Texas Freight Network Technology and Operations Plan

Smart Freight Connector Concept of Operations
Texas Department of Transportation, Freight Planning Branch

Final: December 2020
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<th>Description</th>
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<tbody>
<tr>
<td>AADT</td>
<td>Average Annual Daily Traffic</td>
</tr>
<tr>
<td>AASHTO</td>
<td>American Association of State Highway and Transportation Officials</td>
</tr>
<tr>
<td>ATCMTD</td>
<td>Advanced Transportation and Congestion Management Technologies</td>
</tr>
<tr>
<td>ATIS</td>
<td>Advanced Traveler Information System</td>
</tr>
<tr>
<td>ATMS</td>
<td>Advanced Traffic Management System</td>
</tr>
<tr>
<td>ATRI</td>
<td>American Transportation Research Institute</td>
</tr>
<tr>
<td>AV</td>
<td>Automated Vehicle</td>
</tr>
<tr>
<td>BNSF</td>
<td>BNSF Railway</td>
</tr>
<tr>
<td>C2C</td>
<td>Center to Center</td>
</tr>
<tr>
<td>COff</td>
<td>Corridor Optimization for Freight</td>
</tr>
<tr>
<td>CAT</td>
<td>Cooperative Automated Transportation</td>
</tr>
<tr>
<td>CCTV</td>
<td>Closed Circuit Television</td>
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<tr>
<td>ConOps</td>
<td>Concept of Operations</td>
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<tr>
<td>CRIS</td>
<td>Crash Records Information System</td>
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<tr>
<td>CTECC</td>
<td>Combined Transportation, Emergency &amp; Communications Center</td>
</tr>
<tr>
<td>CTT</td>
<td>Comparative Travel Time</td>
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<tr>
<td>CV</td>
<td>Connected Vehicle</td>
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<tr>
<td>DART</td>
<td>Dallas Area Rapid Transit</td>
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<tr>
<td>DMS</td>
<td>Dynamic Message Sign</td>
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<tr>
<td>FNTOP</td>
<td>Freight Network Technology and Operations Plan</td>
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<tr>
<td>FRATIS</td>
<td>Freight Advanced Traveler Information Systems</td>
</tr>
<tr>
<td>GIWW</td>
<td>Gulf Intracoastal Waterway</td>
</tr>
<tr>
<td>HCRS</td>
<td>Highway Condition Reporting System</td>
</tr>
<tr>
<td>HOV</td>
<td>High Occupancy Vehicle</td>
</tr>
<tr>
<td>ICM</td>
<td>Integrated Corridor Management</td>
</tr>
<tr>
<td>IT</td>
<td>Information Technology</td>
</tr>
<tr>
<td>ITS</td>
<td>Intelligent Transportation System</td>
</tr>
<tr>
<td>METRO</td>
<td>Metropolitan Transit Authority of Harris County</td>
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<tr>
<td>MOU</td>
<td>Memorandum of Understanding</td>
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<tr>
<td>MPO</td>
<td>Metropolitan Planning Organization</td>
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<tr>
<td>NHS</td>
<td>National Highway System</td>
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<tr>
<td>OBU</td>
<td>Onboard Unit</td>
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<tr>
<td>OEM</td>
<td>Original Equipment Manufacturer</td>
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<tr>
<td>PAAC</td>
<td>Port Authority Advisory Committee</td>
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<tr>
<td>PII</td>
<td>Personally Identifiable Information</td>
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<tr>
<td>RIMS</td>
<td>Regional Incident Management System</td>
</tr>
<tr>
<td>RSU</td>
<td>Roadside Unit</td>
</tr>
<tr>
<td>SH</td>
<td>State Highway</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>SOP</td>
<td>Standard Operating Procedure</td>
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<td>STARS</td>
<td>Statewide Traffic Analysis and Reporting System</td>
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<tr>
<td>STRATIS</td>
<td>South Texas Regional Advanced Transportation Information System</td>
</tr>
<tr>
<td>SWRI</td>
<td>Southwest Research Institute</td>
</tr>
<tr>
<td>TCDS</td>
<td>Traffic Count Database System</td>
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<tr>
<td>TCFC</td>
<td>Texas Connected Freight Corridor</td>
</tr>
<tr>
<td>TFMP</td>
<td>Texas Freight Mobility Plan</td>
</tr>
<tr>
<td>THFN</td>
<td>Texas Highway Freight Network</td>
</tr>
<tr>
<td>TIDC</td>
<td>Traveler Information During Construction</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>TMUTCD</td>
<td>Texas Manual on Uniform Traffic Control Devices</td>
</tr>
<tr>
<td>TPAS</td>
<td>Truck Parking Availability System</td>
</tr>
<tr>
<td>TPP</td>
<td>Transportation Planning and Programming</td>
</tr>
<tr>
<td>TTI</td>
<td>Texas Transportation Institute</td>
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<tr>
<td>TxDOT</td>
<td>Texas Department of Transportation</td>
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<tr>
<td>USDOT</td>
<td>United States Department of Transportation</td>
</tr>
<tr>
<td>VC</td>
<td>Vehicle Classification</td>
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<tr>
<td>WIM</td>
<td>Weigh-in-Motion</td>
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1.0 Introduction
The Freight Network Technology and Operations Plan (FNTOP) is anticipated to be the most comprehensive freight technology planning effort among state Departments of Transportation (DOTs) in the U.S. The FNTOP intends to outline potential strategies to guide technology- and operations-related investments on the Texas Multimodal Freight Network (TMFN). The FNTOP includes a review of current and future transportation challenges, opportunities, and the development of user needs informed by 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 across all modes of freight transportation.

This document—titled Concept of Operations—discusses key information for the Smart Freight Connector strategy, which was one of the strategies identified in the FNTOP and recommended by stakeholders for advancement to the ConOps phase. The objective of a ConOps is to describe the operation of the proposed system in a non-technical and easy-to-understand manner. How the system is to be used and its anticipated benefits is described from multiple stakeholder viewpoints as a way to provide a bridge between the needs that motivated the project and the specific technical requirements.

1.1 Project Overview
The primary goal of the FNTOP is to develop a comprehensive plan advising TxDOT on deploying technology based operational strategies to improve freight transportation safety and mobility in Texas. 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 the Texas Department of Transportation’s (TxDOT) needs, challenges, and opportunities in terms of physical Intelligent Transportation System (ITS) 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 will guide Texas’s strategic development and deployment of innovative multimodal freight transportation technologies, techniques, research, and methods.

1.2 Project Reports
The FNTOP is based on a detailed assessment of current and future needs, challenges, gaps, and opportunities that inform strategies and a stand-alone Implementation Plan. These assessments are compiled in the following technical reports:

- **Goals and Objectives Report.** Developed goals and objectives for the FNTOP in alignment with existing and ongoing planning efforts and stakeholder input.

- **State of the Practice Assessment Report.** Assessed the state of the practice regarding freight-related groups, policies, and initiatives in Texas, in addition to existing and emerging domestic and international freight technological and operational developments.

- **Inventory of Existing Conditions Report.** Identified ITS assets, applications, and programs that exist on the TMFN, as well as summarized operational and management processes related to TxDOT and partner use of technology infrastructure.

- **Stakeholder Outreach Summary Report.** Summarized discussions and feedback collected at Texas public agency meetings, deeper-dive discussions with various TxDOT Divisions, Cooperative Automated Transportation (CAT) meeting, Port Authority Advisory Committee (PAAC) meeting, FNTOP regional stakeholder meetings, TxDOT stakeholder webinar workshop, FNTOP briefing with private and public sector stakeholders, as well as the set of one-on-one stakeholder interviews conducted.

- **User Needs Assessment Report.** Identified and assessed the technological and operational needs of the TMFN based on public and private sector stakeholder feedback, which were combined with initial research efforts to establish a set of FNTOP User Needs.

- **Strategies and Conceptual Framework Report.** Documented FNTOP identified strategies that are relevant to the goals and objectives of the FNTOP and based on documented FNTOP User Needs. Identified details of the FNTOP identified strategies, including how they are prioritized and how they could fit together as part of a larger conceptual framework that builds upon the existing Texas ITS program.

- **Concepts of Operations.** Developed in-depth concepts of desired operations and maintenance requirements for the six FNTOP recommended strategies selected for Concept of Operations (ConOps) development.
• **Implementation Plan.** Identified near-term, medium-term, and long-term actions, in addition to considerations necessary for the rollout of each of the 10 FNTOP recommended strategies as they are transitioned from planning to design.

• **Freight Network Technology and Operations Plan.** Will summarize the entire plan development tasks, as well as incorporate the technical and stakeholder engagement tasks completed throughout this project in a final plan.

### 1.3 Stakeholder Engagement

The FNTOP began with research on existing freight initiatives at TxDOT to gain a better understanding of the current challenges faced by the Texas freight community. TxDOT then reached out to a diverse group of stakeholders with a goal to solicit feedback and opinions on the current state of freight operations in Texas and the vision for the application of technology to support future freight operations. The stakeholder interviews verified and supported many of the issues identified by the FNTOP, while also informing the prioritization of potential strategies to address deficiencies in the system.

This outreach included public sector stakeholders (internal and external to TxDOT; federal, state, and local) and private sector stakeholders. A brief overview of the full FNTOP outreach effort is provided below:

• **TxDOT Stakeholder Groups (Division Offices)** – This effort included key personnel from many TxDOT Divisions, including the 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.

• **Freight Network Technology Regional Outreach** – This effort included discussing the FNTOP at the TxDOT CAT Meeting, PAAC Meeting, Houston (TranStar) Stakeholder Meeting, Dallas/Fort Worth Stakeholder Meeting, a dedicated breakout session at the 2019 Texas Mobility Summit in San Antonio, a stakeholder webinar workshop, and a FNTOP briefing with private and public sector stakeholders. At each meeting or session, moderators collected feedback regarding challenges and opportunities associated with technology-based operational strategies to improve freight transportation safety and mobility in Texas.

• **Public/Private Sector Stakeholder Outreach** – This effort consisted of one-on-one phone and in-person interviews (total of 58) with stakeholder representatives in multiple freight modes, freight companies, railroads, original equipment manufacturers (OEMs), startups, industry groups, telecommunications companies, research institutes, MPOs, cities, federal government, and others. A breakdown by type of stakeholder, based on the 58 interviews, is shown in Exhibit 1.
1.4 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 TFMP\(^1\), these assets cover:

- **Highways**: Highways are the predominant mode for freight movement within the state, providing first and last mile connections to rail facilities, maritime ports, airports, and pipelines, as well as serving long haul trips 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 (THFN), 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 moved in Texas. Intrastate trucking 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

\(^1\) Texas Department of Transportation, *Texas Freight Mobility Plan 2018*, March 7, 2018.
railroads for Texas’ three Class I railroads (BNSF Railway, Kansas City Southern Railway Company, and Union Pacific Railroad), Texas’ maritime ports, and many of the state’s rail-served industries.

- **Ports and Waterways**: Texas handles the second highest volume of 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 are 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 (M-69), is also a part of the TMFN. M-69 handles two-thirds of the waterway’s traffic, moving 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 in e-commerce and the associated expectations for 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. Of those, 15 are commercial vehicle crossings, and the other five are rail crossings.

Exhibit 2 provides an overview of the assets designated as a part of the TMFN – namely key roadways, railroads, ports and waterways, airports, and international border crossings. Exhibit 3 maps out where these assets are located in Texas. The TMFN is important because it identifies the key corridors that facilitate the efficient and safe movement of goods in Texas and are the most critical for focused investment.
Exhibit 2: Overview of Texas Multimodal Freight Network Assets

- **313,000** roadway centerline miles
  - 21,661 miles on the Texas Highway Freight Network
  - 745 miles of Critical Rural Freight Corridor
  - 372 miles of Critical Urban Freight Corridor
  - Transporting **1.2 billion tons**

- **10,539** miles of railroads on the TMFN
  - 3 Class I railroads
  - 49 Class III or shortline railroads
  - Transporting **441 million tons**

- **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 GINW, all on TMFN
  - Transporting **598 million tons**

- **24** commercial airports
  - 7 air cargo airports on TMFN
  - Transporting **1.8 million tons**

- **426,000** miles of pipeline
  - 59% intrastate
  - 41% interstate
  - Transporting **837 million tons**

- **20** commercial international border crossings, all on the TMFN
  - 15 commercial vehicle crossings
  - 5 rail crossings
  - Facilitating **73.5 million tons**

Source: Texas Department of Transportation, Texas Freight Mobility Plan 2018 – Executive Summary, March 7, 2018.
Exhibit 3: The Texas Multimodal Freight Network

The Texas Multimodal Freight Network

Source: Texas Department of Transportation, Texas Freight Mobility Plan 2018 – Executive Summary, March 7, 2018.
The 2018 TFMP identified eight goals and associated objectives that help inform and articulate TxDOT’s freight investment priorities, help define freight system investment needs, and identify the desired future performance of the TMFN. Exhibit 4 summarizes these goals, some of which will be utilized later in this document to identify deficiencies in the existing system and justify deployment of the identified strategy.

### Exhibit 4: 2018 TFMP Goals

<table>
<thead>
<tr>
<th>2018 TFMP Goals</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Improve multimodal transportation safety</td>
</tr>
<tr>
<td>Economic Competitiveness</td>
<td>Improve the contribution of the Texas freight transportation system to economic competitiveness, productivity and development</td>
</tr>
<tr>
<td>Asset Preservation and Utilization</td>
<td>Maintain and preserve infrastructure assets using cost-beneficial treatments</td>
</tr>
<tr>
<td>Mobility &amp; Reliability</td>
<td>Reduce congestion and improve system efficiency and performance</td>
</tr>
<tr>
<td>Multimodal Connectivity</td>
<td>Provide transportation choices and improve system connectivity for all freight modes</td>
</tr>
<tr>
<td>Stewardship</td>
<td>Manage environmental and TxDOT resources responsibly and be accountable in decision-making</td>
</tr>
<tr>
<td>Customer Service</td>
<td>Understand and incorporate citizen feedback in decision-making processes and be transparent in all TxDOT communications</td>
</tr>
<tr>
<td>Sustainable Funding</td>
<td>Identify sustainable funding sources for all freight transportation modes</td>
</tr>
</tbody>
</table>

Source: Texas Department of Transportation, Texas Freight Mobility Plan 2018

### 1.5 Summary of Existing Conditions and User Needs

The FNTOP reviewed the existing ITS program in Texas, which represents the vast majority of TxDOT’s real-time traffic management applications that serve roadway user needs, including freight. TxDOT utilizes Traffic Management Centers (TMCs) as one of the key tools to operate and manage its road network. TxDOT is a participant in several advanced mobility initiatives, including an Integrated Corridor Management (ICM) program, a freight signal priority project, and several Connected Vehicle initiatives; that said, the vast majority of the ITS and traffic management program resides in major metropolitan areas, with limited coverage or response capabilities in rural areas. Relevant ITS programs in the context of this strategy are discussed later in Section 2.2. Further details on these programs and others can be found in
the FNTOP State of the Practice Assessment Report and FNTOP Inventory of Existing Conditions Report.

User Needs for the FNTOP were informed by the FNTOP Goals and Objectives, the FNTOP State of the Practice Assessment Report, the FNTOP Inventory of Existing Conditions Report, and input from stakeholders. Relevant user needs that apply to this ConOps are presented in Section 2.5 to aid with traceability of features described later in the document. A full list of FNTOP User Needs can be found as part of the FNTOP User Needs Assessment Report.

1.6 Summary of Strategies and Conceptual Framework Report

The FNTOP developed a series of technological strategies for improving freight operations in Texas. The strategies developed as part of the FNTOP consider the range of existing and emerging solutions available, based on traceability of the solutions to identified user needs prepared as part of the FNTOP User Needs Assessment. Exhibit 5 summarizes the potential strategies proposed to guide technology- and operations-related investments on the TMFN. Based on internal discussion and coordination with TxDOT, 10 of the 12 FNTOP strategies were advanced based on favorable feedback regarding direct relevance/importance to freight needs, uniqueness as a standalone strategy, and value as an application. The two strategies not advanced represented an infrastructure solution (Fiber Optic Expansion) and a strategy deemed to be too similar to another strategy (Freight Integrated Corridor Management).

Key public and private sector stakeholders were engaged to obtain feedback on the 10 strategies, including suggested refinements, and priorities. Through outreach efforts, stakeholders were asked to rank the recommended strategies based on the following questions:

- Does the strategy add value to the Texas Multimodal Freight Network?
- Is the strategy likely to succeed in Texas?

A total of six strategies were recommended to advance to Concept of Operations development. There was consistent agreement among TxDOT and its stakeholders that these strategies had high scores for adding value to the TMFN and were likely to succeed in Texas. The other strategies developed as part of this effort were either underway as part of a separate effort or deferred due to another TxDOT initiative. Exhibit 5 reflects the final recommendations for each strategy.
**Exhibit 5: Summary of Identified FNTOP Strategies**

<table>
<thead>
<tr>
<th>Identified Strategy</th>
<th>Recommendation</th>
</tr>
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<tbody>
<tr>
<td>Truck Parking Availability System</td>
<td>Underway&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>High-Resolution Freight Traveler Information System</td>
<td>Advanced to Concept of Operations</td>
</tr>
<tr>
<td>Centralized Data Repository for Freight Applications</td>
<td>Deferred&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>AV Infrastructure, Connected Signing, and Data Safety Warning Detection System</td>
<td>Advanced to Concept of Operations</td>
</tr>
<tr>
<td>Smart Freight Connector</td>
<td>Advanced to Concept of Operations</td>
</tr>
<tr>
<td>Blocked Rail Crossing Traffic Management System</td>
<td>Advanced to Concept of Operations</td>
</tr>
<tr>
<td>Smart Work Zone Information System</td>
<td>Underway&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>Statewide Traffic Operations Center</td>
<td>Advanced to Concept of Operations</td>
</tr>
<tr>
<td>Binational Traffic Operations Center</td>
<td>Deferred&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Freight Integrated Corridor Management</td>
<td>Not Advanced&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fiber Optic Cable Expansion</td>
<td>Not Advanced&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>1</sup> Included in other TxDOT ongoing initiatives  
<sup>2</sup> Better fulfills goals and objectives of other TxDOT initiatives  
<sup>3</sup> Not advanced due to similarities with Smart Freight Connector strategy  
<sup>4</sup> Not advanced due to being an infrastructure-focused commodity instead of a technological or operational application.

An overall technology framework was developed to demonstrate how the proposed FNTOP strategies could work together as an integrated statewide system. The framework helps illustrate the relationships between the FNTOP strategies and any overlapping opportunities that might allow for easier deployment. All strategies have the potential to be implemented together in functional groups or as stand-alone systems.

