The Texas Freight Network Technology and Operations Plan (FNTOP) developed by the Texas Department of Transportation (TxDOT) Freight Planning Branch builds upon the goals introduced in the 2018 Texas Freight Mobility Plan (TFMP) and outlines identified strategies to guide technology and operations-related investments on the Texas Multimodal Freight Network (TMFN). The FNTOP engaged key public and private sector stakeholders throughout the development of the strategies to obtain feedback, suggest refinements, and evaluate priority levels. The establishment of priorities informed TxDOT’s selection of six strategies for Concept of Operations development, which is the next critical step to the implementation of the FNTOP.

A Concept of Operations document provides a high-level overview of a proposed technology concept that is traceable to stakeholder needs. The Automated Vehicle (AV) Infrastructure, Connected Signing, and Data Concept of Operations that was developed as part of the FNTOP follows both Federal Highway Administration (FHWA) guidance as well as approved standards developed by the International Council on Systems Engineering (INCOSE). This document will be accessible to public and private stakeholders as a starting point for the future deployment of this technology concept.

Overview
At a high level, the AV Infrastructure, Connected Signing, and Data strategy would seek to standardize and consolidate Texas roadway characteristics such as signage and construction zones into a digitized map that depicts the roadway environment for AV trucks and could be offered to all AV vendors as a service. This strategy also serves to deploy “Connected Signs” on roadways and develop a repository of digitized infrastructure data to support both the freight industry as well as the AV industry.
WHY What is the problem or opportunity addressed by the system?

- HELP improve mobility and efficiency of AV operations by offering AVs a greater awareness of the operating environment through technological tools.
- IMPROVE the current state of AV operations in Texas, specifically where AV truck systems can experience issues when encountering complex roadway environments, such as construction zones, areas where operational parameters are changing, and atypical geometric designs.
- OFFER Information on the roadway environment to improve efficiency and safety of automated trucks.
- REDUCE AV “disengagements” so that AVs can more competently travel through complex environments.
- ENHANCE AVs’ ability to “read” roadside signs and interpret their instructions with enough time to react appropriately.

WHO Who are the stakeholders involved with the system?

**Owner**
TxDOT Divisions, TxDOT Districts

**Key Stakeholders**
TxDOT Divisions, TxDOT Districts, TxDOT Traffic Management Centers (TMCs), Original Equipment Manufacturers (OEMs)/Startups

**End-Users**
TxDOT TMCs, Texas Department of Public Safety, Texas Department of Motor Vehicles, OEMs/Startups, AV Trucks, Other Roadway Users

WHAT What are the elements and the high-level capabilities of the system?

<table>
<thead>
<tr>
<th>FEATURES</th>
<th>MAIN FUNCTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Proprietary Digital Map Database</td>
<td>AV vendors would be able to access a digitized map of the Texas roadway environment as a service. The map would be AV technology-agnostic.</td>
</tr>
<tr>
<td>Digital Map Update Capabilities</td>
<td>Permitted users, such as TxDOT, construction contractors, and AV vendors, would be able to contribute mapping data, such as LiDAR surveys done through construction projects or general survey. Users could also automatically contribute improvements, such as updated environments detected by the AV equipment (e.g., a new sign has gone up at ‘x’ location, witnessed crashes, asset conditions), which would be subject to verification or crowd-sourced confirmation.</td>
</tr>
<tr>
<td>Real-Time Notifications from Connected</td>
<td>Location and message information to support AVs in assessing the regulatory, warning, and other signing along a route would be broadcasted through vehicle-to-infrastructure (V2I) transceivers. Intelligent Transportation System (ITS) assets, such as dynamic message signs, would broadcast notifications, advisories, or other messages via V2I to AVs to help support operational awareness.</td>
</tr>
<tr>
<td>Infrastructure</td>
<td></td>
</tr>
<tr>
<td>Facilitate Future Improvements for TMFN</td>
<td>This system will facilitate a stronger AV ecosystem in Texas as Level 4a AVs are tested and enhanced. A stronger ecosystem will shorten development time, allowing additional traffic management benefits to be captured in the future.</td>
</tr>
</tbody>
</table>

*a Level numbers indicate Levels of Driving Automation.

