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<table>
<thead>
<tr>
<th>Acronyms</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AASHTO</td>
<td>American Association of State Highway and Transportation Officials</td>
</tr>
<tr>
<td>CRIS</td>
<td>Crash Records Information System</td>
</tr>
<tr>
<td>DOT</td>
<td>Department of Transportation</td>
</tr>
<tr>
<td>FIDC</td>
<td>Freight Infrastructure Design Considerations</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information System</td>
</tr>
<tr>
<td>NCHRP</td>
<td>National Cooperative Highway Research Program</td>
</tr>
<tr>
<td>RDM</td>
<td>Roadway Design Manual</td>
</tr>
<tr>
<td>THFN</td>
<td>Texas Highway Freight Network</td>
</tr>
<tr>
<td>TFMP</td>
<td>2018 Texas Freight Mobility Plan</td>
</tr>
<tr>
<td>TTTR</td>
<td>Truck Travel Time Reliability</td>
</tr>
<tr>
<td>TxDOT</td>
<td>Texas Department of Transportation</td>
</tr>
</tbody>
</table>
1 Introduction

The roadway system is the backbone of the Texas freight transportation network. Most goods produced or consumed in the state have to travel by truck at least once, and often multiple times, along the supply chain. The roadway system connects areas of production to consumption centers throughout the state, provides last-mile connectivity to intermodal infrastructure (e.g., rail terminals, seaports, airports, and pipelines), and serves as domestic and international gateways, particularly along the southern border. The ability of the roadway network to accommodate these freight flows is critical for the long-term prosperity of the state.

However, much of the roadway system was designed and built decades ago, featuring characteristics that are not optimized for the amount and types of trucks moving through it. In many cases, this makes it difficult for trucks to navigate this system, contributing to congestion, elevating safety risks, and creating conflicts with other vehicles. Many parts of the system were also not designed to support the high loads that are now common throughout the state, and particularly in areas with energy production.

Even if the whole roadway system were reconstructed according to the latest Texas Department of Transportation (TxDOT) guidelines, it might not accommodate best the needs of the existing freight sector, and even less, the needs of the freight sector a couple of decades from now. Because of the longevity of transportation infrastructure, the design choices made today will have impacts well into the future.

A review is required to understand how existing TxDOT roadway design guidance treats freight vehicles to identify opportunities for improving the safety and efficiency of freight movements on Texas roads. At the same time, the characteristics of the existing roadway system need to be catalogued to identify places where the system does not meet the most recent guidance from TxDOT, potentially creating challenges for freight movements in the state.

Failing to innovate and adapt to changing freight needs is likely to decrease the efficiency of the Texas freight transportation system and hurt the competitiveness of the state. A modern roadway system that is thoughtfully designed is necessary to support Texas supply chains, facilitate cross-border trade, and support economic growth that ensures employment and wages that keep up with population increases.
1.1 PROJECT OBJECTIVE

The 2018 Texas Freight Mobility Plan (TFMP) identifies gaps between the operational requirements of today’s trucks and how highways in the state have been designed. The lack of acceleration lanes, inadequate pavement strength, and low vertical clearances (among other factors) create operational constraints for trucks that limit the safe and efficient movement of freight throughout the state. To address these challenges, TxDOT’s Transportation Planning and Programming Division undertook the Freight Infrastructure Design Considerations (FIDC) study with the objective of identifying changes in how roads are designed to better accommodate trucks.

The FIDC study implements a key policy recommendation of the 2018 TFMP by developing freight-centric design criteria to ensure that the roadway infrastructure accounts for the functional needs of freight vehicles and their impact on system conditions. This study is intended to offer considerations for the development and revision of TxDOT’s design manuals and procedures. In some cases, no changes are recommended, while in other cases, specific changes are recommended that would bring Texas closer to national best practices. In a few cases, particularly involving complex processes such as pavement design or traffic operations, further study is recommended along dimensions that could prove to be beneficial for freight movements. The FIDC study does not consider broader issues surrounding the planning of roads, implementation of different technologies (e.g., electrification, automation), or integration of resiliency best practices. While these are likely to have significant positive impacts on freight movements, they go beyond the purview of this study.