Exhibit 6 shows the relationship among integrated services and strategies.
Exhibit 6: Potential Integrated Services and Strategies
1.7 Purpose of the Concept of Operations Document

The development of a ConOps document is the next critical step necessary for each of the six strategies selected for advancement to create implementable solutions as part of the FNTOP. The objective of a ConOps is to describe the operation of the proposed system in a non-technical and easy-to-understand manner. How the system is to be used and its anticipated benefits is described from multiple stakeholder viewpoints as a way to provide a bridge between the needs that motivated the project and the specific technical requirements. Each required functionality must be traceable back to documented user needs prepared as part of the FNTOP User Needs Assessment to ensure that the ITS project addresses real-world issues. The ConOps document is used to collect feedback from the system users and other stakeholders and to validate key assumptions built into the system concept (e.g. who is responsible for what). By building support, gathering feedback, and refining the proposed concept, the ConOps document serves as a high-level guide for subsequent design efforts (e.g. System Requirements, High-Level Design, Detailed Design). It helps advance the strategy into these subsequent phases by reducing the risk of the strategy failing or being delayed due to a lack of agreement or understanding of the proposed concept.

Priorities were established to help inform TxDOT’s selection of the six strategies that advanced to a ConOps. The development of FNTOP strategies, from proposal to ConOps, is outlined in Exhibit 7.

Exhibit 7: Formulation of Strategies from Proposal to Final Texas Freight Network Technology and Operations Plan

Projects that engineer systems—whether the project is a simple ITS deployment or a complex commercial airliner—follow what is called the Systems Engineering Process. This process identifies and outlines procedural steps of how the system is incrementally developed, how the system is incrementally validated by stakeholders, and how the system is to be
measured and accepted. The “V” Development Model, shown in Exhibit 8, is a visualization of one such process. This model was developed based on Systems Engineering industry standards and is part of U.S. Department of Transportation’s (USDOT) best practices for ITS projects. The development processes outlined in the model help transportation agencies use common, consistent, and well-established systems engineering tools and processes to:

- Improve the quality of Intelligent Transportation Systems;
- Reduce the risk of cost and schedule overruns;
- Gain wide stakeholder participation;
- Maintain, operate, and evolve the Intelligent Transportation System;
- Maintain consistency with the regional and state ITS architectures;
- Provide flexibility in procurement options for the agencies; and
- Keep current with the rapid evolution of technology.

Exhibit 8: Systems Engineering V-Model

Development of the ConOps document is the first major step of the Decomposition and Definition phase of the V-Model, where ITS project concepts become more defined. It helps establish the simple expectations of the system so that stakeholders can understand what the project intends to do and understand how it will be later validated when complete.

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2 Federal Highway Administration California Division and Caltrans, Systems Engineering Guidebook for ITS Version 3.0 Website
1.8 Smart Freight Connector Overview
This ConOps is focused on the Smart Freight Connector strategy, which was one of the priority strategies identified in the FNTOP and recommended by stakeholders for advancement to the ConOps phase. This strategy aims to implement traffic management technologies on last-mile corridors that will efficiently manage operations along key routes to intermodal facilities, such as maritime ports and airports. At a high level, this strategy will collect comprehensive traffic and freight-related data to determine the performance of operations along a corridor. When needed, the existing arterial traffic signal system will be adjusted to better accommodate freight traffic, such as prioritizing green movements (i.e. green lights) in one direction or extending yellow clearance times (i.e. yellow lights) to allow slower trucks to successfully clear an intersection. This strategy would explore opportunities to instrument truck staging areas to monitor and broadcast real-time parking availability, as well as deploy truck priority lanes to incentivize certain deliveries (e.g. automated vehicles [AVs], electric vehicles, etc.).

Exhibit 9 provides an illustrative example of the Smart Freight Connector strategy that was previously discussed in the FNTOP Strategies and Conceptual Framework Report.

Exhibit 9: Illustrative Example of Smart Freight Connector Strategy
Key objectives—collected through stakeholder outreach and other FNTOP efforts—that are identified to frame what this system shall ultimately do include:

- Improve mobility, safety, and efficiency for freight movements on last-mile links to critical intermodal facilities;
- Help cut down on circulating trucks that have arrived before their appointment window at the intermodal terminal and are looking for a place to park in the short term;
- Provide the foundation for a fully functional Freight Advanced Traveler Information Systems (FRATIS) project in the future;
- Work with terminal operators to explore drayage optimization opportunities to operate routes as a full FRATIS project;
- Increase deployment of connected vehicle (CV)-related safety and mobility applications upon national adoption of CV-related technologies;
- Invest in high-resolution traffic data services along key proposed truck “last mile” routes;
- Implement traffic management technologies on last-mile freight corridors that will efficiently manage operations along these routes to the intermodal facilities;
- Implement truck priority signals and “green flow progression” (i.e. consecutive green lights along a route) established in real-time based on freight precedence (i.e. directional volumes);
- Implement real-time green time extension (i.e. longer green lights) for truck platoons at traffic signals and increased yellow times (i.e. longer yellow lights) at high-crash intersections, such as ones that can extend to longer intervals during inclement weather when trucks cannot stop as quickly on wet roads;
- Instrument available truck staging areas with parking detection equipment in order to provide truckers with real-time parking availability options prior to their arrival;
- Publish traffic conditions, parking availability, and other intermodal terminal information along the selected corridors on dynamic message signs (DMS); and
- Implement dedicated truck travel lanes where feasible, for exclusive use between intermodal terminals and staging lots, or as freight bypass lanes for truckers that have certain prioritized permissions.

1.9 Organization of the Report
This document is one of the deliverables as defined under Task 2.6: Develop Concept of Operations from the scope of work for Cambridge Systematics, Inc.’s project number 160058.006 named Texas Freight Network Technology and Operations Plan. The scope of work document is TxDOT Work Authorization No. 6, Contract No. 50-6IDP5011. This ConOps
covers the topic areas outlined in ANSI/AIAA-G-043 and IEEE Standard 1362,\(^3\) as recommended by the FHWA for ConOps development.

The remainder of this document is organized into the following sections:

- **Section 2 – The Current Situation in Texas.** This section describes current systems and technologies utilized by stakeholders and how each is being used, deficiencies of the existing systems, desired changes to the systems and priorities, and assumptions and challenges.

- **Section 3 – Concept for the Proposed Smart Freight Connector.** This section contains a description of the desired system and high-level requirements, how it will address the concerns outlined in Section 2, how it will operate, and how users will interface with the system.

- **Section 4 – Benefits, Impacts, and Alternatives to the Smart Freight Connector.** This section describes the expected operational and organizational benefits and impacts of the essential features of the new system, the potential impacts during development, disadvantages and limitations of the proposed system, and alternatives and tradeoffs considered while developing the system concept.

- **Section 5 – Operational Scenarios.** This section identifies potential real-world situations for the system. Each scenario describes how stakeholders respond to and benefit from the implementation and operation of the new system.

- **Section 6 – Next Steps.** This section outlines the next steps of the Texas FNTOP following the development of the Concept of Operations documents, including the near-term development of the Implementation Plan.

- **Section 7 – References.** This section lists all references used in the creation of this document.

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\(^3\) ANSI refers to the American National Standards Institute, AIAA refers to the American Institute of Aeronautics and Astronautics, and IEEE refers to the Institute of Electrical and Electronics Engineer. All three are standards-setting organizations.
2.0 The Current Situation in Texas
The purpose of this section is to highlight the current situation in Texas, including the existing systems currently in operation, and the deficiencies that are present. It later discusses the user classes that could apply to this ConOps document and the User Needs that provide the motivation for new technology-based system investments.

2.1 Description of the Current Situation
The 2018 TFMP provides a comprehensive multimodal freight transportation plan for Texas, which is based on a decade of multimodal strategic planning and stakeholder collaboration at the statewide, regional, and local levels to facilitate continued economic growth and goods movement throughout the state. The TFMP and its related recommendations supports the USDOT National Multimodal Freight Policy and national freight goals; it also includes state-specific recommendations to explore technology options as part of policy and planning initiatives to enhance freight transportation system safety, management, operations, and asset preservation. In the context of implementing solutions that would offer freight-specific traveler information along the THFN, there are several TFMP goals as shown in Exhibit 10 that support this strategy. Key existing conditions associated with the impacts of freight on highway safety, mobility, and system asset conditions and the role of freight in supporting the state economy are discussed in the following subsections.

Exhibit 10: Texas’ Freight Mobility Plan Goals and Objectives Related to the Highway Mode

<table>
<thead>
<tr>
<th>2018 TFMP Goals</th>
<th>Description</th>
<th>Objectives Related to the Highway Mode</th>
</tr>
</thead>
</table>
| Safety          | Improve multimodal transportation safety | • Reduce rates of truck-involved crashes, injuries and fatalities on the Texas Highway Freight Network.  
• Support the deployment of innovative technologies to enhance the safety and efficiency of the Texas Multimodal Freight Network. |
<p>| Economic Competitiveness | Improve the contribution of the Texas freight transportation system to economic competitiveness, productivity and development | • Strengthen Texas’ position as a global trade and logistics hub by improving and maintaining Texas’ multimodal freight network infrastructure and connectivity. |</p>
<table>
<thead>
<tr>
<th>2018 TFMP Goals</th>
<th>Description</th>
<th>Objectives Related to the Highway Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>• Expand public-private and public-public partnerships to facilitate investments in freight improvements that enhance economic development and global competitiveness.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Identify critical freight infrastructure improvements necessary to support future supply chains and logistics needs, and consumer demands.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Support strategic transportation investments to address the rapid increase in key industries, such as energy, plastics, agriculture and automotive production.</td>
</tr>
<tr>
<td>Asset Preservation and Utilization</td>
<td>Maintain and preserve infrastructure assets using cost-beneficial treatment</td>
<td>• Leverage and utilize the Texas Multimodal Freight Network.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Utilize technology to provide for the resiliency and security of the state’s multimodal freight transportation system in response to multi-hazard threats, including natural disasters and man-made threats.</td>
</tr>
<tr>
<td>Mobility and Reliability</td>
<td>Reduce congestion and improve system efficiency and performance</td>
<td>• Reduce the number of Texas Highway Freight Network miles at unacceptable congestion levels (level-of-service D or worse).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Improve travel time reliability on the Texas Highway Freight Network.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Apply the most cost-effective methods to improve system capacity and reliability (including technology and operations).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Leverage technology to improve management and operations of the existing transportation system.</td>
</tr>
<tr>
<td>Multimodal Connectivity</td>
<td>Provide transportation</td>
<td>• Increase Texas supply chain efficiencies by improving connectivity between modes.</td>
</tr>
</tbody>
</table>
2.1.1 Intermodal Connections in Texas

A significant amount of freight uses multiple modes to get from an origin to destination, and most supply chains have multimodal components that necessitate intermodal connectivity. Texas, in particular, has an extensive intermodal network that provides connectivity to major freight gateways and generators, including marine ports, warehousing/distribution centers, airports, international border crossings, and rail intermodal terminals. This network is made up of intermodal connectors that link these rail yards, seaports, airports, and distribution facilities to the THFN. Access to and from these intermodal facilities is along local roadways that connect to the state’s highway freight corridors and serve as the ‘first’ and ‘last’ mile for freight movement. As noted in the 2018 TFMP, Texas has a total of 191 National Highway System (NHS) intermodal connectors, accounting for 180 miles of roadway. Nationally, NHS connectors account for less than one percent of the NHS mileage, but serve as key conduits for the timely and reliable delivery of goods. In Texas, intermodal connectors include 23 airport/truck, 43 port/truck, 18 truck/pipeline and 20 truck/rail connectors, with the remainder serving passenger movements. In particular:

- The 2018 TFMP notes that 14 of Texas’ NHS intermodal connectors fall on the Texas portion of the NHFN, connecting major rail facilities to the roadway network; this is a subset of the 20 NHS rail-truck intermodal connectors in Texas.
- Texas’ top air-cargo airports are located near major metropolitan areas and are connected to the THFN. The NHFN in Texas includes seven intermodal connectors specifically for the following airports: Fort Worth Alliance, Dallas Love Field, Laredo,

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4 Source: FHWA Office of Operations, “NHS Connectors”.
McAllen Miller, San Antonio, El Paso, and Houston Intercontinental. This is a subset of the 23 truck-air intermodal connectors on the Texas portion of the NHS.

- The extensive pipeline network is connected to the rail and highway network, as well as seaports, through nine intermodal connectors on the NHFN and 18 on the NHS.

According to 2016 data from the U.S. Bureau of Labor Statistics, there are 195 intermodal freight facilities in Texas. These include air, port, rail, and truck facilities. Exhibit 11 shows the locations of these facilities throughout the State.
Exhibit 11: Texas Intermodal Freight Facilities

Texas Intermodal Freight Facilities

Source: TFMP 2018 - Bureau of Transportation Statistics, 2017
The 2018 TFMP notes the challenges and weaknesses with the current intermodal connectors in Texas as primarily concentrated in highly congested urban areas, in competition with passenger movements. Many of these connectors have multiple owners, which can challenge coordination and funding activities required to maintain the infrastructure. Additionally, it is noted that the rapid growth of the emerging energy sector makes managing intermodal connections difficult. Given this, the TFMP recommends additional strategic investment in the multimodal freight transportation network to meet the future challenges of moving freight and people. By resolving any system bottlenecks on any of the modes, Texas can accommodate the forecasted freight growth that is expected over the next few decades.

2.1.2 “Last Mile” Problem

With most intermodal facilities being off the main highway network, trucks rely on local roadways to serve as the “first” or “last” mile that connect major corridors to the facilities. The “last mile” term (often interchanged with the term “first mile”) is used to describe the portion of a network chain that physically reaches end-user premises. The phrase has been widely used in the telecommunications, cable television, and internet industries to represent the final link that services customers (e.g. a service into a user’s home or business). This term has been adopted by the transportation and supply chain industries to explain similar challenges on their networks. The word “mile” is used metaphorically, where in reality the length of the last link may be more or less than a mile, but the term widely uses “mile” as an easy reference relative to the many miles of the core network in these systems.

To understand the “last mile” dilemma, it is important to look at the network makeup of a particular freight mode. The Texas highway network is an expansive system of varying types of roads, but it ultimately is made up of a relative few high capacity “trunk” routes (such as interstates, major highways, and principal arterial roadways) and relatively many “twig” routes that branch out to feed many different destinations (such as minor arterials, local roadways, and lesser facilities). The “trunk” routes carry the vast majority of traffic and are often viewed as extremely critical to maintain, which results in more allocated funding to these facilities for operations and maintenance. The “twig” routes—being so numerous—become more challenging and costly to maintain relative to their “trunk” counterparts.

The “last mile” dilemma becomes more pronounced on multimodal transportation networks when factoring in multiple organizations splitting up ownership of assets. On its whole, the TMFN is an interconnected web of links and routes across multiple modes, and it would seem that coordinated expansion and reallocation of network trunk routes would correlate to the increase of freight movement along a single route. However, different modes are operated by different organizations, and each organization tends to manage its network with its own trunk and twig layout. For example, TxDOT may manage the highways leading to a rail terminal, but the rail terminal link may be viewed as a less important link relative to major interstate highways (such as I-35) that TxDOT is also charged with maintaining. With
limited funding, higher volume links for that organization often get expanded and maintained first, despite the significant inefficiencies created by an unimproved intermodal connector/"last mile". This problem only gets more pronounced when factoring in multiple road agencies, such as counties or local governments who may actually own the highway link to the rail terminal and have different agendas altogether.

The “last mile” issue has also historically been more difficult to solve in a transportation network than the telecommunications industry from which the term originated. Even when a “last mile” link is identified by TxDOT (or another owner agency) as being critical for expansion to support the TMFN, expanding that facility to accommodate growth is not always an easy endeavor. Whereas telecommunications companies simply need to upgrade a “last mile” cable, road infrastructure expansion projects require an extensive amount of time, planning, design, and cost. Some infrastructure expansion projects simply cannot be done, not without significantly impacting the property and livelihoods of local community taxpayers. Other projects suffer from complex environmental regulations that limit expansion into sensitive areas, such as wetlands or protected refuges for endangered species. Others simply lack the economic, social, or political backing, despite a demonstrable benefit to the TMFN. Often times, the high startup costs of expanding infrastructure motivates road operators to explore incremental improvements or other countermeasures as an easier alternative.

2.1.3 Economic Impact
Based on the most recent data available on intermodal connectors, the TxDOT intermodal connectors are located primarily at various locations throughout 24 of Texas’s counties. These 24 counties are predominantly urban and contain most of the state’s intermodal facilities. Although these counties are less than ten percent of Texas’ 254 counties, they account for nearly 70 percent of the state’s total freight tonnage movement. Exhibit 12 quantifies the number of counties and freight tonnage where intermodal connectors are and are not present. While many factors can explain why freight tonnage may be higher in these 24 urban counties, it does show that intermodal connectors tend to primarily be located in proximity to key freight activity centers. As such, disruptions on these connectors can have immediate and substantial economic impacts on the freight industry in Texas.

Exhibit 12: Tonnage of Counties With and Without Intermodal Connectors

<table>
<thead>
<tr>
<th>Relationship with Intermodal Connectors</th>
<th>Number of Counties</th>
<th>Total Freight Tonnage (% of total tonnage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counties with NHS Intermodal Connectors</td>
<td>24</td>
<td>2,130,695,573 (70%)</td>
</tr>
<tr>
<td>Counties without NHS Intermodal Connectors</td>
<td>230</td>
<td>893,051,427 (30%)</td>
</tr>
</tbody>
</table>

Source: TxDOT Open Data Portal, 2018 TFMP
2.1.4 Mobility Considerations

Intermodal terminals are single points of exchange between transportation modes and often attract a lot of highway traffic that utilizes the intermodal connector. On the contrary, other NHS routes may accommodate more diverse trucking destinations, which may include long-haul freight, inter-city distribution center transport, or neighborhood package delivery. Exhibit 13 shows the distribution of these NHS routes across Texas. As noted earlier, NHS connectors represent a very small fraction of the overall miles.
Exhibit 13: TxDOT National Highway System

Source: TxDOT Open Data Portal: TxDOT National Highway System
Exhibit 14 looks at the 2018 average annual daily traffic (AADT) for all traffic and trucks on a few sample NHS corridors. The first three corridors are sample intermodal connectors, whereas the last three corridors are general routes. These example NHS connectors provide access to the Port of Brownsville or to major pipeline terminals, as outlined, which are critical to key supply chain operations in Texas.

