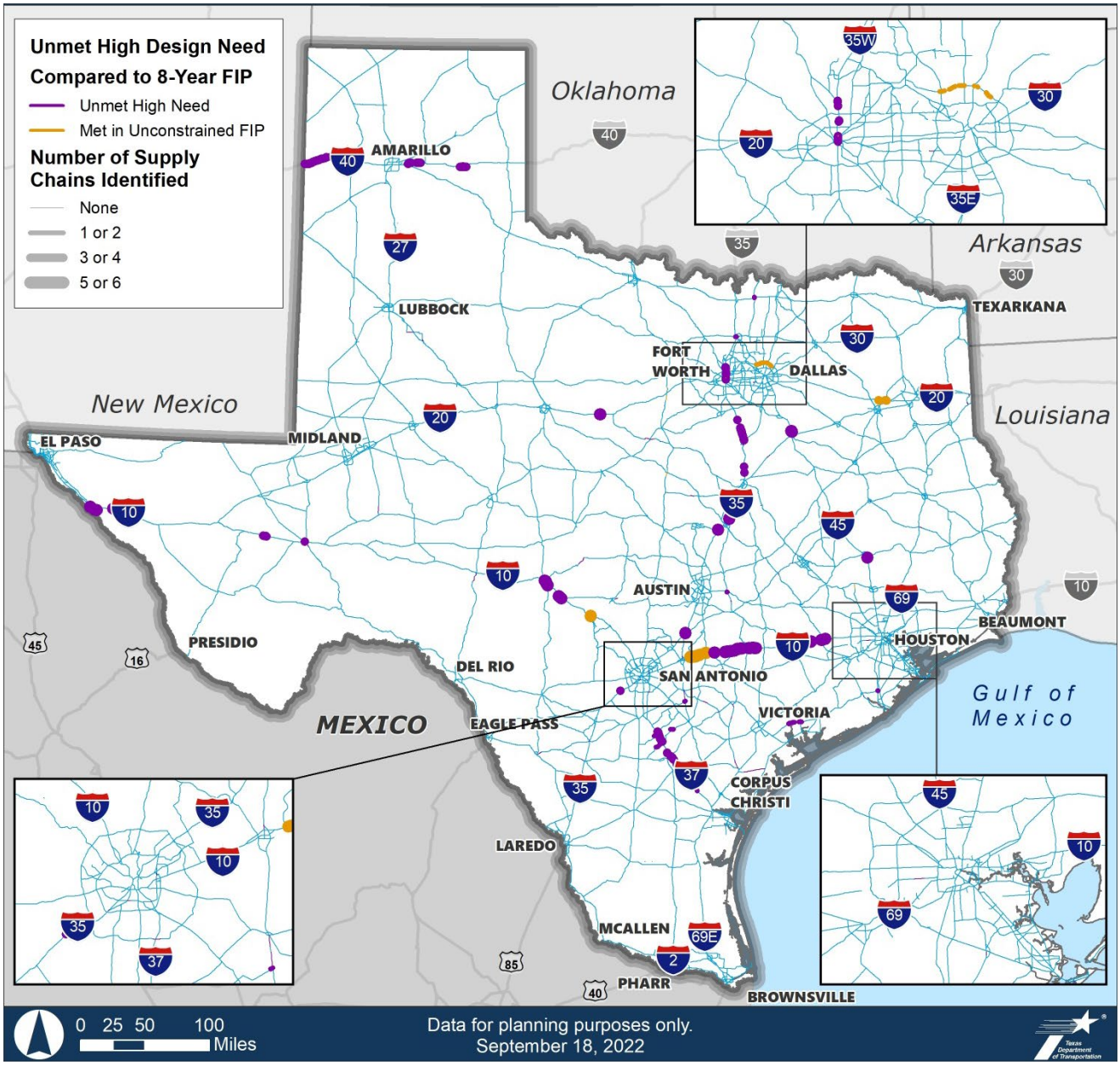
Unmet asset management needs (**Exhibit 66**) and unmet design needs (**Exhibit 67**) are less common, in part due to the assumption that every project likely to impact freight movement will address these concerns to some extent. Individual project elements could be compared to needs during the project development process to confirm non-optimal elements are maintained and designed for freight movement.

EXHIBIT 66: UNMET ASSET MANAGEMENT NEEDS ON THE THFN



Source: TxDOT, 2023 Unified Transportation Program.

EXHIBIT 67: UNMET DESIGN NEEDS ON THE THFN



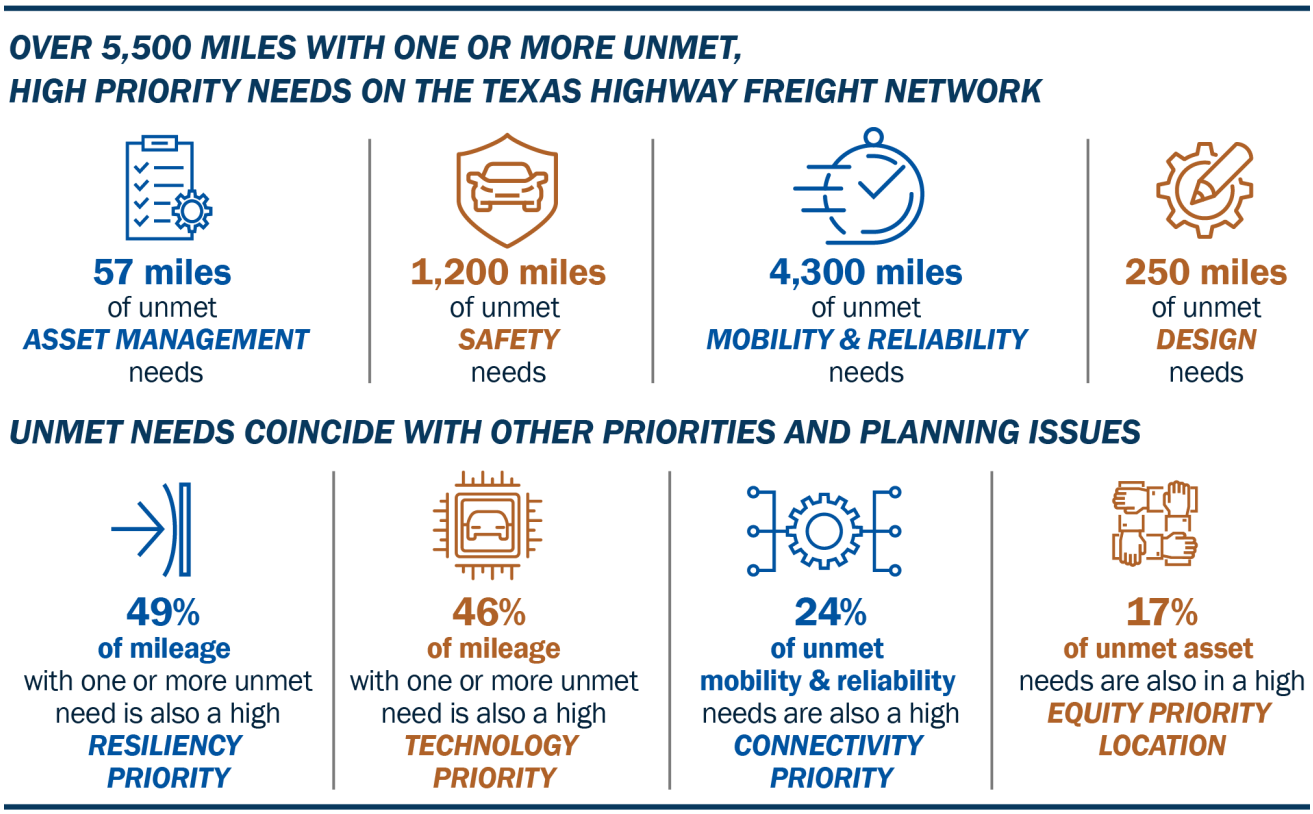
Source: TxDOT, 2023 Unified Transportation Program.

