Texas Freight Network Technology and Operations Plan

State of the Practice Assessment Report

Final: December 2020
## Contents

1.0 Executive Summary ...................................................................................................... 1
   1.1 *Purpose of the State of the Practice Assessment* ........................................... 1
   1.2 *Freight-Related Groups, Policies, and Initiatives in Texas* ...................... 1
   1.3 *Freight Technology Areas* ........................................................................... 8
   1.4 *Key Opportunities for Texas* ....................................................................... 15

2.0 Introduction ................................................................................................................. 18
   2.1 *Project Overview* ....................................................................................... 18
   2.2 *Texas Multimodal Freight Network* ............................................................. 19
   2.3 *Purpose of the State of the Practice Assessment* ..................................... 22
   2.4 *Organization of the Report* ....................................................................... 22

3.0 Freight-Related Groups, Policies, and Initiatives in Texas ....................................... 23
   3.1 *TxDOT Divisions* ....................................................................................... 23
      3.1.1 *Information Technology Division* ...................................................... 23
      3.1.2 *Maritime Division* ............................................................................. 23
      3.1.3 *Rail Division* .................................................................................... 24
      3.1.4 *Research and Technology Implementation Division* ...................... 24
      3.1.5 *Strategic Planning Division* .............................................................. 25
      3.1.6 *Traffic Safety Division* .................................................................... 25
      3.1.7 *Transportation Planning and Programming Division* .................... 26
      3.1.8 *Travel Information Division* .............................................................. 26
      3.1.9 *Bridge Division* .............................................................................. 26
      3.1.10 *Aviation Division* ........................................................................... 27
   3.2 *TxDOT Advisory Committees* .................................................................... 27
      3.2.1 *Texas Freight Advisory Committee* ................................................ 27
      3.2.2 *Port Authority Advisory Committee* .............................................. 27
      3.2.3 *Border Trade Advisory Committee* ................................................. 28
      3.2.4 *Aviation Advisory Committee* ......................................................... 28
   3.3 *Texas Programs and Initiatives* ................................................................... 28
      3.3.1 *Statewide Transportation Systems Management and Operations Program* .............................................................. 29
      3.3.2 *Statewide ITS Strategic Plan* .............................................................. 31
      3.3.3 *Emerging Transportation Technology Plan* .................................... 31
      3.3.4 *Connected and Autonomous Vehicle Task Force* ....................... 32
      3.3.5 *Cooperative Automated Transportation Program* ......................... 32
      3.3.6 *I-10 Corridor Coalition* ................................................................. 33
      3.3.7 *Texas Connected Freight Corridors Project* ................................... 33
      3.3.8 *Enterprise Information Management Program* .............................. 34
      3.3.9 *Texas Technology Task Force* ......................................................... 34
      3.3.10 *Texas Innovation Alliance* .............................................................. 34
      3.3.11 *Texas State Transportation Innovation Council* ......................... 35
      3.3.12 *Intelligent Transportation Society of Texas* .................................. 36
   3.4 *TxDOT Partner Agencies* ............................................................................. 36
      3.4.1 *Texas Department of Public Safety* .................................................. 36
3.4.2 Texas Division of Motor Vehicles ....................................................... 36
3.4.3 Governor’s Broadband Development Council................................. 37
3.4.4 Texas State Energy Conservation Office......................................... 37
3.4.5 United States Customs and Border Protection ................................. 37
3.4.6 United States Department of Transportation ................................. 37
3.5 Research Institutes .............................................................................. 38
3.5.1 Texas A&M Transportation Institute ............................................... 38
3.5.2 University of Texas at Austin Center for Transportation Research... 39
3.5.3 Southwest Research Institute ......................................................... 39
4.0 Freight Technology Areas .................................................................... 40
4.1 Traffic Management ........................................................................... 40
4.1.1 Traffic Management Programs and Technology Developments in Texas .................................................................................. 41
4.1.2 Domestic and International Traffic Management Programs and Technology Developments .......................................................... 49
4.2 Advanced Traveler Information Systems .............................................. 63
4.2.1 ATIS Programs and Technology Developments in Texas ............... 64
4.2.2 Domestic and International ATIS Programs and Technology Developments ..................................................................................... 71
4.3 Dynamic Route Guidance .................................................................. 77
4.3.1 Dynamic Route Guidance Programs and Technology Developments in Texas ................................................................................ 78
4.3.2 Domestic and International Dynamic Route Guidance Programs and Technology Developments .......................................................... 79
4.4 Data Integration and Analytics ............................................................... 83
4.4.1 Data Integration and Analytics Programs and Technology Developments in Texas ............................................................................ 83
4.4.2 Domestic and International Data Integration and Analytics Programs and Technology Developments .......................................................... 87
4.5 Enforcement and Inspection ................................................................. 96
4.5.1 Enforcement and Inspection Programs and Technology Developments in Texas ................................................................................ 98
4.5.2 Domestic and International Enforcement and Inspection Programs and Technology Developments .......................................................... 107
4.6 Connected and Automated Freight Vehicles ....................................... 110
4.6.1 CAV Programs and Technology Developments in Texas .............. 111
4.6.2 Domestic and International CAV Programs and Technology Developments ..................................................................................... 119
4.7 Intermodal Terminal Operations .......................................................... 123
4.7.1 Intermodal Terminal Operations Programs and Technology Developments in Texas ............................................................................ 125
4.7.2 Domestic and International Intermodal Terminal Operations Programs and Technology Developments .......................................................... 132
## 5.0 Summary and Conclusion

5.1 Texas Freight Transportation Needs
5.2 Freight-Related Groups, Policies, and Initiatives in Texas
5.3 Freight Technology Areas
5.4 Key Opportunities for Texas
5.5 Next Steps

## 6.0 References
Exhibits

Exhibit 1: Summary of Freight-Related Groups, Policies, and Initiatives in Texas ........................................... 2
Exhibit 2: Freight Technology Areas .................................................................................................................. 9
Exhibit 3: Summary of Freight Technology Areas in Texas ............................................................................. 11
Exhibit 4: Overview of Texas Multimodal Freight Network Assets ..................................................................... 20
Exhibit 5: The Texas Multimodal Freight Network .......................................................................................... 21
Exhibit 6: Statewide TSMO Goals and Objectives .......................................................................................... 30
Exhibit 7: Summary of Traffic Management Programs and Technology Developments in Texas .......... 42
Exhibit 8: Texas Connected Freight Corridors Deployment Site Map .............................................................. 44
Exhibit 9: Texas Connected Freight Corridor Traffic Management Applications ........................................... 45
Exhibit 10: Gulfway Drive Corridor Location in Port Arthur ............................................................................... 47
Exhibit 11: Port of Brownsville and Connecting Roads of SH 550 and FM 511 ................................................. 48
Exhibit 12: State Highway 48/State Highway 4 Corridor Location ................................................................. 49
Exhibit 13: Summary of Domestic and International Traffic Management Programs and Technology Developments ................................................................................................................................ 49
Exhibit 14: San Diego I-15 ICM Demonstration Site ......................................................................................... 55
Exhibit 15: Dynamic Message Signs on I-15 .................................................................................................... 56
Exhibit 16: I-15 ICM Alternate Route Wayfinding Sign Locations ................................................................. 57
Exhibit 17: I-75 Florida’s Regional Advanced Mobility Elements Study Area ................................................. 58
Exhibit 18: Summary of Advanced Traveler Information System Programs and Technology Developments in Texas ............................................................................................................................................. 64
Exhibit 19: DriveTexas Screenshot .................................................................................................................. 69
Exhibit 20: Summary of Domestic and International Advanced Traveler Information System Programs and Technology Developments .................................................................................................................. 71
Exhibit 21: Summary of Dynamic Route Guidance Programs and Technology Developments in Texas ............................................................................................................................................. 78
Exhibit 22: Summary of Domestic and International Dynamic Route Guidance Programs and Technology Developments .................................................................................................................. 79
Exhibit 23: Bentley SUPERLOAD System ...................................................................................................... 82
Exhibit 24: Summary of Data Integration and Analytics Programs and Technology Developments in Texas ............................................................................................................................................. 84
Exhibit 25: Proposed Road Condition Reporting Information Flow ............................................................. 86
Exhibit 26: Summary of Domestic and International Data Integration and Analytics Programs and Technology Developments ............................................................................................................................................. 88
Exhibit 27: 511 San Francisco Bay Interface .................................................................................................... 90
Exhibit 28: FAST Dashboard—Performance Monitoring and Measurement System .................................... 91
Exhibit 29: Colorado’s COtrip Web Portal ......................................................................................................... 92
Exhibit 30: Florida’s Freight Operations Exchange Data Sources and Interactions ....................................... 94
Exhibit 31: Texas Department of Public Safety Enforcement Locations ......................................................... 97
Exhibit 32: Summary of Enforcement and Inspection Programs and Technology Developments in Texas ............................................................................................................... 98
Exhibit 33: Pre-Clearance Systems Deployment as of 2018 ................................................................. 100
Exhibit 34: Weigh Station Network, PrePass ......................................................................................... 101
Exhibit 35: Drivewyze Bypass Service Site Locations ........................................................................ 101
Exhibit 36: Weigh-In-Motion Stations Statewide ................................................................................... 104
Exhibit 37: Overheight Vehicle Detection Deployments Statewide ...................................................... 105
Exhibit 38: Automated Infrared Screening System Image (Left) and Tire Anomaly Classification System (Right) ..................................................................................................... 106
Exhibit 39: Summary of Domestic and International Enforcement and Inspection Programs and Technology Developments ............................................................................................................................... 107
Exhibit 40: Summary of Connected and Automated Freight Vehicle Programs and Technology Developments in Texas ................................................................................................................ 111
Exhibit 41: Summary of Domestic and International CAV Programs and Technology Developments ........................................................................................................................................................................... 119
Exhibit 42: European Truck Platooning Route Map .............................................................................. 122
Exhibit 43: Summary of Intermodal Terminal Operations Programs and Technology Developments in Texas ........................................................................................................................................................................... 125
Exhibit 44: Ports Included in the Texas Port Connectivity Study ........................................................... 128
Exhibit 45: Texas Port Connectivity Report Projects .............................................................................. 129
Exhibit 46: Map of Joe Fulton International Trade Corridor .................................................................. 130
Exhibit 47: Summary of Domestic and International Intermodal Terminal Operations Programs and Technology Developments ........................................................................................................ 132
Exhibit 48: RCVW Application Concept .............................................................................................. 137
Exhibit 49: Sensys Networks Queue Detection System ......................................................................... 139
Exhibit 50: 2018 Texas Freight Mobility Plan: Texas Freight Transportation Needs and Challenges ................................................................................................................................. 143
Exhibit 51: 2018 Texas Freight Mobility Plan Technology and Operations Program .............................. 144
Exhibit 52: Summary of Freight-Related Groups, Policies, and Initiatives in Texas ......................... 145
Exhibit 53: Summary of Freight Technology Areas ................................................................................ 153
<table>
<thead>
<tr>
<th>Acronyms</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>AASHTO</td>
<td>American Association of State Highway and Transportation Officials</td>
</tr>
<tr>
<td>AAR</td>
<td>American Association of Railroads</td>
</tr>
<tr>
<td>ACE</td>
<td>Automated Commercial Environment</td>
</tr>
<tr>
<td>ADM</td>
<td>Archer-Daniels Midland</td>
</tr>
<tr>
<td>ADS</td>
<td>Automated Driving Systems</td>
</tr>
<tr>
<td>ADVI</td>
<td>Australian Driverless Vehicle Initiative</td>
</tr>
<tr>
<td>AGV</td>
<td>Automated Guided Vehicles</td>
</tr>
<tr>
<td>ASC</td>
<td>Automated Stacking Cranes</td>
</tr>
<tr>
<td>AI</td>
<td>Artificial Intelligence</td>
</tr>
<tr>
<td>Alameda CTC</td>
<td>Alameda County Transportation Commission</td>
</tr>
<tr>
<td>AFV</td>
<td>Alternative Fuel Vehicle</td>
</tr>
<tr>
<td>AFN</td>
<td>Autonomous Freight Network</td>
</tr>
<tr>
<td>API</td>
<td>Application Programming Interface</td>
</tr>
<tr>
<td>ASCT</td>
<td>Adaptive Signal Control Technology</td>
</tr>
<tr>
<td>ATCMTD</td>
<td>Advanced Transportation and Congestion Management Technologies Deployment</td>
</tr>
<tr>
<td>ATIS</td>
<td>Advanced Traveler Information System</td>
</tr>
<tr>
<td>AV</td>
<td>Automated Vehicle</td>
</tr>
<tr>
<td>AVI</td>
<td>Automatic Vehicle Identification</td>
</tr>
<tr>
<td>AVL</td>
<td>Automatic Vehicle Locator</td>
</tr>
<tr>
<td>BCO</td>
<td>Beneficial Cargo Owner</td>
</tr>
<tr>
<td>BTMP</td>
<td>Border Transportation Master Plan</td>
</tr>
<tr>
<td>Caltrans</td>
<td>California Department of Transportation</td>
</tr>
<tr>
<td>CAT</td>
<td>Cooperative Automated Transportation</td>
</tr>
<tr>
<td>CAV</td>
<td>Connected and Automated Vehicle</td>
</tr>
<tr>
<td>CBP</td>
<td>Customs and Border Protection</td>
</tr>
<tr>
<td>CBTC</td>
<td>Communication Based Train Control</td>
</tr>
<tr>
<td>CCTV</td>
<td>Closed-Circuit Television</td>
</tr>
<tr>
<td>CHP</td>
<td>California Highway Patrol</td>
</tr>
<tr>
<td>COoFF</td>
<td>Corridor Optimization for Freight</td>
</tr>
<tr>
<td>CMV</td>
<td>Commercial Motor Vehicle</td>
</tr>
<tr>
<td>CNDB</td>
<td>Container Number Database</td>
</tr>
<tr>
<td>CRISI</td>
<td>Consolidated Rail Infrastructure and Safety Improvements</td>
</tr>
<tr>
<td>CTECC</td>
<td>Combined Transportation, Emergency &amp; Communications Center</td>
</tr>
<tr>
<td>CTR</td>
<td>University of Texas at Austin Center for Transportation Research</td>
</tr>
<tr>
<td>CV</td>
<td>Connected Vehicle</td>
</tr>
<tr>
<td>CVIEW</td>
<td>Commercial Vehicle Information Exchange Window</td>
</tr>
<tr>
<td>CVISN</td>
<td>Commercial Vehicle Information Systems and Networks</td>
</tr>
<tr>
<td>CVSA</td>
<td>Commercial Vehicle Safety Alliance</td>
</tr>
<tr>
<td>DART</td>
<td>Dallas Area Rapid Transit</td>
</tr>
<tr>
<td>DATEX</td>
<td>Data Exchange</td>
</tr>
<tr>
<td>DelDOT</td>
<td>Delaware Department of Transportation</td>
</tr>
<tr>
<td>DFW</td>
<td>Dallas-Fort Worth</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>DHS</td>
<td>Department of Homeland Security</td>
</tr>
<tr>
<td>DMS</td>
<td>Dynamic Message Sign</td>
</tr>
<tr>
<td>DPS</td>
<td>Department of Public Safety</td>
</tr>
<tr>
<td>DrayFLEX</td>
<td>Drayage, Freight, and Logistics Exchange</td>
</tr>
<tr>
<td>DSRC</td>
<td>Dedicated Short-Range Communication</td>
</tr>
<tr>
<td>DSS</td>
<td>Decision Support System</td>
</tr>
<tr>
<td>D-STOP</td>
<td>Data-Supported Transportation Operations and Planning Center</td>
</tr>
<tr>
<td>EARP</td>
<td>Exploratory Advanced Research Program</td>
</tr>
<tr>
<td>EDM</td>
<td>Enterprise Data Management</td>
</tr>
<tr>
<td>EDI</td>
<td>Electronic Data Interchange</td>
</tr>
<tr>
<td>EDITS</td>
<td>European Digital Traffic Infrastructure for Intelligent Transport Systems</td>
</tr>
<tr>
<td>EEBL</td>
<td>Emergency Electronic Brake Lights</td>
</tr>
<tr>
<td>EMAS</td>
<td>Expressway Monitoring and Advisory System</td>
</tr>
<tr>
<td>EMC</td>
<td>Emergency Management Center</td>
</tr>
<tr>
<td>ENSEMBLE</td>
<td>Enabling Safe Multi-Brand Platooning for Europe</td>
</tr>
<tr>
<td>EOC</td>
<td>Emergency Operations Center</td>
</tr>
<tr>
<td>eScreening</td>
<td>Electronic Screening</td>
</tr>
<tr>
<td>E-Seal</td>
<td>Electronic Seal</td>
</tr>
<tr>
<td>ETTP</td>
<td>Emerging Transportation Technology Plan</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>FAA</td>
<td>Federal Aviation Administration</td>
</tr>
<tr>
<td>FAST</td>
<td>Freeway and Arterial System of Transportation</td>
</tr>
<tr>
<td>FDOT</td>
<td>Florida Department of Transportation</td>
</tr>
<tr>
<td>FHWA</td>
<td>Federal Highway Administration</td>
</tr>
<tr>
<td>FITS</td>
<td>Freight Intelligent Transportation System</td>
</tr>
<tr>
<td>FNTOP</td>
<td>Freight Network Technology and Operations Plan</td>
</tr>
<tr>
<td>FM</td>
<td>Farm-to-Market</td>
</tr>
<tr>
<td>FMCSA</td>
<td>Federal Motor Carrier Safety Administration</td>
</tr>
<tr>
<td>FOX</td>
<td>Freight Operations Exchange</td>
</tr>
<tr>
<td>FRAME</td>
<td>Florida’s Regional Advanced Mobility Elements</td>
</tr>
<tr>
<td>FRA</td>
<td>Federal Railroad Administration</td>
</tr>
<tr>
<td>FRATIS</td>
<td>Freight Advanced Traveler Information Systems</td>
</tr>
<tr>
<td>FSP</td>
<td>Freeway Service Patrol</td>
</tr>
<tr>
<td>FSP</td>
<td>Freight Signal Priority</td>
</tr>
<tr>
<td>GCCOG</td>
<td>Gateway Cities Council of Governments</td>
</tr>
<tr>
<td>GCT-B</td>
<td>Global Container Terminal Bayonne</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information Systems</td>
</tr>
<tr>
<td>GIWW</td>
<td>Gulf Intracoastal Waterway</td>
</tr>
<tr>
<td>GoPort</td>
<td>Global Opportunities at the Port of Oakland</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>GUI</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>HAR</td>
<td>Highway Advisory Radio</td>
</tr>
<tr>
<td>HAZMAT</td>
<td>Hazardous Material</td>
</tr>
<tr>
<td>HB</td>
<td>House Bill</td>
</tr>
<tr>
<td>HCRS</td>
<td>Highway Conditions Reporting System</td>
</tr>
<tr>
<td>HOS</td>
<td>Hours-of-Service</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>HOV</td>
<td>High-Occupancy Vehicle</td>
</tr>
<tr>
<td>I-10</td>
<td>Interstate 10</td>
</tr>
<tr>
<td>ICM</td>
<td>Integrated Corridor Management</td>
</tr>
<tr>
<td>IFTA</td>
<td>International Fuel Tax Agreement</td>
</tr>
<tr>
<td>IoT</td>
<td>Internet of Things</td>
</tr>
<tr>
<td>IRP</td>
<td>International Registration Plan</td>
</tr>
<tr>
<td>I-SIG</td>
<td>Intelligent Signal</td>
</tr>
<tr>
<td>IT</td>
<td>Information Technology</td>
</tr>
<tr>
<td>ITD</td>
<td>Information Technology Division</td>
</tr>
<tr>
<td>ITS</td>
<td>Intelligent Transportation Systems</td>
</tr>
<tr>
<td>ITS-Texas</td>
<td>Intelligent Transportation Society of Texas</td>
</tr>
<tr>
<td>JFITC</td>
<td>Joe Fulton International Trade Corridor</td>
</tr>
<tr>
<td>KCRP</td>
<td>Kinney County Railport</td>
</tr>
<tr>
<td>km/h</td>
<td>Kilometers per Hour</td>
</tr>
<tr>
<td>LA Metro</td>
<td>Los Angeles County Metropolitan Transportation Authority</td>
</tr>
<tr>
<td>LBCT</td>
<td>Long Beach Container Terminal</td>
</tr>
<tr>
<td>LIDAR</td>
<td>Light Detection and Ranging</td>
</tr>
<tr>
<td>LRP</td>
<td>License Plate Reader</td>
</tr>
<tr>
<td>LTE</td>
<td>Long Term Evolution</td>
</tr>
<tr>
<td>LVROADS</td>
<td>Las Vegas ROADS</td>
</tr>
<tr>
<td>MaaS</td>
<td>Mobility as a Service</td>
</tr>
<tr>
<td>MAASTO</td>
<td>Mid America Association of State Transportation Officials</td>
</tr>
<tr>
<td>MCSAW</td>
<td>Motor Carrier Size and Weight</td>
</tr>
<tr>
<td>MDOT</td>
<td>Michigan Department of Transportation</td>
</tr>
<tr>
<td>METRO</td>
<td>Metropolitan Transit Authority of Harris County</td>
</tr>
<tr>
<td>MMITSS</td>
<td>Multimodal Intelligent Traffic Signal System</td>
</tr>
<tr>
<td>MTC</td>
<td>Metropolitan Transportation Commission</td>
</tr>
<tr>
<td>MTO</td>
<td>Marine Terminal Operator</td>
</tr>
<tr>
<td>NAFTA</td>
<td>North American Free Trade Agreement</td>
</tr>
<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
</tr>
<tr>
<td>NDOT</td>
<td>Nevada Department of Transportation</td>
</tr>
<tr>
<td>NHP</td>
<td>Nevada Highway Patrol</td>
</tr>
<tr>
<td>NORPASS</td>
<td>North American Preclearance and Safety System</td>
</tr>
<tr>
<td>OBU</td>
<td>On-board Unit</td>
</tr>
<tr>
<td>ODOT</td>
<td>Ohio Department of Transportation</td>
</tr>
<tr>
<td>OS/OW</td>
<td>Oversize/Overweight</td>
</tr>
<tr>
<td>PANYNJ</td>
<td>Port Authority of New York and New Jersey</td>
</tr>
<tr>
<td>PATH</td>
<td>California Partners for Advanced Transportation Technology</td>
</tr>
<tr>
<td>PED-SIG</td>
<td>Pedestrian Signal</td>
</tr>
<tr>
<td>PMMS</td>
<td>Performance Monitoring &amp; Measurement System</td>
</tr>
<tr>
<td>POE</td>
<td>Port of Entry</td>
</tr>
<tr>
<td>POCCA</td>
<td>Port of Corpus Christi Authority</td>
</tr>
<tr>
<td>PREEMPT</td>
<td>Emergency Vehicle Preemption</td>
</tr>
<tr>
<td>PROMET</td>
<td>Project for the Management of European Traffic</td>
</tr>
<tr>
<td>PTC</td>
<td>Positive Train Control</td>
</tr>
<tr>
<td>RCTO</td>
<td>Regional Concept of Transportation Operations</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>RCVW</td>
<td>Rail Crossing Violation Warning</td>
</tr>
<tr>
<td>RFID</td>
<td>Radio-Frequency Identification</td>
</tr>
<tr>
<td>RM</td>
<td>Ranch-to-Market</td>
</tr>
<tr>
<td>RMA</td>
<td>Regional Mobility Authority</td>
</tr>
<tr>
<td>RSU</td>
<td>Roadside Unit</td>
</tr>
<tr>
<td>RTC</td>
<td>Regional Transportation Commission</td>
</tr>
<tr>
<td>SAE</td>
<td>Society of Automotive Engineers</td>
</tr>
<tr>
<td>SAFER</td>
<td>Safety and Fitness Electronic Records</td>
</tr>
<tr>
<td>SANDAG</td>
<td>San Diego Association of Governments</td>
</tr>
<tr>
<td>SCATS</td>
<td>Sydney Coordinated Adaptive Traffic System</td>
</tr>
<tr>
<td>SH</td>
<td>State Highway</td>
</tr>
<tr>
<td>SINTEF</td>
<td>The Foundation for Industrial and Technical Research in Norway</td>
</tr>
<tr>
<td>SPaT</td>
<td>Signal Phasing and Timing</td>
</tr>
<tr>
<td>SRI</td>
<td>Smart Roadside Initiative</td>
</tr>
<tr>
<td>STIC</td>
<td>Texas State Transportation Innovation Council</td>
</tr>
<tr>
<td>STSFA</td>
<td>Surface Transportation System Funding Alternatives Program</td>
</tr>
<tr>
<td>SwRI</td>
<td>Southwest Research Institute</td>
</tr>
<tr>
<td>SWZ</td>
<td>Smart Work Zone</td>
</tr>
<tr>
<td>TACS</td>
<td>Tire Anomaly Classification System</td>
</tr>
<tr>
<td>TCFC</td>
<td>Texas Connected Freight Corridors Project</td>
</tr>
<tr>
<td>TEU</td>
<td>Twenty-foot Equivalent Unit</td>
</tr>
<tr>
<td>TFL</td>
<td>Transport for London</td>
</tr>
<tr>
<td>TFMP</td>
<td>Texas Freight Mobility Plan</td>
</tr>
<tr>
<td>TfNSW</td>
<td>Transport for New South Wales</td>
</tr>
<tr>
<td>THFN</td>
<td>Texas Highway Freight Network</td>
</tr>
<tr>
<td>TIA</td>
<td>Texas Innovation Alliance</td>
</tr>
<tr>
<td>TIDC</td>
<td>Traveler Information During Construction</td>
</tr>
<tr>
<td>TIGER</td>
<td>Transportation Investment Generating Economic Recovery</td>
</tr>
<tr>
<td>TIPS</td>
<td>Terminal Information Portal System</td>
</tr>
<tr>
<td>TMC</td>
<td>Traffic Management Center</td>
</tr>
<tr>
<td>TMFN</td>
<td>Texas Multimodal Freight Network</td>
</tr>
<tr>
<td>TMP</td>
<td>Transportation Management Plan</td>
</tr>
<tr>
<td>TMS</td>
<td>Truck Management System</td>
</tr>
<tr>
<td>TPAS</td>
<td>Truck Parking Availability System</td>
</tr>
<tr>
<td>TPIMS</td>
<td>Truck Parking Information Management System</td>
</tr>
<tr>
<td>TRANSCOM</td>
<td>Transportation Operations Coordinating Committee</td>
</tr>
<tr>
<td>TRATIS</td>
<td>Texas Regional Advanced Transportation Information System</td>
</tr>
<tr>
<td>TRB</td>
<td>Transportation Research Board</td>
</tr>
<tr>
<td>TSMO</td>
<td>Transportation Systems Management and Operations</td>
</tr>
<tr>
<td>TSP</td>
<td>Transit Signal Priority</td>
</tr>
<tr>
<td>TTI</td>
<td>Texas A&amp;M Transportation Institute</td>
</tr>
<tr>
<td>TTTF</td>
<td>Texas Technology Task Force</td>
</tr>
<tr>
<td>TxDOT</td>
<td>Texas Department of Transportation</td>
</tr>
<tr>
<td>TxDPS</td>
<td>Texas Department of Public Safety</td>
</tr>
<tr>
<td>TxFAC</td>
<td>Texas Freight Advisory Committee</td>
</tr>
<tr>
<td>TxDMV</td>
<td>Texas Department of Motor Vehicles</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
</tr>
<tr>
<td>UAS</td>
<td>Unmanned Aircraft Systems</td>
</tr>
<tr>
<td>UAV</td>
<td>Unmanned Aerial Vehicles</td>
</tr>
<tr>
<td>USDOT</td>
<td>United States Department of Transportation</td>
</tr>
<tr>
<td>USDOT-R</td>
<td>USDOT Number Readers</td>
</tr>
<tr>
<td>USMCA</td>
<td>US-Mexico-Canada Agreement</td>
</tr>
<tr>
<td>USPS</td>
<td>United States Postal Service</td>
</tr>
<tr>
<td>V2I</td>
<td>Vehicle-to-Infrastructure</td>
</tr>
<tr>
<td>V2V</td>
<td>Vehicle-to-Vehicle</td>
</tr>
<tr>
<td>VMS</td>
<td>Variable Message Sign</td>
</tr>
<tr>
<td>VIP</td>
<td>Video Image Processing</td>
</tr>
<tr>
<td>VTOL</td>
<td>Vertical Take-off and Landing</td>
</tr>
<tr>
<td>VWIM</td>
<td>Virtual Weigh-in-Motion</td>
</tr>
<tr>
<td>WIM</td>
<td>Weigh-in-Motion</td>
</tr>
<tr>
<td>WSDOT</td>
<td>Washington State Department of Transportation</td>
</tr>
<tr>
<td>WWD</td>
<td>Wrong Way Driving</td>
</tr>
</tbody>
</table>
1.0 Executive Summary

1.1 Purpose of the State of the Practice Assessment

The first step to developing a comprehensive Freight Network Technology and Operations Plan (FNTOP) that positions Texas as a leader in addressing current and emerging freight movement issues through the effective use of technology is to conduct a multimodal freight network technology State of the Practice Assessment on existing and emerging freight technologies. Since the Texas Multimodal Freight Network (TMFN) consists of key roadways, railroads, maritime ports and waterways, airports and international border crossings, it is critical that the State of the Practice Assessment also takes a multimodal approach.

This assessment focuses on the following two areas:

1. Programs and Technology Developments in Texas. This document focuses on developing a comprehensive inventory and assessment of all existing and emerging technology and transportation operations-related programs in Texas that can potentially support safe and efficient multimodal movement of freight throughout Texas. This assessment casts a wide net across all freight modes and all types of technologies that could impact freight transportation, and is supported by inputs from public and private sector stakeholder engagement.

2. Domestic and International Practices in Existing and Emerging Freight Technologies and Operational Practices, Programs, and Policies. This document focuses on current and emerging technological and operational developments both in the U.S. and internationally that illustrate the potential to positively impact the movement of freight. This assessment includes all freight modes, and also encompasses maritime port and international border crossing developments.

1.2 Freight-Related Groups, Policies, and Initiatives in Texas

The existing freight-related groups, policies and initiatives in Texas are summarized in Exhibit 1. Freight-related groups exist for all the major freight modes, establishing forums for feedback from all private sector freight stakeholders. Initiatives are in place that focus on research, implementation, and maintenance—ensuring that innovative technologies are not only tested and confirmed to address existing freight needs before widespread implementation, but also that funding will be secured for long-term operations and maintenance.
**Exhibit 1: Summary of Freight-Related Groups, Policies, and Initiatives in Texas**

<table>
<thead>
<tr>
<th>Freight-Related Groups, Policies, and Initiatives in Texas</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Texas Department of Transportation (TxDOT) Divisions</strong></td>
<td></td>
</tr>
<tr>
<td>Information Technology Division</td>
<td>Responsible for establishing and maintaining the information technology (IT) architecture that serves freight-related intelligent transportation system (ITS) initiatives, including the warehousing of freight-related data.</td>
</tr>
<tr>
<td>Maritime Division</td>
<td>Responsible for streamlining intermodal operations between ships and other forms of transportation that link to maritime ports, such as rail and trucking infrastructure. This Division also plays a large role in developing the Texas Port Capital Program, which provides an avenue for introducing advanced technology into the freight supply chain.</td>
</tr>
<tr>
<td>Rail Division</td>
<td>Responsible for managing the State’s railroad signal preemption systems, improving safety at highway-rail at-grade crossings including identifying safety related technology solutions, and the development of the Texas Rail Plan.</td>
</tr>
<tr>
<td>Research and Technology Implementation Division</td>
<td>Responsible for the facilitation of research initiatives that help transform technological solutions from concept to construction—through both public-sector and private sector pursuits—including the implementation of freight-related technology projects.</td>
</tr>
<tr>
<td>Strategic Planning Division</td>
<td>Responsible for developing planning and implementation strategies for new and innovative transportation infrastructure, as well as the TxDOT Strategic Plan.</td>
</tr>
<tr>
<td>Traffic Safety Division</td>
<td>Responsible for ensuring highway ITS applications are safe and consistent with national and Texas standards, developing traffic safety initiatives, and collecting and analyzing Texas crash data. This Division of TxDOT is interested in any technological improvements that may increase the safety of freight transportation, and is responsible for the Transportation Systems Management and Operations (TSMO) Strategic Plan, as well as the CAT Plan.</td>
</tr>
<tr>
<td>Freight-Related Groups, Policies, and Initiatives in Texas</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td><strong>Transportation Planning and Programming Division</strong></td>
<td>The Freight Planning Branch of this Division supports TxDOT’s comprehensive and multimodal freight planning program and develops the Texas Freight Mobility Plan (TFMP). The TFMP includes a comprehensive Implementation Plan that identifies freight-based technology strategies.</td>
</tr>
<tr>
<td><strong>Travel Information Division</strong></td>
<td>Responsible for providing travel information to and within the State. This Division manages the public-facing information channel for highway conditions on Texas roads, including road closures, traffic incidents, and congestion.</td>
</tr>
<tr>
<td><strong>Bridge Division</strong></td>
<td>Responsible for prioritizing bridge projects statewide, maintaining the Bridge Inspection Database, and managing several bridge strike and overheight vehicle detection systems deployed across the State.</td>
</tr>
<tr>
<td><strong>Aviation Division</strong></td>
<td>Responsible for administering the TxDOT Unmanned Aircraft Systems (UAS) Program, which is used to ensure that all unmanned aerial vehicles (UAV) activities are conducted in compliance with all statutory requirements.</td>
</tr>
</tbody>
</table>

**TxDOT Advisory Committees**

<p>| <strong>Texas Freight Advisory Committee</strong> | Advises TxDOT on freight issues, priorities, projects, and funding needs for freight improvements. The Committee elevates freight transportation as a critical component of the State’s economic vitality and competitiveness. Responsible Division: Transportation Planning and Programming Division. |
| <strong>Port Authority Advisory Committee</strong> | Provides a broad perspective on maritime ports and transportation-related matters for TxDOT policies concerning the Texas maritime port and ship channel systems. The Committee also prioritizes projects for any state funding and identifies landside connectivity needs. Responsible Division: Maritime Division. |
| <strong>Border Trade Advisory Committee</strong> | Advises TxDOT in defining and developing a strategy and makes recommendations to the Texas Transportation Commission and the Governor for addressing the highest priority international border trade transportation challenges. Responsible Division: Transportation Planning and Programming Division. |</p>
<table>
<thead>
<tr>
<th>Freight-Related Groups, Policies, and Initiatives in Texas</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aviation Advisory Committee</td>
<td>Provides input to TxDOT on aviation development programs and serves as its representative among aviation users. Committee members work with members of the Texas Legislature on various aviation issues. Responsible Division: Aviation Division.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Texas Programs and Initiatives</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statewide Transportation Systems Management and Operations Program</td>
<td>The adoption of this TSMO Program aims to shift the culture and function of an agency to institutionalize system-wide management and operations through all business functions and the project development process. It accomplishes this by recognizing traffic management systems as a core priority and through dedicated programs and funding. This opens doors to apply innovative freight technologies to improve freight operations, which are relatively low in cost compared to adding capacity, can be implemented in less time, and potentially offer higher benefit-cost ratios. Responsible Division: Traffic Safety Division.</td>
</tr>
<tr>
<td>Statewide ITS Strategic Plan</td>
<td>The objective of the Plan is to provide a framework to guide the development and deployment of an integrated statewide program for ITS. The ITS Strategic Plan identifies the need for TxDOT to invest in and deploy ITS systems and technologies to facilitate the movement of freight along strategic, high-volume freight corridors, including international border crossings. The Plan was developed as part of a project overseen by TxDOT’s Research and Technology Implementation Office and its implementation is the responsibility of several Divisions, most notably the Traffic Safety Division.</td>
</tr>
<tr>
<td>Emerging Transportation Technology Plan</td>
<td>The objective of the Plan is to provide a framework for addressing emerging transportation technology and develop implementation strategies to integrate technologies such as Connected and Automated Transportation (CAT), UAS, Mobility as a Service (MaaS), emerging freight technologies, and other transformative technologies into State planning practices. Responsible Division: Strategic Planning Division.</td>
</tr>
<tr>
<td>Freight-Related Groups, Policies, and Initiatives in Texas</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Connected and Automated Vehicle (CAV) Task Force</td>
<td>Provides one-stop resource for information and coordination on all ongoing CAV projects, investments, and initiatives in Texas. In addition to documenting public and private entity efforts and facilitating partnerships, the CAV Task Force hosts industry forums and reports lessons learned to facilitate progress and encourage greater collaboration. Responsible Division: Strategic Planning Division.</td>
</tr>
<tr>
<td>Cooperative Automated Transportation (CAT) Program</td>
<td>The objectives of this Program are to promote and support the creation of a culture of innovation and proactive integration of CATs into planning, design, construction, maintenance, and operations of transportation infrastructure. This Program is important because it supports the continued expansion of CAV demonstrations (e.g., truck platooning applications, automated truck delivery systems, automated rail/unmanned aircraft system/ship technologies for freight) along freight corridors. Responsible Division: Traffic Safety Division.</td>
</tr>
<tr>
<td>I-10 Corridor Coalition</td>
<td>The general purpose of the coalition is to oversee coordinated operations and development of the I-10 corridor through California, Arizona, New Mexico, and Texas, reducing the need for separate groups within each of the member states. The I-10 Corridor Coalition developed a Concept of Operations document that laid the groundwork by identifying possible options and technology improvements that could improve goods movement in the I-10 corridor. The I-10 Corridor Coalition is important because it can identify and support specific projects along the corridor to test freight technologies of interest. Responsible Division: Transportation Planning and Programming Division.</td>
</tr>
<tr>
<td>Texas Connected Freight Corridors (TCFC) Project</td>
<td>This project will deploy connected vehicle (CV) technology to trucks in the Texas Triangle Region (Austin, Dallas-Fort Worth (DFW), Houston, and San Antonio). The motivation for this deployment is to boost economic efficiency, increase safety of trucks, and promote the use of emerging technologies. Responsible Division: Traffic Safety Division.</td>
</tr>
<tr>
<td>Enterprise Information</td>
<td>To advance TxDOT’s data strategic needs, the Information Technology Division has developed the Enterprise Information</td>
</tr>
<tr>
<td>Freight-Related Groups, Policies, and Initiatives in Texas</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Management Program</td>
<td>Management Program. It builds on efforts to implement a centralized data architecture that will collect TxDOT's various data sources and transform them into clean, secure, and authoritative data. Responsible Division: Information Technology Division.</td>
</tr>
<tr>
<td>Texas Technology Task Force (TTTF)</td>
<td>The TTTF is made up of a team of professionals from public agencies, private sector industry, and research institutions all working in areas related to transportation technology, including freight. One of its main responsibilities includes producing white papers highlighting various technologies to make each technology more understandable for other entities of the transportation sector. The TTTF is one of the first places a new technology can be “discovered” and communicated to other Divisions of TxDOT. Responsible Division: Strategic Planning Division.</td>
</tr>
<tr>
<td>Texas Innovation Alliance (TIA)</td>
<td>The TIA is a group of public agencies and research institutions that aims to create a “platform for innovation.” Its aim is to encourage people to think of new ideas and solutions to transportation and mobility issues. This Alliance is critical to the promotion of freight technology, as it can be used as a launchpad for freight technology innovations that may be specifically tailored to suit the transportation needs of Texas. Responsible Division: Strategic Planning Division.</td>
</tr>
<tr>
<td>Texas State Transportation Innovation Council (STIC)</td>
<td>The STIC implements technology that has already been proven successful in real-world situations and provides a means for communication among different stakeholders to discuss innovative solutions. In terms of freight technology, the STIC is important to Texas because it can align a pro-technology lobbying platform with the freight technologies that are up for consideration. Responsible Division: Strategic Planning Division.</td>
</tr>
<tr>
<td>Intelligent Transportation Society of Texas</td>
<td>The Intelligent Transportation Society of Texas (ITS-Texas) is an advocacy group for advanced technology transportation solutions, including improved freight technology.</td>
</tr>
<tr>
<td>Freight-Related Groups, Policies, and Initiatives in Texas</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td><strong>Texas Department of Public Safety (TxDPS)</strong></td>
<td>TxDPS goals include enhancing highway and public safety as well as statewide emergency management in Texas. The TxDPS Commercial Vehicle Enforcement Service checks the size, weight, and safety of CMVs operating in Texas. In addition to mobile roadside enforcement, TxDPS operates nearly 100 fixed commercial vehicle enforcement locations throughout the State.</td>
</tr>
<tr>
<td><strong>Texas Department of Motor Vehicles (TxDMV)</strong></td>
<td>The TxDMV handles licensing and registration for CMVs. Motor carriers operating intrastate CMVs on a road or highway in Texas must get a TxDMV number. Oversize/Overweight (OS/OW) CMV permit distribution is a major responsibility of TxDMV. The TxDMV also regulates international carriers through management of NAFTA(^1) permits.</td>
</tr>
<tr>
<td><strong>Governor’s Broadband Development Council</strong></td>
<td>This Council is responsible for identifying barriers to and solutions for expanding broadband (high-speed internet) access to rural communities across the state of Texas, which will be necessary for freight technology innovations to reach across the State.</td>
</tr>
<tr>
<td><strong>Texas State Energy Conservation Office</strong></td>
<td>The Alternative Fuels Program supports public fleets that deploy alternative fuel vehicles (AFVs) and build associated fueling infrastructure, which may be beneficial for advancing TxDOT’s adoption rates of alternative fuel truck fleets.</td>
</tr>
<tr>
<td><strong>United States Customs and Border Protection (CBP)</strong></td>
<td>CBP’s role is the safeguarding of U.S. borders to protect the public from dangerous people and materials. They manage the security of cross border freight movements at all Port of Entry (POEs) across multiple modes and utilize technologies to support credentialing, inspections, and traveler information.</td>
</tr>
<tr>
<td><strong>United States Department of Transportation (USDOT)</strong></td>
<td>USDOT’s role is providing federal funding for nationwide research initiatives and deployment of innovative freight technology-related projects. This is achieved through various grant programs, such as Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) through the Federal Highway Administration (FHWA), and the Consolidated Rail Infrastructure</td>
</tr>
</tbody>
</table>