The main anticipated benefits of the system include:

- This system would allow automated trucks to provide and use supplemental information regarding their environment which would help them operate more efficiently and safely.
- A standardized non-proprietary digital map database and machine-ready messaging could offer navigable information that would reduce the number of AV “disengagements” caused by AV misinterpretation of the roadway environment.
CONCEPT OF OPERATIONS: AV INFRASTRUCTURE, CONNECTED SIGNING, AND DATA

- TxDOT would **support AV operations and development** by working with AV vendors to develop this operational environment that would help improve the “training” of algorithms to manage complex environments needed to reach Level 5 autonomy.
- The availability of data that can be collected from the multitude of automated trucks and vehicles on Texas roadways once AV adoption expands would help TxDOT compile a more comprehensive dataset on asset condition.
- Achieving a consolidated and consistent digital basemap of the roadway environment will help build a strong public-private-partnership between TxDOT and its public sector partners, the AV industry, and the respective standards organization that might certify the mapping standard (e.g., International Organization for Standardization [ISO]).

**HOW How will the system be developed, operated, and/or maintained?**

The non-proprietary digital map database—regardless if hosted by TxDOT or a third-party service—would be supported by an advanced data processing system that would validate Application Programming Interface (API) requests to send or receive digital map data and translate collected data into a clear digitized map environment used by AVs. TxDOT vehicles would conduct LiDAR surveys that would feed into the advanced data processing system to provide data for the non-proprietary digital map database. TxDOT’s Advanced Traveler Information System (ATIS), DriveTexas™, would also provide data feeds from existing ITS assets to the advanced data processing system. TxDOT Districts would be have responsibility over the ITS assets, including the connected infrastructure, although this responsibility (in terms of ownership, operations, and maintenance) may be collaborated with the TxDOT Division that is leading the strategy.

**WHERE What is the geographic and physical extent of the system?**

While the goal is to produce a digital basemap that provides coverage for the entire Texas Highway Freight Network (THFN), not every part of the THFN would be instrumented with connected infrastructure at first. Deployments of “Connected Signage” would be done strategically, focused first on critical freight corridors. Ultimately, the ability to combine public and private sector mapping data using one unified standard would significantly expand the geographic coverage of the digitized routes, benefiting both the public and private sector.

**WHEN What is the sequence of activities that will be performed?**

The table below outlines a time-phased series of activities that are needed to accomplish the planning, implementation, and eventual full deployment of the AV Infrastructure, Connected Signing, and Data system.

<table>
<thead>
<tr>
<th>Near-Term Actions (0-2 years)</th>
<th>Medium-Term Actions (2-5 years)</th>
<th>Long-Term Actions (5-7 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing TxDOT Program/Initial Next Steps</td>
<td>Concept of Operations</td>
<td>System Requirements</td>
</tr>
<tr>
<td>No: Continue collaborating with the Connected and Automated Vehicle industry</td>
<td>✓</td>
<td>□</td>
</tr>
</tbody>
</table>

**Legend**

- ✓ Completed
- □ Need to do
OPERATIONAL SCENARIO
Urban Work Zone

THE PROBLEM
Andre, a safety engineer, is riding along on a delivery from Dallas to Houston with a designated human driver, so he can perform testing on a Level 4 autonomous truck.

THE APPROACH
Andre is concerned the truck will not be able to navigate the unpredictable work zone environment on its own.

However, since the truck downloaded the most up-to-date non-proprietary digital map, it had access to TxDOT’s LiDAR survey of the construction zone...

THE SOLUTION
They arrive safely in Houston.

The information collected by the truck during the drive (e.g., potholes) is uploaded to the digital map database to help other AV trucks.

TxDOT uses the database to track where maintenance is needed on its highways.