The FIDC study focuses on developing design guidance for the Texas Highway Freight Network (THFN). While this study focuses primarily on the movement of trucks, its findings have implications for other freight modes. Intermodal accessibility was a key consideration of the THFN designation. As such, the recommendations of the FIDC study facilitate the movement of freight to and from important multimodal interchanges, such as rail terminals, seaports, airports, and pipelines. Additionally, guidance provided on vertical clearances affects equally bridges carrying trains, and similar principles apply to bridges spanning waterways and rail lines. Nonetheless, the study focuses on roadway issues, as these were identified by stakeholders as being the most pressing, and because this is an area where TxDOT has the most ability to implement meaningful changes.

1.2 TEXAS HIGHWAY FREIGHT NETWORK OVERVIEW

The THFN comprises 21,834 centerline miles of roadway, with 21,397 of these miles on-system (state-maintained highways). The off-system miles represent county roads or local streets important to the last mile movement of freight. Exhibit 1 breaks down the THFN on-system mileage by functional classification and area type. Principal and minor arterials make up the most miles by type, with 15,435 miles combined, representing 72 percent of the THFN mileage. Principal and minor arterials function similarly to limited-access highways that support moderate levels of mobility. Freeways, comprising access-controlled interstates and expressways, are the functional...
classification with the next most THFN mileage, with over 4,600 miles (or 22 percent) of the total. Collectors have the fewest mileage on the THFN, representing six percent of the total mileage. By area type, approximately two-thirds of the THFN mileage is located in rural areas.

**Exhibit 1: Functional Classification Summary by Roadway Type on the Texas Highway Freight Network**

<table>
<thead>
<tr>
<th>Functional Classification</th>
<th>Roadway Type</th>
<th>Total Length (miles)</th>
<th>Percentage of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeway</td>
<td>R1-Rural Interstate</td>
<td>2,000</td>
<td>9%</td>
</tr>
<tr>
<td>Freeway</td>
<td>R2-Rural Other Freeway and Expressway</td>
<td>128</td>
<td>1%</td>
</tr>
<tr>
<td>Freeway</td>
<td>U1-Urban Interstate</td>
<td>1,461</td>
<td>7%</td>
</tr>
<tr>
<td>Freeway</td>
<td>U2-Urban Other Freeway and Expressway</td>
<td>1,062</td>
<td>5%</td>
</tr>
<tr>
<td>Freeway</td>
<td><strong>Subtotal</strong></td>
<td>4,651</td>
<td><strong>22%</strong></td>
</tr>
<tr>
<td>Arterial</td>
<td>R3-Rural Other Principal Arterial</td>
<td>7,808</td>
<td>36%</td>
</tr>
<tr>
<td>Arterial</td>
<td>R4-Rural Minor Arterial</td>
<td>3,237</td>
<td>15%</td>
</tr>
<tr>
<td>Arterial</td>
<td>U3-Urban Other Principal Arterial</td>
<td>3,945</td>
<td>18%</td>
</tr>
<tr>
<td>Arterial</td>
<td>U4-Urban Minor Arterial</td>
<td>445</td>
<td>2%</td>
</tr>
<tr>
<td>Arterial</td>
<td><strong>Subtotal</strong></td>
<td>15,435</td>
<td><strong>72%</strong></td>
</tr>
<tr>
<td>Collector</td>
<td>R5-Rural Major Collector</td>
<td>1,219</td>
<td>6%</td>
</tr>
<tr>
<td>Collector</td>
<td>R6-Rural Minor Collector</td>
<td>21</td>
<td>0%</td>
</tr>
<tr>
<td>Collector</td>
<td>U5-Urban Major Collector</td>
<td>70</td>
<td>0%</td>
</tr>
<tr>
<td>Collector</td>
<td>U6-Urban Minor Collector</td>
<td>1</td>
<td>0%</td>
</tr>
<tr>
<td>Collector</td>
<td><strong>Subtotal</strong></td>
<td>1,310</td>
<td><strong>6%</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>21,397</td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

The THFN is a comprehensive network that reaches every corner of Texas, as shown in Exhibit 2.
1.3 REPORT ORGANIZATION

This report is organized into the following sections:

- **Section 2: Project Approach Summary.** This section describes the tasks informing the development of the FIDC study and provides an overview of how the design criteria were identified that are the most important to freight mobility and operations.

- **Section 3: Assessment of Key Freight Design Attributes where Major Changes are Recommended.** This section provides an analysis of design needs at a corridor level based on data collected for segments of key freight corridors on the THFN. Only attributes where changes are recommended are included in this section.