\(^1\) While the Texas DMV website still refers to NAFTA permits, as of July 2020, NAFTA has been replaced by USMCA.
<table>
<thead>
<tr>
<th>Freight-Related Groups, Policies, and Initiatives in Texas</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>and Safety Improvements (CRISI) Program through the Federal Railroad Administration (FRA).</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Research Institutes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Texas A&amp;M Transportation Institute (TTI)</strong></td>
<td>TTI is a part of the Texas A&amp;M University System that focuses primarily on research and testing of transportation solutions in many different focus areas including freight, connected transportation, and planning and operations.</td>
</tr>
<tr>
<td><strong>University of Texas at Austin Center for Transportation Research (CTR)</strong></td>
<td>CTR is a part of the University of Texas at Austin that combines research in the transportation field with educational opportunities for students. Its three research arms are the Data-Supported Transportation Operations and Planning Center, Network Modeling Center, and Texas Pavement Preservation Center.</td>
</tr>
<tr>
<td><strong>Southwest Research Institute (SwRI)</strong></td>
<td>SwRI is a private, non-profit research group that focuses on research needs in transportation, electronics, defense, biomedical, energy, and other areas. Within intelligent systems research, SwRI does work on advanced traffic management systems, fully autonomous vehicles, connected vehicles (CVs), and intelligent vehicles.</td>
</tr>
</tbody>
</table>

### 1.3 Freight Technology Areas
Technology developments in Texas were compared against domestic and international practices in seven freight technology areas as listed in Exhibit 2.
<table>
<thead>
<tr>
<th>Freight Technology Area</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic Management</td>
<td>A strategy to improve mobility and safety for all modes of transportation by managing operations and promptly responding to travel disruptions. Freight-specific strategies include incident management, emergency management, collision avoidance systems, and freight signal priority.</td>
</tr>
<tr>
<td>Advanced Traveler Information Systems</td>
<td>Any system that acquires, analyzes, and presents information to assist surface transportation travelers in moving efficiently from a starting location (origin) to their desired destination. Features tailored to the freight community include freight information exchange, parking information, weather information, Connected Work Zones, rail crossing information, and border/port wait times.</td>
</tr>
<tr>
<td>Dynamic Route Guidance</td>
<td>Includes technologies that incorporate real-time traffic and roadway conditions allowing drivers to re-route to more optimal routes. Besides information on traffic and incidents, truck drivers or operators need to have additional information on route restrictions, low height or weight posted bridges, hazardous materials restrictions, and availability of truck parking and/or rest areas.</td>
</tr>
<tr>
<td>Data Integration and Analytics</td>
<td>Traffic data is generated from different sources, such as from traditional agency-owned road sensors and from private sector probe-based data aggregators like Google Maps and Waze. The integration of data from multiple sources, and the analysis and sharing of large datasets or “Big Data” is crucial to understand travel patterns, and to help manage traffic and operate transportation systems.</td>
</tr>
<tr>
<td>Enforcement and Inspection</td>
<td>Freight enforcement and inspection are conducted along the roadside or at designated enforcement sites. This freight technology area refers to checking the size, weight, and safety of CMVs operating in Texas.</td>
</tr>
<tr>
<td>Automated and Connected Freight Vehicles</td>
<td>Vehicles can be categorized into levels of automation from no automation to full automation. Enabling technologies include a combination of vehicle-to-vehicle (V2V) communication, radar and cameras, in-vehicle sensor and control systems, and vehicle-to-infrastructure (V2I) communications.</td>
</tr>
</tbody>
</table>
Intermodal terminal operations refers to the interchange between modes at rail terminals, airports, pipelines, and maritime ports, as well as multimodal freight operations. Main areas of operation include water, air, rail terminal access; truck queuing; truck staging/parking; truck appointment systems; drayage operations, maritime terminal operations, rail freight improvements, and international border crossings.

Exhibit 3 summarizes Texas’ strengths and weaknesses in each of the seven freight technology areas and highlights several lessons that can be learned from domestic and international practices.
## Exhibit 3: Summary of Freight Technology Areas in Texas

<table>
<thead>
<tr>
<th>Freight Technology Area</th>
<th>Texas Strengths</th>
<th>Texas Weaknesses</th>
<th>Lessons Learned from Domestic and International Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic Management</td>
<td>• Traffic management centers (TMC) are operational in all the major urban areas in Texas</td>
<td>• TMCs do not share data with each other or agencies that are co-located within each TMC</td>
<td>• Set up a collective platform to share real-time transportation data with other TMCs and agencies (e.g., TxDPS, TxDMV)</td>
</tr>
<tr>
<td></td>
<td>• Texas has forward-thinking plans to utilize connected vehicle (CV) applications to improve freight mobility and safety</td>
<td>• Maritime ports and international border crossings do not contain TMC capabilities</td>
<td>• Design traffic and incident management platforms to be more dynamic and predictive</td>
</tr>
<tr>
<td></td>
<td>• TxDOT has put significant effort into investigating freight strategies and technology areas</td>
<td>• ITS systems across the State are not standardized</td>
<td></td>
</tr>
<tr>
<td>Advanced Traveler Information Systems</td>
<td>• Texas invests in pilot projects to test innovative freight technologies</td>
<td>• The response plans recommended by Dallas’ ICM system only addressed a static set of traffic conditions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Grant application efforts have been successful in</td>
<td>• Many rural regions in Texas do not have traffic and incident management systems</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Traveler information tools are corridor or region-specific</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Some traveler information platforms are not</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Leverage agency data/information to encourage two-way information sharing for enhanced freight traveler information</td>
<td></td>
</tr>
<tr>
<td>Freight Technology Area</td>
<td>Texas Strengths</td>
<td>Texas Weaknesses</td>
<td>Lessons Learned from Domestic and International Practices</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----------------</td>
<td>-----------------</td>
<td>---------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>securing federal funds for freight technology projects</td>
<td>available on mobile devices (e.g., DriveTexas)</td>
<td>• Implement truck parking information systems along the most important Texas freight corridors first</td>
</tr>
<tr>
<td></td>
<td>• Multistate coalitions have been formed to solve common freight issues</td>
<td>• Separate systems are used by TxDOT Divisions for reporting planned and unplanned closures</td>
<td>• Use ITS to automate measurement of freight traveler information (e.g., real-time international border wait times)</td>
</tr>
</tbody>
</table>

**Dynamic Route Guidance**

- The Texas Connected Freight Corridors (TCFC) Project proposes a CV application to help provide higher quality advanced traveler information that includes alternate route information and eco-dynamic freight routing
- There is a deficiency of alternate route options in Texas (especially in rural areas)
- Static or dynamic route guidance is currently not available from Texas transportation agencies
- The majority of available dynamic route guidance applications are private sector commercial products
- TxDOT needs to determine whether there is any value added in internally developing a product for freight-specific needs in Texas
- TxDOT has a “collect data once, share with all that need it” data strategy
- The Enterprise Information Management Program has been initiated to implement TxDOT’s data strategy
- Data is currently spread across disparate sources, in non-standardized formats and often inaccessible via application programming interfaces (API)
- Provide an open data portal for private partners to use for information dissemination and application development
- Develop a web-based performance monitoring and measurement system that is
<table>
<thead>
<tr>
<th>Freight Technology Area</th>
<th>Texas Strengths</th>
<th>Texas Weaknesses</th>
<th>Lessons Learned from Domestic and International Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TxDOT is exploring the applicability of new data sources and data processing methods to improve traffic operations (e.g., crowdsourced data, artificial intelligence [AI])</td>
<td>Lack of two-way communication/ information sharing</td>
<td>accessible by multiple agencies and the public</td>
</tr>
<tr>
<td>Enforcement and Inspection</td>
<td>Lack of two-way communication/ information sharing</td>
<td>There is inadequate data that has been aggregated for planning and effective decision-making</td>
<td>Develop standardized guidelines on how data should be collected, processed and reported</td>
</tr>
<tr>
<td></td>
<td>Texas is Core Compliant in the Innovative Technology Deployment Program (safety information exchange, electronic credential administration, and electronic screening)</td>
<td>OS/OW permit cancellations are not well communicated to truck drivers</td>
<td>Use ITS (e.g., DriveWyze) to automate data sharing and streamline truck inspection processes</td>
</tr>
<tr>
<td></td>
<td>Wide network of TxDPS inspection locations</td>
<td>Permit distribution is the responsibility of TxDMV while route permissions are handled by TxDOT Districts</td>
<td>Reduce the number of roadside inspections by sharing data between operations personnel and drivers beyond what is required in the Innovative Technology Deployment Program (e.g., brake status, weight, tire status)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>There are too few Weigh-in-Motion (WIM) and Vehicle Classification (VC) stations statewide to fully monitor freight routes in Texas</td>
<td>Deploy more WIM and VC equipment to identify corridors with heavy use from overweight trucks</td>
</tr>
<tr>
<td>Freight Technology Area</td>
<td>Texas Strengths</td>
<td>Texas Weaknesses</td>
<td>Lessons Learned from Domestic and International Practices</td>
</tr>
<tr>
<td>-------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Connected and Autonomous Freight Vehicles | - Texas passed legislation to promote development and testing of CAVs  
- CAVs are a major focus area of several Texas technology programs  
- The Texas Connected Freight Corridors (TCFC) Project covering the Texas Triangle is already in the works  
- Multiple pilot tests of AVs and trucks are currently underway in Texas (e.g., TuSimple and Ford) | - CAVs have not yet been commercially deployed in Texas beyond pilot testing  
- The large amount of rural highway mileage in Texas is a major challenge for CAV infrastructure readiness | - Test vehicular communications between trucks from different manufacturers  
- Explore applications of CAVs to improve freight operations at maritime port facilities |
| Intermodal Terminal Operations | - Multiple projects to improve intermodal terminal operations have been proposed  
- Texas is home to many intermodal facilities of all types and modes across different geographies | - Lack of coordination with private industry on the direction of private sector investments | - Consider adding TMC capabilities to maritime ports and international border crossing locations  
- Implement an appointment system at all maritime port container terminals  
- Create a platform for freight-specific traveler information, or integrate with existing platforms |
1.4 Key Opportunities for Texas

TxDOT’s adoption of their TSMO Program opens doors for TxDOT Divisions and Districts to apply innovative freight technologies to improve freight operations, which are relatively low in cost compared to adding capacity, can be implemented in less time, and potentially offer higher benefit-cost ratios. As the workforce changes and potential labor shortages threaten the efficiency of goods movement, Texas will need to consider increasing the use of freight technology to maximize the productivity of the TMFN.

For the FNTOP, the Project Team conducted stakeholder outreach, which included almost 60 interviews with public and private stakeholders in Texas and across the U.S. Through the feedback collected during stakeholder engagement meetings and research conducted as part of this State of the Practice Assessment, several key opportunities to improve freight operations through ITS infrastructure and technologies have been identified. These opportunities may cover several freight technology areas.

- **Texas Connected Freight Corridors Project (TCFC) Integration:** While the grant application scope of the TCFC Project includes 12 CV technology applications for trucks in the Texas Triangle Region (cornered by DFW to the north, Austin and San Antonio to the southwest, and Houston to the southeast), the greater Texas vision is to create a sustainable CV environment in that region to support V2V and V2I safety and mobility applications. The TCFC will continue to evolve and TxDOT should look for integration opportunities in proposed projects to improve Texas’ connected infrastructure and build up an ecosystem to support freight technology and operations as TCFC turns into a TxDOT-branded program.

- **Decision-Support Systems and Predictive Analytics:** The wealth of data currently being generated by existing ITS devices and collected by TxDOT TMCs can be used to develop decision-support systems that forecast traffic conditions and support proactive traffic management on freight corridors.

- **Binational ITS Coordination:** TxDOT’s ITS programs cannot be confined within its borders since Texas and Mexico share 1,254 miles of common border and are joined by 28 international bridges and border crossings. The international border crossings are vital to the economies of Texas and Mexico, and have contributed to Mexico’s status as Texas’ primary trading partner. International border crossing strategies, such as multi-jurisdictional data sharing, estimated border crossing wait times, and streamlined CMV inspection processes may help alleviate freight bottlenecks at the Texas-Mexico border.

- **Open Data Portal:** A common underlying theme seen across the Texas freight transportation system is that available data are being stored in silos. Even Divisions within the TxDOT Central Office use different data archival systems, procedures, and

---

data formats. This complicates the data exchange and communication between the TxDOT Central Office, TxDPS, TxDMV, and the TxDOT Districts, with some relying on manual data sharing practices. An open data portal with standardized data collection, processing, and reporting procedures would be beneficial to improving data sharing and traffic safety and management on a statewide, regional, and local basis. It may introduce opportunities to save costs (e.g., avoid multiple vehicle probe data procurements for data needed across TxDOT Districts and streamline data processing time). In addition, providing real-time data feeds through trusted API connectivity to an Open Data Portal would enable public and private sector application developers to use the data in applications that would benefit the Texas freight community. For example, if field units were reporting a substantial increase in traffic—especially heavy freight traffic—in a certain part of the State, a centralized processing system could evaluate and determine if certain response plans were necessary, such as increased green time on signalized freight corridors (if deployed). This data could potentially support machine learning algorithms for identifying best routes, congestion hotspots, or incidents.

- **Enhanced Freight Traveler Information:** Lack of traveler information was the most frequently mentioned challenge from stakeholder interviews. Currently, TxDOT shares very little freight-specific traveler information with the Texas freight community and receives almost no data from the freight community. This causes a multitude of freight network operational inefficiencies, including a deficiency of wait time information to get through POEs, lack of route guidance system-recommended routes that are designed for CMVs, lack of truck parking availability information, unknown work zone activities that result in road closures, and inefficient route selections when OS/OW permits are cancelled due to construction or maintenance projects. By first establishing an Open Data Portal, TxDOT can leverage the consolidated platform of freight data to provide enhanced freight traveler information to the freight transportation community.

- **Integration with Private Sector Services:** The private sector has developed and continues to enhance logistics-related services for the freight transportation community, such as truck navigation systems, weigh station bypass systems, and truck management systems (TMSs) to optimize operations. Instead of developing tools for the freight transportation community from scratch, TxDOT can partner with private sector companies as a public sector data provider. For example, Drivewyze could work with TxDOT to ingest their Work Zone Data Exchange feed, which would improve the reliability of work zone notifications for truck drivers on Drivewyze’s PreClear platform, which is already used by over two million trucks nationwide.

- **Partnerships with Private Sector Companies:** Texas’s friendly CAV regulatory environment and position as a logistics and transportation hub with the most total miles of interstate routes in the nation makes the State an attractive destination for CAV companies to set up automated freight operations and testing. Partnering with private sector companies such as these creates opportunities for TxDOT to collect new sources of freight data (e.g.,
Electronic Logging Devices or AV operational performance reports) that can be used to evaluate the effectiveness of emerging freight technologies as well as apply connected data to new freight applications.

- **Multi-State/Multi-Jurisdictional Standards Development:** Long-haul truck trips can span multiple states or countries and may require multi-state/multi-jurisdictional ITS solutions in order to improve freight mobility and safety on the highway network. European countries and multi-state coalitions in the U.S. have set good examples with initiatives highlighting the importance of standards development and interoperability to facilitate adoption of various freight-related ITS technology (e.g., DATEX2 in Europe, Mid America Association of State Transportation Officials (MAASTO) Regional Truck Parking Information Management System (TPIMS), Enabling Safe Multi-Brand Platooning for Europe (ENSEMBLE) Consortium, etc.).
2.0 Introduction

2.1 Project Overview
The FNTOP is anticipated to be the most comprehensive freight technology planning effort in the U.S. The FNTOP intends to outline potential strategies to guide technology and operations-related investments on the TMFN. This effort includes a review of current and future transportation challenges and opportunities and user needs gathered through focused public- and private sector engagement. The FNTOP is anticipated to be an invaluable resource to help public agencies and the private sector effectively plan for future deployments of freight technologies, working in partnership with the private sector across all modes of freight transportation.

The main goal of this project is to develop a comprehensive plan based on a detailed assessment of current and future needs, challenges, gaps, and opportunities that inform strategies and a stand-alone Implementation Plan. The main objectives of this project include:

- Identify and assess technological and operational strategies being used on the TMFN or could be used in the future to improve safety, mobility, and facilitate economic competitiveness;
- Identify and assess TxDOT’s needs, challenges, and opportunities in terms of ITS hardware (e.g., traffic detectors, closed-circuit television (CCTV) cameras, dynamic message signs (DMSs), connected vehicle (CVs) roadside units, etc.) and related infrastructure, digital framework and related infrastructure, operations, staffing and expertise, and statewide, corridor, urban, and rural needs and partnerships;
- Assess the TMFN’s current and future technological and operational needs, as well as its readiness and adaptability potential associated with the impacts of existing and emerging technologies;
- Develop strategies, policies, programs, and projects to address technological and operational needs; and
- Develop an Implementation Plan and a set of Concept of Operations documents, with each focused on a near-term freight network technology “early win” deployment concept.

The FNTOP and Concepts of Operations can guide Texas’ strategic development and deployment of innovative multimodal freight transportation technologies, techniques, research, and methods.
2.2  Texas Multimodal Freight Network

The TMFN consists of the State’s freight assets that are most important for moving the largest volumes of freight and that serve the State’s key freight intensive industries. Per the 2018 Texas Freight Mobility Plan\(^3\) (TFMP), these assets cover:

- **Highways:** Currently highways are the predominant mode for freight movement within the State, providing first- and last-mile connections to rail facilities, maritime ports, and airports, as well as serve long-haul trip destined throughout the State and beyond. Texas has over 313,000 miles of public roadways—making it the State with the most extensive highway network. 21,861 miles are on the Texas Highway Freight Network, with 745 miles designated as Critical Rural Freight Corridors and another 372 miles designated as Critical Urban Freight Corridors. In 2016, trucks accounted for 54 percent of total tonnage movement in Texas. Intrastate trucking and tonnage is anticipated to grow significantly as more residents, businesses, and freight locate within the State.

- **Railroads:** With 10,539 track miles (all on the TMFN), Texas has more miles of rail and more railroad employees than any other state. Texas contains five of the seven rail crossings between the U.S. and Mexico, providing critical connections for trade between the two countries. Texas’ 49 shortline railroads serve as first- or last-mile railroads for Texas’ three Class I railroads (BNSF Railway, Kansas City Southern, and Union Pacific), Texas’ maritime ports, and many of the State’s rail-served industries.

- **Ports and Waterways:** Texas handles the second most total maritime tonnage of any state in the nation, with 21 maritime ports and the Gulf Intracoastal Waterway (GIWW) system, and is the leading state for international maritime tonnage. Maritime port and waterway access is necessary to attract and support many businesses, including the petrochemical sector, one of the State’s most important industries. Nine of Texas’ 12 deepwater ports and one of its nine shallow-draft ports are included on the TMFN. Texas’ 379-mile portion of the GIWW, referred to as Marine Highway 69, is also a part of the TMFN. Marine Highway 69 handles two-thirds of the waterway’s traffic and moves approximately 86 million short tons of cargo annually.

- **Airports:** In 2016, six of the top 50 cargo airports in the U.S. (in terms of landed weight) were located in Texas. Out of Texas’ 24 commercial airports, seven are included on the TMFN. Air cargo tonnage is expected to grow at a higher rate than any other mode due to market changes such as the increase of e-commerce and expectations of one- or two-day shipping.

- **Pipelines:** Texas has the most extensive pipeline network in the nation, with 426,000 total miles (59 percent intrastate and 41 percent interstate), carrying 826.6 million tons of cargo in 2016.

---

• **International Border Crossings:** Texas’ 20 commercial international border crossings are also all on the TMFN. Fifteen (15) of these process commercial vehicle crossings and the other five are rail crossings.

Exhibit 4 provides an overview of the assets designated as a part of the TMFN—namely key roadways, railroads, maritime ports and waterways, airports, and international border crossings. The TMFN is important because it includes the key corridors that facilitate the efficient and safe movement of goods in Texas and are the most critical for focusing investment. Exhibit 5 is a map of the TMFN.

*Exhibit 4: Overview of Texas Multimodal Freight Network Assets*

- **313,000** roadway centerline miles
  - **21,861** miles on the Texas Highway Freight Network
  - **745** miles of Critical Rural Freight Corridor
  - **372** miles of Critical Urban Freight Corridor
- **10,539** miles of railroads on the TMFN
  - **3** Class I railroads
  - **49** Class III or shortline railroads
- **21** ports and the Gulf Intracoastal Waterway system
  - **12** deepwater ports
    - **9** included on TMFN
  - **9** shallow draft ports
    - **1** included on TMFN
  - **379** miles of GIWW, all on TMFN
- **24** commercial airports
  - **7** all 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: Texas Department of Transportation, Texas Freight Mobility Plan 2018—Executive Summary, March 7, 2018.
Exhibit 5: The Texas Multimodal Freight Network

Source: Texas Department of Transportation, Texas Freight Mobility Plan 2018—Executive Summary, March 7, 2018.
2.3 Purpose of the State of the Practice Assessment
The first step to developing a comprehensive FNTOP that positions Texas as a leader in addressing current and emerging freight movement issues through the effective use of technology is to conduct a multimodal freight network technology State of the Practice Assessment on existing and emerging freight technologies. Since the TMFN consists of key roadways, railroads, maritime ports and waterways, airports, and international border crossings, it is critical that the State of the Practice Assessment also takes a multimodal approach.

This assessment focuses on the following two areas:

1. Programs and Technology Developments in Texas. This document focuses on developing a comprehensive inventory and assessment of all existing and emerging technology and transportation operations-related programs in Texas that can potentially support a safe and efficient multimodal movement of freight throughout Texas. This assessment casts a wide net across all freight modes and all types of technologies that could be involved with freight transportation, and is supported by inputs from public and private sector stakeholder engagement.

2. Domestic and International Practices in Existing and Emerging Freight Technologies and Operational Practices, Programs, and Policies. This document focuses on current and emerging technological and operational developments both in the U.S. and internationally that illustrate the potential to positively impact the movement of freight. This assessment includes all freight modes, and also encompasses maritime port and international border crossing developments.

2.4 Organization of the Report
This remainder of this report is organized into the following sections:

• Section 3 – Freight-Related Groups, Policies and Initiatives in Texas. This section provides an inventory of various technology and transportation operations-related programs already underway in Texas.

• Section 4 – Freight Technology Areas. This section compares existing and emerging technological and operational developments in Texas to developments both in the U.S. and internationally.

• Section 5 – Summary and Conclusion. This section summarizes the program and technology development inventory compiled and identifies key freight technology and operations related investment opportunities for Texas.

• Section 6 – References. This section lists all references used in the creation of this report.
3.0 Freight-Related Groups, Policies, and Initiatives in Texas

In Texas, there already exists a wealth of freight-related groups, policies, and initiatives in place that can support freight programs and technology developments. In this section, the following freight-related groups, policies, and initiatives are summarized:

- TxDOT Divisions;
- TxDOT Committees;
- Texas Programs and Initiatives;
- TxDOT Partner Agencies; and
- Research Institutes.

3.1 TxDOT Divisions

TxDOT is composed of 34 internal Divisions that focus on specific areas of transportation. Many of these Divisions collaborate as part of the project development process. Among the TxDOT Divisions, there are several key Divisions that are of greater relevance to freight technology programs. These Divisions are outlined below.

3.1.1 Information Technology Division

The Information Technology Division (ITD)\(^4\) supports the IT aspects of TxDOT and helps with data management. Its roles and responsibilities include the housing of technology-related asset inventories and transportation-related engineering and design software. In the context of freight, this Division is responsible for establishing and maintaining the IT architecture that serves freight-related ITS initiatives, including the warehousing of freight-related data.

Many of ITD’s current and planned projects serve a dual purpose. These projects meet the current needs of TxDOT’s customers while helping TxDOT build the foundational capabilities that will be required to support CAV deployments. While many of the specific infrastructure investments needed to support widespread CAV deployment are not clear today due to rapidly changing technology, CAVs will require connected infrastructure that is reliable and secure, the ability to manage massive amounts of data in real time, and advanced mapping and geolocation capabilities. ITD is building these foundational capabilities while partnering with other TxDOT entities to support CAV pilots.

3.1.2 Maritime Division

The Maritime Division oversees marine infrastructure that is vital for maritime port and waterway operations. One of the Division’s key responsibilities is streamlining intermodal operations between ships and other forms of transportation that link to maritime ports, such as rail and trucking infrastructure. One of the ways they do this is by managing and

\(^4\) This Division was formerly known as the Information Management Division (IMD).
maintaining the ship channels and the GIWW, which is analogous to the main “highway” for maritime operations in Texas and is located along the State’s border with the Gulf of Mexico. Most of Texas’ key ports are located along the waterway, so efficiently maintaining and operating the waterway is critical to efficient maritime port operations.

This Division also plays a large role in developing the Texas Port Capital Program, which includes the list of capital projects planned for Texas maritime ports in the near-term. This Capital Program provides an avenue for introducing advanced technology into the freight supply chain, demonstrated by projects such as the study of potential technologies for the Velasco Terminal Main Gate at Port Freeport. The Division also administers the Port Access Improvement (Rider) Program, which has granted funds for projects along the coast that improved and widened public roadways, added truck queuing lanes in high-traffic areas, improved signage and gates at rail crossings, and upgraded intersections near Texas maritime ports. Technological improvements implemented at maritime ports have the potential to affect multiple freight modes as maritime ports typically are intermodal freight hubs served by rail and trucks.

3.1.3 Rail Division
The Rail Division of TxDOT oversees rail transportation for both freight cargo and passengers. Responsibilities include rail project planning, monitoring rail line abandonments, safety inspections, and operational analysis. One key area for this Division is improving highway-rail at-grade crossings to reduce accidents. The Rail Division manages the State’s railroad signal preemption systems (described in more detail in the FNTOP Inventory of Existing Condition report). Given the impact that train traffic can have on trucks that use these highway-rail at-grade crossings, the use of technology to disseminate information regarding train traffic is one technology area that this Division has identified as valuable to help reduce accidents. The Rail Division also oversees the TxDOT-owned South Orient Railroad, which is a rail line that runs from Presidio, at the Mexico border, to San Angelo Junction.

This Division also funds reports and studies that focus on topics such as safety, operations, and technology, including the 2019 Texas Rail Plan, the Metroplex Freight Mobility Study, and the Houston-Beaumont Freight Rail Study. These reports are a great source of information for innovative rail freight technologies. The studies provide information on how some of the innovative technologies can be used safely and effectively within Texas’ rail system.

3.1.4 Research and Technology Implementation Division
The Research and Technology Implementation Division within TxDOT is a key Division in the context of implementing freight-related technology projects. The primary responsibility of this Division is to facilitate research initiatives that help transform technological solutions from concept to construction—through both public-sector and private sector pursuits. This Division
allocates TxDOT funds and pursues federal grant opportunities to support local in-state university research centers and private sector innovators, such as the Texas A&M Transportation Institute (TTI) and the University of Texas at Austin Center for Transportation Research (CTR), in the development of technological solutions to improve the quality of life in Texas. The findings from many of these initiatives are applicable to other state Departments of Transportation (DOTs), positioning Texas to serve as a national leader for transportation innovation.

**3.1.5 Strategic Planning Division**
The Strategic Planning Division is the group in charge of developing planning and implementation strategies for new and innovative transportation infrastructure. This Division mainly focuses on large-scale transportation projects.

This Division is responsible for the TxDOT Strategic Plan, which is where the agency defines its operating procedures, themes, and goals for the next few years. One of the goals for the current Strategic Plan is to better use technology and innovations in transportation, recognizing that simply expanding roadways will not meet the future needs of the transportation system. This indicates an increased preference for implementing advanced freight technology solutions in the near future.

**3.1.6 Traffic Safety Division**
The Traffic Safety Division is primarily responsible for working with roadway designers to ensure that the placement of signs, traffic signals, roadway markings, lighting, and ITS are safe and consistent with national and Texas standards; developing traffic safety initiatives that help reduce fatalities and serious injuries; and collecting and analyzing crash data from Texas roadways and using it to inform the design and planning processes.

In order to help reduce congestion and roadway incidents, this Division has developed a statewide Transportation Systems Management & Operations (TSMO) Strategic Plan (more details provided in Section 3.3.1). 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. TSMO prioritizes mobility solutions which apply technology and other innovative techniques that are relatively low in cost and can be implemented in less time compared to adding capacity. District-level TSMO plans are currently being developed for each of the 25 TxDOT Districts. Each plan will include a 0-5 year project deployment plan as part of the effort.

---

Since traffic safety is a critical component of the transportation system, this Division of TxDOT is interested in any technological improvements that may increase the safety of freight transportation and support their TSMO Strategic Plan.

3.1.7 Transportation Planning and Programming Division
The Transportation Planning and Programming Division is responsible for regional, statewide, and international planning functions and activities; coordination with MPO planning activities; program and project funding allocations and portfolio management; traffic data collection and analysis; data management, support, and reporting; and public involvement and outreach to support project development. The Division collects and reports data used in freight planning applications (e.g., average annual daily traffic, traffic volume, vehicle classification, vehicle speed, WIM, etc.) and coordinates with freight, trade, and policy focused advisory groups including the Border Trade Advisory Committee and Texas Freight Advisory Committee.

The Freight Planning Branch of this Division supports TxDOT’s comprehensive and multimodal freight planning program that fulfills the recommendations of the previous federal legislation, Moving Ahead for Progress in the 21st Century (MAP-21), as well as the requirements of the Fixing America’s Surface Transportation Act, coordination within TxDOT, and other activities such as freight studies. The Freight Planning Branch develops freight plans including the TFMP – TxDOT’s comprehensive multimodal transportation plan, which provides a vision for a safe, reliable, and efficient freight transportation system for Texas that supports economic growth and global competitiveness.

3.1.8 Travel Information Division
The Travel Information Division of TxDOT promotes access to information about travel to and within the State. This Division is mainly focused on the tourism sector, as well as on programs that keep highways free of litter, but it also manages the public-facing information channel for highway conditions on Texas roads; DriveTexas. Traveler information is shared through the DriveTexas web-based application, which contains a map that shows the location of road closures, traffic incidents, and congestion. This Division also has the ability to alert drivers of real-time incidents and inform drivers of future lane closures. This application is particularly helpful for freight operators, providing up-to-date travel information to assist in making informed route decisions, and could be made even more useful through improved data collection methods and data streams that provide more precise data.

3.1.9 Bridge Division
The Bridge Division of TxDOT supports the structural planning, design, review, construction, and inspection of over 55,000 state bridges. This Division develops policies, design standards, manuals, and guidelines for the design, maintenance, and construction of a safe and comprehensive state bridge system. This includes administering the Highway Bridge Program, a federal-aid program that provides funding to enable states to improve the
condition of highway bridges through replacement, rehabilitation, and systematic preventative maintenance⁶. The Bridge Division prioritizes bridge projects statewide, maintains the Bridge Inspection Database, and manages several bridge strike and overheight vehicle detection systems deployed across the State.

3.1.10 Aviation Division
The Aviation Division helps cities and counties to obtain and disburse federal and state funds for reliever and general aviation airports included in the 300-airport Texas Airport System Plan (TASP). This Division also participates in the Federal Aviation Administration (FAA) State Block Grant Program, through which it implements a federal improvement program for general aviation airports.⁷

In terms of freight technology, the Aviation Division administers the TxDOT UAS Program, which is designed to be flexible while ensuring that all UAS activities conducted on behalf of TxDOT are done in the safest manner possible in compliance with all statutory requirements. UAVs can be used to help in infrastructure performance assessment (e.g., pavement or railroad tracks), or eventually for freight delivery.

3.2 TxDOT Advisory Committees
The following Committees were established by the Texas Transportation Commission and TxDOT to engage in freight planning and policymaking. These Committees are established by statute and are subject to Administrative Rules. These Committees report their findings to TxDOT and the Commission for recommended actions.

3.2.1 Texas Freight Advisory Committee
The Texas Freight Advisory Committee (TxFAC) is a body of public- and private sector freight-related leaders who advise TxDOT on freight issues, priorities, projects, and funding needs for freight improvements. The Committee elevates freight transportation as a critical component of the State’s economic vitality and competitiveness.⁸

3.2.2 Port Authority Advisory Committee
This Committee provides a broad perspective on maritime ports and transportation-related matters for TxDOT policies concerning the Texas maritime port and ship channel system. The Committee also prioritizes projects for any state funding and identifies landside connectivity needs.⁹

---

3.2.3 Border Trade Advisory Committee
This Committee advises TxDOT in defining and developing a strategy and makes recommendations to the Texas Transportation Commission and the Governor for addressing the highest priority border trade transportation challenges.10

3.2.4 Aviation Advisory Committee
This Committee provides input to TxDOT on aviation development programs and serves as its representative among aviation users. Committee members work with members of the Texas Legislature on various aviation issues.11

3.3 Texas Programs and Initiatives
The following programs and major initiatives relate directly to TxDOT’s freight objectives. The TxDOT Division offices handle a wide range of services for the agency. For various TxDOT initiatives, these Divisions coordinate internally to serve as stakeholders and—depending on the topic—lead the initiative. These Divisions also may advocate for creation of new Divisions for certain initiatives, usually for initiatives that require an expansion of the TxDOT organizational chart. Coordination between different TxDOT Divisions as well as external public and private sector partners is required for the successful advancement of TxDOT’s freight technology initiatives.

Another effective method to support freight technology initiatives in the State is through policy making and legislation. For example, at least 28 states and the District of Columbia have enacted varying degrees of legislation in regard to the permissiveness of AVs on public roadways. In 2017, Texas passed Senate Bill 2205. The Bill requires driverless vehicles on highways be capable of complying with all traffic laws, be equipped with video recording devices, and be insured just like other cars. It also makes the manufacturer responsible for any broken traffic laws or car wrecks, as long as the automated driving system (ADS) hasn’t been modified by anyone else.12 Subsequent Automated Vehicle (AV) laws and regulations within Texas have been developed to address ambiguities and promote safety, but Texas is generally regarded as being fully permissive of AV operation, which makes it an attractive testing location for national and international developers. An analysis by TTI grouped Texas in the “full operation” category of states.13

Other states have focused their efforts through grant opportunities in coordination with their public universities to test AVs in a controlled environment under less-than-ideal operating conditions.

---

scenarios. In one instance, Ohio is undertaking AV studies as part of its DriveOhio program, in which self-driving vehicles are being explored for truck platooning and rural ADS ride-hail applications. Similarly, the Minnesota DOT undertook extensive testing for winter weather conditions for self-driving vehicles at its MnRoad facility in 2017 and 2018 in order to help facilitate proper legislative requirements.

Other states have opted to permit AVs to operate on public roads, with certain prerequisite requirements needing to be met before being allowed to do so. Similar to Texas, Florida enacted legislation to permit AVs on public roads, which would allow its residents to both drive these vehicles as well as hail driverless ride-share services whenever they become available.

Several state agencies including Michigan, Pennsylvania, and Virginia have developed strategic plans for their Connected and Automated Vehicle Programs, in order to institutionalize and integrate CAVs into all facets of their transportation network and frame CAVs as an opportunity to improve mobility, safety, and economic development. States such as Washington and Iowa have done extension work in preparing Cooperative Automated Transportation (CAT) plans.