Exhibit 68 summarizes the mileage of unmet infrastructure needs compared to Texas' key supply chains and the system-level needs and opportunities including resiliency, technology, connectivity, and equity.

- The petroleum and transportation supply chain corridors intersect with over 100 miles of unmet safety need each.
- Agriculture, petroleum, and transportation corridors intersect with the greatest unmet mobility and reliability need.

- Over 1,000 miles of unmet mobility and reliability need coincide with the highest priority connectivity needs, highlighting the potential for new connectivity to alleviate reliability challenges.
- The highest risk areas from a resiliency standpoint also contain the greatest unmet asset management need, emphasizing the criticality of improving infrastructure to withstand weather events.

EXHIBIT 68: COMPARING UNMET INFRASTRUCTURE NEEDS TO SUPPLY CHAINS AND SYSTEM-LEVEL NEEDS



Source: TxDOT, 2023 Unified Transportation Program.

10.5 UNMET NEEDS ON THE TEXAS NON-HIGHWAY MULTIMODAL FREIGHT NETWORK

Each of the freight modes has funded and unfunded projects, with many projects shovel ready should funding become available. IIJA increased the percentage of NHFP funds that can be allocated to non-highway freight projects from 10% to 30%. This is an opportunity for TxDOT to help advance unfunded non-highway freight projects included in this Plan and documented in **Appendices C, D, and E**. The following provides a high-level summary of unfunded projects for each mode.

- **Port projects.** The connector ($4.3B) and on-port infrastructure ($1.7B) projects described in the Port Mission Plan and summarized above, represent unfunded or partially funded projects that are ready to advance over the next two years, should funding become available.

- **Waterway projects.** The GIWW projects described above represent unfunded or partially funded projects that can be advanced with funding appropriation. The Brazos River and Colorado River projects are approved projects awaiting federal appropriations with total project cost in excess of $572M. In addition, the annual dredging program for the GIWW is currently funded at $30M per year with a funding gap of $24M per year to bring the entire waterway base to its authorized depth. TxDOT can help close this gap by providing funding to ports for maintenance dredging.

- **Rail projects.** The railroads operating in Texas represent private companies. These railroads invest a significant percentage of their revenue into system maintenance and upgrades annually. The projects presented above represent unfunded or partially funded projects that would provide the state with public benefit (e.g., safety, congestion, economic development). The 56 projects costing almost $1.4B are currently unfunded or partially funded.

- **Border crossing projects.** While border crossing projects are called out in the UTP as part of the list of highway projects, the commercial vehicle border crossings represent key freight gateways in Texas and are called out as a distinct part of the TMFN. As described above, there are over $1.1B in partially funded or unfunded border crossing projects documented in the BTMP that are on the THFN representing 11 projects.

- **Air cargo projects.** The airports included in the TMFN each have CIPs that capture air cargo improvement projects and are considered fully funded. Each of these airports also prepare longer-term masterplans that identify future unfunded needs. While a detailed review of masterplans was not included as part of this Plan update, a few examples of unfunded air cargo projects were identified including relocation of the belly freight facility at AUS and widening of Glade Road between Hwy 360 and West Airfield Drive at DFW.

- **Pipelines.** As described above, the pipeline industry invests significantly in the maintenance and expansion of the state's privately held pipeline network. These projects represent private investment undertaken as needed to serve the oil and gas industry. No information is available on unfunded projects.

Chapter 10 presented funded and unfunded projects for each mode. Chapter 11 presents detailed summaries of three key transformative strategies to support Texas Delivers 2050 and identifies key next steps that will serve as a "call to action.".

Chapter 11 Fueling Economic Growth through Future Goods Movement

Trade, commerce, and the movement of freight have been a cornerstone of the Texas economy for generations. Its geographic location, combined with a diverse and talented labor force, robust multimodal freight network, and favorable business climate have led to Texas being a leader in economic growth and trade.

Positioning the state for continued economic prosperity hinges on positioning the state for the future in freight mobility. While the recommendations and projects put forth in **Chapters 8, 9, and 10** provide the foundation for safe, reliant, equitable, and resilient freight mobility throughout the state, there are three freight mobility initiatives that represent a package of recommendations to help evolve the Texas economy and trade through the next generation of freight mobility solutions.

These three initiatives combine numerous policies, programs, technologies, and project recommendations into a focused framework that will unite public and private sector freight industry leaders, providing a vision of the future that sees Texas build on and expand the dominance and reach of its global supply chains. These game-changing initiatives include a Third Coast Gateway, Texas Automated Freight Vehicle Network, and Freight Mobility Innovation Hubs.

Highlights

Over the last five years, there have been significant changes in global supply chains as businesses have both grown and expanded and have had to overcome significant disruptions.

While many actions taken help sustain and grow current activities, **three freight mobility initiatives** can position Texas for the future.

1) Positioning Texas as the key maritime global gateway of North America
2) Designating and developing an AFVN
3) Developing of a network of freight mobility innovation hubs.