- **Section 4: Assessment of Key Freight Design Attributes where No Major Changes are Recommended.** This section reports the results of the design needs analysis for attributes where no changes are recommended.

- **Section 5: Design Needs Prioritization.** This section identifies the design needs impacting safety and mobility on the network by analyzing relationships between design deficiencies and network performance.

- **Section 6: Conclusion.** This section provides a summary of recommendations and provides implementation considerations.

- **Appendix A: Summary of Existing Conditions.** This appendix summarizes the results of the existing conditions analysis, which includes an overview of national guidance and design practices of peer states.

- **Appendix B: Design Comparison Matrix.** This appendix contains the Design Comparison Matrix, which details how national guidance and the design practices of peer states compare to TxDOT’s Roadway Design Manual (RDM).

- **Appendix C: Systemwide Freight Design Needs Analysis.** This appendix summarizes the results of the systemwide design needs analysis of the THFN.
2 Project Approach Summary

The main components of the FIDC study are described in this section. This includes a breakdown of the tasks of the project, with references to the sections or appendices where the key outputs are summarized. This section also contains a description of how the key freight design attributes were identified and prioritized, followed by a short description of how the inventory of existing conditions was performed. Lastly, this section describes how the needs analysis was conducted, and how the results are presented in the report.

2.1 PROJECT TASKS

The development of the FIDC study involved the completion of the following tasks:

- **Task 2.1 – Data Collection and Review of Roadway Design Criteria** compiled and reviewed roadway design guidance from TxDOT, Federal Highway Administration, national committees, peer states, and neighboring states.

- **Task 2.2 – Freight Infrastructure Design and Existing Conditions** developed a list of the design attributes by functional classification that are most critical for freight movement. A matrix was prepared in this task that compares TxDOT’s guidance from the RDM for these attributes with recommendations from national guidance, and peer and adjacent states standards. The existing conditions report encompassing Tasks 2.1 and 2.2 is provided in Appendix A.

- **Task 2.3 – Preliminary Minimum and Optimal Design Features** developed guidance for minimum design features to establish basic criteria for facility designs and optimal design features to establish additional criteria that maximizes designs for freight operations and mobility. The comparison matrix, including an inventory of TxDOT design standards and the minimum and optimal design considerations, is provided in Appendix B.

- **Task 2.4 – Freight Design Needs Assessment** conducted a needs assessment of the THFN by comparing existing design attributes (where available) with TxDOT design standards and the minimum and optimal design considerations. The approach and findings of the needs assessment are summarized in Section 3. For the design attributes that lack existing Geographic Information System (GIS) data, data was manually collected.

- **Task 2.5 – Examples of Optimal TxDOT Practice** identified parts of the THFN where TxDOT design standards are exceeded in a manner that benefits freight movement. These examples are discussed in Section 4.
• **Task 2.6 – Impact of Design Deficiencies** performed an analysis of the relationship between potential design deficiencies and network performance in terms of safety and mobility. Findings are reported in Section 5.

• **Task 2.7 – Design Needs Prioritization** prioritized freight design needs based on impacts to safety and mobility on the THFN. These freight design needs were based on the findings of Task 2.6. The prioritization framework is presented in Section 4.

• **Task 2.8 – Development of Freight Design Considerations** developed freight considerations for better accommodating freight movements on the THFN based on the findings of the previous tasks.

• **Task 4 – Stakeholder Outreach** informed the development of all tasks using comprehensive outreach activities. This included coordination with the Texas Freight Advisory Committee; meetings with working groups, division directors, district engineers; stakeholder workshops, and industry forums.

### 2.2 FREIGHT DESIGN ATTRIBUTES OVERVIEW

#### 2.2.1 PRIORITIZATION

A multilayered process was used to identify the design criteria that have the greatest impact on freight mobility and operations (Exhibit 3). A literature review was conducted to document the universe of design attributes that plausibly affect freight. These attributes were then scored by the project team and TxDOT engineers based on their impact on trucks, data availability to analyze systematically, and cost effectiveness of changing recommendations. A survey was then administered to truck drivers and other freight stakeholders to rate these attributes based on their importance to truck operations. The attributes that truck drivers ranked in the top 10 are shown in Exhibit 4. Sight distances, turning radii, and signage and pavement markings topped the list.