3.3.1 Statewide Transportation Systems Management and Operations Program

Statewide TSMO is a program that implements strategies to improve management and operations of the transportation roadway network. This program requires management and operations stakeholders to work together to define a common vision for transportation system operations in a given region, as opposed to each respective regional road operator conducting its own independent effort in a silo. For Texas, TSMO combines planning, design, operations, and maintenance. This is done to better manage the existing transportation infrastructure, rather than expanding the existing roadway footprint. One of the ultimate goals of TSMO is to make traffic management systems as much of a priority as other projects that require capital investments.

The American Association of State Highway and Transportation Officials (AASHTO) outlines six “dimensions” of TSMO14 as the following, which have all been adopted by the Texas TSMO program:

- **Business Processes:** Includes formal scoping, planning, programming, and budgeting;
- **Systems and Technology:** Includes use of systems engineering, systems architecture standards, interoperability, and standardization;

---

• **Performance Measurement:** Includes measures definition, data acquisition, and data utilization;

• **Culture:** Includes technical understanding, leadership, outreach, and program legal authority;

• **Organization and Workforce:** Includes programmatic status, organizational structure, staff development, and recruitment and retention; and

• **Collaboration:** Includes relationships with public safety agencies, local governments, metropolitan planning organizations (MPOs), and the private sector.

These six dimensions were applied to Texas specifically to create six goals and objectives for the Statewide TSMO program. The goals are outlined in Exhibit 6, which is taken from the TxDOT Statewide TSMO Strategic Plan.

**Exhibit 6: Statewide TSMO Goals and Objectives**

<table>
<thead>
<tr>
<th>Goal</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Reduce crashes and fatalities through continuous improvement of traffic management systems and procedures.</td>
</tr>
<tr>
<td>Reliability</td>
<td>Optimize travel times on transportation systems in critical corridors to ensure travelers are reaching their destinations in the amount of time they expected for the journey.</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Implement projects that optimize existing transportation system capacity and throughput.</td>
</tr>
<tr>
<td>Customer</td>
<td>Provide timely and accurate travel information to customers so they can make informed mobility decisions.</td>
</tr>
<tr>
<td>Service</td>
<td></td>
</tr>
<tr>
<td>Collaboration</td>
<td>Proactively manage and operate an integrated transportation system through multi-jurisdictional coordination, internal collaboration, and cooperation between various transportation disciplines and partner agencies.</td>
</tr>
<tr>
<td>Integration</td>
<td>Prioritize TSMO as a core objective in the agency's planning, design, construction, operations, and maintenance activities.</td>
</tr>
</tbody>
</table>


Traditional project prioritization methods favor capital investments over technology investments. The adoption of this TSMO Program aims to shift the culture and function of an agency to institutionalize system-wide management and operations through all business functions and the project development process. It accomplishes this by recognizing traffic management systems as a core priority and through dedicated programs and funding. This
opens doors to apply innovative freight technologies to improve freight operations, which are relatively low in cost compared to adding capacity, can be implemented in less time, and potentially offer higher benefit-cost ratios.

Examples of TSMO strategies include, but are not limited to:

- Work zone management;
- Advanced traveler information;
- Road weather information systems;
- Freight and commercial transportation management;
- Active transportation and demand management;
- Integrated corridor management (ICM);
- Multimodal traffic management; and
- Incident and emergency management.

### 3.3.2 Statewide ITS Strategic Plan

The ITS Strategic Plan is a project performed by TTI in collaboration with TxDOT and the FHWA. The Plan development was overseen by TxDOT’s Research and Technology Implementation Office and its implementation is the responsibility of several Divisions, most notably Traffic Safety. The objective of the Plan is to provide a framework to guide the development and deployment of an integrated statewide program for intelligent transportation systems (ITS). The ITS Strategic Plan:

- Provides concise ITS strategic plan goals and objectives for TxDOT;
- Highlights the ITS priorities from the regional and local perspective;
- Summarizes national trends in ITS strategies;
- Presents a status report on regional ITS in Texas;
- Introduces anticipated ITS services that TxDOT may need in the future; and
- Presents a candidate ITS archetype as potential guidance for moving forward with ITS across the State.

The ITS Strategic Plan identifies the need for TxDOT to invest in and deploy ITS systems and technologies to facilitate the movement of freight and goods along strategic, high-volume freight corridors, including international border crossings.

### 3.3.3 Emerging Transportation Technology Plan

The Strategic Planning Division prepared a statewide Emerging Transportation Technology Plan (ETTP) to develop implementation strategies to integrate emerging transportation technologies such as Connected and Automated Transportation (CAT), UAS, Mobility as a
Service (MaaS), emerging freight technologies, and other transformative technologies into State planning practices. This Plan identifies and offers strategies to address new and disruptive technologies while implementing the long-term vision outlined in the Texas Transportation Plan 2050.

Building on existing efforts to incorporate emerging technologies into Texas transportation planning, the ETTP widens the view to provide a framework for addressing emerging transportation technology. Specifically, the ETTP provides guidance for four underlying strategies that are needed regardless of the type of technology: data management, scenario planning, project and program development, and business processes. These focus areas will support TxDOT efforts to embrace new technology in full alignment with wider agency goals to make Texas transportation more safe, reliable, and efficient for the movement of people, goods, and data.\textsuperscript{15}

3.3.4  Connected and Autonomous Vehicle Task Force
In 2019, TxDOT created the CAV Task Force to become a central point for CAV advancement in Texas. This Task Force is intended to be the one-stop resource for information and coordination on all ongoing CAV projects, investments, and initiatives in Texas. In addition to documenting public and private entity efforts and facilitating partnerships, the CAV Task Force will host industry forums and report lessons learned to facilitate progress and encourage greater collaboration. The Task Force will continue to enable companies to pursue innovative ideas around CAV technology and build on legislation passed by the 85th Legislature related to how CAVs can operate in Texas.\textsuperscript{16}

3.3.5  Cooperative Automated Transportation Program
CAT is a cooperative ecosystem of physical and digital infrastructure, and emerging vehicle technologies to enable the safe, reliable, and efficient movement of people and goods in a multimodal transportation network. The main objectives of the TxDOT CAT Program are to promote and support the creation of a culture of innovation and proactive integration of CATs into planning, design, construction, maintenance, and operation of transportation infrastructure. The CAT Strategic Plan was developed under the guidance of the TxDOT CAV Task Force and CAT Project Work Group (includes representatives from TxDOT Divisions and Districts), to capture the policies that will provide guidance to the CAT Program Plan. The CAT Program Plan will identify and designate resources for CAT development and deployment, integrate CAT strategies into the implementation and programming processes, and develop an external stakeholder outreach strategy that will help TxDOT partner with public and private sector leaders to advance CAT technology.

\textsuperscript{15}  Texas Department of Transportation. \textit{Emerging Transportation Technology Plan} – Draft, May 2020.

3.3.6 I-10 Corridor Coalition
The I-10 Corridor Coalition is a coalition of western states through which Interstate 10 (I-10) passes. This includes California, Arizona, New Mexico, and Texas. The general purpose of the coalition is to oversee operations and development of the I-10 corridor jointly, reducing the need for separate groups within each of the member states. The steering committee for the group is made up of the director or cabinet secretary of each DOT (or their designee). The steering committee has established the following subcommittees:

- **Technical Subcommittee**: Responsible for future projects implemented along the corridor;
- **Transportation Systems Management and Operations Subcommittee**: Responsible for ensuring that each state’s Transportation Management/Transportation Operation Centers share relevant information and communications with other members; and
- **Communications Working Group**: Responsible for media outreach and engagement.

Outside of TxDOT, the California, Arizona, and New Mexico DOTs, as well as FHWA, Texas DPS (TxDPS), Texas DMV, and the Association of Texas Metropolitan Planning Organizations are all affiliated with the I-10 Corridor Coalition.

In terms of freight technology, the I-10 Corridor Coalition developed a Concept of Operations document that laid the groundwork by identifying possible options and technology improvements that could improve goods movement in the I-10 corridor. The member states of the I-10 Corridor Coalition can fund specific projects along the corridor to test freight technologies of interest. In 2018, I-10 Corridor Coalition state DOTs, with TxDOT as the lead, were awarded an Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) grant request for $6.8 million, with an equal amount of state match. The purpose of the grant is to deploy the I-10 Corridor Coalition Truck Parking Availability System (TPAS), which TxDOT will be managing (see Section 4.2.1.2 for more information). The burden on each state would be lessened because of the multi-state agreement, and the results would be shared across all member states, reducing the need for each state to invest in redundant projects.

3.3.7 Texas Connected Freight Corridors Project
The TCFC Project is a program that will deploy 12 CV technology applications to trucks in the Texas Triangle Region (Austin, Dallas-Fort Worth (DFW), Houston, and San Antonio). The motivation for this deployment is to boost economic efficiency, increase safety of trucks, and promote the use of emerging technologies. TxDOT is partnering with TTI, SwRI, and CTR to achieve these goals. In addition to these formal partnerships, TxDOT will also work with two primary stakeholder groups that are made up of freight companies and public agencies.

The project is split into three phases. The project will start with planning and high-level design where the team develops a more specific strategy to effectively implement these
12 technologies. Key milestones in this phase include developing performance measures to evaluate the effectiveness of the technologies, outreach with relevant stakeholders, and analyzing the safety implications of the project. The team will subsequently build out the actual infrastructure, which includes roadside equipment, on-board units, new servers, and traffic signal system upgrades, and provide training to the system and vehicle operators. Finally, operation of the program will begin, accompanied by oversight support to ensure that the program is operating as smoothly as possible. The U.S. Department of Transportation (USDOT) will eventually evaluate the program independently to see if it could be deployed in other states.

3.3.8 Enterprise Information Management Program

To advance TxDOT’s data strategic needs, ITD has developed the Enterprise Information Management Program. It builds on efforts to implement a centralized data architecture that will collect TxDOT’s various data sources and transform them into clean, secure, and authoritative data. The further goals and subsequent projects associated with the Enterprise Information Management Program are described in greater detail in Section 4.0.

3.3.9 Texas Technology Task Force

The TTTF is a team of professionals working in areas related to transportation technology—particularly emerging transportation technologies. These professionals are from public agencies, such as TxDOT or the Metropolitan Transit Authority of Harris County (Houston METRO); the private sector industry, such as FedEx or INRIX; or from research institutions, such as CTR or SwRI. The Division of Strategic Planning within TxDOT provides staffing support.

One of TTTF’s main responsibilities includes producing white papers highlighting various technologies to make each technology more understandable for other entities of the transportation sector. In terms of freight technology, TTTF has published white papers on data sharing, CVs, mobility-as-a-service, and scenario planning. The TTTF is one of the first places a new technology can be “discovered” and communicated to other Divisions of TxDOT.

3.3.10 Texas Innovation Alliance

The Texas Innovation Alliance (TIA) is a group of public agencies and research institutions that aims to create a “platform for innovation.” This group was created as part of the USDOT Smart City Challenge in 2016, when teams from cities across America collaborated to address prominent smart city solutions. After the Smart City Challenge ended, the TIA remained intact, because members of the group recognized the need for collaboration across government agencies when discussing innovative new ideas.

The Alliance operates more similarly to an entrepreneurial organization than a traditional alliance of public agencies; instead of creating reports about technology that already exist,
its aim is to encourage people to think of new ideas and solutions to transportation and mobility issues. The Alliance accomplishes this through a process of rapidly prototyping ideas, creating pilot projects, and emphasizing public/private dialogue. This dialogue ensures that the private sector is aware of the most important issues facing transportation today and gives them a platform to bring innovative solutions forward. This Alliance is critical to the promotion of freight technology, as it can be used as a launchpad for freight technology innovations that may be specifically tailored to suit the transportation needs of Texas.

Annually, the TIA in partnership with TxDOT and metropolitan regions across the state, host the Texas Mobility Summit, a two-day conference that brings together transportation leaders with the goal of developing shared solutions to the states’ most pressing mobility challenges. The TIA developed a proposal to TxDOT executive leadership recommending a TxDOT-administered grant program to activate the Texas Proving Grounds. The program would leverage state, local, and private resources to catalyze planning, deployment, and research activities in four key areas: 1) New Mobility, 2) Operations & Infrastructure, 3) Freight & Logistics, and 4) Equity & Access. The grant program is designed to offer a clear pathway for public agencies with local funding to partner with the private sector and apply for matching resources in support of planning, deployment, and research activities.17

3.3.11 Texas State Transportation Innovation Council

The Texas STIC is a group that is similar to the TTTF and the TIA, except that this group focuses more on the deployment and communication of innovative transportation solutions instead of the research component. The STIC implements technology that has already been proven successful in real-world situations instead of serving as a “testing ground” for more cutting-edge ideas.

Besides implementing technology, the STIC also provides a means for communication among different stakeholders to discuss innovative solutions. From this forum, they can identify subject matter experts and champions that work together to lobby for innovative technology in Texas.

In terms of freight technology, the STIC is important to Texas because it can align a pro-technology lobbying platform with the freight technologies that are up for consideration. The STIC also has considerable influence over advancing ideas for consideration by key decision-makers by directly advising the TxDOT Director of Strategy and Innovation, as well as the FHWA Texas Division Administrator.18

3.3.12 Intelligent Transportation Society of Texas
ITS-Texas is an advocacy group for advanced technology transportation solutions. It is the Texas chapter of ITS America, which serves a similar role at a national level. Both organizations were started with a focus on intelligent vehicle highway systems, but expanded their scope in the mid-1990s to include all aspects of intelligent transportation. The highlight of ITS-Texas is an annual conference where projects around Texas are presented and the latest developments in intelligent transportation technology are discussed. In the past, intelligent freight technology solutions have been discussed, making ITS-Texas yet another advocate for improved freight technology and cutting-edge advancements.

3.4 TxDOT Partner Agencies
TxDOT has numerous partner agencies which share common goals in freight movement, safety and security, and economic development. A few with directly applicable responsibilities are described below.

3.4.1 Texas Department of Public Safety
The TxDPS goals include enhancing highway and public safety as well as statewide emergency management in Texas. The TxDPS Commercial Vehicle Enforcement Service checks the size, weight and safety of CMV operating in Texas. This ensures compliance with the laws regulating size, weight, safety, registration, and the transportation of persons, hazardous materials (HAZMAT), and other property. It has joint responsibility with the Highway Patrol Division to conduct Traffic and Criminal Law Enforcement, primarily on rural highways.

In addition to mobile roadside enforcement, TxDPS operates nearly 100 fixed commercial vehicle enforcement locations throughout the State. These sites include a range of investments from roadside pull-off areas with limited amenities or technology that are used on an infrequent basis to full-scale enforcement sites with pre-screening technology, weight scales, inspection buildings, and consistent staffing.

3.4.2 Texas Division of Motor Vehicles
The TxDMV is responsible for licensing and registration for CMVs. Motor carriers operating intrastate CMVs on a road or highway in Texas must get a TxDMV number. Granting and distribution of OS/OW CMV permit distribution is a key responsibility of the TxDMV Motor Carrier Division. The TxDMV also regulates international carriers through management of North American Free Trade Agreement (NAFTA)\(^\text{19}\) permits.

---

\(^{19}\) While the Texas DMV website still refers to NAFTA permits, as of July 2020, NAFTA has been replaced by the US-Mexico-Canada Agreement (USMCA).
3.4.3 Governor’s Broadband Development Council
House Bill (HB) 1960, enacted in 2019, creates the Governor’s Broadband Development Council and will be composed of 17 members. The council shall: (1) research the progress of broadband development in unserved areas; (2) identify barriers to residential and commercial broadband deployment in unserved areas; (3) study technology-neutral solutions to overcome barriers identified under Subdivision (2); and (4) analyze how statewide access to broadband would benefit: (A) economic development; (B) the delivery of educational opportunities in higher education and public education; (C) state and local law enforcement; (D) state emergency preparedness; and (E) the delivery of health care services, including telemedicine and telehealth. The Governor’s Broadband Development Council is working to identify barriers to and solutions for expanding broadband (high-speed internet) access to rural communities across the state of Texas, which will be necessary for freight technology innovations to reach across the State.

3.4.4 Texas State Energy Conservation Office
Aiming to improve Texas’ energy security and air quality, the Texas State Energy Conservation Office Alternative Fuels Program supports public fleets that deploy AFVs and build associated fueling infrastructure. The program thrives on strong local initiatives and a flexible approach to developing alternative fuels markets, providing participants with options to address problems unique to their cities and fostering partnerships to help overcome them. This program may be beneficial for advancing TxDOT’s adoption rates of alternative fuel truck fleets.

3.4.5 United States Customs and Border Protection
The United States Department of Homeland Security (DHS) Custom and Border Protection’s (CBP) mission is to safeguard America’s borders to protect the public from dangerous people and materials. They manage the security of cross-border freight movements at all POEs across multiple modes and utilize technologies to support credentialing, inspections, and traveler information.

3.4.6 United States Department of Transportation
The USDOT’s role includes providing federal funding for nationwide research initiatives and deployment of innovative freight technology-related projects. USDOT sponsored the development of the Freight Advanced Traveler Information System (FRATIS) and evaluated the benefits of the I-35 Connected Work Zone project, a cooperative research agreement between USDOT and TxDOT.

USDOT administers various grant programs such as ATCMTD and Surface Transportation System Funding Alternatives Program (STSFA) through the FHWA and the CRISI Program through the Federal Railroad Administration (FRA). Projects funded by FHWA through the ATCMTD grant program include ConnectSmart – Connecting TSMO and Active Demand Management, the TCFC Project, and I-10 Corridor Coalition TPAS. As part of USDOT’s ICM
Initiative, TxDOT received an USDOT ICM Planning Grant for their I-35 ICM project, a heavily
traveled freight corridor.

3.5 Research Institutes
In addition to all the organizations listed above, Texas is home to some of the nation’s
premiere transportation research groups. These include TTI, CTR, and SwRI. These three
research institutes conduct research efforts that advance the state of transportation in
Texas, in the U.S., and around the world.

3.5.1 Texas A&M Transportation Institute
TTI is a world-renowned research organization that is part of the Texas A&M University
System. It primarily focuses on research and testing of transportation solutions in many
different focus areas. Among the many focus areas, those with the greatest connection to
the freight technology sector include:

- **Freight:** This group focuses on improving freight efficiency. It has a particular interest in
  multimodal freight, including the intermodal terminals where freight transfers between
  vehicles or between modes. This focus area has specific sub-groups consisting of
  maritime ports and waterways, railways, air transportation, and international border
  operations.

- **Mobility:** This group examines problems associated with congestion and access to
  transportation, develops innovative solutions, and measures the effectiveness of the
  outcomes. It uses connected probe data to help TxDOT identify transportation
  bottlenecks and is focusing on freight fluidity/supply chain analysis that TxDOT can use
  to support its planning and TSMO work.

- **Planning and Operations:** This group focuses on the data collected from Bluetooth
  devices, cell phones, Global Positioning System (GPS), surveys, and more. This group
  also investigates different data collection and public data dissemination methods.

- **Connected Transportation:** This group focuses on automated and connected
  transportation. One of the group’s biggest assets is the Automated Vehicle Proving
  Ground, which is certified by the USDOT.

Recently, TTI has supported TxDOT on the Assessment of Innovative and Automated Freight
Systems and Development of Evaluation Tools research project, where four freight strategies
and technologies (1. Port Area ITS, 2. Separation of Trucks from Automobiles/Truck-Only
Infrastructure, 3. Truck Parking Information, and 4. Border Advanced Traveler Information)
were advanced for further research. TTI is also currently working on the TxDOT Evaluate
Potential Impact of Truck Platooning on Texas Infrastructure research project. The main

---

https://library.ctr.utexas.edu/Presto/content/Detail.aspx?ctID=UmVzZWFyY2gtW4tUHvZ3Jlc3NfMTExMjY=&rID=Nzg
z&ssid=c2NyZWVuSURfMTE0DI=
objective of this project is to perform an analysis of the Texas on-system highway infrastructure and determine if there are any potential impacts to the number of trucks that can be linked in a platoon\(^2\).

### 3.5.2 University of Texas at Austin Center for Transportation Research

CTR is a research institution that combines research in the transportation field with educational opportunities for students at the University of Texas at Austin. The group has performed research projects for public agencies such as TxDOT, USDOT, and Transportation Research Board (TRB). CTR coordinates the TTTF and collaborates regularly with other Texas organizations like the TIA on several research initiatives. Additionally, CTR has three centers that focus on different areas of transportation innovation. They are:

- **Data-Supported Transportation Operations and Planning Center (D-STOP):** This center is focused on data-driven transportation technologies. This includes the ways in which data is collected and stored/analyzed. The center works with transportation agencies to rapidly implement results to improve real-world transportation infrastructure.

- **Network Modeling Center:** This center focuses on network models, especially those that deal with dynamic traffic assignment, and have applied its models to case studies to projects around the Austin, Texas region.

- **Texas Pavement Preservation Center:** This center promotes the use of pavement preservation strategies to increase the lifespan of roads in cost-efficient ways.

### 3.5.3 Southwest Research Institute

SwRI is a private, non-profit research group that focuses on research needs in transportation, electronics, defense, biomedical, energy, and other areas. SwRI has 10 technical divisions, with “intelligent systems” being most pertinent to freight technology. Within this division, SwRI does work on advanced traffic management systems, fully autonomous vehicles, CVs, and intelligent vehicles. It has previously worked with TxDOT to develop the LoneStar traffic management system. It also has completed projects in the realms of automotive cyber security, advanced engine, drivetrain, and other vehicle parts design, longer energy storage for vehicular batteries, and reducing emissions. Out of the three research institutions identified in this section, SwRI has done the most work with the physical parts of transportation vehicles, rather than the overarching transportation infrastructure.

\(^2\)[https://library ctr utexas edu/ Presto/content/Detail.aspx?ctID=M2Ux Nzn5YmEyZMyZS00ZjBiLWoyODctYzljMzQ3ZmV m0WFllriID=NjEy&siD=MQ%3D%3D&qs=VHj1ZQ%3D%3D&qs=KhwLUII29yZTVwZGF0ZQ9Wzd0MTgwMTE4MDUw MD4wFRPIDwMTgxMTE1MDU1OTU5XSkgTk9UICcC5wZXJhbms6KCpK0%3D%3D&rrtc=VHj1Z0%3D%3D&b mdc=MQ==]
4.0 Freight Technology Areas

Freight transportation plays a critical role in Texas’ economy. Using technology, Texas is able to improve its economic competitiveness by providing safe, efficient, and multimodal freight movement. Specifically, freight transportation technologies help achieve the following:

- Address freight transportation needs and issues;
- Support future growth in freight volume and flow;
- Improve freight mobility across all modes in terms of safety, efficiency, and reliability; and
- Foster increased economic growth through reduced transportation cost and enhanced productivity.

This section of the State of the Practice Assessment report discusses seven primary freight technology areas for Texas, identified through preliminary findings at the project kick-off meeting held in May 2019, stakeholder meetings held in August 2019 and subsequent “deep dive” sessions thereafter with TxDOT Transportation Planning and Programming Division, Information Technology Division, Traffic Safety Division, Travel Information Division, Right-of-Way Division, Rail Division, Maintenance Division, Maritime Division, and Strategic Planning Division. The technology areas covered in this report include:

- Traffic Management;
- Advanced Traveler Information Systems;
- Dynamic Route Guidance;
- Data Integration and Analytics;
- Enforcement and Inspection;
- Automated and Connected Freight Vehicles; and
- Intermodal Terminal Operations.

For each technology area, a description of the existing or emerging technology area is provided, followed by an assessment of the technology and operations-related programs in Texas. To help identify technology gaps and potential areas for improvement, each technology area is also supplemented with a discussion on the state of practice within the U.S. and internationally. Note that locations in Texas with the described technologies and equipment are further documented in the FNTOP Inventory of Existing Conditions.

4.1 Traffic Management

Traffic management is a strategy to improve mobility and safety for all modes of transportation by managing operations and promptly responding to travel disruptions. Traffic management is generally viewed as improving operations for all users, but certain
applications target freight and freight-based activities. In the context of freight, traffic management includes strategies such as Incident and Emergency Management, Collision Avoidance Systems, and Freight Signal Priority (FSP); each described below:

- **Incident Management** is the process of detecting, responding to, and clearing incidents to restore traffic flow. Incident management is generally carried out by the road operator and associated emergency responders, and can include responding to a range of incident types from a vehicle with a flat tire through an overturned tractor trailer. Effective incident management reduces the impact and duration of an incident and improves safety for all travelers on the road by decreasing the likelihood of secondary incidents.

- **Emergency Management** is the process of managing widespread evacuations and guiding traffic safely during an unexpected occurrence of events. This includes major disruptive events, such as hurricanes, where freight operations can be often widely impacted and play a key role in pre and post event activities. This strategy also includes managing freight operations around the emergency area.

- **Collision Avoidance Systems** include the use of in-cab technology to alert truck drivers when there is a safety hazard. For example, when the distance between a truck and nearby vehicle is too close or when the number of road lanes reduces due to a work zone, the driver gets an audible notification from the in-cab equipment to help improve awareness. This could include hazard detection and overheight notification.

- **FSP** is the modification of a traffic signal’s operation to give priority to an approaching truck(s) when detected via using road sensors or CV technology. The traffic signal either extends the green time to allow the truck(s) to make it through the intersection without stopping or reduces the red time to decrease the delay encountered by truck(s).

**4.1.1 Traffic Management Programs and Technology Developments in Texas**

The 2018 TFMP is the overarching document that provides a comprehensive multimodal freight transportation plan for Texas. As part of the TFMP, an implementation plan that addresses the current and future needs of the TMFN is outlined. The following program actions are listed in the TFMP implementation plan for potential traffic management strategies:

- Develop a statewide Commercial Vehicle Traffic Incident Management Program to address commercial vehicle crashes and improve safety and mobility for the motoring public and trucks.

- Convene a statewide Traffic Incident Management Taskforce comprised on law enforcement, fire departments, emergency medical services, towing and recovery, local agencies, and TxDOT to comprehensively address commercial vehicle incidents on the Texas Highway Freight Network (THFN).
• Develop freight movement traffic signal timing/coordination improvements to provide a cost effective strategy to reduce congestion problems, provide for fuel savings, and reduce travel times.

These goals align with various freight traffic management initiatives and programs that are underway in Texas, either as a current deployment or as a proposed effort. The following sections document these programs and projects, focusing on those specifically that benefit freight operations directly or indirectly. Exhibit 7 summarizes each program or technology development’s relevance to the freight community.

Exhibit 7: Summary of Traffic Management Programs and Technology Developments in Texas

<table>
<thead>
<tr>
<th>Traffic Management Programs and Technology Developments in Texas</th>
<th>Freight-Specific</th>
<th>Relevance to Freight Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>TxDOT Traffic Management Centers (TMCs)</td>
<td>No</td>
<td>As TxDOT deploys more freight technology and operation systems, these systems may help to expand upon TMCs’ situational awareness and provide a means for TMC operators to respond to roadway events more proactively.</td>
</tr>
<tr>
<td>Texas Connected Freight Corridors (TCFC) Project</td>
<td>Yes</td>
<td>The TCFC Project plans to utilize CV technologies to improve safety, reduce congestion, and lower fuel consumption of freight trucks along the busiest corridors in Texas.</td>
</tr>
<tr>
<td>Connecting Critical Highway Corridors</td>
<td>No</td>
<td>This initiative plans to deploy additional ITS equipment (cameras, DMSs, and connected infrastructure) along critical freight, travel, and hurricane evacuation routes in Texas to improve traffic and emergency management for all types of vehicles, including freight.</td>
</tr>
<tr>
<td>Dallas US-75 Integrated Corridor Management Project</td>
<td>No</td>
<td>This Project deployed an ICM system that gathered data on traffic, road, and weather conditions that was shared between TMCs, police, and emergency responders to facilitate more streamlined traffic and incident management procedures among agencies for all type of vehicles, including freight.</td>
</tr>
</tbody>
</table>
Traffic Management Programs and Technology Developments in Texas

<table>
<thead>
<tr>
<th>Freight Innovative Technology Project</th>
<th>Freight-Specific</th>
<th>Relevance to Freight Community</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>This Project came up with nine strategy/technology areas that could support TxDOT's efforts to meet its freight planning goals and objectives.</td>
</tr>
</tbody>
</table>

4.1.1.1  *TxDOT Traffic Management Centers*

TxDOT operates TMCs with local collaborative transportation partners. Seven of the key centers are identified below:

- **Austin Combined Transportation, Emergency and Communications Center (CTECC)** involves a partnership between four agencies including the City of Austin, Travis County, TxDOT Austin District, and the Capital Metropolitan Transportation Authority. CTECC provides traffic and emergency management services for the City of Austin and Travis County.

- **Dallas DalTrans** is a partnership between three agencies including the City of Dallas, TxDOT, and Dallas Area Rapid Transit (DART). DalTrans provides traffic and emergency management services for multiple jurisdictions within the Dallas metropolitan area.

- **El Paso TransVista** is managed and operated by the TxDOT El Paso District and provides traffic and emergency management services for El Paso city and county, including traffic conditions near high-traffic international border crossings.

- **Fort Worth TransVision** is managed and operated by the TxDOT Fort Worth District and provides traffic and emergency management services for the Fort Worth area.

- **Houston TranStar** involves a partnership between the City of Houston, Harris County, TxDOT, and METRO. TranStar provides traffic and emergency management services for the Greater Houston area.

- **Laredo South Texas Regional Advanced Transportation Information System (TRATIS)** is managed and operated by the TxDOT Laredo District and provides traffic and emergency management services for the City of Laredo including traffic conditions near high-traffic international border crossings.

- **San Antonio TransGuide** involves a partnership between three agencies including the City of San Antonio, TxDOT, and VIA Metropolitan Transit. TransGuide provides traffic and emergency management services for the City of San Antonio.
4.1.1.2 Texas Connected Freight Corridors Project

The TCFC Project plans to utilize CV technologies to improve safety, reduce congestion, and lower fuel consumption of freight trucks along the busiest corridors in Texas. This Project focuses on the “Connected Triangle,” which includes I-35 (from DFW extending to Laredo), I-45, and I-10 and links Austin, DFW, Houston, and San Antonio. This Project would deploy CV technologies, including vehicle-to-vehicle (V2V) communication devices, in approximately 1,000 trucks, and vehicle-to-infrastructure (V2I) communication devices along the mentioned interstate corridors. The proposed CV applications encompass freight traffic management in terms of reducing CMV crashes and giving traffic signal priority to freight at critical intersections near distribution centers.

Exhibit 8 shows the primary TCFC corridors and additional corridors of interest while Exhibit 9 provides additional details regarding applications planned for deployment as part of this project.

Exhibit 8: Texas Connected Freight Corridors Deployment Site Map

### Exhibit 9: Texas Connected Freight Corridor Traffic Management Applications

<table>
<thead>
<tr>
<th>Application</th>
<th>Location</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work Zone Warning</td>
<td>I-35 (Austin, Temple)</td>
<td>Improve safety of work zones by: • Providing alerts to drivers • Providing work zone information to freight operators</td>
</tr>
<tr>
<td>Low Bridge Height Warning</td>
<td>I-35 I-45/I-10</td>
<td>Preventing collisions by communicating low bridge heights to approaching drivers</td>
</tr>
<tr>
<td>Wrong Way Driving Alert</td>
<td>San Antonio</td>
<td>Reduce crashes by: • Detecting wrong way drivers and alerting them • Notifying freight operators</td>
</tr>
<tr>
<td>Road Weather Warning</td>
<td>I-35</td>
<td>Reduce crashes due to spot weather by: • Providing alerts to drivers • Notifying freight operators</td>
</tr>
<tr>
<td>Pedestrian/Animal Warning</td>
<td>I-35, Austin</td>
<td>Reduce pedestrian/vehicle collisions by: • Detecting pedestrians and alerting drivers • Notifying freight operators</td>
</tr>
<tr>
<td>Emergency Electronic Brake Lights (EEBL)</td>
<td>Austin/San Antonio</td>
<td>Reduce crashes due to traffic queues by providing an emergency EEBL warning system deployed in trucks</td>
</tr>
<tr>
<td>Queue Warning</td>
<td>I-35 I-45/I-10</td>
<td>Reduce crashes due to traffic queues by detecting end of queue conditions and notifying upstream traffic</td>
</tr>
<tr>
<td>Freight Signal Priority (FSP)</td>
<td>San Antonio</td>
<td>Reduce truck idle time near distribution centers</td>
</tr>
</tbody>
</table>

Source: Texas Connected Freight Corridor, Volume 1—Technical Application

#### 4.1.1.3 Connecting Critical Highway Corridors

TxDOT ITD is planning an initiative on major highway corridors to install cameras, DMSs, and connected infrastructure to address current ITS coverage gaps. The corridors are identified as critical freight, travel and hurricane evacuation routes in the State, and with proper instrumentation, TxDOT will be able to improve its ability to communicate with drivers, hence providing better traffic and emergency management.
4.1.1.4 *Dallas US-75 Integrated Corridor Management Project*

The US-75 ICM project was an 18-month demonstration project to implement an ICM system to US-75 extending from Dallas north to SH 121 in Plano, an approximate length of 28 miles. The project was led by DART in coordination with FHWA and TxDOT. The US-75 corridor is a freeway with frontage roads and connecting arterials, along with high-occupancy vehicle (HOV) lanes and DART light rail lines. The vision for implementing ICM is to improve the management and operation of US-75 as an integrated corridor management system.

The ICM system provides information exchange between multiple agencies along the corridor and aggregates road and traffic information to convey to travelers in real-time and to help develop incident response plans. The ICM system is comprised of two major subsystems: the SmartNET/SmartFusion and the Decision Support System (DSS). The SmartNET/SmartFusion provides a platform to gather data on traffic, road and weather conditions, and share it between TMCs, police, and emergency responders. Based on the data collected and using prediction analysis, the DSS notifies the agencies through SmartNET/SmartFusion of the network performance and incident events, and recommends a response plan based on pre-defined rules set by the corridor operating agencies. After a response plan has been selected by the affected agency, traffic and incident data are disseminated to travelers via social media and the 511 DFW service, allowing them to make informed routing decisions.

4.1.1.5 *Freight Innovative Technology Project*

TxDOT, as part of a three phase 2018 FHWA-sponsored project with TTI referred to as “Assessment of Innovative and Automated Freight Systems and Development of Evaluation Tools”, investigated nine strategy/technology areas that could support TxDOT’s efforts to meet its freight planning goals and objectives. The nine strategy/technology areas include the following:

- Automated/zero emission freight systems;
- Freight rail public-private partnerships;
- Alternative fuel freight vehicles;
- Truck-shipper matching systems;
- Port ITS;
- Separation of trucks from automobiles;
- Truck parking information systems;
- Freight village facility development; and
- Border advanced freight traveler information.
As part of the project, test concepts and applications that could address the freight system needs were identified. The following sections highlight projects that are proposed by TTI to improve freight traffic management.

### 4.1.1.5.1 ITS for Truck Traffic in Port Arthur

TTI identified an opportunity to improve truck mobility into and out of Port Arthur along Houston Avenue and Gulfway Dr. (16th St.) between Highway 82 and Highway 73, shown in Exhibit 10 below. The corridor has 15 intersections, and the proposal includes installing advanced traffic signal controllers and detection equipment in order to detect trucks and prioritize the green time to benefit truck traffic.

**Exhibit 10: Gulfway Drive Corridor Location in Port Arthur**

![Gulfway Drive Corridor Location in Port Arthur](image-url)
4.1.1.5.2 Truck Priority along FM 511 in Brownsville

Another proposed project seeks to improve truck mobility around the Port of Brownsville. Truck traffic reaches the Port from I-69 using primarily Farm-to-Market (FM) 511 instead of the alternative tolled route of Highway 550. With the expansion of the Port, truck traffic is expected to increase, leading to congestion and safety concerns along FM 511. This project aims at improving truck mobility along FM 511 by providing traffic signal priority to trucks and also finding alternate routes to better service the Port. The location of the Port and connecting roads are shown in Exhibit 11.

Exhibit 11: Port of Brownsville and Connecting Roads of SH 550 and FM 511

Source: Assessment Of Innovative And Automated Freight Strategies And Technologies—Phase II Final Report

4.1.1.5.3 Truck Priority Corridor for Port of Brownsville Trucks

Improving mobility along State Highway (SH) 48/State Highway (SH) 4 is another TTI project with potential to locally address some of TxDOT’s freight goals. Along the corridor between the Port of Brownsville and the intersection with I-69, there are congestion issues with frequent queuing. The project aims at improving mobility by synchronizing 14 traffic signals...
along the corridor and by giving priority to truck traffic. Exhibit 12 shows the location of the corridor.

Exhibit 12: State Highway 48/State Highway 4 Corridor Location

Source: Assessment Of Innovative And Automated Freight Strategies And Technologies—Phase II Final Report

4.1.2 Domestic and International Traffic Management Programs and Technology Developments

The following sections describe domestic and international practices and initiatives in the area of freight traffic management. Exhibit 13 summarizes each program and technology development’s relevance to the freight community.