**Exhibit 14: AADT on Sample NHS Freight Routes Throughout Texas**

<table>
<thead>
<tr>
<th>Freight Route</th>
<th>NHS Intermodal Connectors</th>
<th>NHS General Routes (Non Connectors)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SH 48 Brownsville/Port Isabel Highway</td>
<td>SH 290 from Austin to Houston</td>
</tr>
<tr>
<td></td>
<td>SH 35 to Major Pipeline Terminal</td>
<td>U.S. 83 from Laredo to Pharr</td>
</tr>
<tr>
<td></td>
<td>FM 1719 to Major Pipeline Terminal</td>
<td>I-10 from San Antonio to Houston</td>
</tr>
<tr>
<td>Average 2018 AADT</td>
<td>12,435</td>
<td>50,394</td>
</tr>
<tr>
<td>Average Truck AADT</td>
<td>554</td>
<td>4,263</td>
</tr>
<tr>
<td>Average Truck %</td>
<td>4.5%</td>
<td>8.5%</td>
</tr>
</tbody>
</table>


In these sample corridors, the intermodal connectors carry less traffic and fewer trucks than other NHS routes. On their own, these sample corridors initially seem to suggest that the NHS general routes are more important because they carry higher traffic volumes and a greater number of trucks, but this fails to consider the accessibility value of traffic going to the intermodal sites. As such, while intermodal connectors may carry less traffic than major NHS corridors, their impact on overall freight access and mobility is significant. This is discussed later in Section 2.3.2, but a key takeaway is that the existing practices used to determine highway segment importance—which often rely on traffic volumes—may not always present the full case.

**2.1.5 Asset Preservation**

TxDOT operates and maintains a statewide data collection program through its weigh-in-motion (WIM) and permanent count stations. These stations gather information on commercial motor vehicle movements to aid in strategic planning and infrastructure repair funding allocations. The locations of TxDOT’s existing WIM and permanent count stations are discussed in Section 2.2.2.4. Data collected from WIM and permanent count stations is

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5 Average AADT considered NHS routes with greater than 1,000 AADT, so as to not include segments without traffic data.
published in the Statewide Traffic Analysis and Reporting System (STARS) II, which is discussed in Section 2.2.1.4.

TxDOT commissioned a WIM and Vehicle Classification (VC) Strategic Plan to help expand the WIM and permanent count station program across the state. One primary goal of this effort is to more comprehensively measure freight operations to help ensure funding is prioritized to support critical needs, including along corridors that support new industrial developments. This strategic plan will examine all “on network” roadways, including those that are designated as intermodal freight connectors; the analysis will help support pavement preservation activities.

Exhibit 15 shows the location of WIM and permanent count stations deployed on NHS Intermodal Connectors in Texas. As of the most recent data, only two intermodal connectors are currently equipped with permanent count stations, and none are equipped with WIM.

**Exhibit 15: Intermodal Connectors Coverage by WIM and Permanent Count Stations**

<table>
<thead>
<tr>
<th>ITS Device Type</th>
<th>Number of Intermodal Connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilities with WIM Stations</td>
<td>0 Intermodal Connectors</td>
</tr>
<tr>
<td>Facilities with Permanent Count Stations</td>
<td>2 Intermodal Connectors</td>
</tr>
</tbody>
</table>

**2.1.6 Safety Challenges**

Prioritizing safety on intermodal connectors is not only important for the health and welfare of the truck drivers who travel along those roads, but also an important metric for maintaining a facility’s operational uptime. Exhibit 16 presents average crash rates per mile along the NHS for intermodal connector and all other NHS segments. Between 2014 and 2016, average crash rates along intermodal connectors were nearly six times higher than average crash rates along all other NHS segments.

**Exhibit 16: Average Crash per Mile on NHS Segments**

<table>
<thead>
<tr>
<th>NHS Segments</th>
<th>Average Crashes Per Mile (2014-2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermodal Connectors</td>
<td>67</td>
</tr>
<tr>
<td>General Routes (Non Connectors)</td>
<td>11</td>
</tr>
</tbody>
</table>

Source: TxDOT Crash Records Information System (CRIS), 2014-2016

Many factors contribute to roadway safety challenges. Trucks take longer to speed up and are slower to stop than passenger vehicles. In general, crashes involving commercial motor vehicles result in a greater rate of fatalities and serious injuries. In addition to the direct impacts of crashes, crashes can directly disrupt an intermodal connector’s capacity, which impacts mobility, operational efficiency, and overall economic prosperity.
2.2 Existing Systems

This section discusses the existing systems in Texas, highlighting systems on the highway network. It is important to understand what systems and functionalities have already been deployed, so that wherever possible, the concept for the proposed system described in Section 3.0 can utilize relevant existing systems to support implementation activities. Refer to the FNTOP Inventory of Existing Conditions Report for additional information on the majority of the existing systems included in this section.

Existing systems focus on three key areas:

- **Centralized Traffic Management** – this includes TxDOT TMCs and the Advanced Traffic Management System (ATMS) platform, as well as traveler information systems that publish real-time or historical traffic and road use data;

- **ITS Field Devices** – this includes traditional equipment like closed circuit television (CCTV), DMS, and traffic detectors, as well as WIM/permanent count stations; and

- **Traffic Operations Systems** – this includes managed lanes and advanced traffic signal systems, Truck Signal Priority, Truck Parking Availability Systems, and FRATIS.

2.2.1 Centralized Traffic Management

2.2.1.1 TxDOT Traffic Management Centers

TxDOT utilizes TMCs as one of the key tools to operate and manage its road network. These TMCs utilize the ITS assets available in each District to improve traffic flow, respond to incidents, and provide public safety information at a region-wide and coordinated level. Seven TMCs currently operate in Texas, which tend to be strategically placed within urban areas where traffic volumes are higher and road incidents are generally more frequent. These TMCs typically provide services along state-owned roads and often manage the ITS assets for an adjacent District that may not have a TMC. Exhibit 17 provides a summary of each TxDOT TMC, while Exhibit 18 shows the location of each TMC. Further details on the TMCs can be found in the FNTOP Inventory of Existing Conditions Report.

In the context of this strategy, TMCs could serve as a potential processing role to monitor and respond to activities on intermodal connectors.
### Exhibit 17: TxDOT Traffic Management Centers

<table>
<thead>
<tr>
<th>TxDOT Traffic Management Centers</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austin Combined Transportation, Emergency &amp; Communications Center (CTECC)</td>
<td>Austin CTECC serves as the TMC for the Austin area; it also serves other centralized public safety operations. It involves a partnership between TxDOT, Travis County, the City of Austin, and the Capital Metropolitan Transit Authority.</td>
</tr>
<tr>
<td>Dallas DalTrans</td>
<td>Dallas DalTrans serves as the TMC for the Dallas area. It involves a partnership between three agencies including the City of Dallas, TxDOT, and Dallas Area Rapid Transit (DART).</td>
</tr>
<tr>
<td>El Paso TransVista</td>
<td>El Paso TransVista serves as the TMC for the El Paso area. Housed within the TxDOT El Paso District, this TMC provides traffic and emergency management information for the region.</td>
</tr>
<tr>
<td>Fort Worth TransVision</td>
<td>Fort Worth TransVision serves as the TMC for the Fort Worth area. It is managed and operated by the TxDOT Fort Worth District and provides traffic and emergency management information for the Fort Worth area and Tarrant County.</td>
</tr>
<tr>
<td>Houston TranStar</td>
<td>Houston TranStar serves as the TMC for the greater Houston area. It involves a partnership between the City of Houston, Harris County, TxDOT, and the Metropolitan Transit Authority of Harris County (METRO).</td>
</tr>
<tr>
<td>Laredo South Texas Regional Advanced Transportation Information System (STRATIS)</td>
<td>Laredo STRATIS serves as the TMC for the Laredo area. It is managed and operated by the TxDOT Laredo District and works in collaboration with the City of Laredo’s Traffic Management Center.</td>
</tr>
<tr>
<td>San Antonio TransGuide</td>
<td>San Antonio TransGuide serves as the TMC for the San Antonio region. It is managed and operated by the TxDOT San Antonio District and works in collaboration with local agencies.</td>
</tr>
</tbody>
</table>
Exhibit 18: TxDOT Traffic Management Centers

TxDOT Traffic Management Centers

Prepared by Cambridge Systematics.
Data for planning purposes only.
July 20, 2020
2.2.1.2 TxDOT Real-Time Traffic Management

TxDOT utilizes LoneStar as the ATMS software for its TMCs, which is based on the ActiveITS system developed by the Southwest Research Institute (SWRI). ActiveITS is used in states other than Texas under different names. An exception to LoneStar’s use is in the Houston TranStar facility, which also utilizes the Regional Incident Management System (RIMS) Platform, developed by the Texas Transportation Institute (TTI) to assist with traffic data collection and other activities like law enforcement reporting. RIMS contains more detailed reporting capabilities to support local law enforcement systems that operate out of Houston TranStar. Further details on the ATMS platforms can be found in the FNTOP Inventory of Existing Conditions Report. The ATMS platforms are summarized in Exhibit 19.

In the context of this strategy, the ATMS could serve as a potential processor to receive notifications of traffic management response plans on intermodal connectors and surrounding freight routes.

Exhibit 19: TxDOT TMCs and ATMS Platforms

<table>
<thead>
<tr>
<th>TxDOT TMC</th>
<th>ATMS Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austin CTECC</td>
<td>LoneStar</td>
</tr>
<tr>
<td>Dallas DalTrans</td>
<td>LoneStar</td>
</tr>
<tr>
<td>El Paso TransVista</td>
<td>LoneStar</td>
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<tr>
<td>Fort Worth TransVision</td>
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<tr>
<td>Houston TranStar</td>
<td>RIMS, LoneStar</td>
</tr>
<tr>
<td>Laredo STRATIS</td>
<td>LoneStar</td>
</tr>
<tr>
<td>San Antonio TransGuide</td>
<td>LoneStar</td>
</tr>
</tbody>
</table>

2.2.1.3 ATIS/DriveTexas

DriveTexas serves as TxDOT’s online, public-facing Advanced Traveler Information System (ATIS) database that provides real-time highway conditions throughout Texas. This data can include existing and future construction projects, road closures, and other delays, as well as real-time traffic information. It is available as a web platform for browser users. DriveTexas receives and publishes data feeds from HCRS (Highway Condition Reporting System), as well as provides links to TxDOT’s ITS pages to show data from LoneStar. It allows the user to link to specific local ITS information, breaking it out among the TxDOT Districts. This provides each District with its own Traffic and Emergency Information page on DriveTexas, where one can view the comprehensive traffic map, travel times, incidents, lane closures, cameras, and DMS, as well as amber alerts, weather, and Department of Homeland Security information.
In the context of this strategy, this type of system could distribute real-time traveler information from equipment added to the intermodal connectors and surrounding freight routes.

2.2.1.4 Statewide Traffic Analysis and Reporting System

TxDOT’s Transportation Planning and Programming (TPP) Division publishes a public-facing data analysis and reporting database called STARS II. The STARS II website includes detailed traffic data and statistics, as well as AADT data and other reported traffic data for transportation planning purposes. The Traffic Count Database System (TCDS), included within STARS II, further details count data that has been collected around the State. An example of STARS II is shown in Exhibit 20.

In the context of this strategy, this type of system could distribute historic traveler information from equipment added to the intermodal connectors and surrounding freight routes.

Exhibit 20: TxDOT STARS II Website

Source: TxDOT

2.2.2 ITS Field Devices

As noted earlier, TxDOT operates an extensive network of ITS field devices as part of its traffic management program. Most ITS deployments are located near major urban areas or along highly traveled routes, as the largest benefit to road users (passenger cars, freight, etc.) is typically captured by focusing investments in areas with the most frequent incidents. Some of the existing ITS equipment provides real-time monitoring and managing capabilities on Texas highways today, including:

- CCTV Cameras;
- DMS;
• Traffic Detectors; and
• WIM/Permanent Count stations.

Approximately 44 of the NHS intermodal connectors in Texas have some form of real-time traffic monitoring capability installed on or near them, based on device locations provided by the TxDOT Traffic Safety Division.

2.2.2.1 Closed-Circuit Television Cameras
CCTV cameras are roadside devices that provide visual coverage of locations along traveled roadways. For highway applications, CCTV cameras are often strategically placed on high-volume corridors and near locations with high concentrations of crashes that require incident management and response. Video feeds are transmitted back to TxDOT Districts for real-time viewing; where TMCs are present, operators may keep these video feeds on in the background for passive monitoring and early detection of non-routine congestion. Across the state of Texas, TxDOT operates over 2,700 CCTV cameras, although most are not on intermodal connectors or their immediate surrounding freight routes (discussed later in Section 2.3.1). Further details on camera locations can be found in the FNTOP Inventory of Existing Conditions Report.

In the context of this strategy, CCTV cameras could serve as a potential data provider to help identify and confirm incidents, and verify and monitor response activities to ensure efficient recovery.

2.2.2.2 Dynamic Message Signs
DMS are electronic roadside signs that can broadcast changeable messages to road users, which may include public safety, traveler information, incident, or other key information. Across the state of Texas, TxDOT operates over 980 DMS, although most are not on intermodal connectors or their immediate surrounding freight routes (discussed later in Section 2.3.1). Further details on DMS locations can be found in the FNTOP Inventory of Existing Conditions Report.

In the context of this strategy, DMS could distribute traveler information to road users that is collected along the intermodal connectors and surrounding freight routes.

2.2.2.3 Traffic Detectors
Road detectors, or sensors, are devices that detect vehicles passing or arriving at a certain point. In the context of a highway, they are used to evaluate flow, density, speed, and (depending on the type) vehicle classification. Detectors can be one of many types, including loop detectors, microwave radar, magnetometers, and video detection. Across the state of Texas, TxDOT operates over 2,500 detectors. This includes only devices used for real-time data collection for traffic management purposes. Many are not on intermodal connectors or their immediate surrounding freight routes (discussed later in Section 2.3.1). Further details
on traffic detector locations can be found in the FNTOP Inventory of Existing Conditions Report.

In the context of this strategy, traffic detectors could serve as a potential data provider to help inform potential traffic management response plans that are utilized along the intermodal connectors and surrounding freight routes.

2.2.2.4 Weigh-In-Motion/Permanent Count Stations
TxDOT owns and operates dedicated WIM and permanent count stations around the state that are used to collect data for planning purposes. Many WIM or permanent count stations are permanent in-field devices to collect annual data, although TxDOT often supplements these stations with temporary device stations to collect partial-year data at specific locations that are then annualized.

Across the state of Texas, TxDOT operates over 40 WIM stations and over 400 permanent count stations. Further details on the WIM and permanent count station program in Texas can be found in the FNTOP Inventory of Existing Conditions Report. In the context of this strategy, this type of system—as well as any systems built in this context—could serve as a potential data provider to help inform traffic management responses along intermodal connectors and surrounding freight routes. For example, real-time data that reports a substantial increase in heavier trucks (measured by WIM) could initiate a traffic management strategy that is more favorable to heavy vehicles, such as traffic signal timing plans that reduce the number of stops.

2.2.3 Traffic Operations Systems
TxDOT utilizes certain operations-based systems to control and manage traffic. These types of systems utilize ITS components to help manage certain features, but they are defined separately due to having a direct impact on the regulatory operations of a facility, lane, or intersection. Examples of applicable systems in Texas that could support this strategy include:

- Managed Lanes;
- Advanced Traffic Signal Systems;
- Truck Signal Priority;
- Dallas ICM;
- Truck Parking Availability System (TPAS); and
- FRATIS.

2.2.3.1 Managed Lanes
TxDOT operates several managed lane facilities on Texas roadways. Managed lanes are a congestion mitigation strategy where designated highway lanes are implemented with
customized operational strategies and managed in response to changing conditions. Most managed lanes include high-occupancy vehicle (HOV) lanes, express lanes, restricted lanes (e.g. trucks or buses only), or reversible lanes, although other types exist around the country. Managed lanes generally offer drivers more travel options, better travel time reliability, and improved traffic flow on both the managed and general-purpose lanes.

In Texas, most managed lane facilities have no fee component, and those with fees offer drivers an option if they prefer the convenience of paying a fee to bypass congestion in general-purpose lanes. Texas’ managed lane programs are in urban TxDOT Districts and, per TxDOT’s latest inventory, represent over 60 deployments.

A key freight benefit of managed lanes is that—depending on operational rules—the facility in question can offer a dedicated lane for trucks. During congested periods along the general-purpose lanes, a dedicated truck lane can allow freight to bypass the congestion. In the context of this strategy, a managed lane could be one operational component along intermodal connectors and surrounding freight routes.

2.2.3.2 Truck Signal Priority
Truck priority devices located at traffic signals are devices that detect the arrival of trucks and submit a priority request with the local traffic signal control for consideration of modifying the green phase. Many truck priority signal systems detect freight vehicles in advance of signalized intersections through sensors and request an extension to the green phase so the trucks do not encounter red lights. With the advent of CV equipment, the future of this system may be based on radio transmissions to the traffic signal. A priority request from a truck would be at the discretion of the traffic signal controller’s logic, and would not override a preemption request from a more critical service like emergency vehicles or trains.

Truck Signal Priority projects in Texas are fairly limited in deployment. The Texas Connected Freight Corridor (TCFC) project identified truck signal priority as one application to help improve freight mobility near distribution centers. TTI is also leading a project for TxDOT that will implement truck priority signals on certain critical freight corridors for demonstration purposes. Further details on Truck Signal Priority can be found in the FNTOP Inventory of Existing Conditions Report.

In the context of this strategy, this type of system could be a traffic management response that is employed along intermodal connectors and surrounding freight routes.

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6 Source: Texas Department of Transportation. Managed Lanes - What They Are and Why We Need Them.
7 Source: Texas Department of Transportation. Inventory of Managed Lanes.
2.2.3.3 Advanced Traffic Signal Systems

Many traffic signals in Texas operate in a traditional manner, either using fixed-time or semi-actuated timing plans. This approach is common for agencies across the United States, as it utilizes a traffic signal timing design that aligns with early-adopted standards and is widely understood and managed by traffic engineers. Sequential traffic signals along a corridor may be interconnected through a landline cable or wireless network to ensure that all timing offsets are being followed (i.e. to maintain “green” progression, where established as part of the signal timing plan design). Where traffic signal interconnects exist or are capable of being built, transportation agencies have options to utilize advanced timing capabilities to improve corridor flow beyond traditional time-of-day signal phasing. Two of these options include “traffic responsive” and “traffic adaptive” timing plans.\(^8\)

“Traffic responsive” timing plans are one option that is commonly used on interconnected traffic signal corridors. For these timing plans, several traffic signal plans are loaded onto each traffic signal controller, usually including several time-of-day plans (AM peak, PM peak, etc.) and other event-related information. All signals that are interconnected on this system are typically controlled by a field master controller or a centralized computer system. The field master controller or centralized computer system makes its decisions by reading sensor data and, depending on the thresholds set by the agency, calls the timing plan that best aligns with the reported conditions. “Traffic responsive” timing plans get their name by responding to traffic conditions after they have transpired.