**Exhibit 3: Design Attribute Prioritization**
**Exhibit 4: Truck Driver Top-10 Design Attributes**

<table>
<thead>
<tr>
<th>Rank</th>
<th>Freight Design Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sight Distance (passing, turning and stopping)</td>
</tr>
<tr>
<td>2 (tie)</td>
<td>Intersection Turning Radius</td>
</tr>
<tr>
<td>2 (tie)</td>
<td>Signage and Pavement Markings</td>
</tr>
<tr>
<td>4</td>
<td>Traffic Signal Timing</td>
</tr>
<tr>
<td>5</td>
<td>Bridge Vertical Clearance</td>
</tr>
<tr>
<td>6</td>
<td>Pavement Quality/Strength</td>
</tr>
<tr>
<td>7</td>
<td>Acceleration/Deceleration Lanes</td>
</tr>
<tr>
<td>8 (tie)</td>
<td>Lane Width</td>
</tr>
<tr>
<td>8 (tie)</td>
<td>Shoulder Width</td>
</tr>
<tr>
<td>8 (tie)</td>
<td>Work Zone Design</td>
</tr>
</tbody>
</table>

The results of this survey were combined with the scoring of the TxDOT engineers and project team to identify the subset of design attributes that are most important for truck operations. Exhibit 5 lists these attributes.

**Exhibit 5: Key Freight Design Attributes for Truck Operations**

<table>
<thead>
<tr>
<th>Type</th>
<th>Freight Design Attribute</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geometrics</td>
<td>Passing Sight Distance &amp; Passing/No-Passing Zones</td>
<td>The length of roadway that the driver of the passing vehicle must be able to see to make a passing maneuver safely.</td>
</tr>
<tr>
<td>Geometrics</td>
<td>Railroad-Highway Grade Crossing Sight Distance</td>
<td>The distance required for a driver to recognize a hazard or potential threat during challenging driving conditions.</td>
</tr>
<tr>
<td>Geometrics</td>
<td>Vertical Grade</td>
<td>The slope along the direction of travel.</td>
</tr>
<tr>
<td>Geometrics</td>
<td>Critical Length of Grade</td>
<td>Maximum length of a designated upgrade on which a loaded truck can operate without an unreasonable reduction in speed.</td>
</tr>
<tr>
<td>Geometrics</td>
<td>Acceleration Lane</td>
<td>A speed-change lane consisting of added pavement at the edge of through-traffic lanes to permit vehicles to accelerate before merging with through-traffic flow.</td>
</tr>
<tr>
<td>Geometrics</td>
<td>Deceleration Lane</td>
<td>A speed change lane consisting of added pavement at the edge of through-traffic lanes to permit drivers to diverge from through-traffic flow without reducing speed until after the diverging maneuver is completed.</td>
</tr>
<tr>
<td>Geometrics</td>
<td>Ramp Length</td>
<td>The length of entry or exit ramps measured at the gore. In the case of ramps connecting to an at-grade intersection, this would be measured from...</td>
</tr>
<tr>
<td>Type</td>
<td>Freight Design Attribute</td>
<td>Definition</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Geometrics</td>
<td>Climbing Lane</td>
<td>Roadway lane design that allows slower travel for large vehicles ascending a steep grade.</td>
</tr>
<tr>
<td>Geometrics</td>
<td>Lane Width</td>
<td>The width of the travel lanes.</td>
</tr>
<tr>
<td>Geometrics</td>
<td>Shoulder Width</td>
<td>The width of the right or left shoulder.</td>
</tr>
<tr>
<td>Intersection</td>
<td>Intersection Sight Distance</td>
<td>The distance required for a driver to recognize a hazard or potential threat during challenging driving conditions.</td>
</tr>
<tr>
<td>Intersection</td>
<td>Turning Radius</td>
<td>The radius of the smallest circular turn that the vehicle is capable of making.</td>
</tr>
<tr>
<td>Intersection</td>
<td>Channelization</td>
<td>The separation or regulation of conflicting traffic movements into definite paths of travel by traffic islands or pavement markings.</td>
</tr>
<tr>
<td>Bridge &amp; Structure</td>
<td>Bridge Vertical Clearance</td>
<td>The height of bridges, structures, and signs over the roadways.</td>
</tr>
<tr>
<td>Bridge &amp; Structure</td>
<td>Railroad-Highway Overpass Bridge Vertical Clearance</td>
<td>Highway structures over railroads (railroad overpass) minimum vertical clearance measured from the top of the track to the lowest part of the bridge.</td>
</tr>
<tr>
<td>Pavement</td>
<td>Pavement Strength/Design Strategy</td>
<td>Pavement type, structure, and design.</td>
</tr>
<tr>
<td>Work Zone</td>
<td>Work Zone Lane Width</td>
<td>The width of the travel lanes in a work zone.</td>
</tr>
<tr>
<td>Work Zone</td>
<td>Work Zone Shoulder Width</td>
<td>The width of the right or left shoulder in a work zone.</td>
</tr>
<tr>
<td>Work Zone</td>
<td>Work Zone Strategy</td>
<td>Best practices to implement in the preparation of traffic control plan development.</td>
</tr>
<tr>
<td>Work Zone</td>
<td>Work Zone Bridge Vertical Clearance</td>
<td>The height of bridges, structures, and signs over the roadways in a work zone.</td>
</tr>
<tr>
<td>Traffic Operations</td>
<td>Traffic-Signal Phasing/Corridor Operation</td>
<td>Traffic-control operations and coordination along a corridor.</td>
</tr>
<tr>
<td>Traffic Operations</td>
<td>Sign &amp; Pavement Marking</td>
<td>Signage and pavement markings advising and channeling vehicles through roadway network.</td>
</tr>
</tbody>
</table>