Exhibit 13: Summary of Domestic and International Traffic Management Programs and Technology Developments

<table>
<thead>
<tr>
<th>Domestic and International Traffic Management Programs and Technology Developments</th>
<th>Domestic and/or International</th>
<th>Relevance to Freight Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nevada DOT WayCare Platform</td>
<td>Domestic</td>
<td>The WayCare platform promotes ITS through the use of multi-agency incident data sharing and analytics to improve</td>
</tr>
<tr>
<td>Domestic and International Traffic Management Programs and Technology Developments</td>
<td>Domestic and/or International</td>
<td>Relevance to Freight Community</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>San Diego I-15 Integrated Corridor Management System</strong></td>
<td>Domestic</td>
<td>This system serves as an example of a well-designed decision-support system that uses predictive algorithms and real-time modelling tools to forecast traffic conditions and select a response plan that maximizes corridor efficiency for all vehicles, including trucks.</td>
</tr>
<tr>
<td><strong>I-75 Florida’s Regional Advanced Mobility Elements</strong></td>
<td>Domestic</td>
<td>This Project is an example of using multimodal ICM to improve traffic management along a corridor through the use of proactive traffic rerouting during incident and emergency events, which helps to improve travel time reliability for all vehicles, including trucks.</td>
</tr>
<tr>
<td><strong>Florida Department of Transportation (FDOT) Emergency Shoulder Use</strong></td>
<td>Domestic</td>
<td>During emergency situations, FDOT allows passenger vehicles to use the emergency shoulder as an additional general purpose lane, freeing up capacity on the other lanes for trucks.</td>
</tr>
<tr>
<td><strong>Interstate Closure Gates for Managing Major Disruptions</strong></td>
<td>Domestic</td>
<td>Closure gates implemented at interstate entrance ramps serve to keep vehicles, especially trucks, who are prone to getting stranded in major snow events, off segments of the interstate that are impassable or unsafe due to extreme weather events.</td>
</tr>
<tr>
<td><strong>Delaware’s Artificial Intelligence Integrated Transportation Management System Deployment Program</strong></td>
<td>Domestic</td>
<td>The Delaware Department of Transportation (DelDOT) plans to use AI to help detect incidents on the roadway faster than human operators can, which can help reduce incident clearance times.</td>
</tr>
<tr>
<td>Domestic and International Traffic Management Programs and Technology Developments</td>
<td>Domestic and/or International</td>
<td>Relevance to Freight Community</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Transportation Operations Coordinating Committee (TRANSCOM)—New York, New Jersey, and Connecticut</td>
<td>Domestic</td>
<td>TRANSCOM integrates incident, construction, travel time, video, and member-agency DMS data to help improve transportation network visibility for all regional member agencies to improve traffic management for all motorists, including trucks.</td>
</tr>
<tr>
<td>U.S. Border ITS and TMCs</td>
<td>Domestic and International</td>
<td>In order to reduce international border crossing wait times for trucks and other motorists, several border states have implemented or are in the process of implementing ITS programs along international borders to improve traffic operations and safety.</td>
</tr>
<tr>
<td>Johnson Controls’ Meridian Traffic Management System in Australia</td>
<td>International</td>
<td>The Meridian system monitors and controls over 60,000 ITS devices, using the data collected by the devices to generate real-time traffic conditions, as well as forecasted future traffic conditions to improve traffic management for all motorists, including trucks.</td>
</tr>
<tr>
<td>FSP Technology Testing in Sydney</td>
<td>International</td>
<td>Transport for New South Wales (TfNSW’s) three-month trial for FSP will be used to evaluate the reduction in truck travel times, fuel savings, and emissions reductions resulting from reducing stop-and-go motion from trucks.</td>
</tr>
<tr>
<td>GreenFlow for Trucks in Europe</td>
<td>International</td>
<td>GreenFlow allows traffic signals to detect approaching trucks and provide them with an earlier or longer green time, which can also help to allow a convoy of two or three connected trucks to pass through the traffic signal together.</td>
</tr>
</tbody>
</table>
4.1.2.1 Nevada DOT WayCare Platform

The Nevada Department of Transportation (NDOT) WayCare platform promotes ITS through the use of multi-agency incident data sharing and analytics to improve traffic management and incident detection, which directly benefits motorists, including truckers. The Southern Nevada TMC is the main center for traffic operations in Southern Nevada. The TMC is operated by four agencies overseeing freeway and arterial operations: NDOT; the Nevada Highway Patrol (NHP); the Nevada Department of Public Safety (DPS-NHP dispatch); and Freeway and Arterial System of Transportation (FAST, a division of the Regional Transportation Commission of Southern Nevada). Although housed in the same facility, the agencies do not have a collective platform on which to share real-time incident data. As a result, data sharing is a challenge impacting the TMC’s ability to respond to incidents immediately.

In September 2017, a pilot project was launched using WayCare platform to share and analyze data between the TMC agencies. WayCare is a cloud-based system that uses in-vehicle data and artificial intelligence (AI) to help in traffic management and incident detection.

It combines historic and real-time traffic data and incident information from multiple sources, including social media, crowdsourcing applications, and in-vehicle telematics. Its AI aggregates this data and notifies users of road conditions as outlined in the phases below, allowing them to evaluate and determine if an incident is present.

The pilot project was implemented in three phases as follows:

- **Phase 1—WayCare deployment to FAST and DPS-NHP.** In this phase, the NHP troopers are able to login to the WayCare platform from their vehicles’ computers to see active
and pending incidents. The same information is shared with FAST, which could check if CCTV cameras are available within the vicinity of the accident to confirm it and produce a video of the scene. The video could then be shared with NHP troopers to make early decisions regarding resources and approach methods prior to arrival to the incident location. The exact location of NHP troopers are also shared with the NHP command staff by having an automatic vehicle locator (AVL) device outfitted in their vehicles. This enables the command staff to understand the location of troopers with respect to the incidents. This integration of data across NHP and FAST allows for quicker verification of incidents and better resolution of certain incident information, such as GPS location.

- **Phase 2—WayCare deployment to NDOT Freeway Service Patrol** The second phase of the pilot project includes FSP having access to the WayCare platform from their vehicles and outfitting their vehicles with AVL. Eliminating paperwork, the FSP could enter incident information into WayCare in real-time and share with all users for safer and quicker incident clearance efforts.

- **Phase 3—WayCare deployment to NDOT Las Vegas ROADS (LVROADS)** The last phase includes LVROADS dispatchers having access to the WayCare platform, enabling them to log disabled and abandoned vehicle calls into the platform. This allows more facilities than those covered in Phase 1 and Phase 2 of the project to be actively managed, as well as allows LVROADS to oversee FSP incident calls and track, manage, and dispatch FSP based on priority.

The pilot project demonstrated that WayCare allows for the seamless communication and sharing of real-time incident information between participating agencies, and that has proven to be critical to incident management. As cited in the National Operations Center of Excellence WayCare Platform Case Study, the WayCare platform demonstrated an average of 12 minutes reduction of incident response times.

In addition, WayCare provides benefit to travellers to make informed choices to avoid disrupted areas. WayCare has an automated feature to send traffic alerts via email, text message, or Twitter to the public, allowing them to make informed route changes. The platform is also integrated with the Waze application, a navigation app that uses crowd-sourced data to provide information regarding traffic, construction events, and incidents. When users post crash information into the Waze application, the TMC verifies the incident.

---

22 NDOT Freeway Service Patrol vehicles patrol fixed freeway routes, helping keep freeways clear by assisting motorists to remove stalled vehicles, as well as providing basic first aid, extinguishing minor vehicle fires, providing traffic control and safety at incident scenes and more.

23 The freeway maintenance and NDOT FSP dispatch.

Once verified, the incident is described as a “TMC-verified” crash on the Waze app. This provides more accurate and timely incident information to the public.

4.1.2.2 San Diego I-15 Integrated Corridor Management System

The San Diego I-15 ICM System serves as an example of a well-designed decision-support system that uses predictive algorithms and real-time modelling tools to forecast traffic conditions and select a response plan that best operates the corridor for all vehicles, including trucks. While the San Diego ICM project did not actively engage the freight community, ICM projects should include response plans with tailored actions for each user group (e.g., motorists, transit, freight, and bicyclists/pedestrians).

The USDOT selected San Diego’s I-15 corridor for a demonstration project of an ICM system. The project includes multiple partners including San Diego Association of Governments (SANDAG) being the lead agency, together with USDOT, California Department of Transportation (Caltrans), the Metropolitan Transit System, the North County Transit District, and the Cities of Escondido, Poway, and San Diego. The project covers a 20-mile section of I-15 from State Route 52 in the City of San Diego to State Route 78 in the City of Escondido, including the state-of-the-art I-15 Express Lanes and major arterial routes on either side of I-15. Exhibit 14 shows the extent of the corridor, which are color coded as north (pink), middle (orange), and south (green) segments.

The objective of the I-15 ICM project is to operate and manage the individual transportation systems as a unified corridor, including the highway, Express Lanes, surrounding arterial roadways, and the transit network. The main aspect of the project is the DSS, which uses predictive algorithms and real-time modelling tools to forecast traffic conditions and select a response plan that best operates the corridor. Response plans could include modified traffic signal synchronization, activated transit priority, coordinated ramp metering, and publishing of alternative travel routes on DMSs. Since 2014, the DSS has been implementing response plans based on triggered real-time simulations of the entire multimodal I-15 transportation network.
Exhibit 14: San Diego I-15 ICM Demonstration Site

As part of the ICM project, a coordinated detour messaging system was put in place in 2016 to help further manage the corridor. The system includes 40 alternate route wayfinding signs on surface streets surrounding the I-15 corridor in the cities of Escondido, Poway, and San Diego. In an event of an incident on the freeway, Caltrans is able to direct the motorists off the freeway using the changeable message signs on I-15, and the wayfinding signs on the alternate routes will guide the motorists through various re-entries to the freeway, as shown in Exhibit 15 and Exhibit 16.

Exhibit 15: Dynamic Message Signs on I-15

Exhibit 16: I-15 ICM Alternate Route Wayfinding Sign Locations

Legend
- ▲ Changeable Message Sign (NB)
- ▼ Changeable Message Sign (SB)
- ◊ Sign Locations
- ☐ Alternate Route ID (I-15 re-entry point)
- ■ ICM Alternate Route Segments (NB)
- ◊ ICM Alternate Route Segments (SB)

4.1.2.3 I-75 Florida’s Regional Advanced Mobility Elements

The I-75 Florida’s Regional Advanced Mobility Elements (FRAME) project is located on I-75 and US 301/441 corridors. The objective of the project is to create a multimodal integrated corridor management solution to better operate and manage the I-75 corridor, and also to reroute traffic from I-75 to the nearby US 301/441 during incidents and emergency events to help improve travel time reliability for all vehicles, including trucks. The project area is shown in Exhibit 17. The AADT is listed along certain segments of the study area corridors, along with the approximate daily truck volumes.

Exhibit 17: I-75 Florida’s Regional Advanced Mobility Elements

Study Area

Source: I-75 Florida’s Regional Advanced Mobility Elements (FRAME), Advanced Transportation Congestion Management Technologies Department, 2016 http://www.cflsmartroads.com/projects/design/future/I-75_Frame_Application.pdf
The extent of the project includes FDOT Districts 2 and 5. As part of the project, each of the Districts will be responsible for implementing CV technologies, such as:

- Adaptive Signal Control Technology (ASCT);
- Multimodal Intelligent Traffic Signal System (MMITSS) with Intelligent Signals (I-SIG) to emit Signal Phasing and Timing (SPaT) data;
- Pedestrian Signal (PED-SIG) safety technology;
- Transit Signal Priority (TSP);
- FSP;
- Emergency Vehicle Preemption (PREEMPT); and
- Roadside and On-board Units (RSUs and OBUs) and CCTVs.

Deploying RSUs and CCTVs will allow gathering of road and traffic conditions information in real-time to manage the I-75 operation. Travel time and incident information would be disseminated to motorists via Florida’s 511 website and smartphone application. Freight, transit and emergency vehicles would receive alerts through OBUs deployed in the vehicles. The MMITSS and ASCT along with traffic signal priority and pre-emption technologies will help improve traffic flow through intersections along the arterial roads.

4.1.2.4 Florida Department of Transportation Emergency Shoulder Use

To help better manage operations during disruptive emergency situations, notably hurricane evacuations, the FDOT implemented a policy allowing motor vehicles to use the emergency shoulder as an additional general purpose lane during emergency situations. Use of the shoulder increases the directional capacity during an evacuation. While trucks, trailers, and buses are not permitted to use the shoulders due to safety reasons, moving passenger vehicles off the general purpose lanes onto the emergency shoulder also results in travel time benefits for the remaining vehicles. This strategy was put in place in September 2017, during Hurricane Irma, and vehicles were allowed to drive on the inside shoulder of northbound I-75 and I-4.

This program is anticipated to replace the former one-way (i.e. contraflow or lane reversal) plans that were previously used during hurricane evacuations on certain corridors. The program has been expanded to cover several other corridors throughout the state during a hurricane, including certain segments of I-4, I-10, I-75, I-95, and the Florida Turnpike.

4.1.2.5 Interstate Closure Gates for Managing Major Disruptions

Several midwestern states have implemented closure gates on their entrance ramps to manage traffic during widespread emergency events. Generally, these gates are used for winter weather closures when a substantial portion of an interstate is impassable or unsafe due to extreme weather events, and the ability for emergency services is limited. Most gate
systems in the early deployments required manual closure, but several systems operate via automation from a remote location. Most notably, Iowa’s gates on I-35 are all automated, and are used extensively for winter weather closures. Each state has slightly differing policies regarding when the gates can be used outside of emergency situations due to winter weather, such as for traffic management or other law enforcement activities.

Although these systems are intended to serve all motorists, trucks are particularly prone to getting stranded in major snow events. These gates have been demonstrated being very effective during major winter events, and states are working on deploying more of them. Georgia DOT utilizes a variant of this gate system for contraflow hurricane evacuation purposes along I-16, and Virginia DOT implemented a comparable system for hurricane evacuations along I-64, I-664, and US-199. This type of freight technology application may be useful in Texas, which is also prone to extreme weather events.

4.1.2.6 Delaware’s Artificial Intelligence Integrated Transportation Management System (AIITMS) Deployment Program

DelDOT operates a multimodal AI transportation management and control system as part of its statewide traffic operations program. It collects and analyzes high-resolution traffic data from freeways, traffic signals, and CAVs, and uses that information to disseminate real-time travel information and traffic congestion solutions to roadway users. The long-term goal is to develop a system that is capable of independently detecting incidents on the roadway before the human operator can, which can help reduce incident clearance times and improve traffic operations for all motorists, including trucks. DelDOT most recently was awarded a $4.9M ATCMTD grant, sponsored by FHWA, to invest in its AIITMS program, which will be used to upgrade digital infrastructure and run pilot programs to test various solutions.

4.1.2.7 TRANSCOM—New York, New Jersey, and Connecticut

TRANSCOM is a coalition between 16 different transportation and public safety agencies in New York, New Jersey, and Connecticut. It was originally created in 1986 to provide a more regional approach to transportation management, to support all motorists including trucks. Some major agencies that are members of the coalition include the New York City DOT, Port Authority of New York and New Jersey, and the Metropolitan Transit Authority. TRANSCOM provides essential elements for regional coordination and decision-making, including accurate ITS data and good working relationships between agencies. Among its many services, it integrates incident, construction, travel time, video, and member-agency DMS data to help ensure all regional agencies understand the ongoing operations as a whole.

The coalition has proven successful dealing with major traffic events across the many local jurisdictions in the region. Most notably, its existing collaborative processes allowed for multimodal transportation issues to be managed well in advance of Hurricane Sandy, which included shutting down trains and subways in advance, as well as coordinating HOV
restrictions at bridge crossings to reduce the amount of traffic entering the region after the hurricane.

4.1.2.8 U.S. Border ITS and TMCs
Several border states have worked to implement ITS programs along international borders to help improve traffic operations and safety for all motorists, including trucks. At the Detroit-Windsor border, the Southeast Michigan Transportation Operations Center acts as the main TMC for the area. It manages the transportation system in metro Detroit and international border crossing times, although it has no responsibility over the transportation system in Canada.

The Washington Department of Transportation (WSDOT) provides traffic information for all international border crossings in the state. WSDOT is part of the Cascade Gateway Border Data Warehouse Project—funded by Transport Canada and FHWA—which aims to develop an architecture for sharing traffic data between the two countries. The system near the border, however, is not directly managed by a TMC.

Along the California-Mexico border, SANDAG, Caltrans, and a number of key local, state, and federal U.S. and Mexican agencies are working to build an innovative border traffic operations program, with the goal of reducing border wait times in the region. The project aims to link the San Diego TMC and a proposed Tijuana TMC in order to coordinate traffic operations binationally. It is, however, still under development, but would be the first binational TMC implementation along the California-Mexico border.\(^\text{25}\)

4.1.2.9 Johnson Controls’ Meridian Traffic Management System in Australia
The Johnson Controls’ Meridian system is an intelligent software solution selected by Roads and Maritime Services in New South Wales as the foundation of their Smart Motorway Management System, which is used to improve traffic management for all motorists, including trucks. The software is deployed at the Tugun bypass at the Gold Coast Airport in Queensland, and the Penlink motorway in Victoria. It is intended to also monitor and manage the M4 highway in Western Sydney.

The Meridian system is a platform that monitors and controls over 60,000 complex ITS devices, such as CCTV, Sydney Coordinated Adaptive Traffic System (SCATS) data, and DMSs installed along a corridor. Meridian is able to analyze the data collected by these devices, making it useful and actionable by conveying real-time traffic and roadway conditions, identifying patterns such as bottlenecks and capacity issues, and using predictive algorithms to forecast future conditions. Besides its integrated operating system, the Meridian features a single graphical user interface (GUI) and uses Geographic Information

Systems (GIS) technology linked to its spatial database allowing the operator to retrieve information about any aspect of a corridor.

4.1.2.10 Freight Signal Priority (FSP) Technology Testing in Sydney
In 2018, Sydney conducted a three-month trial for FSP, which is an initiative by Transport for New South Wales (TfNSW) in conjunction with Roads and Maritime Services and Cohda Wireless technology. 100 trucks are connected to traffic signals along 40 kilometers of busy freight routes in the region. Using Dedicated Short Range Communications (DSRC) wireless technology trucks are able to communicate with traffic signals to keep the lights green as trucks approach the intersection. This eliminates trucks slowing down, stopping, and restarting again. This project is an expansion of an existing CV system that gives priority to public buses running behind schedule in the city, enabled by the existing coordinated traffic signal system.

At the end of the trial, TfNSW, Roads and Maritime Services, and Cohda Wireless will assess the data gathered from the trial, such as truck speeds, travel time, emissions, and fuel consumption. The three entities will determine the results in terms of reduction in truck travel times (where a 20 percent reduction is expected) and the impact of giving priority to trucks on general traffic flow on the corridor and roads in the vicinity.

4.1.2.11 GreenFlow for Trucks in Europe
GreenFlow is a Cooperative Intelligent Transport System developed in the Netherlands by Dynniq. GreenFlow allows traffic signals to detect approaching trucks and provide them with an earlier or longer green time. This helps minimize the travel time of freight and helps improve flow and road safety. Time-to-green and time-to-red information is also transferred via V2I connectivity from the traffic signal, allowing the truck drivers to adjust their speed. In addition, GreenFlow could be integrated with V2V connectivity, allowing a convoy of two or three connected trucks to pass through the traffic signal together. GreenFlow has been implemented in many European cities including Copenhagen, Bordeaux, Tampere, Eindhoven, and Helmond.

4.1.2.12 Vehicle Technology Policy in Europe
In early 2019, the European Parliament voted on and passed a policy that requires all new cars by year 2022 to include a vehicle technology that restricts the flow of fuel to car and truck engines once a specific speed is reached, typically the speed limit. Under new safety rules agreed by the European Union (EU), all new vehicles are required to have this technology, called “intelligent speed assistance” systems, as standard equipment. The EU rules don’t mandate specific technology for the systems, but hopes that this policy helps to reduce emissions and the number of road accidents.26

4.1.2.13 International Cross-Border TMC Operations

Malaysia and Singapore are linked by two border crossing structures and one maritime border. The Singapore Land Transport Authority operates a TMC that monitors the road network over the entire island as well as the two international border crossing roads. They also have an incident management system called the Expressway Monitoring and Advisory System (EMAS). On their website, they provide real-time traveler information to the public. On the Malaysian side, the roads accessing Singapore are managed by the Malaysian Highway Authority, which provides real-time traveler information. Both road agencies appear to only provide the information within their jurisdiction, and do not appear to integrate real-time border-crossing traffic information for public use.

Hong Kong and Shenzhen are similarly linked by six major land crossings that cross this economic border, with four being roadway-based. Similar to the Singapore example, agencies in each respective country provide real-time traveler information up to the Luohu Border Crossing, but there is not a formal mechanism in place to integrate the real-time border-crossing traffic information. International border crossings are an area that can benefit from multi-jurisdictional data sharing in order to improve traffic management for trucks, as well as other motorists.

4.2 Advanced Traveler Information Systems

An Advanced Traveler Information System (ATIS) is any system that acquires, analyzes, and presents information to assist surface transportation travelers in moving efficiently from a starting location (origin) to their desired destination. An ATIS may operate through information supplied entirely within the vehicle (autonomous system) or it can also use data supplied by TMCs. Relevant information may include the location of incidents, weather and road conditions, optimal routes, recommended speeds, and lane restrictions.

TMC-based ATIS is a well-developed concept and widely deployed, especially within more urbanized areas or highway corridors. This type of service supports the general traveling population and is not usually specialized to meet the unique needs of freight movement. A specialized subset of ATIS is FRATIS, a bundle of applications that provides freight-specific dynamic travel planning and performance information and optimizes drayage operations so that load movements are coordinated between freight facilities to reduce empty-load trips.

The key features of FRATIS include: sharing information between the terminal operator, truck dispatcher, and the public that relays both real-time and predicted terminal queue time; real-time routing, navigation, construction, traffic, and weather data; and drayage optimization. FRATIS have been limited in scale of deployment and participation by freight-

related and transportation firms due to the priority given to more broadly utilized information for the general motoring public rather than the often unique informational needs of the freight community. Though ATIS systems do provide information that can be used by trucking firms, often the aftermarket creates specialized applications leveraging use of such information to be even more useful to trucking.

Recognizing the importance of freight, transportation agencies have been supportive of enhancing existing ATIS systems and adding capabilities tailored to the freight community. These include:

- **Freight information exchange**—Enabling cooperative platforms for truck dispatch and other freight operations, or mining data from multiple sources to improve supply chain visibility;
- **Parking information**—Gathering, analyzing, and disseminating information about truck parking availability to drivers;
- **Weather information**—Collection and dissemination of weather/hazard information to truckers and dispatchers;
- **Connected Work Zones**—Information of lane closures due to construction, expected duration, and delays;
- **Rail crossing information**—Delays experienced due to trains at highway-rail at-grade crossings; informing of approaching trains; and
- **Border crossing and maritime port wait times**—Delays experienced crossing international and state borders or wait times at intermodal terminal facilities.

### 4.2.1 ATIS Programs and Technology Developments in Texas

The following sections document ATIS programs and technology developments in Texas, focusing on those specifically that benefit freight operations directly or indirectly. Exhibit 18 summarizes each program or technology development’s relevance to the freight community.

**Exhibit 18: Summary of Advanced Traveler Information System Programs and Technology Developments in Texas**

<table>
<thead>
<tr>
<th>Advanced Traveler Information System Programs and Technology Developments in Texas</th>
<th>Freight-Specific</th>
<th>Relevance to Freight Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-35 Corridor FRATIS and Dallas-Fort Worth FRATIS Deployments</td>
<td>Yes</td>
<td>These demonstration projects showed that freight-specific information could be delivered successfully by public agencies and utilized by the freight community for pre-trip and en-route traveler information.</td>
</tr>
<tr>
<td>Program Description</td>
<td>Freight-Specific</td>
<td>Relevance to Freight Community</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------------</td>
<td>------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>I-10 Corridor Coalition Truck Parking Availability System</strong></td>
<td>Yes</td>
<td>This system will make real-time truck parking information at 37 public truck parking locations along the I-10 corridor from California to Texas available to truck drivers and dispatchers to assist them in making informed parking decisions.</td>
</tr>
<tr>
<td><strong>Houston TranStar Consortium</strong></td>
<td>No</td>
<td>Traveler information is disseminated via DMS as well as TranStar’s website or mobile app, which allows subscribers, including trucks, to receive personalized travel time updates and incident warnings, as well as providing up-to-the-minute traffic and weather information.</td>
</tr>
<tr>
<td><strong>DriveTexas</strong></td>
<td>No</td>
<td>Ongoing enhancements are planned for the DriveTexas platform to integrate more sources of traveler information for dissemination to the traveling public, including trucks.</td>
</tr>
<tr>
<td><strong>El Paso Border Wait Time Pilot</strong></td>
<td>No</td>
<td>This pilot provided access to a mobile app that recommends to international border crossers, including trucks, the best routes and ideal times to travel by tracking border wait times and traffic congestion levels at the El Paso-Juárez POEs in an effort to distribute demand more evenly across the POEs.</td>
</tr>
<tr>
<td><strong>TTI Border Wait Time System</strong></td>
<td>No</td>
<td>TTI developed and deployed a system that monitors Radio-Frequency Identification (RFID) technology present in trucks to measure wait times at seven commercial border POEs across Texas and offers wait time estimates for vehicles, including trucks, traveling from Mexico into the U.S.</td>
</tr>
<tr>
<td><strong>Smart Work Zones (SWZ)</strong></td>
<td>No</td>
<td>TxDOT is one of the first agencies in the U.S. to have formal SWZ programs to help improve public safety and mobility through highway work zones for motorists, including trucks.</td>
</tr>
</tbody>
</table>
4.2.1.1  I-35 Corridor FRATIS and Dallas-Fort Worth FRATIS Deployments
Texas has been involved in ongoing demonstration projects of FRATIS as a proof of concept deployment, with all material developed available as open source for the industry to use. Texas has been the site of two separate FRATIS deployments: the I-35 Corridor FHWA-funded FRATIS and the DFW FRATIS prototype. Each FRATIS deployment occurred in different years (2017-2018 and 2013-2015, respectively) with different end goals.

The I-35 corridor in Texas is one of the most congested roadways and freight-traveled corridors in the country and TxDOT has an aggressive long-term construction program underway. The goal of the I-35 Corridor FRATIS and DFW FRATIS deployments was to improve freight movement efficiency.

For the I-35 Corridor FRATIS, the TxDOT I-35 Traveler Information During Construction (TIDC) provides information such as pre-construction closures, delay predictions and near real-time\(^\text{28}\) construction delay. The system was enhanced with new software and in-vehicle devices to help trucking fleets optimize truck trip dispatch planning. This was undertaken as part of the Texas Corridor Optimization for Freight (COFF) program to help maximize freight operators’ productivity, improve operational efficiency, and reduce safety-related incidents. This program led to the I-35 Connected Work Zone.\(^\text{29}\)

The FRATIS prototype in DFW focused more closely on drayage optimization. This prototype consisted of the following components: optimization algorithms, container terminal gate wait times, route specific navigation/traffic/weather, and advanced notice to terminals. The demonstration projects showed that freight-specific information could be delivered successfully by public agencies and utilized by the freight community for pre-trip and en-route traveler information.\(^\text{30}\)

4.2.1.2  I-10 Corridor Coalition Truck Parking Availability System
In 2019, TxDOT applied for and was awarded an FHWA-funded ATCMTD grant request for $6.8 million on behalf of the four states of the I-10 Corridor Coalition (Arizona, California, New Mexico, and Texas). The ATCMTD grant requires a 50% match by the four states (i.e., another $6.8 million contribution total from the four coalition member states). The grant was awarded to TxDOT, who is managing the project, and the purpose of the grant is to deploy the I-10 Corridor Coalition TPAS.

\(^{28}\) In this context, “near real-time” indicates that there may be a several minutes delay of when construction events are reported in the system.


The project, which began in late 2019, will implement a truck parking availability detection and information system at 37 public truck parking locations along the I-10 corridor from California to Texas. The objective of this system is to make real-time truck parking information available to truck drivers and dispatchers to assist them in making informed parking decisions.

The initial deployment of the I-10 Corridor Coalition TPAS will focus on collecting and publishing truck parking information for public facilities. This will be accomplished through the use of Dynamic Parking Capacity Signs, existing state 511 and road information system platforms, and the development of an I-10 corridor truck parking smartphone application. This application will serve as the basis for anticipated future technology deployments in the I-10 corridor and to ensure that information is available to drivers regardless of private sector involvement. However, data will also be made available to third-party applications and websites to promote widespread use of truck parking availability information. In the future, private sector operated truck plazas may be incorporated into the system and wider options for truck parking information dissemination, will be developed.

4.2.1.3 Houston TranStar Consortium

Houston TranStar is a unique partnership of representatives from the City of Houston, Harris County, METRO, and TxDOT, that shares resources and exchanges information under one roof to keep motorists, including trucks, informed, roadways clear, and lives safe in the fourth most populated city in the U.S. Established in 1993, Houston TranStar has managed southeast Texas’ transportation system and functioned as the primary coordination site for state, county, and local agencies when responding to incidents and emergencies. It was the first center in the nation to combine TMCs and Emergency Management Centers (EMCs). It also was the first to bring four agencies together in one facility.

Houston TranStar monitors traffic incidents with more than 900 regional CCTVs, utilizes dispatch vehicles to remove debris or HAZMAT, communicates with emergency vehicles about the most direct routes to an accident scene, and sends tow trucks to stalled vehicles. DMSs inform travelers about expected travel times and traffic issues ahead. Synchronized traffic signals, speed sensors, Highway Advisory Radio (HAR), ramp meters, and other devices also help keep the region’s traffic moving. Houston TranStar also monitors traffic using Anonymous Wireless Address Matching, which uses anonymous addresses from Bluetooth™ network devices to identify probes and calculate travel times and speeds on instrumented roadway segments. This innovation allows Houston TranStar to provide travel updates to drivers during daily commutes, as well as in emergency evacuation situations.

Traveler information is disseminated via DMS and Houston TranStar’s website, which allows subscribers, including trucks, to receive personalized travel time updates and incident warnings, as well as providing up-to-the-minute traffic and weather information. Travelers
can receive email alerts, texts, or Twitter notifications of traffic conditions. Houston TranStar also offers a free mobile app for Android and iPhone devices to access TranStar information.

Houston TranStar has established a multi-media partnership with the major news outlets in Houston (the 11th largest media market in the country). Houston TranStar’s CCTV images and Automatic Vehicle Identification (AVI) speed data can be seen on local television stations seven days a week, 365 days a year. Houston TranStar also provides other outlets, including Metro Traffic Network and the Houston Chronicle, with traffic and weather-related information so citizens of the region can be kept up-to-date on current driving and weather conditions.

4.2.1.4 DriveTexas
DriveTexas\textsuperscript{31} was created by TxDOT to provide accurate, timely highway operating conditions information for the traveling public, including trucks. The system displays conditions for roadways on the TxDOT-maintained system, including Interstates, U.S. highways, SH, and FM and Ranch-to-Market (RM) roadways in the State. All information is verified by TxDOT personnel.

DriveTexas information is updated 24 hours a day and presented graphically as a map that the user can scroll over and click on a condition icon or line to see a pop-up box with more information about that condition. The map refreshes at 5-minute intervals when viewing the site. Delivery of information is web-based. While a stand-alone mobile app is not yet available, DriveTexas.org is optimized for either a mobile device or a computer. A screenshot of DriveTexas is shown in Exhibit 19.

\textsuperscript{31} https://drivetexas.org.
TxDOT ITD is moving towards consolidating the systems used by Construction, Maintenance, and Travel for reporting planned and unplanned closures and integrating them with the system used by the TMCs for incident related closures. In the future, this information will feed DriveTexas; improving how this information is conveyed to the public through DriveTexas will be addressed through a separate program called Integrated Traveler Information.

4.2.1.5  El Paso Border Wait Time Pilot

In 2017, the City of El Paso partnered with Metropia, Inc. and the Camino Real Regional Mobility Authority (RMA) to launch a beta test of a mobile app designed to improve the international border crossing experience for all travelers, including trucks, at the El Paso-Juárez POEs.

The mobile app provides border crossers with the best routes and ideal times to travel by tracking international border wait times at the POEs. The app will help commuters, both traveling for leisure and commercial purposes, to reduce their wait times at the POEs. Beta testers through their use of the app will contribute border wait time data. The app will provide users with current wait times and traffic congestion levels. It will also predict and display how conditions will change throughout the day to allow travelers to choose the ideal time for crossing the border and guide them through the fastest POEs along the least-congested routes.

The ability to distribute the demand more evenly across six of the bridge crossings and at more varied times will help the City of El Paso reduce wait times and traffic congestion for all border crossers in the area, not just those who utilize the app.
4.2.1.6  **TTI Border Wait Time System**
TTI developed a system that monitors Radio-Frequency Identification (RFID) technology present in trucks to measure wait times at international border crossings. The RFID readers were originally installed in trucks that didn’t already have them. This project was funded by FHWA and CBP is continuing to provide funds to maintain the system. This system was deployed at seven commercial border POEs across Texas by fusing Google’s estimated traffic data with the RFID data and utilizes historical performance to assess true border crossing times. The seven commercial border POEs in Texas include the Veteran’s Memorial Bridge in Brownsville, the Pharr-Reynosa International Bridge, the World Trade Bridge and Colombia Solidarity Bridge in Laredo, the Camino Real International Bridge in Eagle Pass, and the Ysleta Bridge and the Bridge of the Americas (BOTA) in El Paso. The RFID readers were also deployed at the Nogales-Mariposa POE in Arizona and the Santa Teresa POE in New Mexico. This system offers wait time estimates for vehicles traveling from Mexico into the U.S. TTI is evaluating the program to determine how to expand the coverage and technology to other international border crossing locations.

4.2.1.7  **Smart Work Zones**
TxDOT is one of the first agencies in the U.S. to have formal SWZ programs to help improve public safety and mobility through highway work zones for motorists, including trucks. SWZ programs leverage information derived from temporary work zone ITS equipment to improve operations within and around work zones.

TxDOT maintains a public document called “Design Guidelines for Deployment of Work Zone Intelligent Transportation Systems (ITS)” to provide basic guidelines for the consistent and uniform application of SWZ in Texas. TxDOT also provides a “Go/No-Go Decision Tool” to help determine if a specific SWZ System is needed at a particular location. This tool is an Excel worksheet with scoring assigned for certain work zone characteristics to help identify the need for:

- Temporary queue detection systems;
- Temporary speed monitoring systems;
- Temporary construction equipment alert systems;
- Temporary travel time systems;
- Temporary incident detection systems;
- Temporary overheight detection systems; and
- Maximum queue length monitoring systems.
### 4.2.2 Domestic and International ATIS Programs and Technology Developments

Outside of Texas, there are several examples of FRATIS pilot deployments. Notable examples are provided in the following sections. Exhibit 20 summarizes each program and technology development’s relevance to the freight community.

**Exhibit 20: Summary of Domestic and International Advanced Traveler Information System Programs and Technology Developments**

<table>
<thead>
<tr>
<th>Domestic and International Advanced Traveler Information System Programs and Technology Developments</th>
<th>Domestic and/or International Relevance to Freight Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles County Metropolitan Transportation Authority DrayFLEX Program</td>
<td>Drayage, Freight, and Logistics Exchange (DrayFLEX) builds upon previous FHWA FRATIS deployments to provide freight-specific dynamic travel planning information in order to optimize container movements in and around the Ports of Los Angeles and Long Beach, including the exploration of CV technology applications.</td>
</tr>
<tr>
<td>Michigan Truck Parking Information and Management System</td>
<td>The system identifies safe truck parking availability and then delivers that information to drivers in real-time through dynamic parking information signs, a dedicated website, a smart phone application, and CV technology, allowing them to proactively plan routes and make informed parking decisions.</td>
</tr>
<tr>
<td>Mid America Association of State Transportation Officials Regional Truck Parking Information and Management System</td>
<td>This multi-state system collects and broadcasts real-time truck parking availability along high-volume freight corridors throughout eight states in the MAASTO region to help drivers plan their routes and make safer parking decisions.</td>
</tr>
<tr>
<td>GoPort Freight ITS at the Port of Oakland Project</td>
<td>This Project involves a suite of ITS projects intended to improve truck flows, increase the efficiency of goods</td>
</tr>
<tr>
<td>Domestic and International</td>
<td>Domestic and/or International</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Domestic and International Advanced Traveler Information System Programs and Technology Developments</td>
<td>Domestic and/or International</td>
</tr>
<tr>
<td>Iowa 511 Trucker</td>
<td>Domestic</td>
</tr>
<tr>
<td>U.S. Work Zone Intelligent Transportation Systems</td>
<td>Domestic</td>
</tr>
<tr>
<td>Automated Measurement of Real-Time Border Wait Times at U.S.–Canada Land Border Crossings</td>
<td>Domestic and International</td>
</tr>
<tr>
<td>Drivewyze and INRIX Partnership for Connected Truck Notifications</td>
<td>Domestic and International</td>
</tr>
<tr>
<td>Port of Hamburg and Port of Rotterdam Smart Ports</td>
<td>International</td>
</tr>
</tbody>
</table>
### 4.2.2.1 Los Angeles County Metropolitan Transportation Authority DrayFLEX Program

FHWA provided funding for a demonstration project of FRATIS at the Port of Los Angeles (Phase 1, 2013) with one Marine Terminal Operator (MTO) and one drayage company that owned approximately 50 trucks. The demonstration showed improvement in efficiency for the drayage company with reduced idle times and reduced fuel costs. With the success from FRATIS Phase 1, FHWA provided additional funding for Phase 2 (2016 to 2018), which extended the project scope to three MTO's and five drayage companies (including a Beneficial Cargo Owner (BCO), and approximately 250 trucks). Phase 2 continued to use the FRATIS prototype system approach from 2013 with no enhancements.

In response, the Los Angeles County Metropolitan Transportation Authority (LA Metro) undertook the FRATIS Modernization project, now rebranded as Drayage, Freight, and Logistics Exchange (DrayFLEX). DrayFLEX is building upon the previous FHWA FRATIS deployments and making enhancements to the existing FHWA FRATIS architecture, including the exploration of CV technology applications. It will provide freight-specific dynamic travel planning information in order to optimize container movements in and around the Ports of Los Angeles and Long Beach.

DrayFLEX will use information from the MTOs, trucking companies, and traveler information systems to provide status updates on container availability, enable trucking companies to set up automated appointments, and provide truck drivers the best routes to use to and from the maritime ports. The project will include an implementation period of two years and a plan for private sector commercialization.

### 4.2.2.2 Michigan Truck Parking Information and Management System

The Michigan Department of Transportation (MDOT) deployed a Truck Parking Information and Management System along 129 miles of the I-94 corridor. The system identifies safe truck parking availability and then delivers that information to drivers in real-time, allowing them to proactively plan routes and make informed parking decisions. To collect accurate parking availability data, detection cameras and other sensors were deployed at rest areas and private facilities. MDOT developed business-to-business agreements with private truck stops, allowing them to install sensor technology, collect parking data, and license the information to MDOT.
Drawing on information from 15 public and private parking areas, the system uses dynamic parking information signs, a dedicated website, a smart phone application, and CV technology to disseminate reliable, timely parking information to truck drivers.

4.2.2.3 **Mid America Association of State Transportation Officials Regional Truck Parking Information and Management System**

The State of Kansas, in partnership with Indiana, Iowa, Kentucky, Michigan, Minnesota, Ohio, and Wisconsin, through their partnership in MAASTO, are developing a multi-state Regional TPIMS. The project was funded through a $25 million Federal Transportation Investment Generating Economic Recovery (TIGER) grant and matching state funds.

The Regional TPIMS is a network of safe, convenient parking areas throughout eight of the states in the MAASTO region on high-volume freight corridors. These routes are among some of the most important corridors in the MAASTO region with truck volumes on many routes exceeding 25,000 trucks per day. These high truck volumes create congestion at parking sites, making it difficult for truck drivers to locate safe, convenient parking during peak rest hours.