“Traffic adaptive” timing plans are another option that is used in some instances on interconnected traffic signal controllers. For these timing plans, the traffic signal system evaluates the operations at the intersection(s) as reported by the sensor infrastructure, and then selects a custom timing plan that best serves the specific condition. As opposed to “traffic responsive” timing plans, “traffic adaptive” timing plans update their timings in response to real-time traffic conditions, and are able to modify their cycle lengths, offsets, and splits within allowable parameters set by the agency. While most traffic engineers view “traffic adaptive” timing plans as being more robust than others, these types of systems are less common due to cost and complexity.

In Texas, both types of systems have been deployed on the public road network.\(^9\) They are more likely to be installed on signalized arterials where traffic volumes shift dramatically, which generally applies to local community traffic signals. That said, TxDOT adopted the Statewide Special Specification 6293 for an “Adaptive Traffic Signal Control System”, which took effect in August 2018. Establishing this specification standardized adaptive traffic signal control at intersections across the state. While operational type (e.g. isolated


operation, interconnected responsive, interconnected adaptive, etc.) is not quantified as part of a traffic signal inventory, adding these capabilities to an existing traffic signal system is not a complicated undertaking, relative to other major infrastructure investments.

In the context of this strategy, this type of system could be a traffic management response that is employed along intermodal connectors and surrounding freight routes.

2.2.3.4 Dallas Integrated Corridor Management

The US-75 ICM project was an 18-month demonstration project between 2013 and 2014 to implement an ICM system along US-75 extending from downtown Dallas north to SH 121 in Plano, an approximate length of 28 miles. The US-75 corridor is a freeway with one-way parallel frontage roads and connecting arterials, along with 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 transportation system. Following the demonstration period, the Dallas ICM operating agencies continued to use the system.

Although the Dallas US-75 ICM was led by DART, TxDOT was one of the participating stakeholders collaborating on response strategies that ultimately went into the ICM Decision Support System. This ICM project developed a web interface tool called SmartNET that utilizes TxDOT’s existing Center-To-Center (C2C) communication protocols to exchange information between various collaborating agencies. A high-level design for the Dallas US-75 ICM is shown in Exhibit 21.

In the context of this strategy, ICM could be part of how the strategy is operated (technically and institutionally) along intermodal connectors and surrounding freight routes. The processes to select operational plans could be modeled similarly to the Decision Support Systems used to select ICM operational plans.
2.2.3.5 I-10 Corridor Coalition Truck Parking Availability System (TPAS)

As part of a separate effort, and on behalf of the four states of the I-10 Corridor Coalition (Arizona, California, New Mexico and Texas), TxDOT submitted and was awarded an Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) grant application for $6.8 million, with an equal amount of state match, by the USDOT in June 2018. The purpose of the grant award is to deploy the I-10 Corridor Coalition TPAS, which 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 availability signs, existing state 511 and road information system platforms (e.g. DriveTexas), and the development of an I-10 corridor truck parking smartphone application. This application will serve as the basis for anticipated future technology deployments along the I-10 corridor and ensure that information is available to drivers regardless of private sector involvement. Data will also be made available to third-party application providers and websites to promote widespread use of the truck parking...
availability information. In the future, private-sector operated truck plazas may be incorporated into the system and wider options for truck parking dissemination may be developed. An illustration of the high-level concept is shown in Exhibit 22.

In the context of this strategy, this type of system could be part of how the strategy is operated (technically and institutionally) along intermodal connectors and surrounding freight routes. Although TPAS is generally viewed as an application along interstates, the truck staging areas that exist near or adjacent to intermodal connectors could serve as truck parking that would benefit from published real-time parking availability.

Exhibit 22: I-10 TPAS High-Level Concept

Source: I-10 Corridor Coalition Truck Parking Availability System, ATCMTD Grant, Volume 1 – Technical Approach

2.2.3.6 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 FRATIS demonstration and the Dallas-Fort Worth FRATIS prototype. Each FRATIS deployment occurred in different years with different end goals.
For the I-35 Corridor FRATIS, enhancements were made to the TxDOT I-35 Traveler Information During Construction (TIDC) system, which provides information such as pre-construction closures, delay predictions, and near real-time 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.

The FRATIS prototype in Dallas-Fort Worth focused more closely on drayage optimization. This prototype consisted of the following components: optimization algorithms, terminal 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.

In the context of this strategy, this type of system could be a potential public-private partnership opportunity along intermodal connectors and surrounding freight routes if private-sector terminal operators elect to participate in the strategy. Their roles are discussed later in this document.

2.3 Deficiencies of the Current System
The FNTOP State of the Practice Assessment Report and input from FNTOP stakeholders identified several common deficiencies in the existing system.

2.3.1 Asset Preservation and Utilization
As noted in Section 2.2.1.3, TxDOT operates a robust traffic management program through use of ITS devices, primarily real-time assets like CCTV cameras, DMS, and traffic detectors. That said, when looking at the current NHS intermodal connectors in Texas, only 44 have some form of real-time traffic monitoring capability installed on or near them. While this estimate is approximated, it illustrates coverage exists on or near fewer than a quarter of all intermodal connectors in Texas. When an incident occurs on an intermodal connector or adjacent freight route, TxDOT is unlikely to have assets available to monitor, manage, and coordinate a response.

Intermodal connectors that are arterials are also more complex than a traditional freeway system. Arterials with traffic signals and other traffic control devices create additional bottlenecks in traffic operations along the corridor. Historically, public sector agencies have managed arterials through assets like advanced traffic signal systems, discussed in Section 2.2.3.3, but these advanced traffic signal systems require more funding to support their operations than was often available. As such, when these advanced systems are not able to be maintained, significant operational problems often occur, resulting in some practitioners
believing these tools are too complicated to be successful. Organizations that have had success with these advanced traffic management tools generally established multi-agency collaborative bodies and ensured a steady stream of funding. One good example is Operation Green Light\textsuperscript{10} in the Kansas City metropolitan area, which adjusts regional traffic signal timings based on real-time travel conditions.

With the FNTOP focused on improving freight mobility, any technology-based roadway improvements would need to monitor and report on truck volumes in order to recognize if mobility issues are about to occur. WIM is one such tool for detecting the presence of trucks, as well as approximated weights, without disrupting the flow of traffic. VC stations can identify the classification of the vehicle at speed, which can indicate whether a truck is present or not. Data collected from these devices in real-time could inform a transportation management tool of a higher presence of trucks in the traffic stream, allowing activation of a truck-specific signal timing plan that favors freight mobility. The challenge is that TxDOT’s WIM/permanent count station program currently does not report real-time data, as it is used for aggregating historical data for planning studies. That said, shifting to real-time operation for traffic management would not be prohibitive, depending on the application. TxDOT would also need to expand WIM and permanent count stations to more of the intermodal connectors and surrounding freight routes, which—as noted in Section 2.1.5—only provide coverage on two intermodal connector facilities in Texas.

\textbf{2.3.2 Mobility and Reliability}

Investment in traffic management applications has primarily focused on high-volume facilities that serve as a primary trunk line for the THFN. As discussed in Section 2.1.2, this occurs because disruption to trunk facilities would have widespread impacts on the entire network, but—with funding being limited—it often comes at the expense of improving “last mile” connections. Although many of the highway-based last mile routes are still part of a larger TMFN supply chain, they jurisdictionally are viewed as being edges of the system and, thus, fall into the last mile category.

The challenge comes down to rethinking the prioritization of investments in assets that serve a broader goal. To start, Exhibit 23 looks at AADT data for the NHS, splitting between intermodal connectors and other routes. Intermodal connectors are subdivided into those that primarily serve freight (i.e. ports), those that primarily serve passengers (i.e. Amtrak terminals), and those that do both (i.e. airports).

\textsuperscript{10} Source: Mid-America Regional Council. “About Operation Green Light.”
Exhibit 23: AADT Values on NHS Intermodal Connectors and General Routes (Non Connectors) in Texas

<table>
<thead>
<tr>
<th></th>
<th>NHS Intermodal Connectors – Freight Focused&lt;sup&gt;11&lt;/sup&gt;</th>
<th>NHS Intermodal Connectors – Passenger Focused&lt;sup&gt;12&lt;/sup&gt;</th>
<th>NHS Intermodal Connectors – Freight/Passenger Focused&lt;sup&gt;13&lt;/sup&gt;</th>
<th>NHS General Routes (Non Connectors)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average 2018 AADT&lt;sup&gt;14&lt;/sup&gt;</strong></td>
<td>9,160</td>
<td>10,065</td>
<td>17,690</td>
<td>32,650</td>
</tr>
<tr>
<td><strong>Average Truck AADT</strong></td>
<td>1,015</td>
<td>650</td>
<td>1,225</td>
<td>4,475</td>
</tr>
<tr>
<td><strong>Average % of Trucks</strong></td>
<td>11.0%</td>
<td>6.5%</td>
<td>7.0%</td>
<td>13.7%</td>
</tr>
</tbody>
</table>


The analysis in Exhibit 23 represents average volumes and percentages across all NHS facilities in Texas. Other NHS facilities—which include major routes like I-10, I-35, and others—on average carry the highest AADT and AADTT. These facilities represent critical corridors in the state. All three connector categories carry less volumes and lower percent truck traffic. If investment priorities were being established based primarily on volumes or percent trucks, the connectors would likely be overlooked or ranked lower than the main corridors. The other NHS facilities are more likely part of the trunk network than intermodal connectors, meaning they are carrying higher truck volumes that serve other supply chain needs like package delivery, inter-city distribution centers, and long-haul freight routes. The intermodal connectors, with lesser volumes, are primarily serving one identified intermodal facility. In other words, one facility is drawing a large amount of traffic on the intermodal connector, whereas other NHS routes are drawing larger amounts of traffic (on average) to serve a wide variety of facilities/supply chains.

With intermodal terminal facilities being a primary draw for traffic on intermodal connectors, any disruptions to that roadway link can be substantially detrimental to terminal operations. These “last mile” routes often also have limited alternate routes when incidents occur. Incidents along these connectors can create a ripple throughout a much larger multimodal

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<sup>11</sup> Freight Focused Intermodal Connectors include, “Major Pipeline Terminals”, “Major Port Facilities”, and “Major Rail/Truck Terminals”.

<sup>12</sup> Passenger Focused Intermodal Connectors include, “Major Amtrak Station”, “Major Ferry Terminal”, Major Inter City Bus Terminal”, and “Major Public Transportation or Multi-Modal Passenger Terminal”.

<sup>13</sup> Freight/Passenger Focused Intermodal Connectors include “Major Airport”.

<sup>14</sup> Average AADT considered NHS routes with greater than 1,000 AADT, so as to not include segments without traffic data.
transportation system or supply chain. If an agency is only monitoring the performance of its own highway system, that impact may seem minor, but a review of the larger multimodal system would convey more substantial impacts.

### 2.3.3 Safety

As noted in Section 2.1.6, intermodal connectors experience a crash rate that is six times higher than other NHS roadway segments. Every crash has the potential to disrupt roadway operations, leading to delayed arrivals, missed appointments, and fewer freight-related moves that a trucker can make on any given day. TxDOT and its local partners have worked to identify and implement a variety of safety improvements, but many challenges remain. Improvements that reduce this crash rate would help improve the efficiency of intermodal connectors.

Technology has been proven to be a useful tool in helping mitigate safety issues. While TxDOT uses technology in certain cases for safety improvements (e.g. an overspeed detection system), the deployment of this equipment on intermodal connectors is limited. Additionally, with fewer than a quarter of the intermodal connectors having or being near TxDOT-operated ITS assets for traffic management applications, any incidents that do occur may not be managed as promptly as elsewhere on the highway network, resulting in longer durations of disruption.

### 2.3.4 Economic Competitiveness

With the intermodal terminal being by far the primary destination served, intermodal connectors carry a competitive volume of truck traffic relative to other NHS general route facilities. As noted in Section 2.1.3, intermodal connectors are present in counties that account for 70 percent of all freight tonnage moved in Texas, suggesting that they are a vital part of the state economy. Any delays on these facilities can have immediate and direct impacts on a substantial amount of freight moving by truck as well as by other modes. Delayed arrivals limit the ability of these intermodal terminals to provide an efficient exchange of passengers and freight between the modes, which decreases their competitiveness in the marketplace and encourages customers to explore other facilities that are less burdened by transportation issues.

If the status quo is maintained and opportunities to improve traffic operations on intermodal connectors are not pursued, Texas should expect to see more bottlenecks in the multimodal system as freight tonnage increases over the next few decades. Over time, other states with stronger highway ITS programs may find opportunities to provide better intermodal connectivity, decreasing Texas’s economic competitiveness at a national level.

### 2.3.5 Multimodal Connectivity

Multimodal connectivity allows passengers and freight to take advantage of diverse modal options to best serve their mobility needs. Maintaining good connectivity between modes
ensures that efficiencies are captured when moving from one to the other. Last mile roadway links to these intermodal terminals play a key role in this connectivity. Any mobility challenges on these facilities directly impact multiple modes as well as terminal operations, which also impact economic competitiveness.

Some practitioners in the industry argue that modal needs are being transformed by advances in technology. For example, some have made a case that drone delivery will revolutionize supply chain practices. That may be true for neighborhood delivery applications, but many of these advanced technologies are still limited. In reality, heavy freight for long haul trips—which is one of the primary users of intermodal connectors—will likely continue and, as such, intermodal connectors will continue to retain their value on the TMFN; any efforts to improve their efficiencies should therefore be explored.

Similar to economic competitiveness, if the status quo is maintained and opportunities to improve traffic operations on intermodal connectors are not pursued, Texas should expect to see more bottlenecks in the multimodal system as freight tonnage increases over the next few decades. These bottlenecks will curb accessibility to multimodal alternatives, which may encourage use of slower, less competitive freight modes. For example, a freight shipment best served by rail may stay on a truck because access to the rail terminal is excessively congested. Aside from the economic disadvantages with using less competitive modes, other risks—such as an increase of overweight vehicles on the THFN—could occur.

2.4 Profiles of User Classes
The following contains a profile for users and stakeholders that would be involved with the Smart Freight Connector strategy.

2.4.1 TxDOT Divisions
TxDOT Divisions 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.

Several Divisions would be relevant to this strategy. The Traffic Safety Division would likely be involved in any technology used to support this strategy. Since the intermodal connectors are not constrained to one District, they would be instrumental in identifying the need, establishing standardization of deployment, and pursuing internal funding mechanisms to support Districts with interests in deploying this strategy. TPP Division would also be an interested party in identifying where applications deployed as part of this strategy could support its statewide data collection efforts, specifically for new WIM/permanent count deployments. The Maritime Division may be interested, as this strategy could help facilitate development through improved route mobility near maritime facilities. Other Divisions would collaborate on this strategy, based on its relevance to their initiatives.
2.4.2 TxDOT Districts

TxDOT subdivides the state into 25 Districts that have local responsibility over building and maintaining state-owned roads and other applicable transportation infrastructure within their Districts, including ITS devices and systems. Similar to DOTs in other states, not all TxDOT roads are actively managed by TxDOT on a real-time basis, particularly those in more rural settings. These facilities are primarily managed by local and state law enforcement and inspection agencies as well as through traffic management tools, like traffic signals. For these facilities, TxDOT collaborates regularly with these agencies regarding planned construction projects, safety concerns, and other related issues in the longer term.

The Districts would likely be an interested party in determining where any equipment proposed as part of this strategy would be deployed within their Districts. These Districts would collaborate with Divisions to determine ownership, operation, and maintenance of these assets, including those that might be automated. Depending on the infrastructure in question, the Districts may be the best local representative to adopt inter-agency Memorandum of Understanding (MOUs) with local road owners for equipment installed on roads that do not belong to TxDOT.

2.4.3 Traffic Management Centers

TxDOT TMCs manage traffic and incidents on the state-owned road network using data collected from field devices such as traffic sensors and CCTV cameras. These TMCs are often co-located with other agencies and work in collaboration with other transportation groups to manage the transportation system holistically.

The TxDOT TMCs would be an interested party to this strategy in determining where any equipment proposed as part of this strategy would be deployed within their coverage area. With limited resources, TMCs would want to understand how much of the strategy would require active and/or passive operation; TMCs would need to evaluate whether their resources could accommodate additional devices. Since many intermodal facilities are near or within urban areas managed by a TMC, some TMCs would become responsible for new devices and systems. Additionally, TMCs would want to know their roles in terms of being a point-of-contact for system issues and maintenance responses.

2.4.4 Local Communities

Local communities manage non-state owned roads; in some locations, this includes segments of the intermodal connector. Local communities also are focused on needs of their citizens who live and/or work in a particular area. Local communities’ goals may differ from TxDOT’s as they relate to prioritizing freight movements along an intermodal connector. Any freight priorities may be seen as at odds with overall traffic flow and other quality of life goals. Additionally, local communities have to deal with the impacts and consequences of poorly-functioning traffic management tools, traffic congestion on major truck routes, and unauthorized truck parking in neighborhoods due to a shortage of staging lots.
Local communities would be an interested party in this strategy, as they would identify the most prominent drawbacks regarding traffic operations due to an intermodal facility. These drawbacks would help inform the specifics of the strategy, helping focus efforts on key deficiencies, such as parking if a shortage existed or safety improvements if safety was a concern. Local communities may be interested in adopting and managing certain ITS assets, or at least supporting TxDOT’s use of ITS assets on their infrastructure.

2.4.5 Metropolitan Planning Organizations
MPOs oversee regional challenges and work to allocate funding for projects that serve a regional need. Although an MPO must be equitable to all of its communities, it can focus efforts on identifying alternatives that serve the larger good. MPOs also serve as a forum for individual communities to voice their opinions on these alternatives.

MPOs would be an interested party in seeing how this strategy would improve regional traffic operations relative to other endeavors that are under consideration. They would help identify at a regional level which facilities should be prioritized for this strategy, as well as bring all applicable state and local stakeholders to the table. MPOs may be able to solicit funding for this strategy, as well as help establish partnerships.

2.4.6 Intermodal Terminal Groups – Maritime, Railroads, and Others
Intermodal terminal groups represent any public or private entity that manages an intermodal terminal or facility. These groups are responsible for ensuring an efficient exchange of goods and shipments through their facilities. Private sector groups are more profitable when freight exchanges occur efficiently and on time; delays on even one of the transportation modes directly impacts their operations. Most groups operate with a robust schedule in place to ensure a constant flow of freight in and out of their facilities; challenges occur when shipments arrive too late or, in some cases, too early.