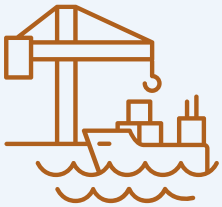
These initiatives require a **vision of what could be** and a willingness to take on additional risk to achieve success.

Texas Delivers 2050 lays out such a vision and a set of recommendations to **drive growth** and continue to **position Texas as a world class logistics hub**.

These three freight mobility initiatives will ensure Texas is a leader in innovation and committed to the future.

STRATEGIC FREIGHT MOBILITY INITIATIVES DRIVING THE FUTURE OF TEXAS

Third Coast Gateway

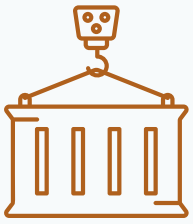


- Create a connected logistics complex within Texas that strengthens Texas' position as a key global gateway serving North America.
- Connect the United States with the world economy, providing supply chain and industrial expansions within Texas and enhance the connections Texas' ports have with Texas, North America, and the world.
- This gateway should have a significant impact on national freight movement trends, changing and strengthening domestic and global supply chains.

Texas Automated Freight Vehicle Network

- Identify, designate, and invest in a statewide automated freight vehicle network to drive the future of Texas as an innovator, leveraging the open regulatory environment the state has created and supporting ongoing private-sector investments in Texas.
- Automated driving systems (ADS) and connected driving systems (CDS) are two of the most potentially transformative technologies being developed, tested, and deployed today, and Texas is serving as an incubator and key testing site.
- ADS and CDS technologies have made significant advancements on the transportation systems in Texas, the United States, and throughout the world and are seen as future solutions to key transportations system challenges.

Freight Mobility Innovation Hubs



- Create a network of freight mobility innovation hubs to serve as incubators to accelerate the deployment and integration of innovative freight technologies into daily supply chain activities, further establishing Texas' position as a leader in innovation.
- The freight mobility innovation hubs would be part of a statewide initiative designed to encourage modernization and advancement of Texas' key industries in rural and urban settings.
- These hubs would help serve as testing grounds for alternative freight delivery concepts such as the freight shuttle, drone/urban air mobility, freight mobility zones, and automated and connected commercial vehicle operations.

11.1.1 THIRD COAST GATEWAY

The Third Coast Gateway is envisioned as a program of projects, technologies, policies, and actions necessary to expand Texas' role as a gateway for global trade. It aims to improve Texas' standing as a leader in global and North American trade. Texas has led the country in exports for 16 consecutive years and is a gateway for trade to and from other states to the rest of the world. Its many competitive ports, highway and rail border crossings, and international pipelines continue to drive Texas' success. However, transportation and technology projects, programs, and policies can be leveraged to further increase the contribution of global trade to the economic well-being of Texas and the nation.

1.8 MILLION
jobs supported by the port industry

597.5 MILLION
total tons of cargo moved makes Texas 1st in U.S. maritime commerce

$102 BILLION
personal income and local consumption supported by the port industry

$7.8 BILLION
State/local tax revenue generated by the port industry

The Texas maritime system includes 11 deep draft ports, nine shallow draft ports, and the 379-mile-long Texas arm of the GIWW. Ports are a vital part of the national freight network, helping farmers move their products to markets overseas, bringing raw materials to Texas manufacturers, and delivering clothes, electronics, and other consumer goods to all Texans. All Texas ports are interconnected by the GIWW, a shallow draft channel that links intrastate barge traffic with ocean-going vessels and handles both domestic and foreign trade.

In 2019, Texas ports generated more than $242 billion in annual overall trade and became the number one state in maritime commerce by tonnage, overtaking Louisiana.[80] Three of the top five ports in the United States based on tonnage were in Texas, with Port Houston becoming the tonnage leader among U.S. ports for the first time.[81] Even during the COVID-19 pandemic, Texas ports remained open for business— protecting jobs, bolstering the economy, and keeping shelves stocked with food and medical supplies for consumers.

The intent of the Third Coast Gateway concept is to create a connected logistics complex within Texas that strengthens Texas' position as one of the key global gateways connecting the United States with the world economy, providing supply chain and industrial expansions within Texas that connect the port system with Texas, North America, and the world. This gateway should have a significant impact on the national freight system, changing and strengthening domestic and global supply chains.

80 USA Trade Online, 2020, United States Census Bureau, U.S. Department of Commerce.

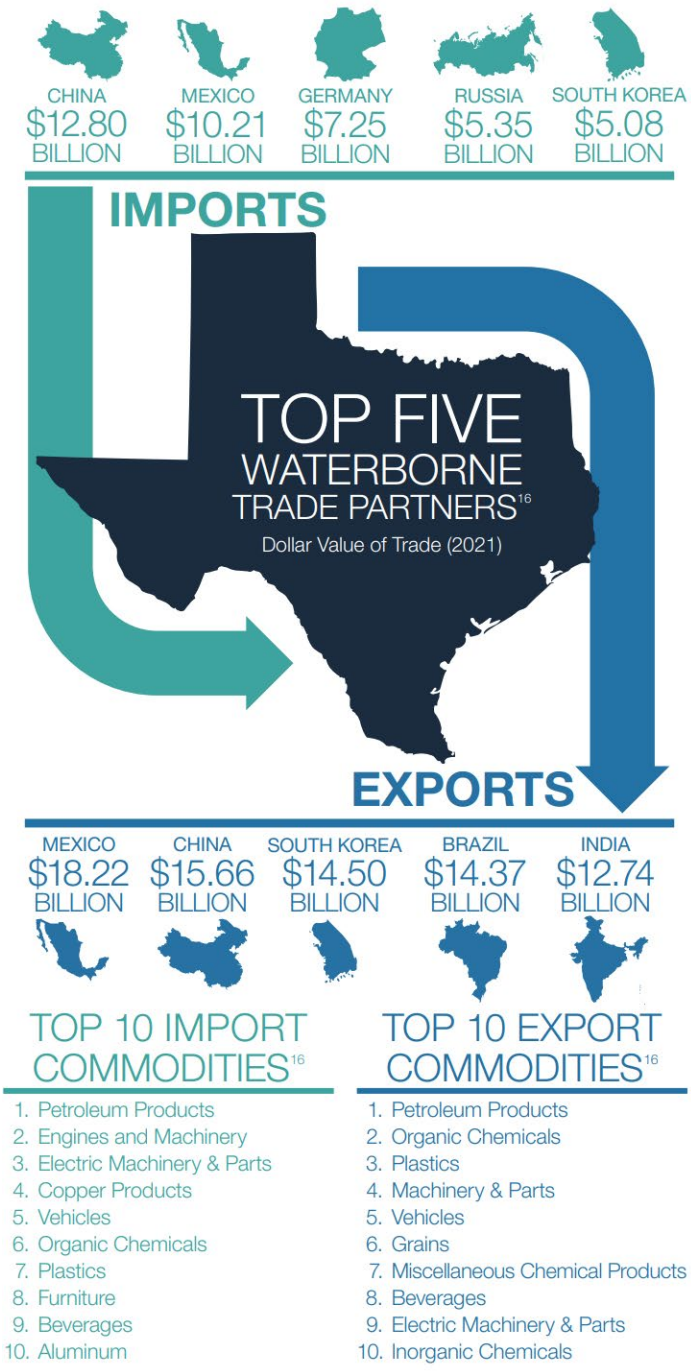
81 Waterborne Commerce Statistics Center, 2020. The U.S. Coastal and Inland Navigation System, 2019 Transportation Facts & Information.