### 2.2.2 STAKEHOLDER COORDINATION AND OUTREACH

Stakeholder-informed analysis is a TxDOT hallmark and crucial to assessment of freight infrastructure design. Two broad and important constituents were engaged through the FIDC study:
• **TxDOT Divisions and Public Partners:** The TxDOT Design Division has responsibility for the policy and guidelines the state establishes for roadway design. TxDOT District Operations have responsibility for design implementation across the diverse conditions and terrain of the state and observe freight activity first-hand. Local planning agencies bear comparable responsibilities in areas outside of TxDOT’s jurisdiction.

• **Private Industry and Truck Drivers:** Shippers and receivers of freight are the source of demand on Texas transportation infrastructure. Logistics service providers meet the demand with freight operations throughout the state. Providers encompass small and large common carrier truck lines, private truck fleets owned by shippers, and the truck drivers themselves, whose daily duty is the provision of safe, reliable service everywhere on the THFN.

The Texas Freight Advisory Committee, which straddles these two constituents because of its public and private membership, provided frequent guidance during the FIDC study. In addition to this coordination, the following key outreach activities conducted:

• Regional forums were held live in 19 locations across Texas, with total attendance by 339 participants in addition to TxDOT personnel (see Exhibit 6). Attendees ranged from local industry to motor carriers and multimodal logistics service providers and included representatives from regional planning agencies.

• An industry needs survey addressed to businesses, logistics operators and truck drivers elicited 453 responses on roadway conditions, safety and mobility issues, work zones and similar topics.

• Webinars were conducted with TxDOT District Operations in three groups covering all districts of the state. District engineers were polled on mobility and safety issues in their parts of Texas and reacted to the findings from forums and the needs survey.

• Truck drivers were surveyed about the relative importance to truck operations of a series of roadway design attributes. This resulted in 72 complete responses, which were used to help prioritize attributes for evaluation and recommendations.

The TxDOT Design Division is a key audience for this report, leading the study team to coordinate with them actively. The Design Division provided review and input at several important stages of analysis: identification of relevant design attributes; prioritization of attributes from the perspectives of mobility, safety, and cost effectiveness; and definition of minimum and optimum values for design consideration. The Design Division has been in the midst of updating the RDM while the FIDC study has been underway, with freight attributes planned for review for the subsequent RDM revision (currently planned for late 2022).
2.2.3 INVENTORY OF EXISTING GUIDANCE

Publicly available guidelines and studies were reviewed to document design practices in Texas for the key freight design attributes listed above. Guidance on geometric attributes came primarily from the RDM published by TxDOT in July 2020. Criteria were first compared to A Policy on Geometric Design of Highways and Streets (7th ed.), the premier national guidance on roadway design, published by the American Association of State Highway and Transportation Officials (AASHTO). This was updated in 2018 and is commonly referred to as the “Green Book.” Most states adopt the criteria proposed by this guidebook, and some even refer to entire sections of this guidance for designing certain types of roads. TxDOT’s design guidelines were then compared to six peer states (Arizona, California, Florida, Michigan, New York, and Washington) identified by TxDOT, ¹ and four neighboring states (New Mexico, Oklahoma, Arkansas, and Louisiana).