Intermodal terminal groups would be an interested party for this strategy because they stand to benefit from a highway mode that operates more efficiently, allowing freight to enter and depart from their facility on a more reliable schedule. Traffic congestion on the last mile segment to their facility can often cause shipments to arrive late, which results in rescheduling issues, missed cut offs, and customer complaints when the delays ripple throughout the system. Additionally, having a solution to better manage early arrivals would help intermodal groups mitigate community impacts; trucks arriving early often elect to park at unauthorized locations in neighborhoods while waiting for their appointment time at the terminal. Some intermodal terminal groups are also interested in exploring opportunities in having more seamless drayage exchange systems in place, such as FRATIS initiatives designed to improve the efficiency of movements in and around these facilities while factoring in traffic issues.
2.4.7 Truckers
Truckers represent a primary end-user of the highway system who are financially affected by the transportation system’s performance. For those who make pickups and drop-offs at intermodal terminals, the number of moves and the efficiency of each move is directly impacted by traffic delays. Additionally, an inability to find proper staging for early arrivals requires truckers to find alternate accommodations, which can sometimes consist of parking in unauthorized locations that present safety concerns and other adverse community impacts.

Truckers would be an interested party for this strategy, as the proposed improvements would create direct and indirect benefits to their operations. Truckers also would offer first-hand experience on the proposed devices and locations, helping TxDOT prioritize strategy components.

2.4.8 Other Users
Other road users also have to deal with disruptions caused by traffic delays on intermodal connectors, primarily those who live or work in the local community. These groups represent passenger cars, transit operators, and other non-freight-related commercial services that have deliveries at or near the intermodal facility. Improvements to traffic operations along these corridors would directly improve trip quality for these users as well.

These other users would be considered end-users for this strategy. Similar to truckers, they would offer first-hand experience of what strategy devices should be prioritized and where, helping TxDOT identify which components of the strategy should receive investment first.

2.5 User Needs
As part of the FNTOP, the User Needs Assessment developed a comprehensive list of User Needs identified through a gap analysis and stakeholder engagement. The specific needs and gaps from the FNTOP User Needs Assessment addressed by this strategy are summarized in Exhibit 24. The assessment prioritized these needs based on relevance, plausibility, and alignment with the 2018 TFMP goals and objectives. The User Needs were divided among seven high-level freight technology areas that were previously established in the FNTOP State of the Practice Assessment Report:

- (T)raffic Management;
- (A)dvanced Traveler Information Systems;
- (D)ynamic Route Guidance;
- (D)ata (I)ntegration and Analytics;
- (E)nforcement and Inspection;
- (C)onnected and Automated Vehicles; and
- (I)ntermodal Terminal Operations.

The naming convention for the user need ID includes the letter code listed above identifying the freight technology area to which it belongs to. For example, in Exhibit 24, UN-T4 represents the fourth User Need for the (T)raffic Management freight technology area. Each User Need is associated with one or more goals from the TFMP and is prioritized as follows:

- **High** – The need is a “must-have” and should be considered essential to the development of the FNTOP.
- **Medium** – The need is a “should-have” or desirable capability for which there is considerable interest, but is not necessarily critical to TxDOT.
- **Low** – The need is a “nice-to-have” or not viable in the near-term.

More information about the FNTOP User Needs and how this strategy can address them is available in the FNTOP User Needs Assessment, as well as the FNTOP Strategies and Conceptual Framework Report.

**Exhibit 24: Affiliated User Needs for Smart Freight Connector Strategy**

<table>
<thead>
<tr>
<th>ID</th>
<th>Preliminary User Needs</th>
<th>Texas Freight Mobility Plan 2018 Goals</th>
<th>Priority</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Traffic Management Freight Technology Area</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UN-T2</td>
<td>Need for toll incentives, congestion pricing, or other incentive programs to incentivize freight to operate on off-peak hours or along less-congested parts of the system.</td>
<td>Economic Competitiveness, Mobility and Reliability</td>
<td>High</td>
<td>Stakeholder Interviews</td>
</tr>
<tr>
<td>UN-T3</td>
<td>Need for more investment in congestion management strategies to address growing traffic.</td>
<td>Economic Competitiveness, Mobility and Reliability</td>
<td>High</td>
<td>Stakeholder Interviews</td>
</tr>
<tr>
<td>UN-T4</td>
<td>Need to develop the Houston-Dallas-San Antonio triangle with new smart technologies to improve operations.</td>
<td>Safety, Economic Competitiveness, Asset Preservation and Utilization,</td>
<td>Medium</td>
<td>Stakeholder Interviews</td>
</tr>
<tr>
<td>ID</td>
<td>Preliminary User Needs</td>
<td>Texas Freight Mobility Plan 2018 Goals</td>
<td>Priority</td>
<td>Source</td>
</tr>
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<tr>
<td></td>
<td></td>
<td>Mobility and Reliability</td>
<td></td>
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</tr>
<tr>
<td>UN-T5</td>
<td>Need for more efficient and dynamic curbside management strategies to manage first and last mile issues.</td>
<td>Economic Competitiveness, Mobility and Reliability</td>
<td>Medium</td>
<td>Stakeholder Interviews</td>
</tr>
<tr>
<td>UN-T7</td>
<td>Need for rural ITS in high-traffic freight areas to help support operations.</td>
<td>Economic Competitiveness, Mobility and Reliability</td>
<td>Medium</td>
<td>Inventory of Existing Conditions, Stakeholder Interviews</td>
</tr>
<tr>
<td>UN-T11</td>
<td>Need for truck only lanes on high-traffic freight routes to handle large freight volumes.</td>
<td>Safety, Economic Competitiveness, Asset Preservation and Utilization, Mobility and Reliability</td>
<td>Low</td>
<td>Stakeholder Interviews</td>
</tr>
<tr>
<td>UN-T13</td>
<td>Need for more urban arterial management to manage freight deliveries.</td>
<td>Economic Competitiveness, Mobility and Reliability</td>
<td>Low</td>
<td>Stakeholder Interviews</td>
</tr>
<tr>
<td>UN-T14</td>
<td>Need for technology to help support emergency evacuation.</td>
<td>Safety, Mobility and Reliability</td>
<td>Low</td>
<td>State of the Practice, Stakeholder Interviews</td>
</tr>
<tr>
<td></td>
<td>Advanced Traveler Information Systems Freight Technology Area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UN-A1</td>
<td>Need for more advanced notice of waiting times at international border crossings and ports to provide awareness to drivers.</td>
<td>Economic Competitiveness, Mobility and Reliability, Multimodal Connectivity</td>
<td>High</td>
<td>State of the Practice, Inventory of Existing Conditions, Stakeholder Interviews</td>
</tr>
<tr>
<td>ID</td>
<td>Preliminary User Needs</td>
<td>Texas Freight Mobility Plan 2018 Goals</td>
<td>Priority</td>
<td>Source</td>
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</tr>
<tr>
<td>UN-A3</td>
<td>Need for more Dynamic Message Signs (DMS) on primary freight corridors to relay traffic information.</td>
<td>Safety, Asset Preservation and Utilization, Mobility and Reliability</td>
<td>High</td>
<td>Inventory of Existing Conditions, Stakeholder Interviews</td>
</tr>
<tr>
<td>UN-A4</td>
<td>Need for more advanced notice of real-time traffic conditions (delays, incidents, construction, weather conditions) to improve routing decisions.</td>
<td>Safety, Economic Competitiveness, Mobility and Reliability</td>
<td>High</td>
<td>State of the Practice, Stakeholder Interviews</td>
</tr>
<tr>
<td>UN-A14</td>
<td>Need for more advanced notice of special events disrupting freight routes for more efficient operations.</td>
<td>Economic Competitiveness, Mobility and Reliability</td>
<td>Low</td>
<td>Stakeholder Interviews</td>
</tr>
<tr>
<td>UN-A16</td>
<td>Need to develop message prioritization and distribute it to certain geo-fenced areas to provide location-specific alerts.</td>
<td>Economic Competitiveness, Mobility and Reliability</td>
<td>Low</td>
<td>State of the Practice, Stakeholder Interviews</td>
</tr>
<tr>
<td>UN-A19</td>
<td>Need to collect weigh-in-motion data in real-time for regional and statewide operations.</td>
<td>Safety, Economic Competitiveness, Mobility and Reliability</td>
<td>Medium</td>
<td>Stakeholder Interviews</td>
</tr>
<tr>
<td>Dynamic Route Guidance Freight Technology Area</td>
<td></td>
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</tr>
<tr>
<td>UN-D3</td>
<td>Need for information on alternative freight-specific routes to improve efficiency on Texas roadways.</td>
<td>Economic Competitiveness, Mobility and Reliability</td>
<td>Medium</td>
<td>Stakeholder Interviews</td>
</tr>
<tr>
<td>UN-D4</td>
<td>Need for more comparative travel time signs (CTT) for freight routes to improve routing decisions.</td>
<td>Economic Competitiveness, Mobility and Reliability</td>
<td>Low</td>
<td>Inventory of Existing Conditions, Stakeholder Interviews</td>
</tr>
<tr>
<td>ID</td>
<td>Preliminary User Needs</td>
<td>Texas Freight Mobility Plan 2018 Goals</td>
<td>Priority</td>
<td>Source</td>
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<tr>
<td></td>
<td><strong>Data Integration and Analytics Freight Technology Area</strong></td>
<td></td>
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<tr>
<td>UN-DI9</td>
<td>Need for data on freight movements to allow for better planning.</td>
<td>Economic Competitiveness, Mobility and Reliability</td>
<td>Low</td>
<td>Stakeholder Interviews</td>
</tr>
<tr>
<td>UN-DI10</td>
<td>Need for certain ITS devices currently used only for TxDOT long-range planning efforts to be upgraded to provide real-time information.</td>
<td>Economic Competitiveness, Mobility and Reliability</td>
<td>Low</td>
<td>Stakeholder Interviews</td>
</tr>
<tr>
<td></td>
<td><strong>Enforcement and Inspection Freight Technology Area</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>UN-E4</td>
<td>Need for more advanced remote monitoring equipment to detect and uniquely identify vehicles over allowable limits on Texas roadways to increase freight compliance to roadway laws by robustly identifying offenders.</td>
<td>Safety, Economic Competitiveness</td>
<td>Medium</td>
<td>Stakeholder Interviews</td>
</tr>
<tr>
<td></td>
<td><strong>Connected and Automated Freight Vehicles Freight Technology Area</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UN-C1</td>
<td>Need for more infrastructure improvements to support automated vehicles (roadway markings, signage).</td>
<td>Economic Competitiveness, Mobility and Reliability</td>
<td>High</td>
<td>State of the Practice, Stakeholder Interviews</td>
</tr>
<tr>
<td>UN-C5</td>
<td>Need for more smart infrastructure to support AVs on the TMFN.</td>
<td>Economic Competitiveness, Mobility and Reliability</td>
<td>Medium</td>
<td>Stakeholder Interviews</td>
</tr>
<tr>
<td>UN-C8</td>
<td>Need for Freight Signal Priority systems to improve freight operations.</td>
<td>Economic Competitiveness, Reliability and Mobility</td>
<td>Low</td>
<td>Stakeholder Interviews</td>
</tr>
</tbody>
</table>
### Assumptions and Challenges

Several key assumptions and challenges would apply to a system that operates as a Smart Freight Connector. These assumptions and challenges are identified in the following sections.

#### 2.6.1 Assumptions

- **All relevant stakeholders find benefit in the strategy** – While improving freight operations to and from an intermodal facility may seem like a benefit, some parties oppose these types of improvements, suggesting that it could lead to negative externalities like induced demand. This assumption is that all relevant parties would agree that
implementation of this strategy on a certain facility is beneficial, which would facilitate good-faith discussions on ownership, operations, and maintenance. This can be most likely to succeed with early discussions and stakeholder collaboration.

- **Strategy is not deployed where bottlenecked** – Deployment of this strategy assumes that corridor selection is made where an actual improvement can be yielded. Some corridors may yield no benefit from this deployment. For example, if a particular corridor has a stop-controlled intersection, providing progressive green lights offers little to no benefit because the stop sign will dictate traffic flow. At that point, the strategy may only help shift traffic queues around the corridor, which may offer marginal benefits. As part of corridor selection process, any geometric, operational, or policy bottlenecks should be identified, and only components that are not constrained should be evaluated and considered so that deployment benefits are properly estimated.

- **Some existing ITS and traffic control field devices/systems could be used** – This strategy would be capable of utilizing existing assets, if relevant and useful. It is assumed that existing assets can be used, regardless of who currently owns/operates them.

- **Strategy can operate on its own** – Although having TMC oversight is advantageous, it is assumed that this strategy has the capability of operating some or all of its features without the need for frequent operator intervention. For example, publishing information about real-time parking availability should be an automated feature.

- **Prioritization can be determined** – It is assumed that criteria can be identified and agreed to as to how intermodal connectors and surrounding freight routes should be prioritized. This would include objective criteria like economic, traffic, or safety-related numbers, as well as subjective criteria like social or community impacts.

- **Focus of this strategy is freight intermodal connectors** – The focus of this strategy is on intermodal connectors that carry freight, as opposed to those that serve passenger needs. Intermodal terminals that primarily serve freight needs include ports, rail terminals, pipelines, and airport cargo facilities. Intermodal terminals that primarily serve passenger needs include airport terminals, Amtrak stations, inter-city bus facilities, and ferries. While many of the freight-based technology applications can also benefit passenger vehicles, the emphasis of value is focused on freight transport.

### 2.6.2 Challenges

- **Interagency cooperation is a must** – Interagency cooperation on this strategy is critical for its success. Local communities that have residents who live and/or work adjacent to this system and may be users of it must be engaged. Building and maintaining support for the strategy will help stem public opposition to the improvements. Establishing clearly-defined MOUs will help agencies understand their roles and coordination responsibilities. Ensuring that each party has well-defined and funded maintenance capabilities will ensure that the system does not break down. This can be a challenge
over time; with rotating administrations in each public agency, funding priorities can change.

- **Intermodal terminal facility cooperation is strongly recommended** – The intermodal terminal facility owners should only benefit from the implementation of this strategy, but the success of this strategy may be limited by terminal-specific bottlenecks. For example, progressive green lights to minimize queues offers minimal or no benefits if the intermodal facility’s gate has an oversaturated queue on a regular basis, effectively becoming the bottleneck. The challenge is that, while most intermodal terminal facility owners will be happy to see public funds used for roadway improvements, they may not feel incentivized to improve their own operations for improving the public good. Establishing early conversations and commitments may aid in mitigating this challenge.

- **TxDOT maintenance of ITS assets that are off the freeway network** – Existing TxDOT maintenance contracts may not be set up to effectively maintain ITS assets that are located off of the traditional freeway network, where most ITS assets are currently located. If deployment of this strategy occurs on a TxDOT road, this may require modifications to funding for personnel to service remote assets outside of a defined maintenance area, or the establishment of MOUs with local partners to maintain these assets. Since maintenance funding is already a challenging topic, modifying or creating new maintenance protocols and agreements may not be easy.

- **Limited expertise with new system equipment** – The new system may require TxDOT to add equipment that may not be part of the current ITS program, which would require additional training for its staff or the maintenance staff defined in an MOU.

- **Integration of the strategy into existing traffic management platforms** – Each TxDOT District with a TMC has their own deployment of LoneStar (and RIMS at Houston TranStar) and more rural TxDOT Districts without TMCs may still be using vendor-specific software to control their ITS devices. Since there is no consistent traffic management platform statewide, the integration of new systems may be straightforward for some and more difficult for others. Additionally, this strategy may be operated by another standalone system that is independent of LoneStar, similar to SmartNET used for the Dallas ICM. Multiple systems can become burdensome to manage and maintain.

- **Accessing ROW for ITS equipment installation on non-TxDOT property** – If TxDOT is the maintainer of the system, MOUs will need to be established to permit state maintenance personnel or contractors to access local property if equipment is not on state-owned public right of way. If some equipment is housed inside of local-owned equipment (e.g. traffic signal controller cabinets), the roles and responsibilities will need to be more clearly defined. If any TxDOT equipment is on private property, such as TPAS equipment in a port-owned staging area, this agreement will need to be more robust. Complicated agreements require a more extensive effort to be successful, which can be a significant challenge until boilerplate language has been developed and accepted.
Some parts of the strategy can be costly – ITS field equipment can be costly, depending on how many sites for each system are deployed. If any operational improvements (i.e. truck priority lanes) require infrastructure in addition to technology, costs could quickly increase, especially if right of way is limited.
3.0 Concept for the Proposed Smart Freight Connector

This section describes the proposed system. It provides an overview of the objectives; discusses ConOps essential features, capabilities and functions; and outlines the system-level operational environment, processes, and necessary support. The level of detail presented is intended to explain how the proposed system is envisioned to fulfill the user needs and requirements.

3.1 Objectives

The Smart Freight Connector strategy aims to implement traffic management technologies on last-mile corridors that will efficiently manage operations along key freight routes that lead to intermodal facilities. At a high level, this strategy will collect comprehensive traffic and freight-related data (e.g., volumes, speeds, occupancies, percentages of trucks, etc.) to determine the operational performance along a corridor. When needed, the existing arterial traffic signal system will be adjusted to better accommodate freight traffic. Where truck staging areas are available, this strategy will instrument the facilities with parking detection equipment in order to provide truckers with real-time parking availability options prior to their arrival. For certain routes, specific travel lanes could be operationally repurposed to provide dedicated truck travel lanes, such as for AVs that drive exclusively between intermodal terminals and staging lots. The goals of this strategy would be to help improve mobility, safety, and efficiency for trucks on last-mile connections to intermodal facilities.

Exhibit 25 provides an illustrative example of the Smart Freight Connector strategy that was previously discussed in the FNTOP Strategies and Conceptual Framework Report.
3.2 Description of ConOps Essential Features, Capabilities, and Functions

This section describes the proposed system and improvements, based on the components identified earlier. The descriptions are provided at a high-level, indicating the operational features and functionalities without specifying design details or technology-specific solutions.

The main features and functions of the Smart Freight Connector strategy are discussed in Exhibit 26.