FREIGHT PASSING THROUGH TEXAS PORTS IS VITAL TO KEY INDUSTRIES

Exports of petroleum products, such as oil, gas, LNG, and plastics, are some of the most profitable commodities that are moved through Texas ports. Crude oil production in Texas increased by nearly 60% during the five years before the 2020 pandemic. In December 2015, a 40-year ban on U.S. crude oil exports was removed, and Houston and Corpus Christi became the leading ports for U.S. crude oil exports.[82]

Natural gas is a byproduct of tight crude oil production, and the domestic natural gas market has been oversupplied, resulting in historically low U.S. prices. Texas has the largest refinery capacity of any state, located primarily near Texas ports, and its refineries export a significant portion of their production. LNG is now efficiently shipped overseas from two Texas ports, increasing the available market for Texas natural gas.

Key markets and commodities for the Texas economy and Texas ports are depicted in the adjacent graphic.[83]



82 Texas Ports: Essential to the Economy, TxDOT and the Texas Maritime Transportation System, TxDOT, Transportation Planning and Programming, Maritime Division, 2021.

83 2024-2025 Port Mission Plan, TxDOT Maritime Division. 2024-2025 Texas Port Mission Plan (txdot.gov).

To better support Texas businesses, the maritime industry must continually improve port facilities, waterways, inland connectivity to the ports, and the GIWW via maritime improvement projects. Port project needs are outlined in the 2024-2025 Texas Port Mission Plan. However, to fully leverage the economic opportunity of the state's port and waterway system, a comprehensive strategy is needed that addresses landside access, market connectivity, labor and workforce, technology deployments, energy diversification, supply chain resiliency, vital partnerships, and community impacts.

This initiative should address at a minimum the following:

- **Port and waterway capacity expansion** – to include terminal capacity and efficiency projects, and harbor deepening and navigational improvements.
- **Roadway connector improvements** – to include capacity and operational improvements on the roadway network providing first-/last-mile connectivity to port facilities.
- **Railroad connector improvements** – to include rail improvements to, and in some cases new, connections to port facilities to support port efficiencies, market access, and expanded modal options.
- **Warehouse and distribution center expansion** – to include investments in international warehouse and distribution center capacity to serve U.S. hinterland markets.
- **Industrial and manufacturing expansion** – to include continued development and attraction of industrial business in Texas to support key emerging industries like automated vehicles, as well as new near or home sourcing opportunities.
- **Roadway and railroad corridor improvements** – to include new capacities and improved connections to U.S. and North American markets for cargo moving through Texas ports.
- **Workforce development programs** – to include new and expanded worker training programs including high school, trade school, apprenticeships, and college focused on supply chains and logistics skills.
- **Deployment of emerging technologies** – to include continued leadership in ADS and CDS testing and deployment tied in part to key components of the Third Coast Gateway system.
- **Connectivity to and Integration with Rural Texas** – to include road and rail connections between the key Gateway elements and the agricultural and mining industries located throughout Texas.

TxDOT, in partnership with local and regional governments, other state agencies, ports, impacted communities, and the private sector, should develop a Third Coast Gateway plan that identifies a program of investments, partnerships, policies, and programs to leverage the freight, trade, and commerce opportunities arising from being home to the nation's third coast.

11.1.2 TEXAS AUTONOMOUS FREIGHT VEHICLE NETWORK

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, and improve mobility, access, and public safety. They deliver advanced information exchange, improved connectivity, and integration within and between vehicular operating systems. To leverage the technology and maintain a leadership role in deployment of automated trucks, TxDOT needs to identify, designate, and invest in a statewide automated freight vehicle network.

AUTONOMOUS AND CONNECTED TECHNOLOGIES ARE IN TEXAS TODAY.

There are a growing number of demonstrations and deployments underway 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.

As technology advancements continue, TxDOT 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.

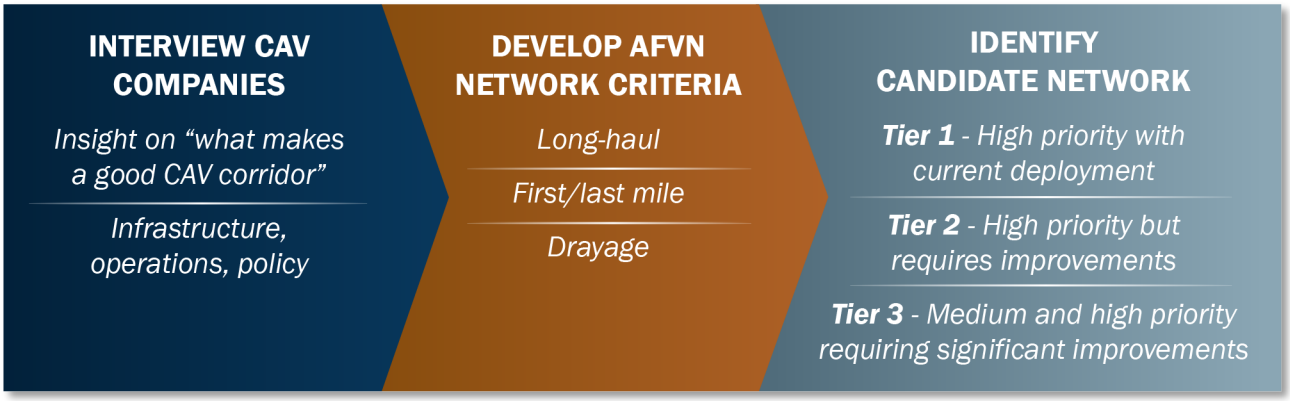
In the context of motor vehicles, the terms automated and connected can cover a wide range of new and existing technologies. In fact, ADS are defined in the Texas Transportation Code as hardware and software that, when installed on a motor vehicle and engaged, are collectively capable of performing without any intervention or supervision by a human operator. Often coupled with terms like electric, advanced, and innovative, these terms generally speak to a broad range of expected features and capabilities in commercial and personal vehicles that will have a significant impact on the transportation and logistics sectors. **Exhibit 69** illustrates the geographic diversity and clustering of current activities taking place in Texas today providing the framework for an innovative future.