TPIMS collects and broadcasts real-time parking availability through a variety of media outlets including DMSs, smart phone applications, and traveler information websites to help drivers proactively plan their routes and make safer parking decisions.

4.2.2.4 **GoPort Freight ITS at the Port of Oakland Project**

In 2018, the Alameda County Transportation Commission (Alameda CTC) provided the Port of Oakland a $12.4 million grant (funded through an ATCMTD grant from FHWA) to advance implementation of the Global Opportunities at the Port of Oakland (GoPort) Program, a package of landside transportation improvements within and near the Port.

The grant is to develop a Freight Intelligent Transportation System (FITS), a system to manage truck arrivals, improve incident response, and connect to regional smart corridor systems. The FITS project is a suite of information technology demonstration projects along West Grand Avenue, Maritime Street, 7th Street, Middle Harbor Road, Adeline Street, and Embarcadero West. These are intended to improve truck traffic flows, increase the efficiency of goods movement operations, and enhance the safety and incident response capabilities throughout the Port.

The purpose of this ITS project is to manage traffic along arterial roadways in the Port environment and disseminate traveler information and data to users and stakeholders. The project will provide a common platform to receive and relay critical Port travel information to partners. The project will include backbone communications infrastructure and systems integration, which provides the communications networking backbone to support future
developments in CV technologies. Note that additional elements of this program are described in Section 4.7.2.1.

4.2.2.5 Iowa 511 Trucker

Iowa 511 is the Iowa DOT’s official traffic and traveler information app, with separate sites for passenger vehicles and trucker-focused traveler information in order to better serve these different stakeholder groups. The Iowa 511 Trucker app provides statewide real-time traffic information for interstates, U.S. routes, and state highways in Iowa. It does not include information for county roads or city streets. Features of the app include:

- A zoom-enabled map with traffic event icons that can be selected;
- Real-time updates on winter road conditions, traffic incidents, road work, construction, and road closures;
- Current traffic speeds and CCTV traffic camera images in select cities (Ames, Cedar Falls, Cedar Rapids, Council Bluffs, Des Moines, Iowa City, Quad Cities, Sioux City, and Waterloo) and across the state;
- DMSs; and
- Highway rest area locations.

4.2.2.6 U.S. Work Zone Intelligent Transportation Systems

The use of ITS in work zones, or SWZs, has been a topic at the state and federal level for over two decades. FHWA recommends and provides many resources on the use of ITS in work zones with demonstrated benefits in the areas of mobility and safety for all motorists, including trucks. FHWA has identified key applications for ITS technology in work zones, which can often serve a combination of the following purposes:

- Traffic monitoring and management;
- Dissemination of traveler information;
- Incident management;
- Enhanced safety of both road users and workers;
- Increased capacity;
- Enforcement;
- Tracking and evaluation of contract incentives/disincentives (performance-based contracting); and
- Work zone planning.

---

32 https://ops.fhwa.dot.gov/wz/its/index.htm

33 Refers to incentive/disincentive provisions (e.g., bonus funds or fees) added by state DOTs to motivate hired contractors to maintain a target travel time through their work zone.
FHWA provides many resources on the use of ITS and technology for their work zone management program, including case studies/assessments, technology applications/options, and SWZ deployment examples. It provides a guidance document called the “Work Zone Intelligent Transportation Systems Implementation Guide” to assist public agencies with implementing ITS in work zones as part of their respective project-based Transportation Management Plan (TMP). FHWA also offers additional resources, including studies done on alternative funding sources for work zone ITS, guidance on using TMCs for work zone management, and other state-reported experience with SWZ.

Many states have experience with deploying SWZs in construction zones, although some states have more formal programs than others. Some examples include, but are not limited to, Arkansas, Florida, Illinois, Indiana, Kansas, Michigan, Minnesota, Nevada, New York, Ohio, and Oregon. The strategies used in each state are often application-dependent, as not all work zones necessitate all SWZ strategies, but common applications include automated queue warning systems, real-time work zone travel times, and stopped traffic ahead examples.

4.2.2.7 Automated Measurement of Real-Time Border Wait Times at U.S.–Canada Land Border Crossings

Queue time detection systems are designed to measure truck queue length and wait times at controlled access points. Systems can be comprised of sensors (e.g. RFID, Bluetooth, license plate readers) positioned at key points approaching the controlled access points. The system detects when the queue exceeds a certain length, relying on the sensors or video cameras that provide a real-time view of queuing activity. Commercial systems using Bluetooth technology to measure vehicle queues and wait times are deployed at international border crossings. The FHWA-sponsored research project “Effort to Test, Evaluate and Deploy Technologies to Automate the Measurement of Real-Time Border Wait Times at United States–Canada Land Border Crossings” demonstrated the effectiveness and reliability of Bluetooth-based wait time systems at international border crossings in New York and Washington. The system is currently operating at two international border crossings, at the New York-Ontario and Washington-British Columbia borders, and reports international border crossing wait times separately for cars and trucks.

4.2.2.8 Drivewyze and INRIX Partnership for Connected Truck Notifications

Drivewyze announced in June 2020, a new partnership with INRIX, to bring real-time dangerous slowdown, queues, and road closure information to truck drivers operating the Drivewyze Connected Truck platform. Leveraging the INRIX Dangerous Slowdowns feature, Drivewyze is able to convey safety events at a highly granular level to provide maximum reaction time for commercial truck drivers in a first-of-its-kind, always on, safety notification service. Drivewyze is able to geo-fence the INRIX data on slowdowns to enable in-cab alerts when a slowdown is detected within two to three miles of the truck. Then, when the
slowdown is imminent, Drivewayze will give another alert displaying ‘Caution: Dangerous Slowdown Ahead.’

The new service is available in all states and can operate across the entire U.S. Interstate System. Already, INRIX has added a new ‘Commercial Vehicle Safety Alerts’ option to its master contract under the I-95 Corridor Coalition’s Vehicle Probe Project, allowing 18 states along the eastern seaboard to contract for this turnkey service via the Coalition.34

4.2.2.9 Port of Hamburg and Port of Rotterdam Smart Ports
Port Community Systems are evolving to include many landside logistic linkages to extend the benefits of maritime port management to include transportation system operations and transport companies. In Europe, two examples of this evolution are described below.

The Port of Hamburg is one of the busiest maritime ports in Europe and a large driver for the regional economy. It employs over 260,000 people and generates over € 750 million in yearly tax revenue for the City of Hamburg. The Port has opted for an Internet of Things (IoT) platform to mitigate the expected rise in traffic and increasing negative externalities (e.g. traffic congestion, pollution, and road safety) caused by maritime port activities. The platform is based on Smart Port infrastructure, intelligent traffic flows, and intelligent trade flows.

The Port of Hamburg works with a variety of local, regional, and national partners on the project. Partners include the City of Hamburg, which is moving to the Smart City model, the state of Hamburg, the Federal Ministry of Transport, and private sector IT solutions providers.

Supporting operations at the Port of Rotterdam, the Portbase Port Community System provides many intelligent services for information exchange between companies and between the public and private sectors. The information exchanges enable participants to optimize their logistics processes. Portbase was created by a merger between Rotterdam’s Port Infolink and Amsterdam’s PortNET. The new non-profit organization was set up in 2009 by the Port of Rotterdam Authority and the Port of Amsterdam. Its goal is to make the logistics supply chains of the Dutch maritime ports as attractive as possible by offering a one-stop shop for logistics information exchange.

4.3 Dynamic Route Guidance
Dynamic Route Guidance includes technologies that incorporate real-time traffic and roadway conditions, allowing drivers to make re-routing decisions to a more optimal route. It is called ‘dynamic’ because it uses real-time traveler information to continuously evaluate

which route is optimal. Real-time traveler information that influences re-routing decisions includes congestion levels, incidents, weather conditions, road closures, and work zones.

For freight transportation, traveler information could be obtained by truck drivers through radio, DMSs, smart phone applications, or in-vehicle GPS, or it could be conveyed through a dispatcher/operator. The challenge for freight is having all the necessary information required to make an informed re-routing choice. Besides information on traffic and incidents, truck drivers or operators need to have additional information on route restrictions, low height bridges, HAZMAT or OS/OW limits, and availability of truck parking or rest areas. The accuracy of this information is also critical for efficient freight planning and movement.

Dynamic Route Guidance relates to the ATIS technology area, discussed in Section 4.2 of this report. Freight-related ATIS constitute the basis for providing dynamic freight routing applications.

4.3.1 Dynamic Route Guidance Programs and Technology Developments in Texas

The following section documents Dynamic Route Guidance programs and technology developments in Texas, focusing on those specifically that benefit freight operations directly or indirectly. Exhibit 21 summarizes each program or technology development’s relevance to the freight community.

Exhibit 21: Summary of Dynamic Route Guidance Programs and Technology Developments in Texas

<table>
<thead>
<tr>
<th>Dynamic Route Guidance Programs and Technology Developments in Texas</th>
<th>Freight-Specific</th>
<th>Relevance to Freight Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas Connected Freight Corridors (TCFC) Project</td>
<td>Yes</td>
<td>One of the CV applications proposed as part of this Project is to provide a higher quality of advanced traveler information that includes alternate route information and eco-dynamic freight routing along the I-35, I-45, and I-10 corridors.</td>
</tr>
</tbody>
</table>

4.3.1.1 Texas Connected Freight Corridors Project

The TCFC Project is a program that will deploy 12 CV technology applications to trucks in the Texas Triangle Region (Austin, DFW, Houston, and San Antonio). The motivation for this deployment is to boost economic efficiency, increase safety of trucks, and promote the use of emerging technologies.
The TCFC, further discussed in Section 4.1.1.2 of this report, is the only Dynamic Route Guidance program currently deployed in Texas. One of the CV applications proposed as part of the TCFC Project is to provide a higher quality of advanced traveler information that includes alternate route information and eco-dynamic freight routing along the I-35, I-45, and I-10 corridors, as well as truck parking availability information along I-35. Better information for freight operators and truck drivers along these busy corridors will help improve freight operations.

4.3.2 Domestic and International Dynamic Route Guidance Programs and Technology Developments

Below are examples of the various Dynamic Route Guidance navigation software and devices developed around the world, some of which are freight-specific. Exhibit 22 summarizes each program and technology development’s relevance to the freight community.

Exhibit 22: Summary of Domestic and International Dynamic Route Guidance Programs and Technology Developments

<table>
<thead>
<tr>
<th>Domestic and International Dynamic Route Guidance Programs and Technology Developments</th>
<th>Domestic and/or International</th>
<th>Relevance to Freight Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>TomTom Truck Navigation</td>
<td>Domestic and International</td>
<td>TomTom has developed a truck navigation system that includes freight-specific information such as designated truck routes, bridge height and weight restrictions, and HAZMAT routes to support CMV routing in the U.S. and Canada.</td>
</tr>
<tr>
<td>INRIX AI Traffic</td>
<td>Domestic and International</td>
<td>Using collected real-time data and leveraging historic data points and predictive algorithms, INRIX AI Traffic detects changes in road conditions and alerts drivers, including trucks, instantaneously via the mobile application, allowing them to make dynamic routing decisions.</td>
</tr>
<tr>
<td>PC*Miler</td>
<td>Domestic and International</td>
<td>PC*Miler generates the shortest, non-restricted routing option for CMVs by total time or distance, taking into</td>
</tr>
<tr>
<td>Domestic and International Dynamic Route Guidance Programs and Technology Developments</td>
<td>Domestic and/or International</td>
<td>Relevance to Freight Community</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>Trimble® MAPS CoPilot Truck Navigation and CoPilot FleetPortal</strong></td>
<td>Domestic and International</td>
<td>account truck restrictions such as toll gates, height, weight, and size.</td>
</tr>
<tr>
<td><strong>Bentley SUPERLOAD</strong></td>
<td>Domestic and International</td>
<td>SUPERLOAD automates the OS/OW permitting process and performs real-time routing that takes into account truck size and weight.</td>
</tr>
<tr>
<td><strong>PTV Map&amp;Guide</strong></td>
<td>Domestic and International</td>
<td>The software considers the truck driver’s drive and rest times with respect to federal CMV driving regulations, and therefore includes information on trucking parking availability and allows drivers to reserve a parking space at select locations.</td>
</tr>
</tbody>
</table>

### 4.3.2.1 TomTom Truck Navigation

TomTom has developed a truck navigation system to support CMV routing in the U.S. and Canada. The system includes freight-specific information such as designated truck routes, bridge height and weight restrictions, and HAZMAT routes. The information is obtained from ProMiles (a firm which develops truck mileage and routing software) and is updated based on user feedback. Users of the system could submit data on route restrictions that are not included in the database. Once verified by TomTom, the data is added. These truck specific attributes are geocoded on the road network, and based on truck characteristics inserted by the user, the system provides appropriate route guidance. TomTom Truck navigation also incorporates real-time traffic data allowing dynamic routing application. The real-time data is gathered from multiple sources such as smart phones, third-party data providers, road sensors, and public agencies, and is collated and stored in the cloud. Users are able to access reports on estimated route travel time, route speed, and incident locations, allowing them to make routing decisions in real-time. TomTom Truck navigation system also features
a fleet management application. It is able to track in real-time truck location, job status (delivery/pickup/transit), and driver performance, and it provides a two-way communication platform between drivers and dispatchers.

4.3.2.2 INRIX AI Traffic
INRIX is a leading provider of traffic information. INRIX gathers real-time traffic data from road sensors and GPS-enabled vehicles and devices, and has a database that covers roads from all around the world. Using this data, INRIX develops mapping and navigation systems. One of their latest products is INRIX AI Traffic, which uses AI to deliver precise and actionable traffic information to drivers. Using collected real-time data and leveraging historic data points and predictive algorithms, INRIX AI Traffic detects changes in road conditions and alerts drivers instantaneously via the mobile application. Drivers, including trucks, can use this product to become informed about slowdowns, incidents, and weather conditions allowing them to make dynamic routing decisions.

4.3.2.3 PC*Miler
PC*Miler is a commercial truck routing, mileage, and mapping software for roads in the U.S. and Canada. Its key feature is a street-level digital map of over 6.9 million miles of North American roadways and it includes the most comprehensive truck restrictions. There are over nine million truck restrictions related to toll gates, height, weight and size restrictions, and over 30 HAZMAT specific road classes and routing categories such as Caustic, Explosive, Flammable, Inhalant, and Radioactive. The software also has eight million points-of-interest, some of which are truck-specific such as rest areas, long combination vehicle lots, and weigh scales.35

From a routing perspective, users can enter a route with an unlimited number of stops and PC*Miler would generate the shortest, non-restricted routing. Users have the choice to optimize the route by total time or distance. The software calculates miles between stops, cumulative miles from origin, cumulative trip cost (including toll costs), and cumulative drive time, and could produce a report with all route details.

4.3.2.4 Trimble® MAPS CoPilot Truck Navigation and CoPilot FleetPortal
CoPilot Truck by Trimble® MAPS is a navigation system that provides truck drivers with safe and efficient routing options. Based on vehicle profiles inserted into the system that identify the truck dimensions and load type, the system generates legal compliant truck routes with assistance from PC*Miler maps. In addition, using INRIX traffic data, CoPilot Truck monitors real-time road conditions and recommends a better route that avoids a significant delay. The system has additional features such as multi-stop route optimization, driver warnings for speeding, a user interface with 2D and 3D map views with navigating instructions, and over five million places including truck-specific points-of-interest such as gas and weigh stations.

35 https://www pcmiler.com/.
CoPilot Truck could also be combined with a web-based fleet management tool (CoPilot FleetPortal) to enable fleet managers to monitor trips on a fleetwide level, share information with drivers such as road closures, check compliance of drivers to assigned routes, and view post-trip summaries with precise mileages and drive times for better planning.

4.3.2.5 Bentley SUPERLOAD

Bentley SUPERLOAD is a comprehensive solution for intelligent permitting and routing of OS/OW loads. It automates the OS/OW permitting process and performs real-time routing that takes into account truck size and weight. Using real-time data, the traffic conditions of a specified route are determined and the route constraints on truck weight and size are analyzed. The specified route is then validated for the truck to follow or a new optimized route is recommended and displayed on a SUPERLOAD interactive map. The dispatcher (most likely) or driver can then adjust accordingly. When a route is not permitted, the map highlights the areas where there are restrictions and provides a description, such as restrictions due to bridge load or height. Exhibit 23 shows a screenshot of the SUPERLOAD interface analyzing a freight route.

Exhibit 23: Bentley SUPERLOAD System

4.3.2.6 **PTV Map&Guide**

The PTV Group developed a truck route planner software used by logistics companies. The Map&Guide software designs a route based on the inserted truck parameters, such as height, weight, length, and axle load, and it takes into account roadway conditions in terms of road construction and closures. The software considers the driver’s drive and rest times with respect to federal CMV driving regulations, and therefore includes information on trucking parking availability and allows drivers to reserve a parking space at select locations. It also recognizes scheduled routes with multiple stops and recommends the optimal route with the minimum trip time and therefore cost. Based on PTV statistics, the Map&Guide software is trusted and used by 55,000 users worldwide.\(^{36}\)

4.4 **Data Integration and Analytics**

Traffic data is generated from different sources, such as from traditional agency-owned road sensors and from private sector probe-based data aggregators like Google Maps and Waze. The integration of data from multiple sources, and the analysis and sharing of large datasets or “Big Data” is crucial to understand travel patterns, and to help manage traffic and operate transportation systems.

4.4.1 **Data Integration and Analytics Programs and Technology Developments in Texas**

TxDOT collects information on traffic and roadway conditions from a variety of sources: the Highway Conditions Reporting System (HCRS), LoneStar, and third-party data sources such as INRIX. In addition, TxDOT has data sharing agreements with approximately 70 partners and it aims to expand that with additional public and private sector partners. Considering the current state of data resources and future plans, TxDOT has developed a data strategy to “Collect data once, share with all that need it”. TxDOT plans to integrate data from the various sources into a single format that feeds into a centralized “Data Lake” where the information is then processed using advanced analytics and shared with the public through platforms such as DriveTexas. TxDOT also aims to develop an Open API\(^{37}\) to share the unified data with partners and third-parties.

The TxDOT data strategy is in line with the 2018 TFMP Strategic Planning Initiatives cited below:

- Develop a Statewide Freight Data Collection, Warehousing, and Archiving Program to gain a better understanding of statewide and regional freight movement and advancing freight performance measurements through multimodal data information to support informed decision-making to address freight mobility.

---


\(^{37}\) A publicly available application programming interface that provides developers with programmatic access to a proprietary software application or web service. APIs are sets of requirements that govern how one application can communicate and interact with another.
• Develop a Statewide TMC Concept of Operations and Implementation Plan that integrates existing regional TMCs across the State to facilitate dissemination of real-time traffic information, including traffic incidents, construction, weather, and special events, etc.

The following sections document data integration and analytics programs and technology developments in Texas, focusing on those specifically that benefit freight operations directly or indirectly. Exhibit 24Exhibit 21 summarizes each program or technology development’s relevance to the freight community.

**Exhibit 24: Summary of Data Integration and Analytics Programs and Technology Developments in Texas**

<table>
<thead>
<tr>
<th>Data Integration and Analytics Programs and Technology Developments in Texas</th>
<th>Freight-Specific</th>
<th>Relevance to Freight Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>TxDOT Innovative Technology Deployment Enterprise Information Management Program</td>
<td>No</td>
<td>The focus of two of the projects included in this program are to integrate and share data across systems to help improve data quality and reduce data redundancy of information that is eventually shared with external partners and the public, including trucks.</td>
</tr>
<tr>
<td>FHWA Initiative on the Use of Crowdsourced Data</td>
<td>No</td>
<td>TxDOT is partnering with FHWA on an initiative regarding the use of crowdsourced data such as from Google, Waze, Facebook, and Twitter to improve traffic operations for all motorists, including trucks.</td>
</tr>
<tr>
<td>Researching Uses of Artificial Intelligence for Enhanced Corridor Management and Operations</td>
<td>No</td>
<td>TxDOT is working with CTR on a research study to understand benefits that AI may offer when considering the vast volumes of data currently collected for the purposes of emerging planning and operations applications for all vehicles, including trucks.</td>
</tr>
</tbody>
</table>

**4.4.1.1 TxDOT ITD Enterprise Information Management Program**

To implement TxDOT’s data strategy, ITD has developed the Enterprise Information Management Program to build on the following efforts:38

---

38 ITD Efforts that Support Connected and Automated Vehicles (CAV), April 2019.
• Implementing a centralized data architecture that will collect TxDOT’s various data sources and transform them into clean, secure, and authoritative data that can be accessed easily by those inside and outside TxDOT that need it.

• Enabling real-time data ingestion, data preparation, Big Data storage, data mining, and machine learning capabilities.

• Setting up data sharing standards, platforms, and agreements to facilitate data collaboration.

• Establishing enterprise governance practices that will address data governance.

The following are two projects proposed as part of the Enterprise Information Management Program:

• Real-Time Data Integration for Traffic Management; and

• Streamlining Road Condition Reporting.

4.4.1.1.1 Real-Time Data Integration for Traffic Management
The objective of this project is to build an infrastructure to integrate real-time data for better traffic management. The system will allow importing data from multiple sources, filtering and processing the data, and then sharing it with TxDOT’s various partners to improve real-time coordination and decision-making across jurisdictional boundaries. Integrating and sharing data across systems in real-time will provide reliable travel time for the public and will allow jurisdictions to cooperate in responding to an incident.

4.4.1.1.2 Streamlining Road Condition Reporting
The scope of this project includes consolidating the reporting of planned and unplanned closures from TxDOT’s Construction, Maintenance, and Travel systems. This program would then integrate the consolidated information with incident-related closures that are reported on another system used by TMCs. This will allow data on road conditions to be entered only once in their respective system and shared across all systems. The integrated system will be flexible to incorporate inputs from multiple sources and formats, and will facilitate manual data entry from any device. The integrated system will be an authoritative source of road conditions data to be shared within TxDOT and externally with partners and the public, including trucks. Exhibit 25 shows the proposed information flow for streamlining road condition reporting.
Exhibit 25: Proposed Road Condition Reporting Information Flow

Source: ITD Freight Technology Plan Presentation, 2018
4.4.1.2 **FHWA Initiative on the Use of Crowdsourced Data**
TxDOT is partnering with FHWA on an initiative regarding the use of crowdsourced data to improve traffic operations for all motorists, including trucks. Crowdsourced data includes data from third-parties such as Google and Waze, and data from social media sites such as Facebook and Twitter. This project was initiated with a kick-off meeting between FHWA and TxDOT ITD and RTI Divisions.

FHWA is separately undertaking workshops on this topic to encourage transportation agencies to explore crowdsourcing as an effective means to improve traffic operations and increase safety on the road while reducing the dependence on agency-owned road sensors and systems.39

4.4.1.3 **Researching Uses of Artificial Intelligence for Enhanced Corridor Management and Operations**
TxDOT is working with CTR on a research study to develop a thorough understanding of the concrete and tangible benefits that AI may offer when considering the vast volumes of data currently collected for the purposes of emerging planning and operations applications for all vehicles, including trucks. A twofold research approach will be used to provide both a broad, high-level summary of the state of the art/practice in AI and its relevance to TxDOT, and an in-depth analysis of one or two selected applications. The review of the state of the art will include a literature and data survey and the creation of a prospectus summarizing the techniques and tools relevant to TxDOT given data availability and planning/operation priorities.

CTR will consider applications involving system performance estimation and system control using Markov and non-Markov decision processes. After completing a preliminary research phase, CTR will host a workshop for TxDOT and its partners to demonstrate the explored concepts and will collect feedback to inform the model application and testing. Project deliverables include a comprehensive report, including a quantitative and qualitative evaluation of the selected use cases, and access to the datasets and source code used in this project. This research project is anticipated to conclude in 2021.

4.4.2 **Domestic and International Data Integration and Analytics Programs and Technology Developments**
The following sections present examples of programs and projects that include the integration, analysis, and sharing of transportation data (non-freight specific). Exhibit 26 summarizes each program and technology development’s relevance to the freight community.

Exhibit 26: Summary of Domestic and International Data Integration and Analytics Programs and Technology Developments

<table>
<thead>
<tr>
<th>Domestic and International Data Integration and Analytics Programs and Technology Developments</th>
<th>Domestic and/or International</th>
<th>Relevance to Freight Community</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>511 San Francisco Bay</strong></td>
<td>Domestic</td>
<td>This platform not only integrates multimodal data from over 70 public agencies into their one-stop website, but also provides an open data portal that the private sector, including the freight community, can use to disseminate data.</td>
</tr>
<tr>
<td><strong>Las Vegas FAST’s Performance Monitoring and Measurement System</strong></td>
<td>Domestic</td>
<td>This system provides access to real-time traffic information and the analytical tools needed to evaluate the effectiveness of operational strategies deployed to improve the transportation system for travelers, including trucks.</td>
</tr>
<tr>
<td><strong>Denver Data-sharing and Colorado COtrip Website</strong></td>
<td>Domestic</td>
<td>The COtrip website, which provides trucker-specific traveler information, uses multi-agency and multi-jurisdictional data sources that have been transmitted to a shared data warehouse in accordance with established regional data standards.</td>
</tr>
<tr>
<td><strong>Denver’s Enterprise Data Management System (EDM)</strong></td>
<td>Domestic</td>
<td>This platform compiles a wide range of real-time information, including freight, and uses AI to help improve traffic management in the City.</td>
</tr>
<tr>
<td><strong>Florida’s Freight Operations Exchange Regional Data Share</strong></td>
<td>Domestic</td>
<td>This platform may be used to establish a national standard for real-time sharing of CMV enforcement data between states which can be used to allow compliant trucks to bypass subsequent weigh stations.</td>
</tr>
<tr>
<td><strong>SMARTFREIGHT in Norway</strong></td>
<td>International</td>
<td>This project aims to develop a system that provides two-way communication between a TMC and individual trucks in order for TMCs to monitor/control truck.</td>
</tr>
<tr>
<td>Domestic and International Data Integration and Analytics Programs and Technology Developments</td>
<td>Domestic and/or International</td>
<td>Relevance to Freight Community</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Data Management and Analytics by Transport for London (TfL)</td>
<td>International</td>
<td>TfL shares real-time and historic transportation data feeds to encourage their community of over 14,000 open data users to create new apps and websites that provide travelers, including trucks, with useful traveler information to make optimal trips.</td>
</tr>
<tr>
<td>DATEX2 in Europe</td>
<td>International</td>
<td>This program is used as an international ITS framework for exchanging traffic information between TMCs in Europe to improve traffic management for all travelers, including trucks, and continues to evolve and adapt its standards to accommodate emerging technologies, such as AVs.</td>
</tr>
<tr>
<td>The Project for the Management of European Traffic (PROMET)</td>
<td>International</td>
<td>This project works to make the TMCs in Austria, Italy, and Slovenia that serve high-volume passenger and freight corridors interoperable and compatible in order to provide efficient management of the cross-border corridor between the three countries.</td>
</tr>
<tr>
<td>EasyWay</td>
<td>International</td>
<td>The goal of this program is to collaborate on the deployment of universal ITS services in Europe to help reduce congestion, improve road safety, and reduce emissions for all travelers, including trucks.</td>
</tr>
<tr>
<td>European Digital Traffic Infrastructure Network for Intelligent Transport Systems (EDITS)</td>
<td>International</td>
<td>This project aims at enabling cross-border, multimodal traveler information based on harmonized traffic data and information gathered at a transnational</td>
</tr>
</tbody>
</table>
Domestic and International Data Integration and Analytics Programs and Technology Developments

<table>
<thead>
<tr>
<th>Domestic and/or International</th>
<th>Relevance to Freight Community</th>
</tr>
</thead>
</table>

level to improve the travel experience for all travelers, including trucks.

4.4.2.1 511 San Francisco Bay

The 511 San Francisco Bay is a successful example of integrating data from different sources and sharing with travelers, including trucks. 511 is a one-stop website for the Bay Area traffic, transit, rideshare, cycling, and parking information. It is led by the San Francisco Bay Area Metropolitan Transportation Commission (MTC), California Highway Patrol (CHP), and Caltrans and includes partnerships with 70 public agencies. Data from all sources are integrated and processed to provide travelers with comprehensive and reliable multimodal travel information. In addition, 511 San Francisco Bay provides an open data portal for private companies such as Google and INRIX to disseminate the 511 data. Developers also use the 511 data to develop applications that would benefit Bay Area travelers. Exhibit 27 shows the 511 San Francisco Bay interface.

Exhibit 27: 511 San Francisco Bay Interface

Source: https://511.org/
4.4.2.2 Las Vegas FAST’s Performance Monitoring and Measurement System

The Regional Transportation Commission of Southern Nevada’s (RTC) FAST Division is responsible for monitoring and controlling traffic on the transportation system in the Las Vegas region. FAST uses its in-house Performance Monitoring and Measurement System (PMMS) to compile and process traffic data gathered from road ITS equipment. The PMMS is a web-based user interface, as shown in Exhibit 28. It provides real-time traffic information to the public and is used as a platform by transportation professionals to create analysis graphs, maps, and reports on network performance for evaluation of operational strategies. This helps to ensure that operational strategies deployed meet their objectives and benefit travelers, including trucks.

Exhibit 28: FAST Dashboard—Performance Monitoring and Measurement System

Source: [http://bugatti.nvfast.org/Default.aspx](http://bugatti.nvfast.org/Default.aspx)

4.4.2.3 Denver Data-sharing and Colorado COtrip

In 2012, the Denver Regional Council of Governments (DRCOG) adopted the Regional Concept of Transportation Operations (RCTO), which is a collaborative plan to improve the management and operations of the transportation system in Colorado. One of RCTO’s several initiatives is to establish a shared data warehouse, where data from multi-agency and multi-jurisdiction sources are collected and shared with the public through a traveler information website. The strategy behind the initiative is that each jurisdiction in Colorado will be responsible for collecting, storing, and managing its own data in real-time, and transmitting it to the shared data warehouse (Colorado TMC) in accordance with standards established in the Regional Integrated Traveler Information Display Guidelines. The guidelines standardize how data are collected, processed and reported. The integrated data is then shared with the public via the COtrip website, shown in Exhibit 29. The COtrip website provides information specific to truckers including truck parking and rest stop locations, chain-up laws and stations, HAZMAT-specific routes, and OS/OW permit procedures.
4.4.2.4 **Denver’s Enterprise Data Management System**

In 2018, the City of Denver launched its Enterprise Data Management (EDM) platform with the help of a $6 million grant from the USDOT, having been a finalist in the Smart City Challenge launched by the USDOT. The EDM platform compiles a wide range of real-time information on traffic, freight, environmental health, and weather from multiple systems and sources across the City including police, TMC, bus, rail, traffic signals, road sensors and air sensors. Real-time data is processed by AI algorithms and disseminated on a map-based dashboard to help City departments in decision-making. According to the manager of Denver’s Smart City Program, most of the data captured today are mobility-related and are used to improve traffic management in the City.40

4.4.2.5 **Florida’s Freight Operations Exchange Regional Data Share**

Florida currently shares data for enforcement through a web-based interface that is primarily aimed at Hours-of-service (HOS) enforcement that CVSA Region II is working to leverage for enhanced modeling, safety, commodity flow, and TSMO strategies. FDOT, through the Motor Carrier Size and Weight (MCSAW) office, currently hosts an application online for registered

---

users. This application allows users to access the data that MCSAW stores for its facilities located throughout the State. In an effort to increase efficiency, MCSAW stores this data in a central repository, the Freight Operations Exchange (FOX), which was previously the Container Number Database (CNDB). FOX is useful for enforcement personnel as it provides various functions which can be incorporated into the Regional Data Exchange. This includes specific watches and allows for personnel to access sightings from specific facilities for roadside enforcement. Specific reports can be generated which can prove beneficial for additional reporting. Interstate travel patterns, including number of vehicles and weights, can quickly be developed. These reports can be useful for staffing, shift times, or other analysis.

FDOT is currently expanding the functionality of FOX to include data sharing between enforcement facilities. This will permit CMVs that have been previously screened and found compliant to bypass subsequent weigh stations if within a certain time parameter. In addition, the interconnection to the ITS network will further refine the algorithms for travel time (i.e. if there is a slow down due to congestion, this will be factored in whether the vehicle needs to be screened again). Eventually, the Regional Data Exchange will support real-time sharing of data between states. Florida is currently working on a data standard for ease of sharing between states. This could be established as the national standard. Each state will need to develop criteria and an approval process for accessing the interface. Florida has an online application that is approved by joint support between the Commercial Vehicle Operations office and MCSAW.41

Exhibit 30 illustrates the data feed currently utilized by FOX. This information could also be exchanged via the regional interface.

41 Florida Department of Transportation. Freight Operations Exchange (FOX) Regional Data Share presentation.
4.4.2.6  SMARTFREIGHT in Norway

SMARTFREIGHT is a project that aims to specify, implement, and evaluate Information and Communication Technology solutions to integrate urban traffic management systems with the management of freight and logistics in urban areas. The project includes developing an electronic data sharing system that integrates technology-based data, traffic management data, and freight distribution/logistics data. The system provides two-way communication between a traffic control center and individual trucks. The main advantages of having a shared system is for TMCs to monitor and control freight traffic, and for freight operators or truck drivers to gather information in real-time on traffic conditions and construction work zones for efficient freight transportation planning and operation. The SMARTFREIGHT project is coordinated by SINTEF (The Foundation for Industrial and Technical Research) in Norway and includes multiple public and private partners. It was funded by the European Commission.

4.4.2.7  Data Management and Analytics by Transport for London

With 6,000 traffic signals and 1,400 cameras used to manage traffic flow, Transport for London (TfL) collects a vast amount of data on how people move across the transportation network in London. TfL is utilizing Big Data techniques to turn raw data into useful information for travelers, including trucks, to make optimal trips. Besides TfL’s in-house
analytics, TfL is also using open sourced data and hackathons\(^{42}\) as ways to utilize and bring value from Big Data. By sharing real-time and historic transport data feeds, along with a Unified API on their website, TfL encourages people to create new apps and websites that provide travelers with accurate information about public transport and road networks.

As cited by TfL, “Around 14,400 open data users are currently registered for TfL’s Unified API, from app developers to academic institutions and satellite navigation providers. More than 650 apps are now being directly powered by open data, giving more choice and convenience, and are regularly used by 42 percent of Londoners”.\(^{43}\) TfL is carrying out hackathons and bringing together developers to create valuable ideas and prototypes on how to use and analyze Big Data to help solve our pressing transportation problems.

### 4.4.2.8 DATEX2 in Europe

Data Exchange (DATEX) was initially created in the early 1990s to facilitate the exchange of information between TMCs in Europe. DATEX2 was more recently developed to expand upon this idea, providing more detailed traffic information for distribution and to help improve traffic management for all travelers, including trucks. With DATEX2, the traffic information is not dependent on language or presentation format. The program has now been deployed throughout Europe, creating an international ITS framework. As new technologies are arising, such as driverless cars, DATEX2 will continue to evolve and adapt its standards.

### 4.4.2.9 The Project for the Management of European Traffic (PROMET)

PROMET began in 2007 and is a joint venture between Austria, Italy, and Slovenia. Its goal is to provide efficient management of the cross-border corridor between the three countries for all travelers, including trucks, and make their TMCs interoperable and compatible. One of their most recent activities consisted of creating an international data exchange link between the TMCs in Italy and Slovenia, which serve high-volume passenger and freight corridors. The PROMET project adheres to the DATEX2 standards of data sharing, described earlier.

### 4.4.2.10 EasyWay

The EasyWay program was created in 2007 to facilitate European harmonization of ITS. The program contains member states, road operators, and public and private sector stakeholders. The goal is to collaborate on the deployment of universal ITS services, with an ultimate goal of reducing congestion, improving road safety, and reducing emissions for all travelers, including trucks. They also have initiatives focused on cross-border TMCs. EasyWay encompasses a number of ongoing projects:

\(^{42}\) A hackathon is a design sprint-like event; often, in which computer programmers and others involved in software development, including graphic designers, interface designers, project managers, domain experts, and others collaborate intensively on software projects.

- **CROCODILE**: This initiative is comprised of public authorities, road administrations, and traffic service providers of 13 European member states. The goal is to set up and provide a data exchange infrastructure, based on the DATEX2 standard referred to earlier. This will include the data collection process for key corridors that is deemed relevant for road safety and truck parking applications. This exchange would start among TMCs and be expanded to end-user service partners and affiliated ITS associations.

- **Mediterranean Traveler Information Services**: The MedTIS project has identified a 4,226-mile corridor involving the countries of France, Italy, Spain, and Portugal. The goal is to implement traveler information services, aiming to provide high-level travel times and enhanced traveler information services in accordance with EU policy objectives.

4.4.2.11 **European Digital Traffic Infrastructure Network for Intelligent Transport Systems**

The EU co-funded a project that aims at enabling cross-border, multimodal traveler information based on harmonized traffic data and information gathered at a transnational level. This program is called European Digital Traffic Infrastructure Network for Intelligent Transport Systems (EDITS) and, rather than creating a centralized system, focuses on improving, updating, and harmonizing existing services within partner regions, which includes Austria, Italy, Slovakia, Hungary, and the Czech Republic.

The EDITS program includes two primary components: 1) Graphic Integration Platform for exchange of GIS data; and 2) data information and exchange specification, based on DATEX2 and others.

4.5 **Enforcement and Inspection**

The basic mission or responsibility of the TxDPS Commercial Vehicle Enforcement Service is to check the size, weight, and safety of CMVs operating in Texas. This ensures compliance with the laws regulating size, weight, safety, registration, and the transportation of persons, HAZMAT, and other property. It has joint responsibility with the Highway Patrol Service to conduct Traffic and Criminal Law Enforcement, primarily on rural highways.

In addition to roadside enforcement as needed, TxDPS operates nearly 100 enforcement locations\(^\text{44}\) throughout the State. These sites include a range of investments from roadside pull-off areas with limited amenities or technology that are used on an infrequent basis to full-scale enforcement sites with pre-screening technology, weight scales, inspection buildings, and consistent staffing. Inspection sites are shown in Exhibit 31.

\(^{44}\) Also commonly called “weigh stations”.
Exhibit 31: Texas Department of Public Safety Enforcement Locations

Texas Department of Public Safety Inspection Sites

Source: Texas DPS.
4.5.1 Enforcement and Inspection Programs and Technology Developments in Texas

Essential elements of CMV enforcement are roadside weighing of vehicles and safety inspections, including checks for proper credentials, payment of applicable taxes, and HOS compliance.

There is a wide range of technologies that can assist officers with their enforcement efforts. Many of these fall under the Federal Motor Carrier Safety Administration’s (FMCSA) Innovative Technology Deployment Grant Program, formerly known as the Commercial Vehicle Information Systems and Networks (CVISN) Program.