**Exhibit 26: Smart Freight Connector Features and Functions**

<table>
<thead>
<tr>
<th>Features</th>
<th>Main Functions</th>
<th>User Need(s) Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real-Time Freight Traffic Data Collection</td>
<td>Traffic detectors and Weigh-in-Motion stations would collect traffic and freight data in real-time to determine the performance of operations along Smart Freight Connectors.</td>
<td>UN-T4, UN-T5, UN-T7, UN-T14, UN-A1, UN-A4, UN-A19, UN-E4,</td>
</tr>
</tbody>
</table>
### Features

<table>
<thead>
<tr>
<th>Features</th>
<th>Main Functions</th>
<th>User Need(s) Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>This information would be used for real-time traffic management strategies, as well as performance monitoring.</td>
<td></td>
<td>UN-DI9, UN-DI10, UN-I1, UN-I6, UN-I7</td>
</tr>
<tr>
<td><strong>Real-Time Traffic Signal Phasing and Timing Updates</strong></td>
<td>This feature would allow for signal phasing and timing improvements for freight, prioritizing signal timings in favor of freight movements upon detection of high freight demand. Progressive green lights along a corridor would reduce inefficiencies from stopping and starting. Increased yellow light intervals can increase safety when applicable for freight—such as during high freight demand or inclement meteorological conditions—by improving their chances to clear an intersection prior to the red light.</td>
<td>UN-T3, UN-T4, UN-T7, UN-T14, UN-A19, UN-C5, UN-C8, UN-I3</td>
</tr>
<tr>
<td><strong>Real-Time Truck Parking Availability System (TPAS)</strong></td>
<td>Truck staging areas would be instrumented with parking detection sensors to monitor real-time parking usage in the lot. These sensors would broadcast the remaining availability to truckers via highway signs.</td>
<td>UN-T3, UN-T4, UN-A16, UN-C5, UN-I3</td>
</tr>
<tr>
<td><strong>Dedicated Truck Priority Lanes</strong></td>
<td>Dedicated truck priority lanes would be a regulated operational improvement to permit use of the lane by certain freight vehicles, such as AVs.</td>
<td>UN-T3, UN-T4, UN-T11, UN-T13, UN-T14, UN-C1, UN-C5, UN-C8, UN-I3</td>
</tr>
<tr>
<td><strong>Facilitation of Future Drayage Optimization Services</strong></td>
<td>Private-sector terminal managers would potentially collaborate with TxDOT to optimize drayage appointments, which could couple with the Smart Freight Connector to align with the USDOT FRATIS program.</td>
<td>UN-I3, UN-I9</td>
</tr>
</tbody>
</table>

Since this system relies on technological processes, the general framework follows the requirements for a successful ITS program. At a high level, a successful ITS program requires 1.) a means to collect data, 2.) a means to process the data, and 3.) a means to distribute that data to the targeted user group. As long as this process is followed, this system will have the necessary building blocks to succeed.
The following sections examine several key components to consider as part of the Smart Freight Connector strategy. The intent is not to define one strategy as the sole approach for all components, but rather outline the key characteristics so that a given strategy can be correctly applied to a situation. The following processes are discussed in the following sections:

- Data Collection;
- Data Processing; and
- Information Distribution.

### 3.2.1 Data Collection

Data collection methods for this system aim to:

1. Collect traffic and freight-related data to determine the performance of operations along last-mile corridors;
2. Instrument truck staging areas where available, with parking detection sensors to determine truck parking availability;
3. Detect heavy vehicle volumes at signalized intersection approaches in order to implement real-time green time extension (e.g. for truck platoons, peak periods for truck traffic); and
4. Detect conditions that may warrant increased yellow times at signalized intersections (e.g. high-crash intersections, inclement weather, oversize/overweight moves, etc.).

Various components to support some or all of these information elements are discussed in the following sections. These components are conceptual in order to illustrate certain general ideas, but other options could feasibly serve the same role.

#### 3.2.1.1 Traffic Detectors

This component would detect and report on whether a vehicle is present within a certain zone, as well as aggregated vehicle volume and classification information. These detection units would typically cover a single point of a road where the device is installed and be applicable for freeway or arterial environments. Presence detection would identify excessive queuing and slow-moving traffic, and aggregated volumes and vehicle classifications would document travel demand and truck percentages. This information would be collected and reported in real-time for use by the processing components in order to determine if action needs to be taken.
Various options exist for collecting this information. Many traditional ITS detector units would apply, such as microwave radar, loop detectors, or video processing. The preferred technology for collecting this information would depend on the specific operating environment, including available right of way, easements, and roadway geometrics.

3.2.1.2 Weigh-in-Motion/Permanent Count Stations
This component would capture and record axle weights and gross vehicle weights as vehicles drive over a measurement site. This would occur at-speed, which means vehicles do not need to come to a stop. This component would be similar to the existing TxDOT WIM and permanent count stations program, except this equipment would be modified to collect and report data in real-time. Similar to the vehicle detection sensors, aggregated vehicle weights and classification information would quantify travel demand and truck percentages (small or large number or trucks) to be used by the processing components to determine if action needs to be taken.

The options for collecting this information are based on the WIM and permanent count stations used throughout Texas; current practices and equipment would be modified to gather and report data in real-time. The preferred technology for collecting this information would depend on available right of way, easements, and roadway geometrics.

3.2.1.3 Parking Sensors
This component would determine parking utilization and availability within a parking lot, such as within a truck staging area along an intermodal connector or a truck parking lot at a Safety Rest Area near an intermodal connector. Similar to other TPAS initiatives, this component would assess parking utilization through either a.) counting entries and exits into the lot and determining the utilization through the difference, or b.) count utilization in each parking stall in order to determine utilization for the entire parking lot. The parking utilization would be reported to the processing system in order to provide insight on parking availability.

Various options exist for collecting this information. The components may be in-ground, surface-mounted, or overhead vehicle detection sensors. The preferred technology would depend on site terrain and the layout of the truck staging areas.

3.2.1.4 Road Weather Information Systems (RWIS)
This component would measure atmospheric, meteorological, pavement, and/or water level conditions. This component would report real-time road weather information at the site, which would be utilized by the processing components to determine if localized conditions are not favorable and warrant some kind of action.

Traditional RWIS equipment has been used by TxDOT in the past, but has fallen out of favor for traffic management applications due to the widespread availability of National Weather
Service data. That said, spot location data has remained useful in many states; for example, a local pavement condition sensor is often used to determine if icing has occurred on bridges, which can trigger a local flashing beacon to warn drivers of inclement conditions. In the context of the Smart Freight Connector, this component would inform the processing components of undesirable meteorological conditions (e.g. low visibility, icing, rain, etc.) that necessitate a traffic management action. While local field devices may seem advantageous, opportunities may also be available to utilize National Weather Service or third-party meteorological data as well.

3.2.1.5 Connected Vehicle Roadside Units
This component provides wireless communications from roadside infrastructure to vehicle On-Board Units (OBU). Roadside units (RSUs) engage with the OBUs of vehicles to receive vehicle travel information, which may include vehicle location, speed, and heading if current draft industry standards are adopted and deployed. This information would be utilized by processing components to identify low travel speeds and queuing to determine if corrective action was warranted from a traffic management perspective.

The component would likely be a CV RSU that aligns with SAE J2735 or other adopted message sets and communications standards, similar to equipment utilized by TxDOT as part of the Texas Connected Freight Corridor project and other CV initiatives.

3.2.1.6 Third-Party Traffic Data Services
With the increase of mobile data, several third-party vendors—including INRIX, HERE, American Transportation Research Institute (ATRI), and Waze—offer traffic data services that provide real-time conditions across an extensive roadway network. These services are commonly used to monitor the movement of probe and location-based data in order to synthesize and estimate travel conditions along particular roadway segments. While this third-party data has varying degrees of accuracy, in the context of this system, it provides an acceptable high-level assessment of travel performance for use by many transportation agencies to support the determination of travel times and truck parking demand, and to inform transportation planning and investment decisions.

TxDOT selectively subscribes to third-party traffic data as part of its larger data collection effort. This provides high-level coverage (e.g. “red-yellow-green” travel conditions) for the vast majority of TxDOT routes throughout the state. This component would include any high-resolution data on traffic operations that can be gathered along the intermodal connector and surrounding freight routes. It would report traffic conditions to the processing component so that, if poor conditions are present, the processing unit would take action.

3.2.2 Data Processing
Data processing methods for this system aim to:
1. Adjust the arterial traffic signal system based on real-time inputs to better accommodate freight traffic, such as prioritizing green movements (i.e. green lights) in one direction or extending yellow clearance times (i.e. yellow lights) for slower trucks to successfully clear an intersection;

2. Estimate and publish real-time parking availability options prior to truckers’ arrival; and

3. Facilitate the incorporation of other FRATIS components, where available.

Components to support some or all of these information elements are discussed in the following sections. These components are conceptual in order to illustrate certain general ideas, but other options could feasibly serve the same role.

3.2.2.1 Arterial Traffic Management System
This component would collect and analyze data from traffic sensors regarding vehicle volumes, occupancies, speeds, weights, and classifications along the intermodal connector and surrounding freight routes. Based on pre-determined algorithms, this system would issue a recommendation for signal timing changes to improve operations. This could be in the form of a traffic responsive or traffic adaptive signal timing plan, based on the configuration and setup of the traffic signals. Additional changes could include changing timing plans to those with increased yellow clearance times, such as during periods of heavy rain or slick roadways.

This component would need to be connected to many data collection and data distribution components. It may be part of a centralized ATMS in a TMC, but is more likely to be a standalone processing unit that resides in the field. Features may be added to provide real-time notifications of active traffic management plans to a TMC, either reported through the ATMS or through a standalone piece of software. Even though the timing plans will need to be set up prior to activating this component, this component will likely operate with automated features, with no operator input required. This is similar to master field controllers for traffic signal systems, but this strategy envisions expanding capabilities to include a greater number of signal timing plans based on the wider degree of inputs (i.e. sensors) generated.

3.2.2.2 Truck Parking Availability System
This component would collect and analyze data from parking detection sensors regarding utilization of truck staging areas or other truck parking areas. Based on pre-determined algorithms, it would assess utilization and report that information to information distribution components. It would also manage any reported component failures and adjust reporting to maintain a high level of accuracy.

This component may be part of a centralized ATMS in a TMC, but could instead be a standalone software that operates on its own. Depending on the state of TPAS in Texas,
some existing system architectures may be able to accommodate the processing of these parking lots.

### 3.2.3 Information Distribution

Information distribution for this system aims to:

1. Adjust signal phasing and timing plans in real-time;
2. Publish travel conditions, parking availability, and other intermodal terminal information along the corridor on Dynamic Message Signs; and
3. Deploy CV-related safety and mobility applications for broadcasting data upon national adoption of CV-related technologies.

These components are conceptual in order to illustrate certain general ideas, but other options could feasibly serve the same role.

#### 3.2.3.1 Traffic Signals

This component would provide updated traffic signal timings, based on instructions issued by the processing components. It would either change the traffic signal timing plan that resides on the controller (if traffic adaptive) or submit a call request for a preset timing plan that resides in the controller’s memory banks (if traffic responsive). The existing traffic signal controller would ultimately need to verify that this new timing plan is in accordance with its allowable parameters, which would be checked upon receipt, in order to ensure motorist safety. Existing safety equipment (e.g. conflict monitors) in the traffic signal controller cabinet would not be changed.

The expectation is that the new traffic signal timings would either improve operations by redistributing “green” time (i.e. giving longer green lights to freight movements that need it) or increasing the “yellow” interval (i.e. increase the yellow light time) to improve clearance times. When the processing unit determines that operations have returned to normal, the traffic signal would receive instructions to return to the original signal timing plan.

#### 3.2.3.2 Roadside Traveler Information Signs

This component would publish real-time parking availability and other traveler information, as reported by the processing components and other services. These would likely come in the form of TPAS signs—likely of a consistent design as those adopted by the other TxDOT TPAS initiatives—or DMS, depending on the specific application. Road users would see the signs and make informed decisions based on the presented information.

#### 3.2.3.3 Connected Vehicle Roadside Units

This component would broadcast real-time parking availability and other traveler information, as reported by the processing components and other services. It is similar to the roadside traveler information signs component, but would utilize CV-related technologies to wirelessly broadcast this information to vehicle OBUs. This component would likely be a
CV RSU that aligns with SAE J2735 or other adopted message sets and communications standards, similar to equipment utilized by TxDOT as part of the Texas Connected Freight Corridor project and other CV initiatives.

3.2.3.4 ATIS/DriveTexas
This component would bridge a communications feed from the processing components to TxDOT’s ATIS platform (DriveTexas) to publish parking availability information and other traffic data generated by this strategy. This component would likely consist of an API that connects between any processing component and the DriveTexas interface. Some work may need to be done to connect these data streams to the DriveTexas platform. Some of this work may be completed as part of other initiatives, such as parking information being integrated as part of other TxDOT TPAS efforts.

3.2.3.5 Statewide Traffic Analysis and Reporting System
This component would bridge a communications feed from the processing components to TxDOT’s STARS II platform so as to automatically publish any WIM and permanent count data that comes from this strategy. This component would likely be an API that connects between any processing component and the STARS II interface. If a mechanism to load data automatically is not developed during deployment of this strategy, this component may aid in developing that type of platform or at least providing a resource where TxDOT can continue the existing practice of loading data into STARS II.

3.3 Conceptual High-Level System Architecture
The physical elements of the Smart Freight Connector are shown in the systems diagram in Exhibit 27. The diagram illustrates how the system elements, such as roadside WIM and traffic signals, are integrated with the processing components. New truck parking sensors and signs would utilize the truck parking management system that TxDOT is likely to procure as part of separate efforts (e.g. I-10 TPAS). The new processing components will interface with the ATMS to provide alerts and notifications to TMC operators who might oversee the system. System logs, detector status, and notification events are archived for reporting purposes, either as part of the ATMS database system or in a separate system. The WIM/permanent count data would be archived in the TCDS and accessible through the STARS II website. Drayage optimization—if pursued—would be developed through private sector systems and would likely interface separately with users, although the systems would likely work together.

Exhibit 28 illustrates the information flows from the field elements of the Smart Freight Connector to the various users. The users associated with the Smart Freight Connector are identified in the diagram, as well as the dissemination methods to provide notification alerts to freight vehicle operators and the traveling public.
Exhibit 27: Systems Diagram for the Smart Freight Connector Strategy

- Traffic Detectors (inc. 3rd party data, CV RSUs)
- Meteorological Data (RWIS)
- Weigh-in-Motion Sensors
- CCTV Cameras
- Truck Parking Sensors

Smart Freight Connector Data Collection Devices

Arterial Traffic Management System

Advanced Traffic Management System

Truck Parking Management System

Traffic Signals

Dynamic Message Signs (DMS)

Connected Vehicle RSUs

STARS II

DriveTexas

Truck Parking Availability Signs

FRATIS Drayage Optimization

Intermodal Facility Operators

TxDOT Processing Systems

Smart Freight Connector Information Distribution

Legend: Existing System | New System
Exhibit 28: Data Flow Diagram for the Smart Freight Connector Strategy
3.4 Modes of Operations

Four modes of operation for the Smart Freight Connector are identified and described in this section:

- Normal Operational Mode;
- Routine Maintenance Mode;
- System Failure Mode; and
- Notification Mode.

The primary mode of operation of the Smart Freight Connector is the **Normal Operational Mode**. In the field, ITS devices, truck parking sensors, and WIM and permanent count stations would function remotely and monitor operations on the corridor. These devices would transmit status signals periodically to the central processing system, which may relay status information to the TMC where operators would view information. Data on axle weights and vehicle classification captured by the weight detection sensors deployed at WIM station sites would be archived in the TCDS and accessible through the STARS II website.

In the **Notification Mode**, the roadside controller would be triggered by data from the traffic detectors and WIM stations that certain pre-programmed thresholds have been exceeded. The roadside controller would issue pre-programmed commands to the traffic signal controllers to request specific timing plans, phasings, and offsets that best reflect the current corridor conditions. This notification would be transmitted to TxDOT as status information so that interested personnel would know which corridor program is in operation. Truck parking systems would continue to collect utilization data without disruption. When the roadside controller determines that conditions have fallen back below the pre-programmed threshold, it would issue a command to return to normal operations.

In the **Routine Maintenance Mode**, some or all of the system would be taken off line. Any roadside elements that are part of the Smart Freight Connector would be maintained based on a defined schedule according to TxDOT specifications and requirements. Preventative maintenance would be performed to clean DMS and truck parking signs, test, and calibrate WIM and permanent count sensors and inspect communication devices. During routine maintenance, any part of the system not taken off line would continue to operate like normal. Any equipment that is dependent on information from an offline device will have an automated default response. For example, traffic signals will continue to operate, but will return to a default time-of-day plan.

In the **System Failure Mode**, a break in communications or a malfunctioning device would trigger an error message that alerts TxDOT. If the failure only affects communications between the roadside controller and the TMC, all devices would continue to function locally,
TxDOT will be alerted to the failure and would not be aware of system status until the failure was fixed. If the failure affects communications between the roadside controller and other assets, each asset will transition to an automated default response. For example, if truck parking availability cannot be computed at the staging lots, the roadside signs will display a default message, such as “XX”, to convey that no information is available. Upon detecting a system failure, TxDOT would initiate troubleshooting according to Standard Operating Procedures (SOPs).

3.5 Support Environment
This section identifies the major elements in the information technology (IT) environment that would support the operations of the Smart Freight Connector strategy. The expected resources (e.g. hardware, software, networking, and business processes, etc.) are described as follows:

- TxDOT-owned ITS devices deployed under this strategy (including WIM and permanent count stations) would be integrated into the IT environment. This includes the roadside controller that provides information to TxDOT.

- Any TxDOT-owned TPAS systems and sensor infrastructure deployed under this strategy for truck staging areas along intermodal connectors and surrounding freight routes would operate under a separate subsystem, similar to the infrastructure in place for other TxDOT TPAS efforts.

- Persistent data such as device configuration parameters and network addresses would be archived and maintained in accordance with enterprise IT policies on data retention.

- The new Smart Freight Connector subsystem would utilize current TxDOT communication protocols to exchange requests, responses, and messages with other subsystems and applications.

- User security would be administered using assigned accounts with password protected access in accordance with existing IT security policies and procedures that are applicable to the IT environment of the ITS program.

- Tools and methods to secure data such as encryption would be done so in accordance with enterprise IT policies on information security.

- District IT administrators would maintain servers, applications, and networks associated with the operation of the ATMS. Preventative maintenance would be performed at scheduled intervals and technical support would be provided to TMC operators and other users in accordance with organizational IT policies and procedures.

- The TCDS and the STARS II website would provide a data archiving, analytics, and reporting platform to allow access to the WIM/permanent count data collected on Smart Freight Connectors.
4.0 Benefits, Impacts, and Alternatives to the Smart Freight Connector

The purpose of this section is to identify the benefits and impacts created with the deployment of this strategy. This section also identifies alternative options to this strategy and notes their respective drawbacks relative to the strategy proposed in this ConOps.

4.1 Benefits

This subsection summarizes the key benefits that TxDOT should expect from deployment of this strategy. From a benefits perspective, the implementation of this strategy would have the following impacts:

- **Improved Freight Mobility for Trucking Fleets** – A comprehensive Smart Freight Connector that collaboratively strategizes to move traffic efficiently would improve mobility for trucking fleets that utilize the corridor. If coupled with a private-sector drayage optimization service, this could further reduce lost time due to idling, delay, or empty movements.