The detailed comparison of TxDOT design practices to peer states and national guidance is presented in Appendix A. The purpose of this analysis was to identify places where TxDOT’s design criteria could be changed to facilitate a wider range of truck operations. The comparison is also useful to assess the compatibility of Texas’ design criteria with other states, facilitating the efficient travel of trucks across state boundaries to serve national markets. This comparative analysis informs the recommendation of minimum and optimal design criteria for accommodating trucks.

A comparison matrix was developed (see Appendix B) that summarizes TxDOT’s design criteria and shows how they compare to peer states and the national guidance. The comparison matrix presents the criteria by functional classification and assesses whether TxDOT’s criteria are higher or lower

than the peer states. The comparison matrix also presents the recommended minimum and optimal criteria.

2.3 FREIGHT DESIGN NEEDS ANALYSIS OVERVIEW

An analysis was conducted to assess whether the THFN meets TxDOT’s design guidelines for the key freight design attributes, and the minimum and optimal design criteria recommended by the FIDC study. This analysis had two components:

- A system-level evaluation of the attributes that were available in GIS data
- A manual review of selected corridors for attributes that were not available in GIS data

Of the key freight design attributes, only the following were documented in existing TxDOT GIS data:

- Lane width
- Outside shoulder width
- Bridge vertical clearances for highway and railroad underpasses.

Appendix C presents the results of the system-level needs assessment of these attributes that are described in GIS data. Maps and tabular summaries of the design needs analysis are provided in Appendix C.

An analysis of specific roadway segments in Texas was conducted to manually assess the design criteria that were not available in the GIS inventory data. These locations were identified by scanning six major corridors in the state using the following criteria:

- Key freight corridors on the THFN identified through the Freight System Designation process for the TFMP.
- Hot spot areas on the THFN with a high frequency of truck-involved crashes.\(^2\)
- Segments that have planned improvements in the Unified Transportation Plan project database.
- The systemwide freight design needs assessment that identifies the segments on the THFN that do not meet minimum design considerations.
- The systemwide freight design needs assessment that identifies the segments on the THFN that meet optimal design considerations.

Exhibit 7 lists the corridor segments evaluated manually and Exhibit 8 shows these segments in a map. In total, 30 segments were evaluated, for a combined 293 miles of roadway.

\(^2\) TxDOT Crash Records Information System (CRIS) DOT, 2015 to 2019.
### Exhibit 7: THFN Segments Analyzed Manually