The following sections document enforcement and inspection programs and technology developments in Texas, focusing on those that specifically benefit freight operations directly or indirectly. Exhibit 32 summarizes each program or technology development’s relevance to the freight community.

Exhibit 32: Summary of Enforcement and Inspection Programs and Technology Developments in Texas

<table>
<thead>
<tr>
<th>Enforcement and Inspection Programs and Technology Developments in Texas</th>
<th>Freight-Specific</th>
<th>Relevance to Freight Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>FMCSA Innovative Technology Deployment Program Elements and Deployment</td>
<td>Yes</td>
<td>Texas’ compliance with the Innovative Technology Deployment Program and meeting program requirements in safety information exchange, electronic credential administration, and electronic screening demonstrates its commitment to improving CMV safety.</td>
</tr>
<tr>
<td>Weigh-in-Motion</td>
<td>Yes</td>
<td>A number of enforcement sites in Texas are equipped with WIM technology, which allows TxDPS to screen CMVs based on weight without requiring them to stop.</td>
</tr>
<tr>
<td>Other Electronic Screening (eScreening) Technology</td>
<td>Yes</td>
<td>TxDPS also uses over-dimension systems, thermal imaging and tire pressure monitoring, and radiological scanners to help with CMV enforcement and inspection activities.</td>
</tr>
</tbody>
</table>

4.5.1.1 FMCSA Innovative Technology Deployment Program Elements and Deployment

The FMCSA Innovative Technology Deployment Program provides grants to states for:

- Improving safety and productivity of motor carriers, CMVs, and their drivers;
• Improving efficiency and effectiveness of CMV safety programs through targeted enforcement;
• Improving CMV data sharing among states and between states and FMCSA; and
• Reducing Federal, state, and industry regulatory and administrative costs.\textsuperscript{45}

Texas is a participant in the FMCSA Innovative Technology Deployment Program and is Innovative Technology Deployment Core Compliant, meaning that it meets program requirements across three functional areas:

1. Safety Information Exchange;
2. Electronic Credential Administration; and
3. Electronic Screening (eScreening).

Each of these areas is described in the following sections.

\textbf{4.5.1.1.1 Safety Information Exchange}
To comply with this FMCSA Innovative Technology Deployment Program area, states must use an automated inspection software to record CMV inspections, connect with the national Safety and Fitness Electronic Records (SAFER) system to allow for exchange of carrier data between states, and implement a Commercial Vehicle Information Exchange Window (CVIEW) that exchanges credential and safety data with SAFER. The CVIEW also typically has an easy-to-read interface that helps officers quickly identify a carrier, determine its safety history and credentials status, and determine if they should target that vehicle for enforcement.

\textbf{4.5.1.1.2 Electronic Credentials Administration}
This program area requires automation of at least 10 percent of International Registration Plan (IRP) and International Fuel Tax Agreement (IFTA) credentialing be conducted electronically. It also requires that the state participate in the IRP and IFTA Clearinghouses, which share information and automate fund transfers between participating jurisdictions.

\textbf{4.5.1.1.3 Electronic Screening}
Using data obtained through the Safety Information Exchange criteria above, eScreening is designed to target enforcement resources on high-risk and non-compliant CMVs by allowing compliant carriers with good safety records to bypass enforcement sites, thus saving those companies time.

eScreening technology can consist of many different systems. The first is pre-clearance or pre-screening technology which identifies a vehicle and queries a State’s CVIEW to determine credential and safety status while the vehicle is on the highway. There are three main approaches to identify the vehicle, two of which are voluntary, the last is involuntary. The first uses a transponder to identify a vehicle. The main vendors using this approach are Help Inc. (PrePass), North American Preclearance and Safety System (NORPASS), and International Road Dynamics (NJPass and NCPass). The second approach uses a mobile phone-based technology to identify vehicles with the major vendor being Drivewyze. The third technology is automated license plate readers (LRP) and/or USDOT Number Readers (LPR/USDOT-R). FMCSA is technology-neutral and does not promote one type of eScreening system over another.

National deployment of these systems is shown in Exhibit 33. Texas currently has 21 locations (32 if counting sites on opposite sides of a divided highway as separate locations) outfitted with Drivewyze and three outfitted with PrePass.46 Exhibit 34 and Exhibit 35 show the Prepass and Drivewyze locations in Texas.

Exhibit 33: Pre-Clearance Systems Deployment as of 2018

Source: FMCSA, PrePass, Drivewyze, NORPASS.

Exhibit 34: Weigh Station Network, PrePass

Exhibit 35: Drivewyze Bypass Service Site Locations

Source: PrePass Service Coverage Maps

Source: Drivewize Coverage Map
The three approaches to identify the vehicle (transponders, mobile phone applications, and LPR/USDOT-R) are described in the following sections.

### 4.5.1.1.3.1 eScreening: Transponders

Under the transponder approach, trucks enroll in a program and are assigned a small wireless transponder designed to be mounted on the windshield. When one of these trucks approaches an equipped inspection site, an electronic reader mounted over the roadway automatically scans the transponder and identifies the vehicle. A computer at the inspection site accesses the vehicle information associated with the transponder and validates it to ensure compliance with a set of requirements determined by the State. As the truck passes beneath a second reader, a signal indicating whether the vehicle may bypass the station is transmitted back to the transponder. If the vehicle’s information cannot be validated, if it fails one of the screening requirements, or if it is selected at random, a red light on the transponder alerts the driver to stop at the associated site. If the vehicle’s credentials, safety, and weight configurations are all in order, a green light on the transponder will notify the driver to bypass the site.

Use of transponders as a screening tool began in the middle to late 1990s. Due to years of refinement, the vehicle identification rate of these systems is nearly 100 percent. The primary weakness of this approach is that it depends on commercial carriers opting in. Based on discussions with the IRP, States, and eScreening programs, out of a total population of approximately 525,000 interstate carriers with 2.7 million vehicles (power units), there are an estimated 750,000 vehicles participating in a bypass program with eScreening transponders. This means that more than 70 percent of the interstate carrier population is not eligible for a bypass and must enter a site if it is open, and this number may be higher depending on the specific State, site, and technology in use.

### 4.5.1.1.3.2 eScreening: Mobile Phone Application Technology

This strategy is based on services provided by mobile application providers. The only products currently on the market are Drivewyze and, more recently, PrePass from Help Inc. In this approach, the enrollment process starts with the driver downloading and installing an application on their mobile phone. When the driver starts their trip, they turn on the application and start driving. The application will alert the driver when they cross a boundary drawn in a mapping program (a practice called geo-fencing) and are approaching an inspection location. Similar to the transponder technology, the vehicle is identified and compared against a list of criteria. Once a decision has been made, the driver is notified to continue driving or to pull into the inspection site via an alert on their cell phone.

---

47 Random pull-in rates are typically set at 5 percent during normal operations.
The use of cell phone-based technology reduces the need for in-ground installation of transponder equipment. This allows the system to be deployed quickly across a wide range of site designs and locations. However, the reliance on mobile phones can limit effectiveness in some areas of the country. Also, as in the transponder approach, this strategy relies on voluntary adoption of the applications across the CMV fleet.

4.5.1.3.3 eScreening: Automated License Plate Reader and USDOT Number Reader/Recognition

Another approach to eScreening is automated LPR and USDOT-R. These use optical recognition software to read a vehicle’s license plate (for LPR systems) or USDOT number (for USDOT-R systems) and then identify the vehicle in a database. LPR/USDOT-R systems are involuntary and do not require special equipment on the vehicle or carrier buy-in. The bypass/pull-in decision is sent to the driver using a roadside DMSs.

The strength of this strategy is its potential ability to evaluate every vehicle traveling down a highway without requiring carriers to opt-in. The main limitation is the correct identification or read rate of the LPR/USDOT-R. Quality of equipment (camera, strobe, controller, and communications) and environmental conditions (fog, snow, and rain) can impact accuracy. This strategy also depends on having a reliable database of CMV license plates and USDOT numbers from across the U.S. This system is more commonly found on site entrance ramps where personnel have the ability to manually enter a license plate or USDOT number if the software cannot identify the vehicle and where lower vehicle speeds increase system accuracy. Even so, processing speed and accuracy are improving, and the technology is increasingly being deployed on the highway network.

4.5.1.2 Weigh-in-Motion

In addition to safety and credential information, enforcement sites can screen vehicles based on weight. Weigh-in-Motion (WIM) technology can be deployed on the highway mainline or on the entrance ramp to a site. In either scenario, trucks are weighed as they pass over the WIM at speed. Although this measurement is not accurate enough to issue a weight citation directly (the margin of error is too high), it can screen out trucks with empty loads or that are obviously under the allowed weight. This helps TxDPS efficiently utilize static scales located at some enforcement sites or portable scales that officers can carry in their vehicle. Across the state of Texas, TxDOT operates over 40 WIM stations, shown in Exhibit 36. Data from a WIM can be integrated with the eScreening technology discussed above so that a vehicle is screened on weight, safety, and credentials information and a bypass or pull-in directive can be sent to the driver via the transponder, smartphone application, or DMS.

TxDOT also utilizes WIM equipment to determine the weights of vehicles operating on the roadway network for planning purposes. WIM equipment collects traffic volumes by vehicle
classification and weight. The data also includes date, time, vehicle length by axle spacing, speed, and axle weight. There are two types of WIM systems used: bending plate and piezo.

Exhibit 36: Weigh-In-Motion Stations Statewide
4.5.1.3 Other eScreening Technology

In addition to the systems listed above, there are a number of other types of eScreening technology that can be used to help enforcement and inspection activities.

4.5.1.3.1 Over-Dimension Systems

Over-dimension checks can be done using lasers, typically located on the entrance ramp to an inspection facility. Vehicles can be scanned to confirm they meet height, width, and length limits, or whether they are over-dimension and have the proper permits. In Texas as of 2019, there are 21 over-height vehicle detection and warning systems (OVDS) locations operational across 11 Districts, serving 14 low-clearance bridge underpass locations, as broken down in Exhibit 37. These systems are managed and coordinated by the Bridge Division. All OVDS sites are operational, except for the ones in the Odessa District, which are currently under construction. Over-dimension checks can also be used as a driver notification system, often approaching low-clearance bridges or tunnels. OVDS alerts and directs the driver via warning signs and warning bells to take corrective action.

Exhibit 37: Overheight Vehicle Detection Deployments Statewide

<table>
<thead>
<tr>
<th>District</th>
<th>Roadways</th>
<th>Status</th>
<th>Number of Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlanta</td>
<td>US259, SH 11, SH 49, FM 1997, FM31</td>
<td>Operational</td>
<td>10</td>
</tr>
<tr>
<td>Austin</td>
<td>I-35 (southbound)</td>
<td>Operational</td>
<td>3</td>
</tr>
<tr>
<td>Corpus Christi</td>
<td>US 77</td>
<td>Operational</td>
<td>1</td>
</tr>
<tr>
<td>Dallas</td>
<td>I-635</td>
<td>Operational</td>
<td>2</td>
</tr>
<tr>
<td>Fort Worth</td>
<td>SH 121 (southbound)</td>
<td>Operational</td>
<td>1</td>
</tr>
<tr>
<td>Houston</td>
<td>I-10</td>
<td>Operational</td>
<td>2</td>
</tr>
<tr>
<td>Laredo</td>
<td>I-35 (southbound)</td>
<td>Operational</td>
<td>1</td>
</tr>
<tr>
<td>Odessa</td>
<td>I-20, I-30</td>
<td>Under Construction</td>
<td>25</td>
</tr>
<tr>
<td>Pharr</td>
<td>I-30</td>
<td>Operational</td>
<td>1</td>
</tr>
<tr>
<td>San Angelo</td>
<td>LP 306</td>
<td>Operational</td>
<td>1</td>
</tr>
<tr>
<td>Yoakum</td>
<td>I-10</td>
<td>Operational</td>
<td>1</td>
</tr>
</tbody>
</table>
**4.5.1.3.2 Thermal Imaging and Tire Pressure Monitoring**

Brake and tire monitoring systems are becoming more popular in the U.S. for enforcement. These systems provide data on hard-to-see areas of the truck to inspectors while the vehicle is approaching the enforcement site.

Exhibit 38 shows examples of these systems:

- **Brake Thermal Imaging**: This system measures heat produced when trucks brake to determine if brakes are functioning properly. In this image (Exhibit 38), the brakes on the left side of the picture are not engaged and so appear cold on the infrared image.

- **Tire Anomaly Classification System (TACS)**: Produced by International Road Dynamics, TACS can detect missing, flat, or worn tires at highway speeds.

![Exhibit 38: Automated Infrared Screening System Image (Left) and Tire Anomaly Classification System (Right)](image)

**4.5.1.3.3 Radiological Scanners**

Texas has deployed radiological scanners at 32 enforcement sites throughout the State to scan trucks for radiological material, which can be used in medicine, power generation, research, and manufacturing, and by the military. Deployment of these sensors is typically done in coordination with the U.S. DHS. Radiological scanners are viewed as a valued instrument in inspecting CMV at high-volume international border crossings (as well as other high-traffic locations) to detect illicit goods such as weapons and drugs. They can be used as a secondary inspection for vehicles flagged as suspicious or ideally deployed as an advanced screening for all vehicles before reaching an inspection station or agent.
4.5.2 Domestic and International Enforcement and Inspection Programs and Technology Developments

The following sections introduce additional technology applications used domestically and internationally to expedite the enforcement and inspection process for CMVs. Exhibit 39 summarizes each program and technology development’s relevance to the freight community.

Exhibit 39: Summary of Domestic and International Enforcement and Inspection Programs and Technology Developments

<table>
<thead>
<tr>
<th>Domestic and International Enforcement and Inspection Programs and Technology Developments</th>
<th>Domestic and/or International</th>
<th>Relevance to Freight Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart Roadside Initiative</td>
<td>Domestic</td>
<td>This USDOT initiative aims to streamline CMV inspection procedures by allowing CMVs to transmit information to roadside inspection facilities prior to reaching the facility and allowing certain CMVs to bypass the inspection site.</td>
</tr>
<tr>
<td>Virtual Weigh Stations</td>
<td>Domestic</td>
<td>This type of inspection site uses a combination of WIMs with a vehicle detection system in place of a fixed inspection facility and allows officers to monitor the WIM data stream off-site and selectively choose which vehicles to pull-over for further inspection.</td>
</tr>
<tr>
<td>Electronic Seals</td>
<td>Domestic</td>
<td>This type of tool uses onboard electronics or sensors to help determine if containers have been tampered with, which contributes to container shipping security and may help to speed up certain types of inspections.</td>
</tr>
<tr>
<td>Enforcement in Europe</td>
<td>International</td>
<td>European countries use more accurate enforcement technologies for low-speed applications allowing officials to focus on other aspects of CMV inspection, whereas in high-speed applications, enforcement systems are used more to preselect size-questionable CMVs from the traffic stream.</td>
</tr>
</tbody>
</table>
4.5.2.1 Smart Roadside Initiative

The Smart Roadside Initiative (SRI) is one of several USDOT research and development projects intended to improve freight efficiency and safety by providing for the exchange of important safety and operational information. The project defined a framework to connect CMVs, motor carriers, enforcement resources, highway facilities, intermodal facilities, toll facilities, and other nodes on the transportation system in order to provide better information exchange between operations personnel and drivers. The architecture can support functions such as pre-clearance at maritime ports, travel time information gathering, supply chain visibility, and dynamic routing.

SRI was tested in the CMV pre-screening environment in which vehicles transmit their relevant details to roadside inspection facilities prior to reaching the facility. Using screening software, inspectors determined whether the vehicles needed to be inspected or could bypass the inspection site. Drivers were notified of the need to stop via smartphone app and DMS entering the site. Additionally, the SRI pilot demonstrated a smart parking application in which, based on the truck’s location, available parking within a given distance would be presented on the driver’s smartphone.

Much of the technology included in the SRI framework is now part of the USDOT Innovative Technology Deployment Program. However, the SRI focuses on transmission of vehicle data beyond what is required in the USDOT Innovative Technology Deployment Program (such as brake status, weight, and tire status), while in motion data transmission may play a role in future AV inspection procedures.

4.5.2.2 Virtual Weigh Stations

As technology continues to improve, many states are moving towards deploying Virtual Weigh-in-Motion stations (VWIM) or virtual inspection sites. VWIMs combine a mainline WIM with a vehicle detection system (either transponder, smartphone app, LPR/USDOT-R, or an optical camera) to detect vehicles that are potentially overweight.

In an environment where budgets are tight, VWIMs offer many of the benefits of eScreening and WIMs. However, vehicles still must be physically weighed (typically on portable scales) in order to enforce weight violations which is slower than using a static scale at a fixed inspection site, and mobile enforcement units that monitor the VWIM do not benefit from infrastructure (landlines and internet, restrooms, inspection barns, etc.) that can be found at fixed sites.

VWIMs are often deployed to cover bypass routes around a fixed facility, in areas where traffic volumes do not necessitate the placement of a large fixed facility, or in locations where adjacent land uses or the cost of land make it difficult to construct fixed infrastructure. Officers monitor the data stream from the VWIM and can selectively choose which vehicles to pursue and pull-over. Depending on the location, these officers may be
situated at the main fixed facility (if the VWIM is covering a bypass route nearby) or a couple miles downstream of the VWIM if there are no nearby fixed sites and can utilize rest areas, pull-offs, or other pre-selected locations downstream of the VWIM to inspect and weigh trucks. While VWIMs have not been officially deployed in Texas, they have recently been tested by the Odessa District in the Permian Basin.

4.5.2.3 Electronic Seals
Although not directly tied to enforcement and inspection, container security is an item of concern for many shippers across all modes of transportation. To better help determine if a container has been tampered with, many container shippers utilize a new tool called Electronic Seals (E-Seals) to ensure the safety and integrity of container shipments. E-Seals replace the traditional mechanical bolt seals and reduce the physical inspection required to determine if tampering has occurred. There are several technologies that support E-Seals:

- Onboard electronics can generate keys, collect data and document events. This ensures that every time the seal is opened, event data is recorded. Specific codes can be inputted into these electronics by the shipper. The recipient can then look for the same codes, determining whether the product has been opened or tampered with.

- Onboard sensors can read the conditions around the container including vibrations, directionality, and speed of movement. These measurements can help determine whether the product has been tampered with or corrupted.

E-Seals can utilize RFID, GPS, and cellular wireless technologies to support the services identified above. Although they offer no direct improvements to transportation mobility outside of speeding up certain inspections, they contribute to container shipping security. There is limited understanding regarding how widely e-seals are used within the shipping industry, but as the upfront equipment cost falls and real-time shipment tracking proves its value, more are being deployed.

4.5.2.4 Enforcement in Europe
Technology used for enforcement varies across the EU, but there are common practices. Many countries use WIM technologies based on piezoquartz or piezoceramic sensor technologies used in fixed sites to measure weight. The Swiss use an automated profile measuring device in low-speed applications and the Germans use a gantry laser system in high-speed applications. In low-speed applications (less than 10 kilometers per hour (km/h)) suitable for legal enforcement, these systems were purported to provide a more complete and accurate dimensional picture of a vehicle and allow enforcement officials to focus on other aspects of inspection. In high-speed applications, these systems can be used to preselect size-questionable vehicles from the traffic stream.
### 4.6 Connected and Automated Freight Vehicles

The development of CAVs for freight continues to advance significantly. Stakeholders, including members of TxFAC and participants in the statewide workshops held as part of the development of the FNTOP, believe that CAV technology will have the greatest impact of all technologies on freight movement in Texas, especially in the near to medium term. Vehicles can be categorized into levels of automation from no automation to full automation, and most automated technologies deployed today fall somewhere in the middle. Technologies used to support CAV deployment include a combination of V2V communication, radar and cameras, in-vehicle sensor and control systems, and V2I communications. The Commercial Vehicle Safety Alliance (CVSA) is expected to publish a report in the near future providing guidance on how to inspect autonomous commercial vehicles.

CAV applications as applied to freight, include, but are not limited to:

- **Truck Platooning**: the linking of two or more trucks in a convoy. These vehicles closely follow each other at a set, close distance by using (CV) technology and automated driving support systems.
- **Autonomous Trucks**: utilizes advanced technological systems such as sensors, cameras, and vehicle control systems which in turn limit or eliminate the requirement of a driver for operating the truck.
- **V2I**: utilizes smart infrastructure that communicates to connected trucks, generally providing safety notifications or dynamic traveler information. The TCFC provides numerous examples for V2I applications.
- **Autonomous Trains**: completely automated trains which possess their own intelligence communication system (communication-based train control or CBTC) that decides their movement such as how much distance has been traveled, where to stop, when to stop, etc.
- **UAVs**: such as automated drones, aircraft, or marine craft may be used to ship items on a more flexible schedule in areas where congestion (urban areas), lack of infrastructure (rural areas), or security-sensitive cargo (military operations) can pose challenges for current trucks.

There are numerous public and private efforts devoted to developing, testing, and deploying connected and automated freight vehicles worldwide. There is an urgency among transportation agencies to become familiar with the technologies and to prepare for their implementation.

The efforts described below are designed to move Texas forward to meet the future CAV needs of the freight community and are in line with the program actions outlined in the implementation plan in the 2018 TFMP. The following documents some of those efforts.
### 4.6.1 CAV Programs and Technology Developments in Texas

Texas has been a popular location for CAV tests and pilots. The section below covers a sample of projects and pilots underway within Texas at the time of this report. Exhibit 40Exhibit 21 summarizes each program or technology development’s relevance to the freight community.

**Exhibit 40: Summary of Connected and Automated Freight Vehicle Programs and Technology Developments in Texas**

<table>
<thead>
<tr>
<th>Connected and Automated Freight Vehicle Programs and Technology Developments in Texas</th>
<th>Freight-Specific</th>
<th>Relevance to Freight Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas Connected Freight Corridors (TCFC) Project</td>
<td>Yes</td>
<td>This project will deploy CV technology to trucks in the Texas Triangle Region to boost economic efficiency, increase safety of trucks, and promote the use of emerging technologies.</td>
</tr>
<tr>
<td>AllianceTexas Mobility Innovation Zone</td>
<td>No</td>
<td>The two initial focus areas for this testbed are a holistic UAS Proving Grounds for aerial technologies and a set of autonomous trucking use cases expanding from short to long-haul.</td>
</tr>
<tr>
<td>TuSimple Autonomous Truck Pilots and Autonomous Freight Network</td>
<td>Yes</td>
<td>TuSimple’s autonomous trucks successfully demonstrated Level 4 autonomous technology in a multi-state pilot test and announced their launch of a complete autonomous truck ecosystem, involving the truck, digital mapped routes, shipping terminals, and in-house autonomous operations monitoring system.</td>
</tr>
<tr>
<td>Ford Commercial Transportation Service</td>
<td>No</td>
<td>Ford announced plans to launch a commercial transportation service in Austin in 2021 using purpose-built self-driving hybrid vehicles to carry either people or goods.</td>
</tr>
<tr>
<td>Waymo Autonomous Long-Haul Trucks and Minivans</td>
<td>No</td>
<td>Waymo intends to deploy autonomous tractor-trailers as well as minivans in Texas to test new environments and eventually launch a commercial freight hauling business.</td>
</tr>
<tr>
<td>Drive.ai Autonomous Ride-Hailing Pilot</td>
<td>No</td>
<td>Drive.ai successfully demonstrated Texas’ first AVs on public roads with an autonomous ride-hailing pilot in the City of Frisco, followed by a similar program in Arlington.</td>
</tr>
<tr>
<td>Connected and Automated Freight Vehicle Programs and Technology Developments in Texas</td>
<td>Freight-Specific</td>
<td>Relevance to Freight Community</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>UberAir Demonstration Flights</td>
<td>No</td>
<td>Uber plans to launch UberAir demonstration flights using new Vertical Take-off and Landing aircraft technology with Dallas being one of the first launch markets.</td>
</tr>
<tr>
<td>Kodiak Robotics Autonomous Long-Haul Trucks</td>
<td>Yes</td>
<td>Kodiak Robotics opened a new facility in North Texas to support its autonomous freight operations and began making commercial deliveries in mid-2019 with human safety drivers behind the wheel.</td>
</tr>
<tr>
<td>Embark Autonomous Trucks</td>
<td>Yes</td>
<td>Embark completed a 2,400 mile coast-to-coast journey along I-10, using machine learning to reconstruct a model of the world using only its sensors in real-time, instead of pre-mapping the entire route.</td>
</tr>
<tr>
<td>Starsky Robotics Autonomous Trucks</td>
<td>Yes</td>
<td>While no longer in operation, Starsky Robotics AV trucks, designed to be autonomous on the highway and remote controlled from afar by human drivers for the first and last miles, successfully booked and loaded a shipment from Dallas to Longview without any human involvement.</td>
</tr>
<tr>
<td>Peloton Truck Platooning Technology</td>
<td>Yes</td>
<td>Peloton is in the process of advancing their truck platooning technology already used in Texas to allow a single truck driver to safely operate two tractor-trailers in a platoon using V2V technology.</td>
</tr>
<tr>
<td>Aurora Autonomous Trucks</td>
<td>Yes</td>
<td>Aurora’s self-driving technology designed to be applied to any vehicle will be tested on commercial routes in DFW with a mix of minivans and Class 8 trucks.</td>
</tr>
<tr>
<td>National Aeronautics and Space Administration (NASA) Drone Traffic Management System</td>
<td>No</td>
<td>NASA is testing its air traffic control system for UAVs in Corpus Christi which will eventually be used to monitor package and person delivery by drone.</td>
</tr>
</tbody>
</table>
4.6.1.1 Texas Connected Freight Corridors Project

The Texas vision for TCFC is to create a sustainable CV environment that covers the 865-mile Texas Triangle of I-35 (including extension to Laredo), I-45, and I-10 linking Austin, DFW, Houston, and San Antonio. This environment would support V2V and V2I safety and mobility applications being developed by public agencies and the CV industry. The project goals are to deploy V2V and V2I applications with CMVs to address the greatest freight safety and mobility needs of the State.

The TCFC project is building on the ITS technologies already deployed in the TxDOT Districts across the State. The TCFC project will deploy infrastructure condition monitoring technologies on TxDOT fleet vehicles to support maintenance activities. The project will also deploy CV (V2I and V2V) technologies to support safety and mobility applications (i.e., end-of-queue, work zones, road weather, and wrong-way driving warnings) along these interstate corridors.

In addition, the project will deploy freight-specific technologies. Both truck parking availability systems and international border wait time notifications will be deployed to provide freight operators and truck drivers with better information on parking availability and international border crossing wait times. The data from CV V2I and V2V applications will also be shared with truck platooning technologies to improve the safety and efficiency of these planned deployments.

Telecommunication technology will be deployed to support the CV applications. Of the corridors in the TCFC project, I-35 has the most urban regions along its corridor. Thus, the project team is proposing an emphasis on DSRC wireless technology in this corridor. The I-45 and I-10 corridors are more rural in nature and offer more cost-effective deployment using other communication, such as cellular (4G, and 4G Long Term Evolution or LTE). This approach will also allow the public agencies to compare the benefits, performance, and infrastructure cost for different CV deployment scenarios.

The project will support the following CV applications:

- In-vehicle Traveler Information;
- Eco-Dynamic Routing;
- Work Zone Warning;
- SPaT Corridor for Improved Pedestrian/Bicycle Safety;
- Truck Parking Reservations;
- Border Wait Times;
- FSP;
• Low Bridge Height Warning;
• Queue Warning;
• Road Weather Warning;
• Wrong Way Driving (WWD);
• Truck Platooning; and
• EEBL—V2V application

4.6.1.2 **AllianceTexas Mobility Innovation Zone**

AllianceTexas is a 27,000-acre master-planned development and inland port north of Fort Worth, which is home to Federal Aviation Administration’s Southwest Regional Headquarters, Fort Worth Alliance Airport, BNSF Railway’s Alliance Intermodal Facility, FedEx Southwest Regional Sort Hub, Amazon Air’s newest regional air hub, and more than 500 global and regional brands. The commercial developer, Hillwood, wants to create a cutting-edge center of innovation that will be a global catalyst for the future of mobility. Hillwood plans to collaborate with its anchor corporations, future customers, policy makers, regulators, entrepreneurs, and academic institutions to develop a first-of-its-kind mobility innovation “do-tank” for partners to develop, test, scale, and commercialize advanced mobility technology and business models. Hillwood has engaged Deloitte’s Future of Mobility Global Practice team to develop the strategic direction, business model, and operating platform for the AllianceTexas Mobility Innovation Zone. Through this collaboration, the goal is for AllianceTexas to serve as a fully integrated testbed and convening place for stakeholders throughout the innovation lifecycle.48

In April 2019, Hillwood convened a diverse set of stakeholders to identify priority mobility use cases, and understand their needs in a built environment and the hurdles to commercialization. The session helped launch the initial two focus areas for the AllianceTexas Mobility Innovation Zone: a holistic UAS Proving Grounds for aerial technologies and a set of autonomous trucking use cases expanding from short to long-haul.49

4.6.1.3 **TuSimple Autonomous Truck Pilots and Autonomous Freight Network**

Besides operations in China, TuSimple has headquarters in San Diego and is expanding the autonomous truck driving market in the U.S. TuSimple autonomous trucks are currently delivering mail in Arizona between Phoenix and Tucson. The trucks are equipped with cameras, Light Detection and Ranging (LIDAR), radar sensors, a self-driving computer, and a 1,000-meter perception system. This enables fully autonomous deliveries from one depot to


49 [https://www.alliancetexasmiz.com/](https://www.alliancetexasmiz.com/)
another, which requires both highway and local street driving. The truck perception system identifies obstacles in adverse weather conditions and provides 35 seconds of time to react, making trucking safer.\footnote{50 https://www.tusimple.com/}.

In May 2019, TuSimple partnered with the U.S. Postal Service (USPS) to undertake a two-week pilot program to deliver mail between Phoenix, Arizona and Dallas, Texas. Three of TuSimple’s autonomous trucks completed roundtrips between the USPS distribution facilities in Phoenix and Dallas, an approximate distance of 1,000 miles each way. The pilot program tested Society of Automotive Engineers (SAE) Level 4 autonomous technology, where an on-board computer is in control during the entire drive. To comply with current federal laws, a safety engineer and driver were on board to monitor performance.

In July 2020, TuSimple announced the launch of the Autonomous Freight Network (AFN), a national transportation network consisting of self-driving trucks, digital mapped routes, shipping terminals, and TuSimple Connect (their autonomous operations monitoring system) to complete the ecosystem needed to support autonomous trucks. UPS, Penske Truck Leasing, U.S. Xpress, and McLane, a supply chain services company have partnered with TuSimple on the launch. The goal of the network is to deploy Level 4 autonomous trucks that can operate on the road without a safety driver.\footnote{51 https://www.freightwaves.com/news/tusimple-to-build-5g-network-of-autonomous-trucking}

The Network will take shape in three stages, with a goal of having self-driving autonomous trucks become commercially available by 2024:

- **Phase I** (2020-21) will offer service between Phoenix and Tucson, Arizona, Dallas, Houston, San Antonio, and El Paso, Texas.
- **Phase II** (2022-23) will expand AFN service from Los Angeles, California to Jacksonville, Florida, connecting the East and West coasts.
- **Phase III** (2023-24) will expand driverless operations nationwide, adding major shipping routes throughout the lower 48 states, which will allow customers to utilize their own TuSimple-equipped autonomous trucks on the AFN by 2024.

4.6.1.4 *Ford Commercial Transportation Service*

Ford Motor Company announced on September 25, 2019 that it plans to launch a commercial transportation service using automated vehicles in Austin, Texas in 2021. Ford’s self-driving system, now being tested in Fusion Hybrid sedans, is being jointly developed with Argo AI, a Pittsburg-based startup of which Ford is a majority stakeholder. The purpose-built hybrid vehicles that will be used can be equipped to carry either people or goods. Ford plans
to begin manually driving Fusion test vehicles in Austin in order to map city streets and assess driver and pedestrian behaviors ahead of the commercial launch in 2021.\(^{52}\)

4.6.1.5  **Waymo Autonomous Long-Haul Trucks**

In January 2020, Waymo announced its intention to deploy autonomous tractor-trailers as well as minivans in Texas as it seeks to learn about new road conditions and environments. Waymo had previously deployed their Firefly vehicle prototype (with no steering wheel or pedals) in Austin in October 2015.\(^{53}\) Waymo plans to eventually launch a commercial freight hauling business.

4.6.1.6  **Drive.ai Autonomous Ride-Hailing Pilot**

Drive.ai did an eight-month autonomous ride-hailing pilot in the City of Frisco. City officials noted it generated over 3,000 trips and 5,000 riders and was Texas’ first autonomous vehicle on public roads. The program utilized Nissan NV200 vans. Drive.ai has subsequently followed up with a similar autonomous ride-hailing program in Arlington.

4.6.1.7  **UberAir Demonstration Flights**

In 2016, Uber announced their Uber Elevate program that is investing in Vertical Take-off and Landing (VTOL) aircraft technology to incorporate air travel into their passenger service model. This new service, called UberAir, will launch in three initial markets. As stated by Uber, demonstration flights are expected to begin in 2020, with the first commercial operations in 2023. The goal is to minimize travel time between large cities and their neighboring suburbs, with Melbourne (Australia), Los Angeles, and Dallas being the first launch markets. UberAir has become feasible because of the development of specific VTOL aircraft. They are light and fully electric, allowing for cheaper and more efficient air travel. With Uber leading the way on this new type of ridesharing, the industry is pioneering new ways of relieving congestion in major cities.

4.6.1.8  **Kodiak Robotics Autonomous Long-Haul Trucks**

Kodiak Robotics is a startup developing self-driving technology to revolutionize long-haul trucking through their use of technology to make highways safer and reduce the cost and time it takes to transport freight. They opened a new facility in North Texas to support their autonomous freight operations and testing, attracted by the State’s friendly CAV regulatory environment and position as a logistics and transportation hub with the most total miles of

---


interstate routes in the nation. They began making their first commercial deliveries in Texas in mid-2019, with human safety drivers behind the wheel.\textsuperscript{54}

\textbf{4.6.1.9 Embark Autonomous Trucks}
In 2017, Embark began moving refrigerators for Electrolux from Los Angeles, California to El Paso, Texas – the world’s longest automated freight route. Embark automated trucks has a driver at the wheel at all times. In 2018, Embark completed a 2,400 mile coast-to-coast journey along I-10, disproving the freight community’s concern that mapping the long distances traveled by automated trucks would act as a barrier to expansion. Instead of first pre-mapping the entire route, which has become standard in the AV industry, Embark used machine learning to reconstruct a model of the world using only its sensors in real-time.\textsuperscript{55}

\textbf{4.6.1.10 Starsky Robotics Autonomous Trucks}
Starsky Robotics\textsuperscript{56} self-driving trucks were designed to be autonomous on the highway, but would be remote controlled from afar by human drivers for the first and last miles. The company worked together with tech logistics company Loadsmart to complete the first autonomous dispatch and delivery of freight. Using Loadsmart’s AI-powered pricing and load-matching technology, combined with Starsky’s self-driving trucks, the duo were able to book and load a shipment from Dallas to Longview (135 mile trip) without any human involvement. This test provided the feasibility of eliminating back-office human intervention typically needed to dispatch each truck for each load, and making the shipment process more seamless.\textsuperscript{57}

\textbf{4.6.1.11 Peloton Truck Platooning Technology}
Peloton Technology is a connected and automated vehicle technology company based in Silicon Valley, California. Peloton developed a SAE Level 4 Automated Following System that augments a human truck driver’s ability with automated vehicle technology. The Automated Following System includes a human driver in the lead truck guiding a fleet of two unmanned trucks operating autonomously behind the lead truck. The system utilizes V2V communications and radar-based systems, combined with vehicle control algorithms. The human driver in the lead vehicle is able to guide the steering, acceleration, and braking of the follow trucks and connects the safety systems between the trucks with minimal latency.


\textsuperscript{55} https://www.fleetowner.com/technology/autonomous-vehicles/article/21701890/embark-completes-automatedcoasttocoast-truck-trip

\textsuperscript{56} As of March 2020, they announced that they would be shuttering its doors.

\textsuperscript{57} https://dallasinnovates.com/testing-ground-why-north-texas-is-a-growing-hub-for-selfdriving-trucks/
The Level 4 Automated Following System is being tested and is expected to double the amount of freight a truck driver can haul in a single trip, resulting in cost savings.

The company has already rolled out its Level 1 PlatoonPro system, which requires a driver in both the lead and following trucks. The driver in the second truck needs to steer the vehicle, but the system controls the powertrain and brakes to manage the following distance. PlatoonPro is being used by six fleet customers in real-world conditions mostly in Texas, with a perfect safety record and average fuel savings of more than seven percent. The customers have reported infrequent instances where other vehicles cut into an established platoon, which has been a major safety concern regarding truck platooning.58

4.6.1.12 Aurora Autonomous Trucks
Aurora, an AV technology startup backed by Amazon, is expanding into Texas as it aims to accelerate the development of self-driving trucks. The company plans to test commercial routes in DFW with a mix of Fiat Chrysler Pacifica minivans and Class 8 trucks. Aurora’s self-driving technology is designed to be applied to any vehicle, but their first commercial product will be geared towards the trucking industry.59

4.6.1.13 National Aeronautics and Space Administration Drone Traffic Management System
NASA worked together with industry partners since 2015 to develop a cloud-based software system to ensure safe unmanned drone flights below 400 feet. The system would act like air traffic control for drones by tracking them to help avoid collisions and ensure smooth flight paths. This will supplement the FAA’s existing systems, which are currently responsible for 5,000 daily airplane flights. NASA began testing its drone traffic management system in Corpus Christi in 2019 to collect data on how drones perform in heat, humidity, and with a potential loss in radio signal over the ocean. Drone traffic oversight will be transferred from the aeronautics division of NASA to the FAA after the system is tested successfully in windy urban areas like Corpus Christi. In urban areas, drones run into challenges such as buildings that disrupt visibility or affect wind patterns, but also interfere with radio communication with unmanned aircraft. Additional drone challenges to overcome include how well drones developed by different manufacturers share and respond to information from the traffic management system, whether drones can detect each other, or handle losing GPS. Eventually, the system will be used to monitor package and person delivery by drone.60

60 https://www.discovermagazine.com/technology/nasas-air-traffic-control-system-for-drones-nearing-completion
4.6.2 Domestic and International CAV Programs and Technology Developments

The following sections present several examples of notable CAV programs and technology developments outside of Texas at the time of this report. Exhibit 41 summarizes each program and technology development’s relevance to the freight community.