EXHIBIT 69: MAJOR TEXAS ADS/CDS ACTIVITIES

Source: TxDOT. Texas Senate Bill 1308 Study, 2022.

DEVELOPING THE TEXAS SOLUTION

The future of freight is changing daily, and Texas is preparing to lead the nation in deploying emerging freight technologies. **To ensure the state and the TMFN are ready, TxDOT should designate and develop the Texas AFVN.** The following is a sample framework that could be enhanced to identify candidate network facilities. Once identified and designated, TxDOT should develop an AFVN masterplan to guide the buildout of the network through projects, policies, programs, and technology deployments.



The designation of the AFVN will be a critical first step in transforming how freight moves, ensuring that Texas remains a leader in innovation, taking an active role in helping support and advance private sector investments. The AFVN will build on key TxDOT initiatives like the Texas Connected Freight Corridors (TCFC) Project and will prioritize based on areas of industry deployment (e.g., Texas Triangle). This network will help prioritize and guide smart infrastructure and technology friendly design investments.

In addition, the designation of the AFVN will create and drive other opportunities throughout Texas. The AFVN will communicate to the private sector that the state is an active partner. It is anticipated this new designation will result in additional testing and deployments by private industry, resulting in further economic success and growth for Texas. The expansion of ADS and CDS in Texas will go beyond the AFVN impacting communities and industries adjacent to, and in some cases off, the AFVN. The AFVN and the resulting growth in ADS and CDS will help create new opportunities for industry and improve safety for communities (e.g., reduced illegal truck parking, improved truck routing). These developments will be a key part of Texas' leadership in freight and logistics innovation.

Examples of key developments and opportunities include but are not limited to:

- **Clustering of Key Freight Activity Centers.** As CAV applications advance, like automated drayage, there is likely to be some clustering of key transload and distribution facilities at inland ports or logistics centers to take advantage of new technology offerings in a shared environment.
- **Urban Delivery – Last 50 Feet.** "Ports-to-porch" or last 50 feet delivery options are rapidly evolving and must be considered early in the planning process to identify policy and legislative requirements. Urban air mobility (drone deliveries), personal delivery devices, which will share space with pedestrians and bicyclists, and other alternative delivery systems will be explored and included in the project development phases.
- **Urban Delivery – Staging.** Dedicated freight mobility innovation zones in urban environments should be incorporated into planning activities to facilitate the shift from commercial vehicles to smaller delivery devices. Similarly, locations for delivery of parcels in dense housing developments could be standardized to increase efficiency and avoid conflicts with other modes.
- **Automated Borders.** Fully automated cross-border freight operations could reduce inspection requirements, thus reducing crossing times and congestion at the Texas-Mexico border. Coupled with truck ports capable of serving traditional and automated trucks, these systems facilitate seamless trade.

The AFVN will help serve as a key incubator to ongoing technology deployment and economic growth in Texas and will be a critical addition to the TMFN. As the ADS/CDS industry continues to test and deploy vehicles and systems equipped with these technologies, there is a long-term benefit to the economy and public safety. The ongoing S.B. 1308 Study, commissioned by the Texas Legislature in 2021, specifically looks at the impacts of ADS and CDS technologies on border operations, public safety, and transportation workforce. Under all future scenarios, these technologies are estimated to have a positive impact on the state of Texas, and technology stakeholders communicated the need and desire for “smart infrastructure” which the AFVN would help advance.

TxDOT, in partnership with the private sector, should designate and invest in the AFVN, building on the significant work completed to date by the state on regulatory reform, development of key strategies like the Texas Connected Freight Corridor, and ongoing investments by the private sector in development, testing, and deployment of automated and connected driving systems.

11.1.3 FREIGHT MOBILITY INNOVATION HUBS

Texas is home to one of the most developed and expansive multimodal freight transportation systems in the world. With that said, Texas Delivers 2050 lays out a set of recommendations to drive future success by ensuring the system continues to evolve and meet the growing and changing needs of industry. A third key initiative supports the Third Coast Gateway and Texas Automated Freight Network initiatives discussed above. This third initiative involves the creation of Freight Mobility Innovation Hubs.

These hubs will serve as incubators to help accelerate the deployment and integration of innovative freight technologies in daily supply chain activities. Deployment would be accomplished by helping co-locate similar innovators and the users of those innovations to advance the state of the practice. These hubs would help serve as testing grounds for alternative freight delivery concepts such as the freight shuttle, drone/urban air mobility, freight mobility zones, and automated and connected commercial vehicle operations. This would rely on partnerships with the private sector. Key economic development organizations, beginning with the Governor's Office of Economic Development, would also need to be engaged to help attract and fund key activities.

Given the size and diversity of Texas, **a network of hubs should be developed in key rural and urban settings throughout the state.** Each site would be customized to support the unique needs of the industries in the region. While the technologies themselves may be similar, their applications would be different, with some addressing urban delivery, while others might address automated farm equipment.

These freight mobility innovation hubs would be part of a statewide initiative designed to support the modernization and advancement of Texas' key industries. This initiative would begin with the development of a strategic plan by TxDOT and its partners that will identify the vision/mission, key objectives, geographic coverage, focus areas, key partners, roles and responsibilities, business model, possible economic incentives, and more. This effort should be coordinated with existing economic development and incubator programs as well as the ongoing efforts by TxDOT related to CAVs and innovation.

The private sector in Texas has already begun to invest in and develop "innovation hubs" to help bring together like-minded companies to help support and advance innovative business practices and technology applications. The freight mobility innovation hub concept would complement the efforts of these organizations, as well as help expand the "innovation incubator" concept throughout Texas to a diverse rural and urban marketplace. Key elements of this initiative will be to learn from, support, and expand on these best practices to benefit all of Texas. Two examples of industry leaders are summarized in the two call outs including AllianceTexas and Houston Regional Express Access Lanes (REAL).