- **Improved Economic Competitiveness for the Texas Freight Industry** – A comprehensive Smart Freight Connector would improve economic competitiveness of the Texas freight industry by reducing bottlenecks on intermodal connectors and surrounding freight routes that delay deliveries and reduce a driver’s available HOS due to wasted time stuck in traffic. This would translate to an increase in on-time deliveries along the THFN, which would have positive effects on the rest of the TMFN.

- **Increased Corridor Throughput through Better Traffic Control** – Aligning “green light” progression along a corridor to fit real-time truck movements would improve operating efficiency, reduce fuel consumption by limiting the number of stops and time spent idling, and increase on-time arrivals at the intermodal facility. The presence of dedicated truck-only lanes—either for transiting the corridor or bypassing certain delays—would improve efficiency for trucks approved to use the lane.

- **Better Accommodation of Early Arrivals** – Providing real-time parking availability information at staging lots near intermodal facilities would allow truckers to make informed parking decisions if they are early for their appointment window at the intermodal terminal. The real-time availability would help them recognize which lots were available, or if alternative parking options should be explored when still several miles from the intermodal terminal. This would reduce circulating trucks and minimize unauthorized parking of trucks in adjacent community neighborhoods.

- **Improved Safety** – By providing traffic control devices that respond in real-time to traffic conditions, opportunities to improve safety can be realized. Increasing the yellow phasing when truck volumes are high could help reduce crashes by giving slower trucks sufficient time to clear the intersection. By adjusting “green light” progression in real-time based on the truck volumes, excessive queueing at traffic signals can be reduced or
mitigated, reducing the likelihood of back-of-queue collisions. Additionally, by providing real-time information about parking availability at truck staging lots, truckers can make informed parking decisions in lieu of parking in unauthorized—and potentially unsafe—locations.

- **Societal Benefit of Improved Operations** – The intermodal connectors and surrounding freight routes primarily serve freight movements, but they also accommodate residential, commuter, and other commercial trips that facilitate economic activity in the region. Although traffic congestion is generally an accepted reality, communities are much less willing to accept excessive congestion caused by high truck volumes along intermodal connectors providing access to intermodal terminals in mixed use communities. The slower starts and stops, vehicle noise and emissions, and conflicts with other roadway users can result in community opposition. In many instances, travelers will search for alternate routes, which can detract from the economic potential of the area. By improving real-time operations on the intermodal connector and surrounding freight routes, the host community may see benefits as the environment is viewed more favorably by motorists, potentially encouraging investment in land use along these corridors.

### 4.2 Impacts

This subsection describes the impacts that TxDOT and its stakeholders should expect as a result of the strategy’s deployment. First, impacts to the operational and institutional policies and constraints are highlighted, which TxDOT should review as part of the planning process for this strategy. It then highlights the operational and organizational impacts that TxDOT should expect during deployment, as well as any impacts incurred as a result of development. Lastly, it documents the expected impacts to stakeholders.

#### 4.2.1 Policies

The following summarizes some of the key operational and institutional policies to support system development:

- **Traffic Management** – The system shall be consistent with TxDOT SOPs for TMC activities and tasks. The system must not interfere with the operations of the TMC, and operator involvement must be minimal (e.g. infrequent confirmation that the components are all online).

- **Data Sharing** – The system will comply with TxDOT agreements for sharing data with regional TMCs, external agencies, and third parties.

- **Operational Uptime** – Any system investment should be in operation 24 hours per day, seven days a week, 365 days per year, as time spent offline will decrease the user’s perceived value of the system. The system must utilize equipment that can fail in isolation so as to not take the entire system offline for a minor outage.
**System Architecture Design** – The deployment of Smart Freight Connectors will require flexibility in the system architecture design to respond to changing conditions, improved technology, and other technological developments. The design should include updating existing data formats and communication protocols to industry standards, as applicable.

**Compliance with Communication Standards** – This strategy will utilize the latest adopted communication standards in the transportation industry, which may include the CV application standards (among DSRC, C-V2X, other later adopted protocols, or a hybrid of each) or more traditional sources like Bluetooth, RFID, Wi-Fi, or others.

**Compliance with Design Standards** – The system must utilize infrastructure that is designed in compliance with any applicable design standards or guides, including the American Association of State Highway and Transportation Officials (AASHTO) A Policy on Geometric Design of Highways and Streets, the AASHTO Roadside Design Guide, the Texas Manual on Uniform Traffic Control Devices (TMUTCD), and applicable Texas design guides.

**Data Quality, Latency and Reliability (parking availability, traveler information posted on DMS)** – The system shall provide data in a timely manner to provide end-users with current information. Any information dissemination devices on Smart Freight Connectors shall provide reliable data to drivers.

**Data Security and Privacy** – The system will comply with any legal requirements for the protection, security, and privacy of data provided by and shared with stakeholders during system development, testing, and implementation. The system will not compromise any personally identifiable information (PII).

**Driver Distraction Laws** – Applications will be designed in a fashion that prevents potential safety hazards from distracted driving. For instance, any roadside signs will follow design standards established in the TMUTCD.

### 4.2.2 Constraints

The following summarizes some of the key operational constraints of system development:

- **Budget Constraints** – Funding is limited, which means a full-measure solution may not be attainable at the initial deployment. Additional funds will be necessary to expand the system beyond the initial deployment.

- **Maintenance** – The system will include ITS hardware that will need maintenance and replacement. This will require TxDOT staff or a TxDOT-funded maintenance contractor to dedicate time for system upkeep.

- **ATMS Integration** – New processing components for this system are not currently integrated into the ATMS platform. TMC operators would have to be able to view status and messages from connected infrastructure, as well as real-time information from WIM/permanent count stations.
- **Limited ROW** – This strategy may involve the placement of equipment at locations that are off of TxDOT ROW. TxDOT Districts may engage in MOUs with local communities for efficient management of equipment.

- **Limited ITS Deployment** – ITS assets, such as CCTV cameras, can support efforts to remotely monitor a situation as it unfolds, but their deployment is often along major urban corridors with peak-hour commuter traffic. It is possible that devices and components supporting the Smart Freight Connector would not be near existing ITS assets.

- **Coordination with the intermodal facility (e.g. ports)** – Since the Smart Freight Connector will be deployed on last-mile corridors that service intermodal facilities, some features will only be fully beneficial if the intermodal facility also participates, such as by offering expanded drayage information or optimization tools through a FRATIS initiative, establishing a gate queue management service, or implementing other reservation systems. However, involvement of the private sector will be dependent on supporting their business needs, which may be prioritized elsewhere and be outside of TxDOT’s control.

- **Non-freight modes cannot be neglected at signalized intersections, even during peak freight travel times** – Some of the Smart Freight Connector technology aims to increase freight efficiency on last-mile corridors, especially during peak hours, but this may come at a cost to non-freight traffic (e.g. waiting longer at red lights). To minimize negative public perception, a careful balance must be found between competing modes.

### 4.2.3 Operational Impacts

From an operational perspective, the implementation of the Smart Freight Connector strategy would have the following impacts:

- **Standalone Responsive Capabilities** – Many of these features can be set up to operate as part of a closed-loop system, with all agreed-to response plans and countermeasures set up prior to the system going online. While there are many advantages to integrating it back into the TxDOT ATMS platform, it does not necessarily have to be. This is advantageous because it reduces the requirement for a TMC operator—either at TxDOT or some other agency—to continuously monitor the performance of the system.

- **Optimized Drayage Exchange If Coupled With Intermodal Terminal Operating System** – A successful FRATIS deployment requires a drayage optimization application in addition to a dynamic travel planning and performance application. Many benefits will be gained by improving transportation system performance on the intermodal connectors and surrounding freight routes, but those benefits increase dramatically when incorporating a drayage optimization application at the intermodal terminal itself. While this ConOps does not dictate that drayage optimization occur for this strategy to be successful, it does identify an opportunity to collaborate with the private sector to help build this program.
Increased Operational Data Coverage on Non-Freeway Routes – TxDOT’s highway network—particularly in urban areas—has an extensive ITS program for collecting, processing, and distributing traffic information. Implementation of a data-rich program like a Smart Freight Connector on an intermodal connector and surrounding freight routes would expand that data coverage off the freeway network, allowing future uses of this data to make informed planning and design decisions.

4.2.4 Organizational Impacts
From an organizational perspective, the implementation of the Smart Freight Connector strategy would impact both the public and the private sector.

4.2.4.1 Public Sector
The Smart Freight Connector would represent an effort by TxDOT to focus its real-time traffic operations program on localized issues that have immediate and wide-reaching impacts beyond the highway mode. In addition to simply improving multimodal connectivity, this project would be an opportunity to collaborate with local transportation agencies to improve traffic operations. Depending on the intermodal connector in question, TxDOT may be able to aid the local community’s ITS program by funding technology that could be used on their infrastructure.

Depending on organizational agreements, TxDOT’s operations and maintenance costs may increase to support this system, which may necessitate training staff to service any new or unfamiliar technology that is deployed. The local transportation agency—if adopting the equipment—may also be responsible for operations and maintenance. Outside of transportation agencies, local law enforcement may need to increase their efforts to enforce any new regulatory requirements, such as a managed truck-only lane for certain qualified vehicles.

As an additional benefit, deploying the Smart Freight Connector would be an opportunity for TxDOT to collaborate with intermodal terminal operators. With public funds being used to improve mobility into their facility—which in turn increases economic revenue—there may be an opportunity to explore a private-sector contribution that improves freight mobility in the region. Although TxDOT participates in many forums with the private sector, having a real-world project in consideration can help facilitate actionable investment on both the public and private side of freight mobility.

4.2.4.2 Private Sector
The Smart Freight Connector would improve the operational efficiencies of private sector users, both the truckers on the road, the operators at the intermodal terminal, and the other for-profit transportation modes that move goods into and out of the terminal. Organizational impacts should be minimal to these groups, and their benefits would be increased revenues resulting from improved efficiencies. Intermodal terminal operators could be more
significantly impacted by this strategy if they opted to support TxDOT in a larger FRATIS application by providing a drayage optimization component. These operators—who would likely benefit from a drayage optimization tool—would have to determine how it would fit into their current operations, and how it would be supported over the long-term.

### 4.2.5 Impacts During Development

Depending on the components of a particular Smart Freight Connector deployment, construction-related impacts are expected for roadway and truck parking operations. Field equipment will need to be installed, which may require closing travel lanes or parking areas in order to facilitate construction. When the system is being commissioned, staff will need to test and validate the system to ensure that it is functioning properly.

Continued involvement from TxDOT and other public agency owners is recommended to make sure the system continues operating in the best interest of road users. This may require interim checks and improvements to the system, which could impact traffic operations in the short-term due to lane closures or other disruptions.

### 4.2.6 Impacts to Stakeholders

Relevant stakeholders for the Smart Freight Connector strategy are listed in Exhibit 29. Stakeholders are denoted by roles of owner, key stakeholder, and/or end-user. TxDOT would own, operate, and maintain the system in collaboration with local partner agencies. End-users will include truck operators that move goods along intermodal connectors and surrounding freight routes.

#### Exhibit 29: Relevant Stakeholders for the Smart Freight Connector Strategy

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Role</th>
<th>Strategy Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>TxDOT Divisions</td>
<td>Owner</td>
<td>• Will identify the Division to manage and fund the strategy.</td>
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<td></td>
<td></td>
<td>• Will collaborate with other Divisions and Districts who might lead this effort.</td>
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<td></td>
<td></td>
<td>• Will develop the strategy and identify funding needs for capital and O&amp;M.</td>
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<td>• Will identify corridors for deployment.</td>
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<td>• Will identify how data collected under this strategy can support ongoing data collection efforts.</td>
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<tr>
<td></td>
<td></td>
<td>• Will collaborate with Districts regarding ownership, operation, and maintenance</td>
</tr>
<tr>
<td>Stakeholder</td>
<td>Role</td>
<td>Strategy Impact</td>
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<tr>
<td>------------------------------------------------</td>
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</tr>
<tr>
<td>TxDOT Districts</td>
<td>Owner/Key Stakeholder</td>
<td>• Will collaborate with Divisions regarding ownership, operation, and maintenance requirements associated with any technological field deployments.</td>
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<tr>
<td></td>
<td></td>
<td>• Will assist in determining corridors for technology deployments.</td>
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<tr>
<td></td>
<td></td>
<td>• Will work with Divisions to engage in interagency MOUs for the equipment installed off TxDOT ROW.</td>
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<tr>
<td>TMCs</td>
<td>Key Stakeholder /End-User</td>
<td>• Will be a point of contact for system issues and maintenance requests.</td>
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<td></td>
<td></td>
<td>• Will determine which field devices need active and/or passive management, and will allocate resources to accommodate them.</td>
</tr>
<tr>
<td>Local Communities</td>
<td>Owner/Key Stakeholder</td>
<td>• Will assist in determining corridors for technology deployments.</td>
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<tr>
<td></td>
<td></td>
<td>• Will support any corridors that are agreed-to and receive TxDOT equipment on community-owned infrastructure.</td>
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<tr>
<td></td>
<td></td>
<td>• Will identify impacts of this strategy on local stakeholders.</td>
</tr>
<tr>
<td>MPOs</td>
<td>Key Stakeholder</td>
<td>• Will look at the regional impacts of this strategy.</td>
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<td></td>
<td></td>
<td>• Will help identify which facilities should be prioritized and bring stakeholders to the planning process.</td>
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<td></td>
<td></td>
<td>• Will assist in soliciting funding for this strategy.</td>
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<tr>
<td>Intermodal Terminal Groups – Maritime, Railroads, and Others</td>
<td>Key Stakeholder</td>
<td>• Will assist in determining the specifics of this strategy, such as device and corridor selection.</td>
</tr>
<tr>
<td>Stakeholder</td>
<td>Role</td>
<td>Strategy Impact</td>
</tr>
<tr>
<td>-----------------------------</td>
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<tr>
<td></td>
<td></td>
<td>• May offer drayage-optimization scheduling systems as part of their operation to support FRATIS initiatives.</td>
</tr>
<tr>
<td>Truckers</td>
<td>End-User</td>
<td>• Will utilize the intermodal connectors to continue business as usual.</td>
</tr>
<tr>
<td>Trucking Companies/Dispatchers</td>
<td>End-User</td>
<td>• Will review routing and delivery times based on data available on ideal delivery times.</td>
</tr>
<tr>
<td>Other Users</td>
<td>End-User</td>
<td>• Will utilize the intermodal connectors to continue business as usual.</td>
</tr>
</tbody>
</table>

4.3 Alternatives To This Strategy

The proposed ConOps for this strategy comes with many benefits and impacts, but it inherently comes with prerequisite requirements in order to be successful in the long-term. While it meets the goals and objectives defined in the FNTOP strategy, it is not the only option available. This subsection identifies the inherent disadvantages and limitations of this strategy, and then contrasts the strategy against candidate alternatives that would also satisfy the intent, but were rejected due to being less advantageous.

4.3.1 Disadvantages and Limitations

The strategy in this ConOps is expected to have several disadvantages and limitations, which form prerequisite requirements that TxDOT will need to satisfy for it to fully succeed. Unlike the policy and constraint considerations identified earlier, these disadvantages and limitations will need to be continuously addressed.

- **System Development, Operations, and Maintenance May be Costly** – New hardware and software would be needed to implement this strategy, as well as network communication infrastructure to ensure all components are successfully integrated. While this is not necessarily a complex system, it requires careful design, funding, and staff for ongoing operations and maintenance, and the ability to respond if an issue is reported. The costs associated with this strategy may limit the number of sites deployed in the short term.

- **Geographic Coverage** – Not every intermodal connector or intermodal terminal-serving road would be instrumented with this strategy. Deployments would be done strategically to focus on the most critical corridors. Under this scenario, benefits would likely be isolated only to those corridors.

- **Politics of Multiple Owners** – Although TxDOT likes to collaborate with other state and local agencies to improve the transportation system, having multiple groups responsible for the ownership of this strategy may prove challenging if the politics of the other agencies change in the future. These changes could result in loss of funding, loss of
maintenance support, or complete decommissioning of any components on agency infrastructure.

- **Ability to Facilitate Change** – No two intermodal connectors are the same. Some intermodal connectors are already designed to maximize freight flow and accommodate early arrivals, leaving no room for technology to offer an improvement. This primarily applies to shorter intermodal connectors with no traffic signals and no issue with truck staging of parking. Determining which intermodal connectors cannot be improved is a step that would be undertaken as part of subsequent strategy planning efforts.

### 4.3.2 Alternatives and Tradeoffs Considered

Given the above disadvantages and limitations, alternative options and tradeoffs were examined in lieu of the strategy in its proposed form. The alternative options listed below explore different approaches to improving the availability and use of the Smart Freight Connector. It is important to note that some of these alternatives may seem intuitively nonsensical, but they are worth noting to confirm that all options have been explored and rejected for the stated reasons.

#### 4.3.2.1 Alternative 1: “Do Nothing” Approach

This alternative would maintain the current situation, which would require no changes to the existing program, no increases in costs, and require no additional staff. Intermodal connectors and surrounding freight routes that serve as last mile access points to other modes would continue operating with the current level-of-service and safety rates as present today, although it is expected that traffic volumes will increase in future years as freight movement also increases. Traffic control devices would regulate the movement of trucks with their current features and capabilities, rather than incorporate new technologies that could allow different timings to accommodate different traffic conditions.

If this alternative is pursued, TxDOT would expect to maintain the status quo, capturing none of the benefits outlined in Section 4.2.3 and Section 4.2.4.1.

This alternative is not recommended because it maintains the same shortcomings of the current situation. Without any form of operational improvements, the TMFN will experience worsening bottlenecks at intermodal transfer points due to congestion on the highway system.

#### 4.3.2.2 Alternative 2: Reduced Technology Scope

This alternative would deploy the Smart Freight Connector strategy on intermodal connectors and surrounding freight routes that are recommended, but it would be with a significantly reduced technology scope. This would often come from situations where certain applications within the strategy are deemed not applicable to the ITS program. For example, TxDOT may elect to keep all yellow traffic signal phases at the state standard, or choose to not invest in any adaptive traffic systems due to poor experience on previous projects. While
still beneficial in its own right to truckers along the route, a reduced technology scope may yield marginal improvements relative to the full FNTOP strategy.

It is important to note that this approach is not a time-phased deployment, nor does this approach discourage use of doing that type of deployment. For a Smart Freight Connector, TxDOT may elect to deploy a full scope of technology, but may do so incrementally due to funding or other resource constraints. Rather, this approach simply limits the capabilities of the technology used to a limited scope.