<table>
<thead>
<tr>
<th>No.</th>
<th>Corridor Segments</th>
<th>District</th>
<th>Limits</th>
<th>Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I-10 East</td>
<td>El Paso</td>
<td>I-110 to Zaragoza Road</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>US 287</td>
<td>Fort Worth</td>
<td>I-30 to Little Road</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>US 290</td>
<td>Houston</td>
<td>Tall Hickory Lane to Huffmeister Road</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>I-35 North</td>
<td>San Antonio</td>
<td>N Weldner Road to Roy Richard Drive</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>I-69 North</td>
<td>Houston</td>
<td>Will Clayton Pkwy to Townsend Ramp</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>IH 27/US 87 (P2P)</td>
<td>Amarillo</td>
<td>S Washington St to W St Francis Ave</td>
<td>18</td>
</tr>
<tr>
<td>7</td>
<td>US 59</td>
<td>Lufkin</td>
<td>S Meadows St to 287</td>
<td>10</td>
</tr>
<tr>
<td>8</td>
<td>US 277</td>
<td>Laredo</td>
<td>Elm Creek Drive to Main St</td>
<td>6</td>
</tr>
<tr>
<td>9</td>
<td>US 90</td>
<td>Laredo</td>
<td>Wildwood Dr to E Gibbs St</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>US 77</td>
<td>Corpus Christi</td>
<td>E General Cavazos Blvd to FCC Monitoring Rd</td>
<td>4</td>
</tr>
<tr>
<td>11</td>
<td>US 287/US 87</td>
<td>Amarillo</td>
<td>Success Blvd to Watson Ln</td>
<td>4</td>
</tr>
<tr>
<td>12</td>
<td>US 290</td>
<td>Austin</td>
<td>Squirrel Run to Jordan Tatsch Rd</td>
<td>10</td>
</tr>
<tr>
<td>13</td>
<td>I-69</td>
<td>Houston</td>
<td>I-610 to Hamblem Rd</td>
<td>16</td>
</tr>
<tr>
<td>14</td>
<td>I-10 East</td>
<td>Houston</td>
<td>N Mason Rd to US 290</td>
<td>18</td>
</tr>
<tr>
<td>15</td>
<td>I-10 East</td>
<td>San Antonio</td>
<td>UTSA Blvd to Fresno St</td>
<td>9</td>
</tr>
<tr>
<td>16</td>
<td>I-35W</td>
<td>Fort Worth</td>
<td>US 81 to Keller Haslet Rd</td>
<td>6</td>
</tr>
<tr>
<td>17</td>
<td>I-35</td>
<td>Laredo</td>
<td>Shiloh Dr to Houston St</td>
<td>5</td>
</tr>
<tr>
<td>18</td>
<td>I-40/US 287</td>
<td>Amarillo</td>
<td>S Rosa St to County Rd A</td>
<td>12</td>
</tr>
<tr>
<td>19</td>
<td>US 290</td>
<td>Houston</td>
<td>N Eldridge Pkwy to Antoine Dr</td>
<td>10</td>
</tr>
<tr>
<td>20</td>
<td>US 87</td>
<td>San Angelo</td>
<td>Riverside Golf Course Rd to Knickerbocker Rd</td>
<td>4</td>
</tr>
<tr>
<td>21</td>
<td>I-10</td>
<td>El Paso</td>
<td>US 375 to US 793</td>
<td>16</td>
</tr>
<tr>
<td>22</td>
<td>I-10</td>
<td>San Antonio</td>
<td>FM 1621 to Walters Rd</td>
<td>11</td>
</tr>
<tr>
<td>23</td>
<td>I-35</td>
<td>Waco</td>
<td>W Pine St to US 579</td>
<td>11</td>
</tr>
<tr>
<td>24</td>
<td>I-35</td>
<td>San Antonio</td>
<td>US 132 to Rolling Meadow Ln</td>
<td>13</td>
</tr>
<tr>
<td>25</td>
<td>I-69 E</td>
<td>Pharr</td>
<td>S F St to US 77 BR S</td>
<td>8</td>
</tr>
<tr>
<td>26</td>
<td>I-45</td>
<td>Dallas</td>
<td>US 287 to TX 31</td>
<td>16</td>
</tr>
<tr>
<td>27</td>
<td>US 287</td>
<td>Childress</td>
<td>US 70 to US 203</td>
<td>14</td>
</tr>
<tr>
<td>28</td>
<td>US 290</td>
<td>Bryan</td>
<td>US 36 to US 2447</td>
<td>8</td>
</tr>
<tr>
<td>29</td>
<td>US 59</td>
<td>Lufkin</td>
<td>FM 357 to FM 2108</td>
<td>20</td>
</tr>
<tr>
<td>30</td>
<td>US 87</td>
<td>Amarillo</td>
<td>Perico Ln to Texas 102</td>
<td>16</td>
</tr>
</tbody>
</table>
These locations were chosen according to the criteria above to provide a sample of infrastructure characteristics on the THFN. Data was collected that described the remaining attributes for these locations. Design criteria relating to intersections were collected at all 468 intersections identified on these corridors. Design criteria relating to the ramps and acceleration lanes were collected for all 643 ramps identified. Criteria that varied along the corridor were collected at every 1-mile interval. The results of this data collection are presented when design deficiencies are discussed in Section 3.
Exhibit 8: Corridor Needs Assessment Locations

The next section describes the assessment of freight design attributes where major changes are recommended.
3 Assessment of Key Freight Design Attributes where Major Changes are Recommended

This section provides a summary of the assessment of each freight design attribute for which changes are recommended. It describes existing guidance in Texas, provides considerations that could improve the freight accommodation of the design, and reports any deficiencies found along the THFN. As described in the previous section, some deficiencies were evaluated throughout the THFN while others were evaluated at 30 segments on the THFN (shown in Exhibit 8). The purpose of this section is not to provide all the background and analysis conducted to develop the recommendations, but instead to summarize key highlights and takeaways. The full description of the inputs that went into this analysis are included in Appendix A: Existing Conditions Report, Appendix B: Design Comparison Matrix, and Appendix C: Systemwide Freight Design Needs Analysis of the Texas Highway Freight Network.