AllianceTexas

AllianceTexas is home to the Mobility Innovation Zone (MIZ), a one-of-a-kind infrastructure offering mobility visionaries full access to an unparalleled ecosystem, resources, and partnerships essential to comprehensively scale and commercialize new technologies. Automated truck technology is essential to improve the middle mile and long-haul delivery systems across the supply chain.

The MIZ is a unique landscape built on collaboration and opportunity. That combination works to connect people, places, and ideas which push innovation in surface mobility forward. At AllianceTexas, ideas become real-world advancements in automated freight transportation.

Surging demand has stressed the supply chain and made automated truck technology essential to optimize freight movement. With smart infrastructure, multimodal ports, and access to miles of major roadways in every direction, the MIZ is an ideal hub for innovation in automated transport vehicles.

Automated truck technology will transform freight transportation, driving cost savings and operational efficiency across the supply chain.

Automated Drayage Over Private and Public Roads

Move cargo from intermodal yards along public and private roads to a distribution center using automated transport trucks.

Automated Logistics Integration in Long-Haul Trucking

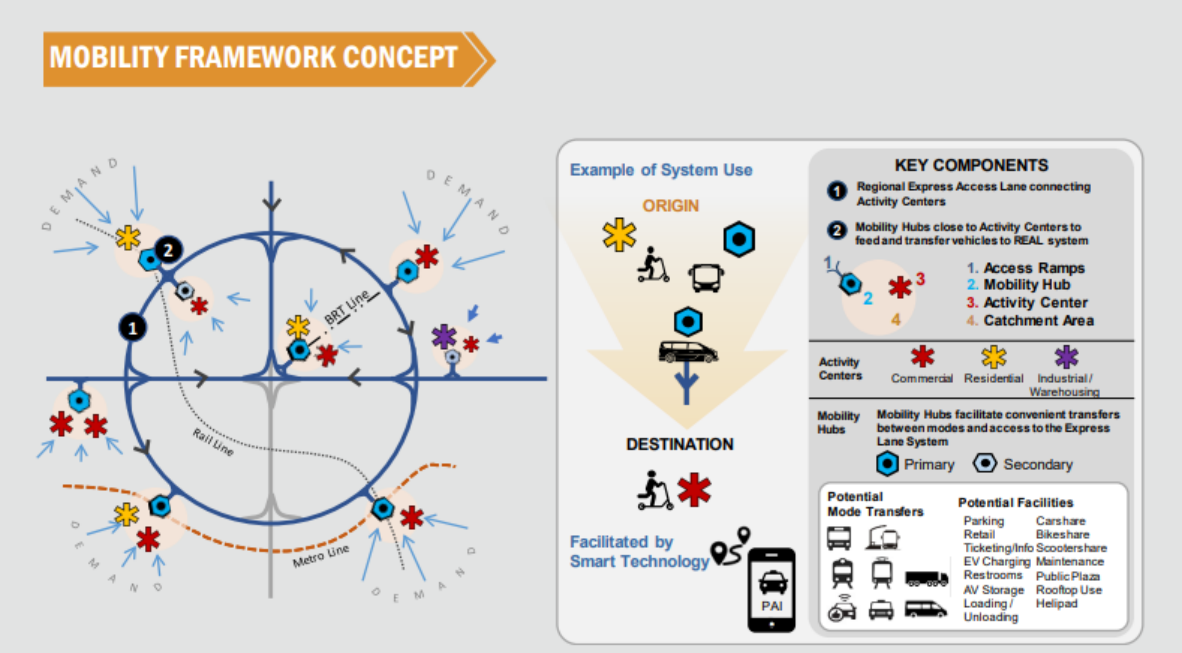
Automated vehicles move cargo from an intermodal yard or distribution center to a transfer hub for pick-up by long-haul automated freight vehicles.

Unmanned Aircraft System Innovations

As technology advancement of Unmanned Aircraft Systems (UAS) outpaces regulation, the establishment of a UAS proving grounds within the MIZ will allow for private- and public-stakeholders to accelerate the development and commercialization of UAS technologies and solutions while informing the future regulatory framework in suburban and urban settings. The accelerated adoption of UAS depends on the ability to test new mobility innovations safely and effectively. Part industrial and part residential, the MIZ makes it possible for drone delivery testing to scale in a real-world environment, reaching neighboring residential communities.

Houston REAL

TxDOT's Houston District is developing a comprehensive plan entitled, The Regional Express Access Lanes (REAL) Plan. The REAL Plan proposes an agile transportation system connected through mobility hubs that will mitigate some of the region's most pressing mobility problems and be adaptable to future growth and innovation. REAL is an improved and scalable mobility concept which starts in neighborhoods and provides users a multimodal, interconnected transportation system to move people and freight to their destination safely and more reliably. The REAL system will provide enhanced transportation choices and improved access to opportunities for the entire region.



TxDOT, in partnership with local communities and the private sector, should develop freight mobility innovation hubs. These hubs would function as incubators for advanced freight delivery systems, ensuring Texas' freight system remains cutting edge while helping the state attract and compete for the most innovative businesses.

The three key initiatives described above overlap with each other and are fed by the other policy, program, and technology recommendations presented in Texas Delivers 2050 — all designed to drive the success and competitiveness of Texas.

Chapter 12
Implementing the Recommendations

Texas Delivers 2050 lays out a set of recommendations to drive the future of Texas' freight program. These recommendations build on the work completed as part of the 2018 TMFP and represent policies, programs, and projects to yield supportive, stimulative, and transformative outcomes for freight mobility, reliability, and safety.

To be successful, the freight program must effectively combine a mix of recommendations to take advantage of economic opportunities and mitigate the challenges facing freight mobility. The recommendations presented in this chapter are grouped into the following categories:

- **Policies** ensure the actions hold true to the freight vision and its direct connection to TxDOT's multimodal long-range plan, the Texas Transportation Plan.
- **Programs** ensure the actions result in established processes and procedures to support the policies by creating transparent, repeatable initiatives designed to achieve specific goals.
- **Technology and operations** ensure the freight program incorporates innovations in the freight transportation industry.

Highlights

Three broad approaches:

1. Supportive

Maintaining and sustaining the existing TMFN to meet acceptable conditions and performance targets is necessary for Texas to serve its existing businesses and residents and maintain competitiveness.