Exhibit 41: Summary of Domestic and International CAV Programs and Technology Developments

<table>
<thead>
<tr>
<th>Domestic and International CAV Programs and Technology Developments</th>
<th>Domestic and/or International</th>
<th>Relevance to Freight Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caltrans Three-Truck Platoon Test</td>
<td>Domestic</td>
<td>The project investigated the potential to improve freight operations by building on previous research and development of two-truck platoons to develop and test three-truck platoons.</td>
</tr>
<tr>
<td>Ohio Unmanned Aircraft System Center</td>
<td>Domestic</td>
<td>The Ohio UAS Center was created to research and integrate unmanned aircraft technologies into statewide operations such as medical transport of organs by drones.</td>
</tr>
<tr>
<td>European Truck Platooning Challenge/Enabling Safe Multi-Brand Platooning for Europe (ENSEMBLE) Consortium</td>
<td>International</td>
<td>This challenge highlights the required cooperation between public and private sector stakeholders to prevent countries from creating a patchwork of truck platooning rules and regulations.</td>
</tr>
<tr>
<td>TuSimple Maritime Port Automation</td>
<td>International</td>
<td>TuSimple plans to test using autonomous trucks to carry freight containers around the Port of Caofeidian as a potential solution to increase maritime port efficiency.</td>
</tr>
<tr>
<td>Ocado Fully Automated Warehouse</td>
<td>International</td>
<td>Online-only supermarket Ocado builds fully automated warehouses powered by thousands of robots used to lift, move, or sort groceries more efficiently than human workers.</td>
</tr>
</tbody>
</table>

4.6.2.1 Caltrans Three-Truck Platoon Test

The project investigated the potential to improve freight operations by building on previous research and development of two-truck platoons to develop and test three-truck platoons.
Caltrans was awarded a $1.6 million grant under the FHWA's Exploratory Advanced Research Program (EARP) to study and pilot partially automated truck platooning. LA Metro worked with Caltrans, Gateway Cities Council of Governments (GCCOG), UC Berkeley Partners for Advanced Transportation Technology (PATH), Cambridge Systematics, Volvo Technology of America, and Peloton Technology on this effort. The goal of the project was to augment existing adaptive cruise control technology with the addition of V2V communications to allow for close proximity truck platooning. As part of this effort, LA Metro and GCCOG worked with Caltrans to simulate the truck platooning concept and technology on the I-710 corridor where dedicated truck lanes were being evaluated. This project went beyond research and culminated in the demonstration of automated truck platooning in Los Angeles County in March 2017.

4.6.2.2 Ohio Unmanned Aircraft System Center
In 2019, the Ohio Department of Transportation (ODOT) released its 2019 TSMO Action Plan, with one goal being to formalize UAS applications. This goal ties into the ongoing statewide efforts to advance UAS technology. In 2013, the Ohio UAS Center was created to research and integrate unmanned aircraft technologies into statewide operations, as well as manage all unmanned aircraft operations for ODOT. Since its creation, ODOT—through this Ohio UAS Center—has been able to pilot the UAS program and serve as a shared resource for local and state agencies for UAS program development and flight operations. This UAS program has allowed for the pilot of drone operations efforts, such as medical transport of organs by drones and drone surveys to bring about traffic signal timing changes.

The Ohio UAS Center, along with other partners, developed a system called SkyVision, a ground-based detect-and-avoid radar system at the Springfield-Beckley Municipal Airport in Springfield, OH. The system utilizes three existing FAA active radar systems to track unmanned aircraft, which would allow for drone flights beyond the FAA’s existing line-of-sight operational restriction. Approval was given to operate beyond line-of-sight up to 1,000 feet above-ground-level (400 feet above-ground-level is the current FAA allowance), which has allowed the Ohio UAS Center to facilitate research and development testing, certification, and commercialization of UAS systems across the state, as well as providing a testbed for evaluating the safety of test UAS aircraft.

4.6.2.3 European Truck Platooning Challenge/ENSEMBLE Initiative
This challenge, initiated by the Dutch EU Presidency, fosters European cooperation between truck manufacturers, member states, logistics service providers, road operators, road and vehicle approval authorities, research institutes, and governments. Such cooperation on
platooning is vital to prevent countries from creating a patchwork of rules and regulations, which could hinder manufacturers and road users from investing in CAVs.⁶¹

In the 2016 European Truck Platooning Challenge, six truck platoons (of six different vehicle manufacturers) drove from a range of European countries to the APM Terminals, Maasvlakte II in the Port of Rotterdam in the Netherlands. The truck platoons departed from their home base or production location. Scania left from Södertälje (south of Stockholm) and drove through Sweden, Denmark and Germany to the Port of Rotterdam, making stops in Zolder, Belgium and in Zwolle, Netherlands (a route of over 2,000 kms, and crossing several borders). Volvo started from Gothenburg, Sweden, driving through the same countries, and stopped in Vilvoorde, Belgium. Daimler started from Stuttgart and MAN from Munich in Germany. IVECO departed from Brussels and DAF from their production location in Westerlo, Belgium. Exhibit 42 shows a map of the truck platooning routes.

---

The test cases involved six brands of automated trucks - DAF Trucks, Daimler Trucks, Iveco, MAN Truck & Bus, Scania, and Volvo Group—that have been driving in platoons on public roads from several European cities to the Netherlands. The teams from the six brands platooned on motorways in normal traffic conditions. Local conditions dictated where they could platoon. The demonstration was declared a success and proponents of truck platooning cited it as “proof that we can overcome the institutional and operational challenges of running in different countries.”  

Following the European Truck Platooning Challenge, the EU-funded ENSEMBLE consortium was formed in 2018 to implement and demonstrate multi-brand truck platooning on European roads over three years together with the same six truck manufacturers. This paves the way for the adoption of multi-brand truck platooning in Europe that will improve fuel efficiency.

---

economy, reduce carbon dioxide emissions, improve traffic safety, and increase efficiency throughout the road freight sector. The final ENSEMBLE multi-brand truck platooning demonstration is planned on public roads in 2021.

4.6.2.4 TuSimple Maritime Port Automation
Chinese robotics company TuSimple plans to use maritime port automation as a proving ground for over-the-road autonomous trucks. By the end of 2019, it had planned to have 20 of its self-driving vehicles carrying containers around the Port of Caofeidian, China. Caofeidian, a district of the City of Tangshan, is a 300,000 twenty-foot equivalent unit (TEU) container terminal that is large enough that TuSimple can test its technology in a realistic environment.

TraPac at the Port of Los Angeles, Maasvlakte 2 in Rotterdam, and Yangshan Phase 4 in Shanghai already use robotic trucks to carry containers within the bounds of the facility site. In addition, Singapore is trialing semi-autonomous truck "platooning," with one human-operated vehicle ahead and several self-driving trucks following closely behind. However, Caofeidian may be the first maritime port to test fully self-driving, over-the-road truck systems.

4.6.2.5 Ocado Fully Automated Warehouse
British online-only supermarket Ocado has built fully automated warehouses that can run 24 hours a day without having to hire late-night shift workers. The warehouse is populated with over a thousand robots that lift, move, or sort groceries day and night, processing 3.5 million items every week. Their actions are coordinated by a central computer, which ensures that the robots are used as efficiently as possible. All robots are interchangeable, which makes them easy to replace if they break down, or add more if Ocado wants to scale up operations. They are more efficient than humans and cheaper to employ. Ocado still employs human workers to handle tasks that the robots are not yet adept at, but they don’t have to worry as much about labor shortages. Ocado also sells its technology to other grocery chains in France, Canada, and Sweden.  

4.7 Intermodal Terminal Operations
Texas has an extensive multimodal freight transportation system, and the interchange between modes at rail terminals, airports, and maritime ports is crucial for freight mobility. Intermodal Terminal Operations includes multimodal freight needs as well as the connectivity between the freight highway network and interchange points, and it covers the following main topics:

- Water, Air, Pipeline, Rail Terminal, and Warehouse/Distribution/Industrial Center Access: The design and operational conditions of local roadways providing first-mile/last-mile connectivity by truck to intermodal terminals affects the efficiency of freight movement

and impacts the surrounding communities. Examples of issues that often occur on these roads include insufficient capacity, narrow lanes and shoulders, short or no dedicated queuing lanes, low vertical clearances, inadequate intersections, modal conflicts, steep grades and sharp corners, lack of wayfinding signage, and inadequate pavement design to support OS/OW trucks.

- **Truck Queuing**: Long queues of trucks at intermodal terminals and major warehouse/distribution/industrial centers is a recurring issue. During peak activity, trucks often must wait on state and local roadways to access the terminal entrances, creating safety, traffic, and emissions concerns. There are queue detection systems that are designed to measure truck queue length and wait times. These systems are placed at key points approaching the terminal gates and use sensors and video cameras to provide real-time data of the queuing activity.

- **Truck Staging/Parking**: Providing accommodations, such as truck queuing lanes or designated truck staging and parking areas, could help mitigate long queuing at intermodal terminals and major warehouse/distribution/industrial centers. Truck staging and parking can be located in close proximity to terminals and can be designed to facilitate truck movement from/to the freight highway network and terminal.

- **Truck Appointment Systems**: Terminal appointment systems are used to coordinate terminal capacity with truck arrivals. By setting appointments for truck drivers to arrive at the facility, the flow of trucks throughout the day is more efficient. This reduces queuing and waiting time and improves the use of the terminal’s capacity.

- **Drayage Operations**: Drayage is the transportation of freight for short distances by trucks. It may include trucking between terminals, or trucking from terminals to warehouses, distribution centers, or directly to the final destination. There are software solutions developed to provide insight into supply chain analytics and to support and optimize drayage operations through better coordination and monitoring of the process. New data availability from CAVs, connected infrastructure, and probe devices opens up opportunities to understand freight movements in more granular detail and determine ways to better optimize drayage operations.

- **Maritime Terminal Operations**: Maritime terminals have the goal of maximizing the number of goods that transit through their facilities and improving the overall efficiency of their operations. To assist with their operations, these maritime terminal operators use a variety of container tracking and matching tools to improve real-time container location visibility and automated freight-matching (i.e., the process of assigning goods to trucks will be automated).

- **Rail Freight Improvements**: Rail freight operators enact technology solutions to better track shipments, mitigate delays and bottlenecks, reduce conflicts at highway-rail at-grade crossings, and get more capacity and reliability from their existing networks.
Examples of solutions include positive train control, automatic train operation, and software to coordinate across railroads.

- **International Border Crossings:** CBP manages the security of cross border freight movements at all POEs across multiple modes and utilizes technologies to support credentialing, inspections, and traveler information. These include ATIS and systems for advanced inspection and approval.

### 4.7.1 Intermodal Terminal Operations Programs and Technology Developments in Texas

The following sections document intermodal terminal operations programs and technology developments in Texas, focusing on those specifically that benefit freight operations directly or indirectly. Exhibit 43 Exhibit 21 summarizes each program or technology development’s relevance to the freight community.

#### Exhibit 43: Summary of Intermodal Terminal Operations Programs and Technology Developments in Texas

<table>
<thead>
<tr>
<th>Intermodal Terminal Operations Programs and Technology Developments in Texas</th>
<th>Freight-Specific</th>
<th>Relevance to Freight Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>TxDOT Port Connectivity Study</td>
<td>Yes</td>
<td>The study identified connectivity challenges between 14 maritime ports along the Texas Gulf Coast and major freight corridors and proposed projects to help the maritime ports to meet the growth potential of global trade opportunities.</td>
</tr>
<tr>
<td>Truck Queuing Along Joe Fulton Corridor</td>
<td>Yes</td>
<td>This project proposes to develop staging areas and utilize CV communications with trucks to help reduce truck queueing along the Joe Fulton Corridor, a National High Priority corridor.</td>
</tr>
<tr>
<td>Texas Maritime Terminal Technologies</td>
<td>Yes</td>
<td>Maritime terminal operators use a variety of freight tracking and matching tools to improve real-time visibility of freight location/status and automate freight-matching in order to improve operational efficiencies.</td>
</tr>
<tr>
<td>Positive Train Control (PTC) in Texas Railroads</td>
<td>Yes</td>
<td>PTC, used to automatically stop a train before certain types of incidents occur, has been deployed on 100 percent of BNSF and UP’s rail network in Texas.</td>
</tr>
</tbody>
</table>
## Intermodal Terminal Operations

### Programs and Technology Developments in Texas

<table>
<thead>
<tr>
<th>Automated Gate Systems</th>
<th>Freight-Specific</th>
<th>Relevance to Freight Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>These systems provide drayage trucks secure and timely access in and out of loading/transfer areas and are widely utilized at freight terminals in Texas.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Real-Time Train Monitoring at Port of Beaumont</th>
<th>Freight-Specific</th>
<th>Relevance to Freight Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>In an effort to reduce truck queuing around the Port of Beaumont, this proposed system would monitor for approaching trains and alert truckers to detour to the staging area until the at-grade highway-rail crossing is clear.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Texas International Border Crossing Technologies</th>
<th>Freight-Specific</th>
<th>Relevance to Freight Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>CBP utilizes an RFID system to generate accurate wait times for CMVs to support a streamlined and efficient process to reduce inspection and credentialing delays.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COAST Autonomous Rail Yard Deployment</th>
<th>Freight-Specific</th>
<th>Relevance to Freight Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>COAST Autonomous plans to deploy the first self-driving vehicles at an U.S. rail yard, in an effort to improve operational efficiency and safety.</td>
<td></td>
</tr>
</tbody>
</table>

### 4.7.1.1 TxDOT Port Connectivity Study

The TxDOT Maritime Division has undertaken a Port Connectivity Study as part of the 2020–2021 Texas Port Mission Plan, which highlights the importance of investing in maritime ports to meet the growth potential of global trade opportunities. The study includes assessing the existing status of inland or first-mile/last-mile connectivity at 14 public maritime ports along the Texas Gulf Coast illustrated in Exhibit 44, including the following:\(^\text{64}\)

- Port of Orange;
- Port of Beaumont;
- Port of Port Arthur;
- Port Houston;
- Port of Galveston;
- Port of Freeport;
- Port of Bay City;

• Port of Palacios;
• Calhoun Port Authority;
• Port of Victoria;
• Port of Corpus Christi;
• Port of Harlingen;
• Port of Port Isabel; and
• Port of Brownsville.
The study focused on roadway connections between the maritime ports and major freight corridors and identified connectivity challenges and areas of concern at each of the maritime ports. Challenges for maritime port connectivity included inadequate design for freight traffic, operational issues such as truck queuing, modal conflicts, and incompatibility with surrounding land uses. The project identified 42 potential improvement projects with an estimated cost of $210 million, distributed among several categories as shown in Exhibit 45.
4.7.1.2 Truck Queuing Along Joe Fulton Corridor

Another project proposed under the Freight Innovative Technology project includes alleviating truck queuing along Joe Fulton International Trade Corridor (JFITC), as shown in Exhibit 46, a two-way arterial roadway located along the north bank of the Inner Harbor of the Port of Corpus Christi Authority (POCCA). The corridor was developed by POCCA and TxDOT to connect the major freight corridors of I-37 and US 182. It was designated by Congress as a National High Priority corridor, which qualifies it for either direct or indirect funding from the Intermodal Surface Transportation Efficiency Act (ISTEA), the Transportation Equity Act for the 21st Century (TEA-21), or the Safe, Accountable, Flexible, Efficient Transportation Equity Act (SAFETEA-LU).

Along the JFITC, grain trucks often queue and idle when waiting to enter the Archer-Daniels Midland (ADM) grain elevators. The project proposes a mix of infrastructure and ITS solutions to enhance freight mobility and accordingly the safety and air quality of the corridor. The project aims to develop staging areas along JFITC for grain trucks to idle and a CV system that will provide truck drivers with real-time information on the status of the grain elevator (i.e. whether it is able to accommodate a new batch of trucks).
4.7.1.3 Texas Maritime Terminal Technologies
At Texas maritime ports, private sector maritime terminal operators are responsible for onboarding carriers to help exchange goods between the various transportation modes. The goal of these for-profit operators is to maximize the number of goods that transit through their facilities and improve the overall efficiency of their operations. To assist with their operations, these maritime terminal operators use a variety of freight tracking and matching tools to improve real-time visibility of freight location/status and automate freight-matching. For example, some terminal operators that were interviewed as part of the FNTOP report using Macropoint to track and match freight as part of their operation. These terminal operators also use Electronic Data Interchange (EDI) to help exchange business information in a standardized electronic format, which reduces the need to send information from one company to another using paper. Maritime port operators regularly use DMSs to direct traffic.

4.7.1.4 Positive Train Control in Texas Railroads
The rail industry’s deployment of PTC – highly advanced technology designed to automatically stop a train before certain types of incidents occur – along with other technological advancements and changes in operating practices, allow more crew flexibility by creating safety redundancies. BNSF and UP have both installed PTC on 100 percent of their network in Texas.

4.7.1.5 Automated Gate Systems
At intermodal terminals, maritime ports, and railyards, providing drayage trucks secure and timely access into and out of the loading and transfer areas can be a challenge. One technology solution is automated gate systems. These systems typically include a kiosk-type
interface for drivers to interface with and software to expedite screening and credential review. Such systems are widely utilized at freight terminals in Texas and elsewhere.

One example is the UP Dallas Intermodal Terminal in Wilmer. Fairfield Economic Development notes that the “high-tech, biometric secured automated gate system entrance allows a trucker to process a container through the gate in 30-90 seconds, as compared to a national average of four minutes.”

4.7.1.6 Real-Time Train Monitoring at Port of Beaumont
As part of the Freight Innovative Technology Project undertaken in cooperation with TxDOT and FHWA, TTI has identified an opportunity to reduce freight congestion around the Port Beaumont by installing a train monitoring system. Rail trains often block the main entrance to the Port during maritime port-related rail activity. Due to the blockage, arriving trucks start queuing, causing disruption on city streets. The train monitoring project proposes to install a train monitoring system near the Port entrance and a DMS for trucks located prior to a truck staging area. If installed, the system will monitor trains and alert truck drivers when the Port is blocked or about to be blocked by trains, so that truck drivers will route to the staging area. When the entrance is cleared, truck drivers will also receive a message to proceed to the gate. The system provides real-time coordination of truck movement based on rail activity.

4.7.1.7 Texas International Border Crossing Technologies
CBP manages the security of cross border freight movements at all POEs across multiple modes and utilizes technologies to support credentialing, inspections, and traveler information. Several of the technologies discussed in the ATIS section are applied to Texas POEs.

To generate accurate wait times for CMVs, CBP utilizes a border crossing information system, developed as a result of a project with FHWA funding. The system relies on RFID technology. Carriers can access wait times at https://bwt.cbp.gov/ for POEs on both the northern and southern border.

The Automated Commercial Environment (ACE) system permits the trade community to submit their information to CBP and partners through an EDI or secure data portal. It supports a streamlined and efficient process to reduce inspection and credentialing delays.

The Texas-Mexico Border Transportation Master Plan (BTMP) includes additional international border technology recommendations.

---

65 https://www.fairfieldtx.com/site-selection/transportation/rail/
4.7.1.8 COAST Autonomous Rail Yard Deployment
In July 2019, COAST Autonomous announced their plans to deploy the first self-driving vehicles at an U.S. rail yard. These AVs will be deployed at the Kinney County Railport (KCRP), which is operated by Harbor Rail Services of California, on behalf of UP, to help in areas such as staff transportation, supplies and equipment deliveries, perimeter security, and lawn mowing. COAST Autonomous has completed 3D mapping of the facility. These AVs are intended to free up additional labor to work on railcars, improve efficiency, and help keep the facility safe at night – all ways for Harbor Rail to improve their customer service and innovative applications of freight technology.66

4.7.2 Domestic and International Intermodal Terminal Operations Programs and Technology Developments
The following sections present several examples of notable intermodal terminal operations programs and technology developments outside of Texas at the time of this report. Exhibit 47 summarizes each program and technology development’s relevance to the freight community.

Exhibit 47: Summary of Domestic and International Intermodal Terminal Operations Programs and Technology Developments

<table>
<thead>
<tr>
<th>Domestic and International Intermodal Terminal Operations Programs and Technology</th>
<th>Domestic and/or International</th>
<th>Relevance to Freight Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>GoPort Freight ITS at the Port of Oakland</td>
<td>Domestic</td>
<td>The implementation of a maritime port TMC and freight ITS information system is being used to improve truck access and circulation at one of the top 10 busiest container ports in the U.S.</td>
</tr>
<tr>
<td>Port Authority of New York and New Jersey Truck Management System (TMS)</td>
<td>Domestic</td>
<td>The TMS allows truckers to make appointments for container pick up or delivery, which helps to reduce trucker turn-times.</td>
</tr>
<tr>
<td>Port Authority of New York and New Jersey Terminal Information Portal System</td>
<td>Domestic</td>
<td>This system consolidates information regarding all six container terminals into a single web portal and also allows users to receive notifications on the status of their containers and bookings.</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Domestic and International Intermodal Terminal Operations Programs and Technology</th>
<th>Domestic and/or International</th>
<th>Relevance to Freight Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Railinc Clear Path™ Railroad Operational Coordination Software</td>
<td>Domestic</td>
<td>This software helps railroads coordinate and plan the movement of trains through Chicago.</td>
</tr>
<tr>
<td>FHWA Railroad-Focused V2I Applications</td>
<td>Domestic</td>
<td>FHWA has explored a Rail Crossing Violation Warning V2I application that would predict and warn drivers of predicted and imminent rail crossing violations for vehicles, including trucks.</td>
</tr>
<tr>
<td>Siemens Integrated Truck Guidance</td>
<td>Domestic and International</td>
<td>This application combines logistics scheduling data with real-time regional traffic data to provide an accurate status of the flow of goods and traffic conditions around a freight terminal.</td>
</tr>
<tr>
<td>Trinium Transportation Management System</td>
<td>Domestic and International</td>
<td>This system allows freight companies to automate the entire intermodal trucking operation with modules geared towards dispatch and drayage optimization.</td>
</tr>
<tr>
<td>Traficon Traffic Video Detection</td>
<td>Domestic and International</td>
<td>This product processes CCTV camera footage to derive traffic data such as vehicle count, speed headway, and queue length and can generate alarms to help manage truck traffic when queue lengths reach a certain threshold.</td>
</tr>
<tr>
<td>Sensys Networks Queue Detection</td>
<td>Domestic and International</td>
<td>Queue detection technology can be used to identify freight bottlenecks, or estimate wait times at international border crossings or container terminal gates.</td>
</tr>
<tr>
<td>Maritime Container Terminal Automation</td>
<td>Domestic and International</td>
<td>Several maritime ports have adopted a combination of automated guided vehicles, automated stacking cranes (ASCs), bridge cranes, and rail-mounted</td>
</tr>
</tbody>
</table>
Domestic and International Intermodal Terminal Operations Programs and Technology | Domestic and/or International | Relevance to Freight Technology
---|---|---
Gantry cranes to increase container terminal capacity.

Automated Measurement of Real-Time Border Wait Times at United States–Canada Land Border Crossings | Domestic and International | A queue time detection system is currently operating at two international border crossings in the Niagara area and reports crossing wait times separately for cars and trucks.

4.7.2.1 GoPort Freight ITS at the Port of Oakland
In 2017, the FHWA awarded the Alameda CTC a $9.72 million grant to implement the GoPort Freight ITS project. The Port of Oakland is one of the top 10 busiest container ports in the U.S. and handles 99 percent of regional containerized goods in Northern California. The Port is a multimodal freight hub that includes marine terminals, rail facilities operated by UP and BNSF Railway, and a network of arterial roads for truck movement. The Port is facing significant operational problems, such as roadway queuing at the Port terminal gates, inefficient arterial traffic movement through intersections, recurrent traffic congestion, and illegal parking violations. In addition, the Port has limited systems to address incidents, such as overturned trucks that block approaches to container terminal gates. In response, the Alameda CTC and the Port of Oakland have developed the GoPort program to improve rail access and truck access and circulation within the Port. The program includes three infrastructure improvements and a suite of ITS projects. The program’s ATIS component is described in Section 4.2.2.4.

The infrastructure improvements include upgrades of roadways and intersections to improve access and minimize conflicts between different modes. The ITS component of the program includes the development of an ITS and Technology Master Plan to manage truck arrivals to the Port and to improve incident response. The GoPort program includes multiple partners and stakeholders including the City of Oakland, Caltrans, UP, BNSF Railway, San Francisco Bay Area Rapid Transit, MTC, and several utility entities.

Based on the ITS and Technology Master Plan and Concept of Operations, the Alameda CTC and the Port of Oakland identified a comprehensive freight transportation technology and congestion management concept called the GoPort Freight ITS. The key components of the initial phase of implementation include the following:

---

• **GoPort TMC**, which includes the expansion of the Port’s Emergency Operations Center (EOC) to include TMC capability enabled by the deployment of technology at key freight arterials and connecting freeways, including the Primary Highway Freight System (PHFS) roadways on the National Highway Freight Network in Alameda County. Technology deployments include CCTV, communication systems including Wi-Fi, queue detection systems, adaptive traffic signal systems, DMSs, RFID readers, smart parking, and WIM scales. The TMC/EOC will also include the integration of existing databases and the application of advanced analytics to share freight specific information on the existing eModal platform, and regionally with Caltrans District 4 and MTC’s 511 traveler information system.

• **GoPort Freight ITS Information System**, which includes providing a platform to share both real-time and historical data on congestion levels, truck access, major travel routes, incidents, terminal queues, parking conditions, rail crossing information, ship arrival, and container availability. This includes the integration with the TMC and the development of an application and a web portal for users such as truck drivers and dispatchers, maritime port operators, and marine and rail operators to access the information.

4.7.2.2  **Port Authority of New York and New Jersey Truck Management System**

In 2017, the Port Authority of New York and New Jersey (PANYNJ) implemented a Truck Management System (TMS) at the Global Container Terminal Bayonne (GCT-B). The system allows truck drivers to make an appointment for container pick up or delivery at GCT-B during a specified time. Drivers are allowed to enter when their reservation is validated via a read of the truck’s RFID tag or license plate. This system is new to maritime ports where truckers arrive at random and are received on a first-come, first-serve basis. The TMS helps minimize truck dwelling time and improves efficiency for both the terminal and drayage trucks. The system accommodates trucker turn-times of 45 minutes on average for single transaction (pick-up or delivery) and 60 minutes for dual transactions (pick-up and delivery).

4.7.2.3  **Port Authority of New York and New Jersey Terminal Information Portal System**

The PANYNJ launched a Terminal Information Portal System (TIPS) in 2015, which is a web portal consolidating information regarding all six container terminals in the Port of New York and New Jersey. TIPS provides the following information in real-time:

• **Port and Terminal Information**: Blocks of news from the Port Authority, as well as each container terminal operator, are posted on the TIPS home page. At a glance, users are

---

69 The PHFS is a network of highways identified as the most critical highway portions of the U.S. freight transportation system. The National Highway Freight Network includes the following subsystems of roadways: PHFS, other interstate portions not on the PHFS, Critical Rural Freight Corridors, and Critical Urban Freight Corridors.

70 [https://www.panynj.gov/port/port-newsletter.html](https://www.panynj.gov/port/port-newsletter.html).

able to read announcements pertaining to early or late closures, traffic conditions, and weather-related measures for each of the six container terminals.

- **Import Container Availability:** By entering a container number, users can view the container's current location, availability for pickup, and any applicable holds, as well as the Federal agency applying those holds. Status of freight charges and demurrage\(^72\) are also visible, as well as expiration of free time (before demurrage applies), if applicable.

- **Export Booking Inquiries:** TIPS associates each booking number with a quantity of empty containers. Users may use the platform to see how many containers are booked for a shipment, how many empties and loads have been received, and how many are still outstanding, as well as information about when the containers can be returned.

- **Vessel Schedules:** Users can review vessel schedules for each of the six terminals.

- **Empty Container Information:** Users can view information about when and where empty containers can be returned.

In addition, users can create “watch lists” to receive notifications on the status of their containers and bookings. Once the status is known, users can use the PANYNJ TMS to book an appointment for pick up and/or delivery.

4.7.2.4 **Railinc Clear Path™ Railroad Operational Coordination Software**

In Chicago, a major hub for rail freight requiring rail-to-rail and intermodal transfers, the American Association of Railroads (AAR) has worked with private sector software developers and Class I railroads to implement Clear Path™. Clear Path™, developed by Railinc, helps railroads coordinate and plan the movement of trains through Chicago and enables the exchange of timely, accurate, and actionable information. Coordination between Class I railroads is typically a challenge and Clear Path was specifically cited as a potential regional solution in the Metroplex Freight Mobility Study.\(^73\)

4.7.2.5 **FHWA Railroad-Focused V2I Applications**

FHWA has explored a Rail Crossing Violation Warning (RCVW) application project that provides real-time condition-based audible and visual alerting to vehicle operators to predict and warn drivers of predicted and imminent rail crossing violations for vehicles, including trucks, approaching or stopped within active highway-rail at-grade crossings, respectively.\(^74\)

As part of the project, researchers developed a system concept, architecture, and design. Demonstrated in Exhibit 48, the RCVW would work at active highway-rail at-grade crossings with an approaching train. Warnings issued by CV roadside units would be communicated to approaching CVs and rail operators when a train and CV are detected as approaching or

---

\(^72\) A charge applied to shipments left in a terminal after the allotted free time.


present, creating a potential conflict. Non-CV-equipped vehicles would continue to rely on flashing beacons and the lowering of automatic gates to indicate that a train is approaching the intersection.

Exhibit 48: RCVW Application Concept

4.7.2.6 Siemens Integrated Truck Guidance
Siemens developed an Integrated Truck Guidance application to optimize and harmonize the operations of freight terminals, such as maritime ports, airports and freight distribution centers. This application combines logistics scheduling data with real-time regional traffic data to provide an accurate status of the flow of goods and traffic conditions around a terminal. This information is shared with truck drivers, terminal operators, and logistics providers, providing a transparent communication platform that helps eliminate bottlenecks and increase the efficiency at terminals. Siemens is working with the Port of Duisburg in Duisburg, Germany, on a pilot project to implement the truck guidance system at the Port.

Truck drivers use a smartphone to log into the Integrated Truck Guidance system. The system determines their position using GPS and retrieves real-time traffic data for their respective route and destination. Drivers and recipients including terminal operators and logistics providers are notified whether the scheduled and estimated arrival times match up. If they do, the system provides the driver with a route recommendation. If not, the driver is
routed to the next available loading area. If significant delays are expected, the application informs the driver about available parking spaces in the vicinity to wait until a loading area is available. All parties are informed throughout the process for more efficient handling of trucks at terminals.

4.7.2.7 **Trinium Transportation Management System**

Trinium Technologies is a provider of enterprise software for intermodal trucking and container drayage. Their flagship product is the Transportation Management System that enables companies to automate the entire intermodal trucking operation from order receipt to customer service to operation to billing and driver settlements. The Transportation Management System includes a Dispatch Module which helps rationalize the dispatch process and improve the driver-to-dispatcher ratio, in addition to various other specialized modules. The three main specialized modules related to dispatch/drayage optimization are described below:

- **Trinium MC2** is a web-based mobile application for truck drivers that is compatible with smart phones or tablets. It is integrated with the Trinium Dispatch Module and so dispatch instructions can be sent, received, acknowledged, and completed by the driver via the application. Through GPS tracking and electronic Proof of Delivery (POD), dispatchers are able to monitor drivers and orders more efficiently.

- **Trinium Availability Manager** is the container tracing module. It enables the Transportation Management System to interface with pier and rail web sites for tracking and tracing containers. When a container order is entered into the software, the track and trace process is completely automated, reducing the manual effort involved with managing notifications, calculating estimated time of arrivals, monitoring box availability, and monitoring the last free day over multiple web sites.

- **Trinium Event Management** provides automatic email alerts when the status of an order/dispatch changes and includes a set-up for reports and custom queries to be emailed automatically to dispatchers and/or customers.

The Transportation Management System software can interface directly with mileage software such as PC*Miler (discussed in Section 4.3.2.3), as well as with fuel management service providers and mobile communications platforms.

4.7.2.8 **Traficon Traffic Video Detection**

Traficon is a leading technology provider in the field of vehicle detection based on Video Image Processing (VIP). One of the products provided by Traficon is the VIP3D.1/VIP3D.2 vehicle presence and data detector. The detector accepts visual images as input from cameras already installed to monitor traffic and processes them to derive traffic data such as vehicle count, speed headway, and queue length. Data is in real-time and for specific detection zones, which could be customized. The Traficon detection system provides real-
time data on queuing and can generate alarms to help manage truck traffic when queue lengths reach a certain threshold.

4.7.2.9 Sensys Networks Queue Detection
Sensys Networks is a technology company providing traffic detection and integrated traffic data systems for traffic management purposes. FlexMag is one of its products that detects in real-time vehicle presence and movement via wireless magnetometer technology. It could be installed in-pavement much easier than loop detectors and being impervious to weather, unlike video and radar, it requires less maintenance. The sensors interact with wireless access points mounted nearby to aggregate traffic data such as speed, density and volume in real-time and send it to a central operations system. To detect queuing, the sensors could be installed at two or more points as shown in Exhibit 49, thus providing real-time data on the queuing length. This can be used to identify freight bottlenecks or estimate wait times at international border crossings or container terminal gates.

Exhibit 49: Sensys Networks Queue Detection System


4.7.2.10 Maritime Container Terminal Automation
As maritime ports continue to grow, there has been an increased interest in automation within the maritime terminals. In 2018, the global semi- and fully-automated container
terminal market was worth about $9.09 billion, and is expected to increase to $10.89 billion in 2023. Many maritime terminals have recognized the benefits of workforce reduction in an automated environment and are looking to move toward some degree of automation.

Two maritime ports in Asia have adopted these types of systems. The Port of Qingdao is Asia’s first fully automated terminal. It began operation in 2017 with an average loading efficiency of 26.1 containers per crane hour, but has increased to 33.1 containers per crane hour, which is 50 percent higher than the average (around 22 per hour) worldwide for container movement. Investment in automation has reduced the number of workers needed to unload a shipment from 60 to nine. Also in Asia, the Port of Shanghai is the world’s largest fully automated maritime port and the busiest. The Port is envisioned to be operated by 130 automated guided vehicles (AGV), 26 bridge cranes, and 120 rail-mounted gantry cranes when fully complete, with a goal of having a significantly smaller workforce.

Similar systems have been pursued in Europe. In Holland, the Port of Rotterdam Massvlakte II facility is one of the world’s most technologically advanced and environmentally sustainable container terminals. Container movement within this facility is controlled remotely by battery-powered, automated guided vehicles. These vehicles can carry up to two containers at a time from quayside to container yard. The facility itself is powered by wind turbines, running entirely on wind-generated electricity.

The type of full automation that is in use today at Long Beach Container Terminal’s (LBCT’s) Middle Harbor facility, and at the TraPac terminal in Los Angeles, is patterned after the ECT Delta terminal in Rotterdam, which opened in 1993. Middle Harbor and TraPac operate the only fully automated terminals in North America. The operation is based upon the use of AGVs and automated stacking cranes (ASCs).

4.7.2.11 Automated Measurement of Real-Time Border Wait Times at U.S.–Canada Land Border Crossings

As discussed in Section 4.2.2.7, the efficiency of international border crossings is improved by reliable queue time detection systems. These systems measure truck queue length and wait times at controlled access points. Systems can be comprised of sensors (e.g. RFID,

---


77 The area around a concrete, stone, or metal platform lying alongside or projecting into water for loading and unloading ships.

Bluetooth, license plate readers) positioned at key points approaching the controlled access points. A queue time detection system is currently operating at two international border crossings in the Niagara area and reports crossing wait times separately for cars and trucks.

5.0 Summary and Conclusion

5.1 Texas Freight Transportation Needs

In the development of a supportive state of the practice report, it is critical to understand how freight technologies can support the Texas freight community’s needs. The 2018 TFMP provided detailed analyses and insight into the needs, including the following top 10 freight transportation needs:

1. **System Capacity**: Issues related to system capacity include rail capacity constraints, congestion and bottlenecks on key freight corridors, exploring alternative parallel corridors/redundancy, and improving merging lanes at interstate interchanges.

2. **System Operations**: Efficient system operations require investing in transportation infrastructure, developing comprehensive incident management systems, addressing OS/OW/over-dimensional trucks, and updating and maintaining aging infrastructure.

3. **Safety**: Addressing safety issues consists of adequate truck parking, including overnight/rest stops; reducing the number of highway-rail at-grade crossings; improving and updating roadway geometrics; addressing vertical clearance issues; and increasing education/awareness of the public about CMV needs.

4. **Multimodal Connectivity**: Identifying regional corridors, improving port-rail connections, and increasing the number of multimodal connection points will improve multimodal connectivity throughout the State.

5. **Rural Connectivity**: Improving north/south connectivity to the border, increasing rural access to the existing freight network, and improving rail availability and connectivity in rural areas will enhance rural connectivity.

6. **NAFTA\(^79\) and International Border Crossings**: Key issues that must be addressed for improved NAFTA and international border crossings include congestion at the international border, customs processing time, international border crossing staffing issues, and implementing cross-border technologies. Needs that also must be evaluated include improving the connection of U.S. interstates to Mexico’s infrastructure and determining the impact of Mexican infrastructure improvements on the U.S.

7. **Freight Asset Preservation and Operations**: Maintaining the existing THFN in good condition and modernization of the system are top priorities with TxDOT and freight stakeholders.

\(^79\) While the 2018 TFMP refers to NAFTA, as of July 2020, NAFTA has been replaced by the USMCA.
8. **Education/Public Awareness:** Communicating the importance of freight movement to the public, improving the public’s understanding of freight operational needs, expanding communication between the public- and private-sectors and clarifying their roles and responsibilities related to funding, and maintaining infrastructure are all crucial to educating the public.

9. **Funding/Financing:** Focusing on funding for high-priority multimodal freight corridors, balancing existing transportation funding needs between highway and other modes, and creating alternative measures (i.e., new revenue streams) for allocating funding are key to addressing funding/financing issues.

10. **Energy/Environmental:** Supporting and implementing policies and activities that reduce the cost of alternative fuels and understanding the impact of growing industry and freight tonnage on infrastructure are important energy/environmental issues that need to be reviewed.

Exhibit 50 summarizes the freight transportation needs and challenges identified by assessing existing conditions, projecting future needs based on forecasts of freight movement in 2045, and stakeholder input collected through the 2018 TFMP efforts. Most of these freight transportation needs require institutional, legislative, or capital improvements. Several of the freight transportation needs identified in the 2018 TFMP can be supported through the use of technology, including congestion, system operations, safety, and some of the international border crossing issues.