Even though benefits would be gained relative to the “Do Nothing” approach, this alternative is not recommended because—by its own policy—it would not allow the strategy to explore all opportunities to improve freight mobility along the corridor. While a time-phased approach may operate similarly in terms of deploying certain technologies one at a time, that approach is far superior because it considers exploration into new options (i.e. it thinks “forward” to other options), whereas this alternative is extremely limiting by prohibiting certain applications.

4.3.2.3 Alternative 3: Deployment Without Objective Justification

This alternative would deploy the Smart Freight Connector strategy at locations that are high-profile to help draw attention to the program, but with limited strategic value. Normally, TxDOT would commission a planning and prioritization study to determine which intermodal connectors and other roads were good candidates for a Smart Freight Connector, usually based on the strategy’s capability to offer improvements on that facility. That study may yield a list of eligible sites, each with a priority rating, which would inform how to invest as funding becomes available. This alternative may follow the same process, but bases its selection off of which sites or corridors are most visible to users, and often correlates to some kind of political motivation. While this alternative draws a lot of good attention to this strategy, that attention is more beneficial for showcasing rather than actual improvement to freight operations. In fact, by showcasing the solution on a corridor with a low need, the benefits may be negligible relative to the costs involved, which would only showcase a mediocre application.

It is important to note that, similar to the previous alternative, this alternative is not discouraging use of a time-phased deployment, which aims to build out strategic systems as funding becomes available. Nor does it intend to discourage pilot projects, which are great opportunities to trial new systems and applications. Rather, the issues of this alternative come from poor motivations that aim to deploy this strategy for the wrong reasons. While many opinions may exist as to where this strategy should be deployed, its success with all users requires it to offer a clear benefit, which can only be determined through a careful planning study with stakeholder collaboration.
Even though benefits would be gained relative to the “Do Nothing” approach, this alternative is not recommended because it adopts the Smart Freight Connector for the wrong institutional reasons. Failing to apply this into the right corridors would likely result in poor performance relative to costs and lead to eventual decommissioning.

4.3.2.4 Alternative 4: Private Sector Leads Strategy
This alternative would deploy the Smart Freight Connector strategy on certain strategic corridors, but rely on private-sector partnerships to potentially build and fund the system. The thought is that, since private-sector intermodal terminal operators would benefit from improved capabilities on the highway network, they should be willing to subsidize or cover the costs of improving the road network. TxDOT and local road operators would still retain certain key responsibilities and would lead the project, but the private sector would have a very large role and influence on this strategy.

TxDOT will still benefit by exploring public-private partnership opportunities, but this alternative delegates away much of the influence to the private sector. While some private sector groups may be interested, it is anticipated that many would not consider providing this high degree of funding, stating that the taxes they pay from the economic revenue they generate should cover the system. Even among exception cases, private sector groups have different motivations than the public sector’s responsibility for providing a safe transportation system, so there could be conflicts of interest that sour relationships in the long-term. Some of this may be mitigated through memorandums of understanding, but ultimately, the loss of the private-sector funding source would be a strong negotiation tool that could focus the system on private-sector priorities instead of TxDOT’s goals.

This alternative is not recommended as currently written because it takes away a lot of TxDOT’s role on this strategy. It does not suggest that all private partnerships are bad, but that TxDOT would need to carefully work with these partners to define roles, responsibilities, and funding expectations that work in interest of all parties involved.

4.3.2.5 Alternative 5: Local Road Authority Leads Strategy
This alternative would deploy the Smart Freight Connector strategy on certain key strategic corridors, but rely on local road authorities to operate and maintain all systems. The involvement of local road authorities in general is quite likely given that they may own parts of the intermodal connectors and surrounding roadways, but this alternative considers that TxDOT basically hands all control over to these local groups. TxDOT would likely fund the procurement and implementation, often through a state or federal funding mechanism, and then the local authorities would oversee day-to-day operations. This type of arrangement currently exists with TxDOT traffic signals in certain jurisdictions, so it is not a new approach. TxDOT benefits from reduced funding costs by not having to operate and maintain the strategy, and the local road authority gets to set its own operational guidelines that serve the interests of its local community.
Despite these benefits, this alternative is not recommended as currently written because it takes away a lot of TxDOT’s role on this strategy and substantially increases the risk for failure. Many local road authorities operate successful ITS programs, but their funding is generally more at risk because of smaller budgets, especially when politics are favoring a different method. For example, if the community is pushing against being a “drive through” community for trucks, they might elect to defund any regional improvement that encourages use by trucks. TxDOT will still benefit by having the local community involved in the strategy, but it will be more advantageous if TxDOT remains the lead agency.

4.3.2.6 Alternative 6: Build More Traditional Infrastructure
This alternative would build more infrastructure—more lanes, more roads, more bridges—to improve the intermodal connectors in lieu of technology options. While some traffic control hardware may be upgraded to the latest standards (e.g. actuated signals), any new technology would be limited due to the focus (and funding) being on steel- and concrete-based improvements. If built correctly, more infrastructure could dramatically improve the mobility and safety challenges along the corridor. It would require careful planning to justify the purpose and need, as well as extensive design to ensure that all benefits could be captured while meeting design standards. Since this would likely be a high-profile construction project, TxDOT would receive attention from the public like any other major public works project, which would be good politically for any leadership that is looking to open a new facility during their tenure.

Despite these benefits, this alternative is not recommended because it is extremely costly to rebuild an entire facility, much less several facilities. ITS assets historically demonstrate good benefit-cost ratios when deployed and maintained properly, which is good to note because they also can be deployed at a much lower capital cost than a major infrastructure project. While such a project may have its own justification separate from this strategy, employing the technology option can be done for a lower cost and in a shorter time horizon than the alternative.
5.0 Operational Scenarios

This section presents five operational scenarios that describe situations in which the Smart Freight Connector strategy could significantly improve the safety, mobility, and efficiency of truckers near intermodal facilities. Each operational scenario describes the users involved and the issues that are intended to be addressed, as well as the outcomes or benefits the users are expected to experience through the deployment of this strategy. The following operational scenarios do not address all of the desired Smart Freight Connector improvements, nor do they represent a comprehensive set of use cases, but rather demonstrate some of the key situations that this system could help serve and improve. Exhibit 30 summarizes the operational scenarios presented in this section.

Exhibit 30: Summary of Operational Scenarios

<table>
<thead>
<tr>
<th>#</th>
<th>Scenario</th>
<th>FNTOP Stakeholders Involved</th>
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<td>“Green Progression” for Freight</td>
<td>TMC Operator, Truckers, Other Users</td>
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<td>Extended Yellow Light – Inclement Weather</td>
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<td>Real-Time Truck Parking Availability Systems</td>
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5.1 “Green Progression” for Freight

Sal is a truck driver for Truck International, one of Texas’s premiere trucking companies that makes deliveries across the state and throughout the southern United States. Sal regularly makes deliveries from his home in the Dallas-Fort Worth area down to the Port of Galveston. Coming down I-45, he uses State Highway (SH) 275 as a connection to the Port of Galveston. With over 10 years of driving experience, Sal has moved many containers into and out of the Port, and he has seen the traffic around the Port grow extensively over these years.

At 9 a.m. on a Tuesday, Sal is making a routine container delivery to the Port of Galveston. He is very much aware of the tropical storm that had come through the area over the weekend. While the damage around Galveston is minimal, many other shippers from around the United States elected to delay delivery of their containers to the Port, not wanting to put their truck drivers at risk. Today, truck drivers are trying to make up for lost time and, as a result, truck traffic is substantially higher than average. As Sal exits I-45 for SH 275, he witnesses a large volume of trucks doing the same. Pockets of delay begin to emerge as unfamiliar truck drivers travel slower than familiar drivers, causing turbulence in the traffic stream. This becomes even more problematic at traffic signals, where stopped trucks...
accelerate slowly when the lights turn green. Sal recalls SH 275 having many queueing issues in the past during times like these, where idling trucks would spill back for miles and create quite an eyesore for the local community.

Fortunately, Sal is aware that TxDOT has invested heavily in smart traffic technology around the Port of Galveston. He recalls the public service campaign titled “Your New Smart Freight Connector”, where traffic signals along SH 275 are designed to respond to freight traffic in real-time by providing more green lights/green time so freight is able to move consistently along the corridor with fewer stops. Newly-installed WIM devices and traffic detectors report truck volumes, speeds, classifications, and weights to a roadside processing device. When certain pre-determined thresholds are exceeded, the roadside processing device requests that all traffic signals along the corridor change to a new timing plan designed specifically to accommodate high volumes of truck traffic. Through a careful statewide planning study, TxDOT had prioritized this route for implementation, due to its large volume of freight traffic.

Today, the WIMs and traffic detectors have identified a high volume of heavy trucks. The system instructs all traffic signals along the corridor to select a coordinated timing plan that prioritizes the movement of freight, which includes longer green intervals on the main routes. As a result, the propagating queues from years past are nowhere to be found. Instead, trucks arrive at the Port of Galveston’s gate shortly after leaving the interstate, which allows them to better meet their gate appointment times and minimizes stress for the drivers. As the surge of trucks eventually dies down, the WIM and traffic detectors confirm that normal levels have been restored and the traffic signals are returned to their original time-of-day traffic signal timing plans.

Sal is happy with the new system, as it allows him and his company to be more economically competitive with container deliveries at the Port of Galveston by having a more predictable arrival. Additionally, by not idling in traffic, Sal is saving money by not wasting fuel, all while cutting down on tailpipe emissions.

5.2 Extended Yellow Light – Inclement Weather
It is currently 2 p.m. on a Wednesday at the San Antonio TransGuide traffic management center. Jane works as an operator and is halfway through a busy shift. Over the past few hours, a tropical storm has impacted the southeastern coast of Texas. Coastal cities, such as Corpus Christi and Brownsville, have experienced strong wind and heavy amounts of rainfall. Traffic is moving much slower than usual, but luckily there have been few crashes.

About 30 minutes later, at 2:30 p.m., Jane receives a notification from a WIM device. The device is located on County Road 54, a heavy freight route that connects Interstate 37 to the Port of Corpus Christi. This route is also one of TxDOT’s Smart Freight Connectors, which are crucial last-mile corridors throughout the state. Since these corridors were implemented a few months ago, Jane has witnessed the system actively manage traffic on several
occasions, adjusting traffic signal timing to improve operations for trucks. Today, the WIM indicates in real-time that truck volumes are significantly higher than average on this route.

Jane accesses a nearby CCTV camera, confirming that there is a higher than normal amount of truck traffic on the route. She also notices that due to the ongoing tropical storm, the trucks are moving at slower speeds in order to be more cautious of the inclement conditions. Prior to implementation, slower travel speeds allowed for safe braking at intersections, but trucks would take a long time to accelerate up to speed once the light turned green. With the extensive queueing that resulted, some trucks were caught in the middle of the intersection when the light changed from yellow to red, creating a potentially unsafe condition.

However, the Smart Freight Connector’s field processor has evaluated the increase in truck volume and the real-time weights. With insight from the TxDOT ATMS about poor meteorological conditions, it has sent a request to the traffic signal controllers along the corridor to change their traffic signal timing plans to one with a longer yellow interval. With this adjustment, trucks are able to pass through the intersection and, if caught with a yellow light, are able to clear prior to the all-red phase. This increases safety by not having vehicles in the intersection when other movements are given the green light, and prevents trucks from slamming on the brakes due to the yellow light being too short for their travel speed.

After 30 minutes, Jane notices that conditions have improved and trucks are operating at speed. The Smart Freight Connector’s field processor maintains the extended-yellow phase for another 15 minutes out of caution, but eventually instructs the traffic signals to return to their routine time-of-day operations.

Jane is happy with the results of the system’s actions. As the first time she has dealt with a major weather event on a TxDOT Smart Freight Connector, she is confident this approach will continue to work in the future.

5.3 **Real-Time Truck Parking Availability Systems**

Travis is a short-haul truck driver who works for a large supermarket chain in Fort Worth, Texas. For over 10 years, he has focused on picking up loads from distribution centers and delivering them to the supermarket’s largest locations. Generally, he picks up freight shipments from large intermodal facilities in the region, such as the Fort Worth Alliance Airport.

It is currently 8 a.m. on a Wednesday morning and Travis is preparing for his first pickup of the day. His dispatcher has provided him with all the necessary information, and Travis sees that he will be picking up a large load from an intermodal facility adjacent to the Fort Worth Alliance Airport.
With these types of pickups, Travis knows he must usually wait outside the facility if he arrives earlier than his appointment window. Westport Parkway is the major arterial that connects I-35W to the various distribution centers and intermodal facilities near Alliance Airport. To accommodate early arrivals, truck staging areas have been built at various locations along the arterial. From experience, Travis knows that this corridor can have heavy congestion and truck staging areas can fill up quickly. Travis checks DriveTexas and sees that traffic is clear and there are over 30 truck parking spots in the staging area on Westport Parkway, just outside of the intermodal facility.

Travis begins the 45 minute drive towards his destination. At about 9:45 a.m., he is approaching the exit for Westport Parkway and is over 30 minutes early for his appointment. He takes the exit and immediately spots a sign for the truck staging area. It indicates to Travis in real-time that there are still 20 open parking spaces. It identifies several other staging areas and the associated real-time parking availability for those lots, should Travis’s preferred staging area be full. Travis arrives at his preferred staging area and finds plenty of available parking. He parks and waits until it is closer to appointment window at the intermodal facility, which—prior to the implementation of this system—Travis normally would have circulated through the local community and parked in front of someone’s residential home, hoping that the homeowner would not get upset.

Travis feels as though his morning was stress free. The staging areas, as well as the real-time sensors that broadcast to DriveTexas, make his work much easier and more flexible. The rest of his pickup goes smoothly and he is en route to deliver the shipment to a large grocery store in North Fort Worth.

5.4 Dedicated Truck Lanes & Staging Areas – AV Trucks
Megan is a safety engineer for an AV company. Her company is involved in testing SAE Level 4 automated trucks in Texas, partnering with local businesses throughout the state to test short and long-haul deliveries. Deliveries to and from intermodal facilities have also been a focus area for Megan’s company. Megan’s role is to sit in the passenger seat and monitor the truck’s AV system; should the AV system experience any issues, Megan would then inform her human driver colleague to be ready to assume control of the vehicle.

On a Thursday afternoon, at 4 p.m., Megan and her affiliated human driver are en route to pick up a shipment from the Port of Brownsville. They are currently testing a Level 4 automated truck and, as they travel south on I-69E, the truck’s system seems to be operating normally. A few minutes later, the truck takes the exit for SH 48 and continues north towards the port.

SH 48 is a crucial intermodal corridor for freight, as it connects the city of Brownsville and the Port of Isabel to the Port of Brownsville. In fact, this corridor was recently included in TxDOT’s Smart Freight Connectors program, meaning it received a number of technological
and operational upgrades. Since this is the first time that Megan has tested a Level 4 automated truck on this corridor, she is looking out for any infrastructure elements that will assist her with her test.

As Megan continues on SH 48, she notices a regulatory sign that indicates that the leftmost lane is designated as an AV truck priority lane. TxDOT, in collaboration with the Port, identified the value of AV trucking to the state’s economy and has set up incentives for freight operators who adopt this equipment. Today, Megan’s truck reads the regulatory sign correctly and merges with the other AV trucks into the truck priority lane. About a mile later, after bypassing the other trucks and cars on the road, she notices a sign that indicates an approaching truck staging zone, and displays in real-time the number of spots available. Since the AV truck is early for its appointment window, it knows to pull into the staging lot.

Now parked in the staging zone, Megan waits for about 10 minutes. She notices that the truck is called for its appointment and automatically begins to head towards the port’s gates, using the AV priority lanes from before. About five minutes later, she is at the port’s gates. It is not until this moment that she has to assume control of the truck.

Megan is impressed with how efficiently the AV priority lanes and truck staging areas were utilized by the AV truck she was testing. As she initiates the drive towards her destination, once again utilizing the truck priority lane as she leaves the port, she sees how the TxDOT Smart Freight Connectors will accommodate AVs around ports in the coming years.

5.5 Performance Monitoring
A TxDOT District in the Upper Gulf Coast region of Texas has recently implemented a Smart Freight Connectors strategy. Through a comprehensive planning process, the District identified crucial freight corridors that provide last-mile connectivity to intermodal facilities. These routes received a number of technological and operational traffic management solutions, such as real-time truck parking availability systems, weigh-in-motion for detecting heavy freight use, traffic signal upgrades, and truck priority lanes.

After one year of operation, the District decides to evaluate the performance of the Smart Freight Connectors. Historic data collected by weigh-in-motion on the corridors is reviewed. The WIM on Smart Freight Connectors serve the normal function of collecting approximate weight measurements of all trucks, but they also have real-time capabilities, providing notifications when there are large volumes of freight in a finite time period. The District sees a comprehensive dataset, showing historic instances of heavy freight volumes by date and time. This data is extremely useful for helping estimate pavement life, as well as identify if enforcement is needed at particular times of day to ensure safety.

Aside from the WIM, the District also looks at the data collected by the vehicle sensors in the truck staging areas. These sensors detect the number of open parking spaces at staging
areas on Smart Freight Connectors, broadcasting in real-time to signs on approaching highways and storing the time-based availability in a database. TxDOT District employees are able to access this historical data and utilize it for parking studies. Studies can help determine which staging areas are generally full during peak hours and would benefit from expansion.

With the success of the initial Smart Freight Connectors, the TxDOT District looks at other key last-mile freight corridors for future implementation.
6.0 Next Steps

This Smart Freight Connector ConOps is one of six ConOps documents being prepared as part of the FNTOP. As noted earlier, these six strategies were chosen through a selection process that vetted a total of 10 identified strategies with key stakeholders. Each ConOps intends to further answer how each specific strategy would operate, which systems it would interface with, and how various user groups would be impacted by the introduction of the strategy. Based on this document, this strategy is ready for TxDOT to advance to implementation planning in the future, which would include the development of system requirements and high-level design (detailed further in the Implementation Plan as shown in Exhibit 31).

In addition to the ConOps development, the FNTOP is also developing an Implementation Plan that explores the near-, medium-, and long-term actions that will drive the successful implementation of the 10 FNTOP strategies. This will include an assessment of the readiness of each strategy. The goal is to inform the next steps beyond the FNTOP as these strategies are transitioned from planning to design. This will include outlining how the Smart Freight Connector strategy would ultimately come to fruition, utilizing insights provided as part of this ConOps.

*Exhibit 31: Next Step in the Texas FNTOP*
7.0 References

The following is a list of relevant documents, standards, and references used in preparing this document:


- TxDOT Crash Records Information System (CRIS), 2014-2016


- TTI Assessment of Innovative and Automated Freight Strategies and Technologies—Phase II Final Report, 2018