2. Stimulative

Enhancing the TMFN to improve conditions and performance above current levels while ensuring equitable freight mobility solutions positions Texas to continue to retain and attract people, businesses, and jobs and to preserve the quality of life for all Texans.

3. Transformative

Evolving the TMFN to position for emerging technology that will revolutionize freight mobility ensures a resilient, equitable, and efficient freight network necessary for Texas to lead in innovation and economic growth.

Achieving Texas' freight mobility vision requires recommendations across these three approaches be advanced simultaneously.

12.1 KEY ACTIONS TO IMPLEMENT RECOMMENDATIONS

Completion and adoption of Texas Delivers 2050 is just the beginning. To meet the challenges of today and tomorrow, the recommendations presented in **Chapters 8, 9**, and expanded upon in **11** must be advanced. Most of these recommendations will be led by TxDOT, but even those supported by TxDOT will need leadership from the state to fulfill the "call to action." The **22 Policy Recommendations, 8 Program Recommendations,** and **14 Technology and Operational Recommendations** provide a roadmap for TxDOT and its partners. The actions for each of these recommendations are summarized below in **Exhibit 70, Exhibit 71,** and **Exhibit 72** and are grouped as supportive, stimulative or transformative and by short and medium term.

EXHIBIT 70: POLICY ACTIONS

	Short-term	Medium-term
Supportive	TxDOT should continue to expand and administer a comprehensive and multimodal freight-planning program that integrates freight considerations and needs within TxDOT's performance-based project selection process.	TxDOT should evaluate feasibility of incorporating freight infrastructure design standards with respect to commercial vehicle movement on the Texas Highway Freight Network.
	TxDOT should ensure effective implementation of Texas Delivers 2050 through a commitment to appropriate staffing and resources, subject to legislative appropriations.	TxDOT should continue implementing the new vertical clearance standard of 18 feet 6 inches on the Texas Highway Freight Network.
	TxDOT should comply with federal requirements for freight planning and future project funding eligibility.	TxDOT should encourage public- and private-sector partnerships that target the various modes and users of the freight transportation network.
	TxDOT should integrate freight considerations into TxDOT district and MPO planning, project development, programming, and implementation efforts.	TxDOT should identify multimodal opportunities, in coordination with private sector, to address current and projected freight flows.
	TxDOT should include freight considerations in the UTP project development and prioritization process.	TxDOT should partner with local planning partners on strategies to address urban freight congestion and bottlenecks.
	TxDOT should identify, preserve, protect, and invest in the Texas Multimodal Freight Network across the state.	TxDOT should continue to invest in the Texas Trunk system, including CRFCs, to enable the transport of energy, food, and other critical raw materials.

	Short-term	Medium-term
	TxDOT should support strategic initiatives of the Governor's Office of Economic Development & Tourism.	TxDOT should support industry efforts to enhance workforce training, recruitment and retention in the transportation and logistics industries.
	TxDOT should, in coordination with planning partners, address freight movement safety "hot spots".	TxDOT should improve binational coordination and planning to expedite the delivery of border crossing projects.
	TxDOT should monitor and support appropriate policies that encourage technology deployment while ensuring public interests are protected.	TxDOT should expand the development of advanced real-time information systems and increase the dissemination of dynamic travel information.
	TxDOT should explore funding for existing freight programs, such as the Texas Rail Relocation Fund, Port Access Account Fund, and the Ship Channel Improvement Fund.	TxDOT should, in partnership with the railroads, support strategies that reduce the number of at-grade highway/rail crossings.
Stimulative	TxDOT should further the understanding of the role of the TMFN in supporting the state's key supply chains.	TxDOT should target investment in the Texas Multimodal Freight Network as a critical component of the state's economy and to enhance supply chain fluidity.
	TxDOT should identify opportunities to advance high priority multimodal projects based on the increased availability of National Highway Freight Program funds for intermodal projects.	TxDOT, in coordination with the railroads, support rail connections to the international border to alleviate congestion at key freight gateways, freight generators and ports of entry.
	TxDOT, in coordination with its planning partners and the private sector support growing e-commerce and urban freight deliveries such as drones and delivery robots.	TxDOT should develop and incorporate resiliency performance measures in transportation planning, policy, and infrastructure investment decisions.
	TxDOT, in coordination with its planning partners, advance a Third Coast Global Gateway concept of a one-stop, unified, coordinated, and comprehensive information portal for all transportation modes.	TxDOT, in coordination with its planning partners, continue the advancement of recommendations from the Statewide Truck Parking Study.
	TxDOT should pursue federally available funds through discretionary grants for multimodal freight projects.	TxDOT should coordinate on a statewide traffic management system by integrating data provided by existing traffic management centers to provide comprehensive traveler information.

	Short-term	Medium-term
	TxDOT should improve communication between public agencies to streamline project delivery and build consistency among various jurisdictions in regulations, permitting, planning and preservation of the freight network.	TxDOT should advance the highest priority projects on the Texas Multimodal Freight Network by ensuring they are fully funded.
	TxDOT should expand stakeholder outreach for freight planning efforts to include community and public outreach using high- and low-tech techniques, especially in vulnerable communities.	
Transformative	TxDOT should designate an Automated Freight Vehicle Network (AFVN) in coordination with the private sector to prepare for the future of freight mobility by identifying and investing in the most promising facilities on the TMFN for early technology deployment.	TxDOT should partner with emerging technology leaders and the private sector to ensure Texas is a leader for freight mobility technology.
	TxDOT should develop guidance for MPOs and local planners on how to update complete streets policies to include the full range of passenger and freight modes.	TxDOT should advance the Weigh-in-Motion (WIM) and Vehicle Classification (VC) strategic plan.
	TxDOT, in coordination with its planning partners, establish a Third Coast Global Gateway task force.	The state should develop digital infrastructure and integration policies necessary to enable the development of digital twins and implementation of emerging freight mobility technologies.
	TxDOT should support the establishment of a statewide Supply Chain Council consisting of industry representatives to advise various state agencies on a variety of supply chain challenges and opportunities.	TxDOT should encourage development of advanced air mobility options in Texas.
	TxDOT should monitor the development of the policies, programs, and infrastructures necessary to accommodate fuel diversification by freight network users.	TxDOT should support technology and operational strategies and deployment of integrated border- crossing management solutions.
	TxDOT should encourage a robust community impact assessment and outreach program related to freight movement that includes examining community impacts and evaluating and communicating the equity considerations of those impacts.	TxDOT should examine alternative public funding sources that provide adequate, stable, and equitable revenue streams given the trends impacting future freight transportation demand and operations.