Technology and operations-related recommendations that were developed as part of the 2018 TFMP are shown in Exhibit 51. These provide more specific guidance to focus a review of relevant opportunities that can be drawn from the state of the practice review.
Exhibit 50: 2018 Texas Freight Mobility Plan: Texas Freight Transportation Needs and Challenges

Source: Texas Department of Transportation, Texas Freight Mobility Plan 2018—Executive Summary, March 7, 2018.
### Exhibit 51: 2018 Texas Freight Mobility Plan Technology and Operations Program

<table>
<thead>
<tr>
<th>Program: Technology and Operations</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop and implement a statewide Freight Technology-Based Solutions Program focused on enhancing freight transportation system management and operations, and asset management by improving safety, increasing freight mobility for people and freight through deployment of Intelligent Transportation Systems (ITS). This program will comprise of:</td>
<td></td>
</tr>
<tr>
<td>- Develop a Statewide Traffic Management Center Concept of Operations and implementation Plan that integrates existing regional Traffic Management Centers across the State to facilitate dissemination of real-time traffic information including traffic incidents, construction, weather, and special events, etc.</td>
<td>High</td>
</tr>
<tr>
<td>- Develop a Statewide Commercial Vehicle Traffic Incident Management Program to address commercial vehicle crashes and improve safety and mobility for the motoring public and trucks.</td>
<td>High</td>
</tr>
<tr>
<td>- Convene a Statewide Traffic Incident Management Taskforce comprised on law enforcement, fire department, emergency medical services, towing and recovery, local agencies, and TxDOT to comprehensively address commercial vehicle incidents on the freight network.</td>
<td>Medium</td>
</tr>
<tr>
<td>- Expand the deployment of sophisticated real-time traveler information technologies to mitigate congestion, improve safety and facilitate freight flows.</td>
<td>Medium</td>
</tr>
<tr>
<td>- Develop and implement a Highway Freight Network Operations and Management Plan that outlines a comprehensive strategy for better operating and managing the existing highway infrastructure to maximize existing capacity of the Freight Network.</td>
<td>Medium</td>
</tr>
<tr>
<td>- Develop freight movement signal timing/coordination improvements to provide a cost effective strategy to reducing congestion problems, provide for fuel savings, and reducing travel times.</td>
<td>Medium</td>
</tr>
<tr>
<td>- Adopt, expand and deploy ITS technologies to improve mobility and safety for both passenger and freight.</td>
<td>High</td>
</tr>
<tr>
<td>- Expand Weigh-In Motion (WIM) program to major freight gateways, generators, and corridors.</td>
<td>Medium</td>
</tr>
<tr>
<td>- Form partnerships with the auto industry, telematics (such as GPS providers and telecommunications companies), academic institutions, research and development organizations, USDOT and other the public sector road authorities to foster innovative freight transportation technology solutions.</td>
<td>Medium</td>
</tr>
</tbody>
</table>

5.2 Freight-Related Groups, Policies, and Initiatives in Texas

The existing programs in Texas with a freight technology component covered in Section 3.0, are summarized in Exhibit 52. These programs cover a comprehensive set of freight transportation areas. Programs exist for all the major freight modes, establishing forums for feedback from all private sector freight stakeholders. Programs are in place that focus on research, implementation, and maintenance – ensuring that innovative technologies are not only tested and confirmed to address existing freight needs before widespread implementation, but also that funding will be secured for long-term operations and maintenance.

Texas has continued to stay on top of emerging freight transportation trends in a proactive manner, which is apparent through the recent formation of the CAV Task Force. With so many programs taking place simultaneously sometimes covering overlapping freight topics or issues, it is critical that these programs keep open lines of communication so that resources will not be wasted on redundant efforts across programs. Achieving improvements in overall system performance is especially important to support the anticipated growth of freight cargo across all modes by 2045.

Exhibit 52: Summary of Freight-Related Groups, Policies, and Initiatives in Texas

<table>
<thead>
<tr>
<th>Freight-Related Groups, Policies, and Initiatives in Texas</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TxDOT Divisions</td>
<td></td>
</tr>
<tr>
<td>Information Technology Division</td>
<td>Responsible for establishing and maintaining the information technology (IT) architecture that serves freight-related ITS initiatives, including the warehousing of freight-related data.</td>
</tr>
<tr>
<td>Maritime Division</td>
<td>Responsible for streamlining intermodal operations between ships and other forms of transportation that link to maritime ports, such as rail and trucking infrastructure. This Division also plays a large role in developing the Texas Port Capital Program, which provides an avenue for introducing advanced technology into the freight supply chain.</td>
</tr>
<tr>
<td>Rail Division</td>
<td>Responsible for managing the State’s railroad signal preemption systems, improving safety at highway-rail at-grade crossings, and the development of the Texas Rail Plan.</td>
</tr>
<tr>
<td>Freight-Related Groups, Policies, and Initiatives in Texas</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Research and Technology Implementation Division</td>
<td>Responsible for the facilitation of research initiatives that help transform technological solutions from concept to construction—through both public-sector and private sector pursuits—including the implementation of freight-related technology projects.</td>
</tr>
<tr>
<td>Strategic Planning Division</td>
<td>Responsible for developing planning and implementation strategies for new and innovative transportation infrastructure, as well as the TxDOT Strategic Plan.</td>
</tr>
<tr>
<td>Traffic Safety Division</td>
<td>Responsible for ensuring highway ITS applications are safe and consistent with national and Texas standards, developing traffic safety initiatives, and collecting and analyzing Texas crash data. This Division of TxDOT is interested in any technological improvements that may increase the safety of freight transportation, and is responsible for the TSMO Strategic Plan, as well as the CAT Plan.</td>
</tr>
<tr>
<td>Transportation Planning and Programming Division</td>
<td>The Freight Planning Branch of this Division supports TxDOT’s comprehensive and multimodal freight planning program and develops the Texas Freight Mobility Plan (TFMP).</td>
</tr>
<tr>
<td>Travel Information Division</td>
<td>Responsible for providing travel information to and within the State. This Division manages the public-facing information channel for highway conditions on Texas roads, including road closures, traffic incidents, and congestion.</td>
</tr>
<tr>
<td>Bridge Division</td>
<td>Responsible for prioritizing bridge projects statewide, maintaining the Bridge Inspection Database, and managing several bridge strike and overheight vehicle detection systems deployed across the State.</td>
</tr>
<tr>
<td>Aviation Division</td>
<td>Responsible for administering the TxDOT Unmanned Aircraft Systems (UAS) Program, which is used to ensure that all UAV activities are conducted in compliance with all statutory requirements.</td>
</tr>
<tr>
<td>Freight-Related Groups, Policies, and Initiatives in Texas</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td><strong>TxDOT Advisory Committees</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Texas Freight Advisory Committee</strong></td>
<td>Advises TxDOT on freight issues, priorities, projects, and funding needs for freight improvements. The Committee elevates freight transportation as a critical component of the State’s economic vitality and competitiveness. Responsible Division: Transportation Planning and Programming.</td>
</tr>
<tr>
<td><strong>Port Authority Advisory Committee</strong></td>
<td>Provides a broad perspective on maritime ports and transportation-related matters for TxDOT policies concerning the Texas maritime port and ship channel systems. The Committee also prioritizes projects for any state funding and identifies landside connectivity needs. Responsible Division: Maritime Division.</td>
</tr>
<tr>
<td><strong>Border Trade Advisory Committee</strong></td>
<td>Advises TxDOT in defining and developing a strategy and makes recommendations to the Texas Transportation Commission and the Governor for addressing the highest priority international border trade transportation challenges. Responsible Division: Transportation Planning and Programming Division.</td>
</tr>
<tr>
<td><strong>Aviation Advisory Committee</strong></td>
<td>Provides input to TxDOT on aviation development programs and serves as its representative among aviation users. Committee members work with members of the Texas Legislature on various aviation issues. Responsible Division: Aviation Division.</td>
</tr>
</tbody>
</table>

**Texas Programs and Initiatives**

| **Statewide TSMO Program**                                | The adoption of this TSMO Program aims to shift the culture and function of an agency to institutionalize system-wide management and operations through all business functions and the project development process. It accomplishes this by recognizing traffic management systems as a core priority and through dedicated programs and funding. This opens doors to apply innovative freight technologies to improve freight operations, which are relatively low in cost compared to adding capacity, can be implemented in less time, and potentially offer higher benefit-cost ratios. Responsible Division: Traffic Safety Division. |

147
<table>
<thead>
<tr>
<th>Freight-Related Groups, Policies, and Initiatives in Texas</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Statewide ITS Strategic Plan</strong></td>
<td>The objective of the Plan is to provide a framework to guide the development and deployment of an integrated statewide program for ITS. The ITS Strategic Plan identifies the need for TxDOT to invest in and deploy ITS systems and technologies to facilitate the movement of freight along strategic, high-volume freight corridors, including international border crossings. The Plan was developed as part of a project overseen by TxDOT’s Research and Technology Implementation Office and its implementation is the responsibility of several Divisions, most notably the Traffic Safety Division.</td>
</tr>
<tr>
<td><strong>Emerging Transportation Technology Plan</strong></td>
<td>The objective of the Plan is to provide a framework for addressing emerging transportation technology and develop implementation strategies to integrate technologies such as Connected and Automated Transportation (CAT), Unmanned Aerial Systems (UAS), Mobility as a Service (MaaS), emerging freight technologies and other transformative technologies into State planning practices. Responsible Division: Strategic Planning Division.</td>
</tr>
<tr>
<td><strong>CAV Task Force</strong></td>
<td>Provides one-stop resource for information and coordination on all ongoing CAV projects, investments and initiatives in Texas. In addition to documenting public and private entity efforts and facilitating partnerships, the CAV Task Force hosts industry forums and report lessons learned to facilitate progress and encourage greater collaboration. Responsible Division: Strategic Planning Division.</td>
</tr>
<tr>
<td><strong>CAT Program</strong></td>
<td>The objectives of this Program are to promote and support the creation of a culture of innovation and proactive integration of CATs into planning, design, construction, maintenance and operations of transportation infrastructure. This Program is important because it supports the continued expansion of CAV demonstrations (e.g., truck platooning applications, automated truck delivery systems, automated rail/unmanned aircraft system/ship technologies for freight) along freight corridors. Responsible Division: Traffic Safety Division.</td>
</tr>
<tr>
<td>Freight-Related Groups, Policies, and Initiatives in Texas</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>I-10 Corridor Coalition</td>
<td>The general purpose of the Coalition is to oversee coordinated operations and development of the I-10 corridor through California, Arizona, New Mexico, and Texas, reducing the need for separate groups within each of the member states. The I-10 Corridor Coalition developed a Concept of Operations document that laid the groundwork by identifying possible options and technology improvements that could ease goods movement in the I-10 corridor. The I-10 Corridor Coalition is important because it can fund specific projects along the corridor to test freight technologies of interest. Responsible Division: Transportation Planning and Programming Division.</td>
</tr>
<tr>
<td>TCFC Project</td>
<td>This project will deploy CV technology to trucks in the Texas Triangle Region (Austin, DFW, Houston, and San Antonio). The motivation for this deployment is to boost economic efficiency, increase safety of trucks, and promote the use of emerging technologies. Responsible Division: Traffic Safety Division.</td>
</tr>
<tr>
<td>Enterprise Information Management Program</td>
<td>To advance TxDOT’s data strategic needs, ITD has developed the Enterprise Information Management Program. It builds on efforts to implement a centralized data architecture that will collect TxDOT’s various data sources and transform them into clean, secure, and authoritative data. Responsible Division: Information Technology Division.</td>
</tr>
<tr>
<td>TTTF</td>
<td>TTTF is made up of a team of professionals from public agencies, private sector industry, and research institutions all working in areas related to transportation technology, including freight. One of its main responsibilities includes producing white papers highlighting various technologies to make each technology more understandable for other entities of the transportation sector. The TTTF is one of the first places a new technology can be “discovered” and communicated to other Divisions of TxDOT. Responsible Division: Strategic Planning Division.</td>
</tr>
<tr>
<td>TIA</td>
<td>The TIA is a group of public agencies and research institutions that aims to create a “platform for innovation.”</td>
</tr>
</tbody>
</table>

149
<table>
<thead>
<tr>
<th>Freight-Related Groups, Policies, and Initiatives in Texas</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas STIC</td>
<td>Its aim is to encourage people to think of new ideas and solutions to transportation and mobility issues. This Alliance is critical to the promotion of freight technology, as it can be used as a launchpad for freight technology innovations that may be specifically tailored to suit the transportation needs of Texas. Responsible Division: Strategic Planning Division.</td>
</tr>
<tr>
<td>ITS-Texas</td>
<td>The Texas STIC implements technology that has already been proven successful in real-world situations and provides a means for communication among different stakeholders to discuss innovative solutions. In terms of freight technology, the STIC is important to Texas because it can align a pro-technology lobbying platform with the freight technologies that are up for consideration. Responsible Division: Strategic Planning Division.</td>
</tr>
<tr>
<td>TxDOT Partner Agencies</td>
<td>ITSTexas is an advocacy group for advanced technology transportation solutions, including improved freight technology.</td>
</tr>
</tbody>
</table>

### TxDOT Partner Agencies

<table>
<thead>
<tr>
<th>TxDPS</th>
<th>TxDPS goals include enhancing highway and public safety as well as statewide emergency management in Texas. The TxDPS Commercial Vehicle Enforcement Service checks the size, weight, and safety of CMVs operating in Texas. In addition to mobile roadside enforcement, TxDPS operates nearly 100 fixed commercial vehicle enforcement locations throughout the State.</th>
</tr>
</thead>
<tbody>
<tr>
<td>TxDMV</td>
<td>The TxDMV handles licensing and registration for CMVs. Motor carriers operating intrastate CMVs on a road or highway in Texas must get a TxDMV number. OS/OW CMV permit distribution is a major responsibility of TxDMV. The TxDMV also regulates international carriers through management of NAFTA(^\text{80}) permits.</td>
</tr>
</tbody>
</table>

80 While the Texas DMV website still refers to NAFTA permits, as of July 2020, NAFTA has been replaced by USMCA.

---

Governor’s Broadband Development Council                      | This Council is responsible for identifying barriers to and solutions for expanding broadband (high-speed internet)
<table>
<thead>
<tr>
<th>Freight-Related Groups, Policies, and Initiatives in Texas</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas State Energy Conservation Office</td>
<td>access to rural communities across the state of Texas, which will be necessary for freight technology innovations to reach across the State.</td>
</tr>
<tr>
<td>United States CBP</td>
<td>Their Alternative Fuels Program supports public fleets that deploy alternative fuel vehicles (AFVs) and build associated fueling infrastructure, which may be beneficial for advancing TxDOT's adoption rates of alternative fuel truck fleets.</td>
</tr>
<tr>
<td>USDOT</td>
<td>CBP's role is the safeguarding of America's borders to protect the public from dangerous people and materials. They manage the security of cross border freight movements at all POEs across multiple modes and utilize technologies to support credentialing, inspections, and traveler information.</td>
</tr>
<tr>
<td>Research Institutes</td>
<td>USDOT's role is providing federal funding for nationwide research initiatives and deployment of innovative freight technology-related projects through various grant programs such as ATCMTD through the Federal Highway Administration (FHWA) and the Consolidated Rail Infrastructure and Safety Improvements (CRISI) Program through the Federal Railroad Administration (FRA).</td>
</tr>
<tr>
<td>TTI</td>
<td>TTI is a part of the Texas A&amp;M University System that focuses primarily on research and testing of transportation solutions in many different focus areas including freight, connected transportation, and planning and operations.</td>
</tr>
<tr>
<td>University of Texas at Austin CTR</td>
<td>CTR is a part of the University of Texas at Austin that combines research in the transportation field with educational opportunities for students. Its three research arms are the Data-Supported Transportation Operations and Planning Center, Network Modeling Center, and Texas Pavement Preservation Center.</td>
</tr>
<tr>
<td>SwRI</td>
<td>SwRI is a private, non-profit research group that focuses on research needs in transportation, electronics, defense, biomedical, energy, and other areas. Within intelligent systems research, SwRI does work on advanced traffic</td>
</tr>
<tr>
<td>Freight-Related Groups, Policies, and Initiatives in Texas</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td></td>
<td>management systems, fully autonomous vehicles, connected vehicles (CVs), and intelligent vehicles.</td>
</tr>
</tbody>
</table>

5.3 **Freight Technology Areas**

Exhibit 53 summarizes Texas’ strengths and weaknesses in each of the seven freight technology areas and highlights several lessons that can be learned from domestic and international practices. Overall, Texas has a vibrant freight community and a high level of technology in place to support it. Data sharing and the use of data to support real-time system management emerge as opportunities based on the limited number of data sharing programs that exist in Texas currently.
### Exhibit 53: Summary of Freight Technology Areas

<table>
<thead>
<tr>
<th>Freight Technology Area</th>
<th>Texas Strengths</th>
<th>Texas Weaknesses</th>
<th>Lessons Learned from Domestic and International Practices</th>
</tr>
</thead>
</table>
| Traffic Management      | • TMCs are operational in all the major urban areas in Texas  
                         • Texas has forward-thinking plans to utilize CV applications to improve freight mobility and safety  
                         • TxDOT has put significant effort into investigating freight strategies and technology areas | • TMCs do not share data with each other or agencies that are co-located within each TMC  
                         • Maritime ports and international border crossings do not contain TMC capabilities  
                         • ITS systems across the State are not standardized  
                         • The response plans recommended by Dallas' ICM system only addressed a static set of traffic conditions  
                         • Many rural regions in Texas do not have traffic and incident management systems | • Set up a collective platform to share real-time transportation data with other TMCs and agencies (e.g., TxDPS, TxDMV)  
                         • Design traffic and incident management platforms to be more dynamic and predictive |
| Advanced Traveler Information Systems | • Texas invests in pilot projects to test innovative freight technologies  
                         • Grant application efforts have been successful in securing federal funds for freight technology projects | • Traveler information tools are corridor or region-specific  
                         • Some traveler information platforms are not available on mobile devices (e.g., DriveTexas) | • Leverage agency data/information to encourage two-way information sharing for enhanced freight traveler information  
                         • Implement truck parking information systems along the |
<table>
<thead>
<tr>
<th>Freight Technology Area</th>
<th>Texas Strengths</th>
<th>Texas Weaknesses</th>
<th>Lessons Learned from Domestic and International Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Multistate coalitions have been formed to solve common freight issues</td>
<td>• Separate systems are used by TxDOT Divisions for reporting planned and unplanned closures</td>
<td>most important Texas freight corridors first</td>
</tr>
<tr>
<td></td>
<td>• Separate systems are used by TxDOT Divisions for reporting planned and unplanned closures</td>
<td>• Lack of freight-specific traveler information currently available (especially from maritime ports and railroads)</td>
<td>• Use ITS to automate measurement of freight traveler information (e.g., real-time international border wait times)</td>
</tr>
<tr>
<td>Dynamic Route Guidance</td>
<td>• The Texas Connected Freight Corridors Project proposes a CV application to help provide higher quality advanced traveler information that includes alternate route information and eco-dynamic freight routing</td>
<td>• There is a deficiency of alternate route options in Texas (especially in rural areas)</td>
<td>• The majority of available dynamic route guidance applications are private sector commercial products</td>
</tr>
<tr>
<td></td>
<td>• There is a deficiency of alternate route options in Texas (especially in rural areas)</td>
<td>• Static or dynamic route guidance is currently not available from Texas transportation agencies</td>
<td>• TxDOT needs to determine whether there is any value added in internally developing a product for freight-specific needs in Texas</td>
</tr>
<tr>
<td>Data Integration and Analytics</td>
<td>• TxDOT has a “collect data once, share with all that need it” data strategy</td>
<td>• Data is currently spread across disparate sources, in non-standardized formats and often inaccessible via application programming interfaces (API)</td>
<td>• Provide an open data portal for private partners to use for information dissemination and application development</td>
</tr>
<tr>
<td></td>
<td>• TxDOT is exploring the applicability of new data sources and data</td>
<td>• Lack of two-way communication/information sharing</td>
<td>• Develop a web-based performance monitoring and measurement system that is accessible by multiple agencies and the public</td>
</tr>
<tr>
<td>Freight Technology Area</td>
<td>Texas Strengths</td>
<td>Texas Weaknesses</td>
<td>Lessons Learned from Domestic and International Practices</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Enforcement and Inspection</td>
<td><strong>processing methods to improve traffic operations (e.g., crowdsourced data, AI)</strong></td>
<td><strong>There is inadequate data that has been aggregated for planning and effective decision-making</strong></td>
<td><strong>Develop standardized guidelines on how data should be collected, processed and reported</strong></td>
</tr>
</tbody>
</table>
| Connected and Automated Freight Vehicles| **Texas is Core Compliant in the Innovative Technology Deployment Program (safety information exchange, electronic credential administration, and electronic screening)**  
**Wide network of TxDPS inspection locations**  
**Texas passed legislation to promote development and testing of CAVs**  
**CAVs are a major focus area of several Texas technology programs** | **OS/OW permit cancellations are not well communicated to truck drivers**  
**Permit distribution is the responsibility of TxDMV while route permissions are handled by TxDOT Districts**  
**There are too few WIM and VC stations statewide to fully monitor freight routes in Texas**                                                                                     | **Use ITS (e.g., DriveWyze) to automate data sharing and streamline truck inspection processes.**  
**Reduce the number of roadside inspections by sharing data between operations personnel and drivers beyond what is required in the Innovative Technology Deployment Program (e.g., brake status, weight, tire status)**  
**Deploy more WIM and VC equipment to identify corridors with heavy use from overweight trucks**                                                                                      | **Test vehicular communications between trucks from different manufacturers**  
**Explore applications of CAVs to improve freight operations at maritime port facilities**                                                                                           |
<table>
<thead>
<tr>
<th>Freight Technology Area</th>
<th>Texas Strengths</th>
<th>Texas Weaknesses</th>
<th>Lessons Learned from Domestic and International Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermodal Terminal Operations</td>
<td>• Multiple projects to improve intermodal terminal operations have been proposed&lt;br&gt;• Texas is home to many intermodal facilities of all types and modes across different geographies</td>
<td>• Lack of coordination with private industry on the direction of private sector investments</td>
<td>• Consider adding TMC capabilities to maritime ports and international border crossing locations&lt;br&gt;• Implement an appointment system at all maritime port container terminals&lt;br&gt;• Create a platform for freight-specific traveler information, or integrate with existing platforms</td>
</tr>
<tr>
<td></td>
<td>• The Texas Connected Freight Corridors (TCFC) Project covering the Texas Triangle is already in the works&lt;br&gt;• Multiple pilot tests of AVs and trucks are currently underway in Texas (e.g., TuSimple and Ford)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


5.4  **Key Opportunities for Texas**

TxDOT’s adoption of their TSMO Program opens doors for TxDOT Divisions and Districts to apply innovative freight technologies to improve freight operations, which are relatively low in cost compared to adding capacity, can be implemented in less time, and potentially offer higher benefit-cost ratios. As the workforce changes and potential labor shortages threaten the efficiency of goods movement, Texas will need to consider increasing the use of freight technology to maximize the productivity of the TMFN.

For the FNTOP, the Project Team has conducted stakeholder outreach, which included almost 60 interviews with public and private stakeholders in Texas and across the U.S. Through feedback collected during stakeholder engagement meetings and subsequent research conducted as part of this State of the Practice Assessment, several key opportunities to improve freight operations through ITS infrastructure and technologies have been identified. These opportunities may cover several freight technology areas.

- **TCFC Integration:** While the grant application scope of the TCFC Project includes 12 CV technology applications for trucks in the Texas Triangle Region (cornered by DFW to the north, Austin and San Antonio to the southwest, and Houston to the southeast), the greater Texas vision is to create a sustainable CV environment in that region to support V2V and V2I safety and mobility applications. The TCFC will continue to evolve and TxDOT should look for integration opportunities in proposed projects to improve Texas’ connected infrastructure and build up an ecosystem to support freight technology and operations as TCFC turns into a TxDOT-branded program.

- **Decision-Support Systems and Predictive Analytics:** The wealth of data currently being generated by existing ITS devices and collected by TxDOT TMCs can be used to develop decision-support systems that forecast traffic conditions and support proactive traffic management on freight corridors.

- **Binational ITS Coordination:** TxDOT’s ITS programs cannot be confined within its borders since Texas and Mexico share 1,254 miles of common border and are joined by 28 international bridges and border crossings. The international border crossings are vital to the economies of Texas and Mexico, and have contributed to Mexico’s status as Texas’ primary trading partner. International border crossing strategies, such as multi-jurisdictional data sharing, estimated border crossing wait times, and streamlined CMV inspection processes may help alleviate freight bottlenecks at the Texas-Mexico border.

- **Open Data Portal:** A common underlying theme seen across the Texas freight transportation system is that available data are being stored in silos. Even Divisions within the TxDOT Central Office use different data archival systems, procedures, and data formats. This complicates the data exchange and communication between the

---

TxDOT Central Office, TxDPS, TxDMV, and the TxDOT Districts, with some relying on manual data sharing practices. An open data portal with standardized data collection, processing, and reporting procedures would be beneficial to improving data sharing and traffic safety and management on a statewide, regional, and local basis. It may introduce opportunities to save costs (e.g., avoid multiple vehicle probe data procurements for data needed across TxDOT Districts and streamline data processing time). In addition, providing real-time data feeds through trusted API connectivity to an Open Data Portal would enable public and private sector application developers to use the data in applications that would benefit the Texas freight community. For example, if field units were reporting a substantial increase in traffic—especially heavy freight traffic—in a certain part of the State, a centralized processing system could evaluate and determine if certain response plans were necessary, such as increased green time on signalized freight corridors (if deployed). This data could potentially support machine learning algorithms for identifying best routes, congestion hotspots, or incidents.

- **Enhanced Freight Traveler Information**: Lack of traveler information was the most frequently mentioned challenge from stakeholder interviews. Currently, TxDOT shares very little freight-specific traveler information with the Texas freight community and receives almost no data from the freight community. This causes a multitude of freight network operational inefficiencies, including a deficiency of wait time information to get through POEs, lack of route guidance system-recommended routes that are designed for CMVs, lack of truck parking availability information, unknown work zone activities that result in road closures, and inefficient route selections when OS/OW permits are cancelled due to construction or maintenance projects. By first establishing an Open Data Portal, TxDOT can leverage the consolidated platform of freight data to provide enhanced freight traveler information to the freight transportation community.

- **Integration with Private Sector Services**: The private sector has developed and continues to enhance logistics-related services for the freight transportation community, such as truck navigation systems, weigh station bypass systems, and TMSs to optimize operations. Instead of developing tools for the freight transportation community from scratch, TxDOT can partner with private sector companies as a public sector data provider. For example, Drivewyze could work with TxDOT to ingest their Work Zone Data Exchange feed, which would improve the reliability of work zone notifications for truck drivers on Drivewyze’s PreClear platform, which is already used by over two million trucks nationwide.

- **Partnerships with Private Sector Companies**: Texas’s friendly CAV regulatory environment and position as a logistics and transportation hub with the most total miles of interstate routes in the nation makes the State an attractive destination for CAV companies to set up automated freight operations and testing. Partnering with private sector companies such as these creates opportunities for TxDOT to collect new sources of freight data (e.g., Electronic Logging Devices or AV operational performance reports) that can be used to
evaluate the effectiveness of emerging freight technologies as well as apply connected data to new freight applications.

- **Multi-State/Multi-Jurisdictional Standards Development:** Long-haul truck trips can span multiple states or countries and may require multi-state/multi-jurisdictional ITS solutions in order to improve freight mobility and safety on the highway network. European countries and multi-state coalitions in the U.S. have set good examples with initiatives highlighting the importance of standards development and interoperability to facilitate adoption of various freight-related ITS technology (e.g., DATEX2 in Europe, MAASTO Regional TPIMS, ENSEMBLE Consortium, etc.).

### 5.5 Next Steps

As made evident by the technology programs listed in Section 3.0 and the Texas technology developments highlighted in Section 4.0, there are many initiatives taking place concurrently to improve freight operations in Texas. As a next step, the FNTOP Project Team will develop an inventory of existing technology applications on the TMFN by reviewing relevant planning documents, operational manuals, and ITS asset management data, and compiling and mapping state and partner data on existing ITS and related technology infrastructure. This will include summarizing operational and management processes related to state and partner use of the technology infrastructure. The FNTOP Project Team will also assess how the technologies impact the performance on the TMFN in terms of safety, operations, mobility, and economic impact. The continued stakeholder outreach efforts by the FNTOP Project Team will inform the development of technology-based strategies for TxDOT to pursue to improve the safety and mobility of freight transportation in Texas.
6.0 References

- Texas Department of Transportation, Texas Freight Mobility Plan 2018, March 7, 2018
- TxDOT Highway Bridge Program: https://www.txdot.gov/inside-txdot/division/bridge/programs.html
- TxDOT Aviation: https://www.txdot.gov/inside-txdot/division/aviation.html
- Texas Freight and International Trade, Texas-Mexico Border Transportation Master Plan: http://www.movetexasfreight.com/

Technology Programs in Texas

- The Texas Tribune, New law clears the way for driverless cars on Texas roads: https://www.texastribune.org/2017/06/15/lawmakers-clear-way-driverless-cars-texas-roads-and-highways/
- FHWA, Capability Maturity Frameworks Overview: https://ops.fhwa.dot.gov/tsmoframeworktool/cmf_overview.htm
• ITD Freight Technology Plan Presentation, 2018.
• ITD Efforts that Support Connected and Automated Vehicles (CAV), April 2019.
• Strategic Usage of Crowdsourced Data—Update for the Executive Steering Committee, April 2019.
• TxDOT Intelligent Transportation Systems website, http://its.txdot.gov/.
• Texas Innovation Alliance, 2019, http://txinnovationalliance.org/.
• Texas Innovation Alliance, Transportation and Municipal Infrastructure Committee, March 6, 2018: https://legistarweb-production.s3.amazonaws.com/uploads/attachment/pdf/156738/Presentation-_TX_Innovation_Alliance.pdf
• Texas A&M Transportation Institute, 2019, https://tti.tamu.edu/.
• University of Texas at Austin Center for Transportation Research, 2019, https://ctr.utexas.edu/.

• Southwest Research Institute, 2019, https://www.swri.org/.

• TxDOT, TxDOT Research Project, Assessment of Innovative and Automated Freight Systems and Development of Evaluation Tool – Phase III: https://library.ctr.utexas.edu/Presto/content/Detail.aspx?ctID=UmVzZWFyY2gtcA==&rID=NjEy&ssid=c2NyZWVuSURfMDExMDI=

• TxDOT, TxDOT Research Project, Evaluate Potential Impact of Truck Platooning on Texas Infrastructure: https://library.ctr.utexas.edu/Presto/content/Detail.aspx?ctID=M2UxNzg5YmEtYzMyZS00ZjBlLtWlLyODctYzljMzQ3ZmVmOWFl&rlID=NjEy&sslID=MQ%3D%3D&rrtc=VHJ1ZQ%3D%3D&bmdc=MQ==

Freight Technology Areas

Traffic Management


• I-75 Florida’s Regional Advanced Mobility Elements (FRAME), Advanced Transportation Congestion Management Technologies Department, 2016 http://www.cflsmartroads.com/projects/design/future/I-75_Frame_Application.pdf.


• Europe Will Use Vehicle Tech to prevent Speeding, Save Thousands of Lives, 2019 https://usa.streetsblog.org/2019/03/05/europe-will-use-vehicle-tech-to-prevent-speeding-save-thousands-of-lives/.

• TRANSCOM—(https://data.xcmdata.org/DEWeb/Pages/aboutus.jsp).

• TRANSCOM, Regional Transportation Management Coordination During Hurricane Sandy: http://onlinepubs.trb.org/onlinepubs/conferences/2013/mpo/edelman.pdf.


• U.S.-Canada Border and Singapore-Malaysia Border. (https://library.ctr.utexas.edu/Presto/content/Detail.aspx?ctID=M2UxNzg5YmEtYzMyZS00ZjBILWlyODctYzljMzQ3ZmOWF1&rid=Mzk1&qrs=RmFsc2U=&ph=VHJ1ZQ==&bcktLo=L=VHJ1ZQ==&rrtc=RmFsc2U=).


Advanced Traveler Information System


- Houston TranStar Consortium https://www.houstontranstar.org/.
- MI Truck Parking Information and Management System https://www.michigan.gov/mdot/0,4616,7-151--336551--,00.html.
- MAASTO Regional Truck Parking Information Management System http://www.maasto.net/TPIMS.html.

• INRIX, Drivewyze Partners with INRIX to Expand State Highway Safety Programs into Connected Trucks: https://inrix.com/press-releases/drivewyze/

• Smart Ports—Hamburg/Rotterdam

• PortBase Port of Rotterdam

**Dynamic Route Guidance**


**Data Integration and Analytics**

• ITD Efforts that Support Connected and Automated Vehicles (CAV), April 2019.

• FHWA State of The Practice on Data Access, Sharing, and Integration, December 2016

• FHWA EDC-5 Workshop: https://ltap.enrollware.com/schedule.

• Denver Smart City, https://www.denvergov.org/content/denvergov/en/denver-smart-city/iot-platform.html.

• “How Denver uses data to quickly find multi-dimensional answers” article, 2018

• Florida Department of Transportation. Freight Operations Exchange (FOX) Regional Data Share presentation.
• “Opening Data Fully to Improve London’s Transport Network” article, 2018

• “TfL Hackathon Showed Data can keep Transport Running and People Safe” article, 2017
  https://www.theregister.co.uk/2017/09/18/tfl_hackathon_results/.

• DATEX. (https://datex2.eu/datex2/about).

  (https://library.ctr.utexas.edu/Presto/content/Detail.aspx?ctID=M2UxNzg5YmEtYzMyZS00ZjBjLWlyODctYzljMzQZmVmOWFl&rID=Mzk1&qrs=RmFsc2U=&ph=VHJ1ZQ==&bcktol=VHJ1ZQ==&rrtc=RmFsc2U=).

Enforcement and Inspection

• Texas Department of Public Safety

• Commercial Motor Vehicle Size and Weight Enforcement in Europe

• North Central Texas Council of Governments—Commercial Vehicle Enforcement

• Pre-clearance: Drivewyze Weigh Station By-Pass
  https://drivewyze.com/how-it-works/.

• Weigh-in-Motion

• Smart Roadside Initiative

• Overheight Detection

• Virtual Weigh Station

• European Commercial Vehicle Enforcement

• Drivewyze
  https://drivewyze.com/coverage-map/states/.

• Drivewyze Coverage Map: https://drivewyze.com/coverage-map/
• PrePass

• FMCSA Innovative Technology Deployment Program

• IRD Inc.

• Baltimore DOT Additional Automated Enforcement Locations:

• E-Seals: Uses, Standards and Providers:

**Connected and Automated Vehicles**

• Texas Connected Freight Corridors Project


• AllianceTexas Mobility Innovation Zone: https://www.alliancetexasmiz.com/

• TuSimple Website: https://www.tusimple.com/.

• Freightwaves, TuSimple launches ‘5g network’ for autonomous trucking: https://www.freightwaves.com/news/tusimple-to-build-5g-network-of-autonomous-trucking


• Dallas Innovates, Testing Ground: Why North Texas is a Growing Hub for Self-Driving Trucks: [https://dallasinnovates.com/testing-ground-why-north-texas-is-a-growing-hub-for-selfdriving-trucks/](https://dallasinnovates.com/testing-ground-why-north-texas-is-a-growing-hub-for-selfdriving-trucks/)


• Discover, NASA’s Air Traffic Control System for Drones Nearing Completion: [https://www.discovermagazine.com/technology/nasas-air-traffic-control-system-for-drones-nearing-completion](https://www.discovermagazine.com/technology/nasas-air-traffic-control-system-for-drones-nearing-completion)


• Autonomous Shuttle Pilot in Canyons Village, Utah (http://www.avshuttleutah.com).

• Uber Elevate. (https://www.uber.com/elevate.pdf/),

• Ohio UAS Center. (http://www.dot.state.oh.us/Divisions/Operations/Traffic-

• Louisiana’s Autonomous Truck rules Will Take Effect Aug. 1
(https://www.ttnews.com/articles/louisianas-autonomous-truck-rules-will-take-effect-
aug-1).

• DriveOhio (https://drive.ohio.gov/wps/portal/gov/driveohio/about-
driveohio/resources/register-for-autonomous-vehicle-testing).

• Automated Shuttle Bus Pilot Project
(http://www.dot.state.mn.us/automated/bus/index.html).

• European Truck Platooning Challenge

• Truck Platooning Pilot in Germany Deemed Runaway Success - May 10, 2019
https://www.truckinginfo.com/331644/platooning-pilot-in-germany-deemed-runaway-
success.

• Scania starts truck platooning trials in Spain and announces Chinese R&D partnership
https://www.traffictechnologytoday.com/news/autonomous-vehicles/scania-starts-

• Semi-automated truck convoys get green light for trials on British highways
https://www.scmp.com/news/world/europe/article/2108260/semi-automated-truck-
convoys-get-green-light-trials-british.

• Japan trials truck platooning
https://www.automotivelogistics.media/japan-trials-truck-platooning/20117.article.

• WA Initiative—New Australian partnership to focus on truck platooning
truck-platooning/.

• Chinese Port Trials Autonomous Tractor-Trailers
https://www.maritime-executive.com/article/chinese-port-trials-autonomous-tractor-
trailers.

• Autonomous semi-trucks have been driving along 1-10 for months and no one noticed,
2019, https://www.azmirror.com/2019/08/16/autonomous-semi-trucks-arizona-ups-
tusimple/.

• U.S. Postal Service Delivers Mail Using TuSimple’s Self-Driving Trucks, 2019,
https://www.forbes.com/sites/alanohnsman/2019/05/21/robo-truck-unicorn-tusimple-
hauling-mail-for-us-postal-service-in-paid-test-runs/#ffe434a35675.
• Peloton’s new automated vehicle system gives one driver control of two trucks, 2019 [https://techcrunch.com/2019/07/17/pelotons-new-automated-vehicle-system-gives-one-driver-control-of-two-trucks/].


Intermodal Terminal Operations


• Fairfield Texas, Rail: https://www.fairfieldtx.com/site-selection/transportation/rail/


• FHWA, Federal Highway Administration Awards Nearly $10 Million Grant to California’s GoPort Freight Project in Alameda County: https://www.fhwa.dot.gov/pressroom/fhwa1717b.cfm


• Traficon USA Traffic Video Detection, http://www.kargor.com/CL_VIP3D_USAsize_Sep08_email.pdf.


• Trinium’s Intermodal Trucking and Drayage Software, https://www.triniumtech.com/trucking/trucking-software.


• Gateway Cities Technology Plan for Goods Movement, Background Research Reports, 2012.


Summary and Conclusion

• TxDOT, Texas-Mexico Border Crossings: https://www.txdot.gov/inside-txdot/projects/studies/statewide/border-crossing.html