EXHIBIT 71: PROGRAM ACTIONS

	Short	Medium
Supportive	TxDOT should develop a Texas Delivers 2050 roll-out plan to include TxDOT Divisions and Districts, MPOs and other planning partners, and the private sector.	TxDOT should develop a statewide supply chain and multimodal freight network resiliency enhancement plan to address implications of disruptions on the TMFN and to key industries and improve the resiliency of the TMFN.
	TxDOT should partner with stakeholders to further the understanding of the economic role of freight.	TxDOT should implement a WIM and VC program to oversee the implementation of the strategic plan.
	TxDOT should advance the BTMP implementation program.	TxDOT should initiate a Truck Parking Availability System (TPAS) program with the goal of expanding TPAS to all interstates in Texas.
	TxDOT should continue to facilitate the binational collaboration through the BTAC, Binational regional advisory councils, and dialogue with the Mexican entities.	TxDOT should develop a first and last mile connectivity program to identify and address the current needs and to enhance the technology readiness of these corridors.
	TxDOT should create a rural freight connectivity program focused on development and implementation of corridor master plans.	
	TxDOT should create a Texas Highway Freight Network Safety Program to improve safety and mobility on the THFN.	.
Stimulative	TxDOT should deliver freight planning training on incorporating freight into planning and operations for TxDOT Divisions, Districts, MPOs, and regional and local planning staff.	TxDOT should develop industrial access and freight supportive land use and development guidance in coordination with private sector industrial developers.
	TxDOT, in coordination with its planning partners, develop a TMFN grant program targeting federal discretionary grants for high priority multimodal freight projects.	TxDOT should support the integration of workforce development opportunities into existing public outreach programs, especially along the TMFN.
	TxDOT should implement the safety warning detection program.	TxDOT should explore “bypass” routes, usage incentives, technology enhancements, and the role of land use in freight bottlenecks relief.
	TxDOT should continue coordination with private sector rail partners to identify funding programs to implement railroad improvements and technology advancements on the TMFN.	TxDOT should partner with airports, and the business and host communities to help implement recommendations developed by the Texas Aviation System Plan.

	Short	Medium
	TxDOT should partner with Texas ports and other private sector stakeholders to identify and implement technology solutions to improve mobility and reliability at Texas ports.	
Transformative	TxDOT should develop an Automated Freight Vehicle Network program to assess and ensure the technology readiness of the state's key trade and commerce routes.	TxDOT should explore demand management strategies aimed at freight trips and logistics service providers as well as consumers and shippers who generate the demand for the freight trips.
	TxDOT, in coordination with its planning partners, should elevate the "3rd Coast" concept as a key gateway of North America.	

EXHIBIT 72: TECHNOLOGY AND OPERATIONS ACTIONS

	Short-term	Medium-term
Supportive	TxDOT should implement WIM/VC Strategic Plan.	TxDOT, in coordination with the railroads, should develop rail crossing management system.
	TxDOT should expand TPAS system to interstates.	TxDOT should integrate freight considerations into the TSMO Plan.
	TxDOT should expand safety warning detection system.	TxDOT should deploy safety warning detection system.
Stimulative	TxDOT should assess feasibility of integrating statewide traffic management information into existing TMCs.	TxDOT should support the expansion of broadband and 5G capabilities along the THFN.
	TxDOT should develop integrated traffic management and operations data exchange platforms.	TxDOT should deploy smart freight connector technology for select TMFN facilities.
Transformative	TxDOT should continue to test and deploy the TCFC system.	TxDOT should develop a binational freight traffic operations system.
	TxDOT should support private sector development of innovative freight mobility hubs.	TxDOT should incorporate machine learning and predictive analysis into its technology solutions.
	TxDOT, in partnership with the private sector, should develop a freight automation program to invest in the AFVN.	

12.2 IMMEDIATE NEXT STEPS AND CALL TO ACTION

As TxDOT begins to implement these actions it will be necessary to further define timelines, roles and responsibilities, and resources needed, In addition, several immediate next steps should be considered:

- **Advance Texas Delivers 2050 within TxDOT.** The TxDOT Freight Branch should initiate a "road show" for all divisions and all districts. This will provide the opportunity to discuss what parts of the plan and specifically what strategies are of most interest to each unique district and division. This is critical to identify champions for specific strategies.

- **Advance Texas Delivers 2050 with external partners.** The TxDOT Freight Branch should initiate a campaign to share the freight plan to its partners. This should consist of speaking engagements at conferences, key industry meetings, and virtual webinars to give public and private partners the opportunity to understand key recommendations and to communicate level of interest. In addition, TxDOT should develop promotional materials so that regional planning partners and economic development agencies have educational materials to inform their projects. Most of the recommendations have support roles for a variety of stakeholders, so this is critical.

- **Develop action plans for each of the three freight mobility initiatives.** TxDOT should identify project teams for each of three initiatives (Third Coast Gateway, Texas Automated Freight Vehicle Network, Freight Mobility Innovation Hubs). TxDOT's role will vary by initiative, with the most important initial function being to identify and bring the right stakeholders together to begin plan development.

- **Select other key priorities.** Based on the feedback from TxDOT leadership, districts, and divisions and external partners, recommendations can be prioritized based on timeline, available resources, identification of a lead/champion, and overall acknowledgement of value add to the affected stakeholders.

- **Develop project teams.** Once top priorities are selected, project teams and a project management plan should be created to define expectations, key actions, key contacts, and next steps.

- **Develop a strategy tracker.** The TxDOT Freight Branch should create a project tracker for each strategy. As a strategy becomes active, the tracker would provide up-to-date information on key actions and progress. This tracker will help TxDOT monitor the progress, impact, and ultimately the success of each strategy. It also can be used to document why some strategies may be delayed or deemed not to be a priority. This tracker can then be used to feed directly into the next freight plan update.

These initial steps will help ensure the recommendations developed as part of Texas Delivers 2050 are presented, discussed, and advanced based upon agreed upon priorities and available resources. Implementation of these recommendations will be critical to transform goods movement, global trade, and commerce, strengthening the resiliency and competitiveness of Texas' supply chains.

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TEXAS DELIVERS 2050
TEXAS FREIGHT MOBILITY PLAN

Texas Department of Transportation

https://www.txdot.gov/projects/planning/freight-planning.html