The freight design considerations recommended in this section were generated by reviewing national design guidance, peer state practices, adjacent state practices, academic publications, and stakeholder input. These were the sources of the research conducted for this section. Section 3 contains the attributes for which changes were recommended by the assessment, while Section 4 contains attributes for which no changes were recommended.

Two levels of freight design considerations are provided. First, “minimum” criteria were established representing the lowest level of freight accommodations recommended to ensure a baseline level of safety and mobility. In most cases, the “minimum” criteria recommended is the criteria in the RDM, used presently to design roads. In a few cases, the “minimum” criteria elevated beyond current practice. Second, “optimal” criteria were established that rise to national leadership in freight accommodation. In some cases, the “optimal” and “minimum” criteria were the same, as observed when the RDM equals national best practices, or when no basis was available to develop different recommendations between the two types of criteria. A detailed accounting of “minimum” and “optimal” criteria for each freight design attribute is presented in the comparison matrix included in Appendix B. This matrix includes references to the sections of design guidance pertaining to each attribute. This matrix also shows recommendations by roadway functional classification, because trucks should be accommodated differently on a highway than a local arterial. Recommendations by functional classification are not provided in this section for brevity. Recommendations are provided only for the main functional classifications relevant for each attribute.
3.1 ACCELERATION LANE LENGTH

3.1.1 DEFINITION
A speed change lane, consisting of added pavement at the edge of through-traffic lanes, permits vehicles to accelerate before merging with through-traffic (see Exhibit 9). Acceleration lanes reduce the differences in speed between mainline and ramp traffic, which helps improve safety especially for larger vehicles that accelerate more slowly, especially when loaded.

3.1.2 EXISTING GUIDELINES
The RDM provides requirements for acceleration lane lengths for various highway design speeds, and includes adjustments to the acceleration lane lengths based on roadway vertical grades. According to the RDM, the minimum required acceleration lane length for a highway design speed of 65 mph and an entrance ramp design speed of 45 mph is 600 feet. The minimum required acceleration lane length for a highway design speed of 70 mph and an entrance ramp design speed of 50 mph is 580 feet.

3.1.3 RECOMMENDED CONSIDERATIONS
Increase acceleration lane lengths at locations along the THFN where high truck volumes are present along or near the highway. Longer acceleration lanes have been recommended in existing guidance and research studies, including:

- AASHTO’s Green Book states that an acceleration lane length of at least 1,200 feet plus the taper is desirable wherever it is anticipated that the ramp and freeway will frequently carry traffic volumes approximately equal to the design capacity of the merging area.

- California Department of Transportation (Caltrans) provides guidelines for freeway entrances where truck volumes exceed 20 vehicles per hour on ascending ramps with sustained upgrades exceeding 2 percent. Under this condition, an acceleration lane/auxiliary lane of 1,500 feet is recommended for “satisfactory operation conditions.” These recommendations take additional consideration for acceleration lanes present on upgrades or downgrades. Caltrans also makes allowances for the effect of ramp metering on acceleration lengths. When present, metering eliminates the ability of vehicles to accelerate on the ramp; therefore, Caltrans requires additional acceleration lanes in these cases. Ramp metering is common in several cities in Texas and therefore could be causing issues for loaded trucks that need to accelerate to merge into mainline traffic. In these cases, longer acceleration lanes are warranted.
• National Cooperative Highway Research Program (NCHRP) Report 505 (2003), “Review of Truck Characteristics as Factors in Roadway Design” also suggests that acceleration lanes are beneficial for trucks, particularly when loaded, and recommends considering additional allowances than made in contemporaneous design guidance.

• Research on acceleration lanes also recommends longer lengths for accommodating heavy trucks.³

Similar recommendations could be considered in Texas.

3.1.4 JUSTIFICATION

Heavy trucks take longer to get up to speed, causing other vehicles to move around them, posing a safety risk. Other disruptions resulting from the slower moving truck can cause vehicles to back up behind the truck, leading to congestion. Studies have shown a dramatic increase in vehicular accidents when the speed differential between large trucks and passenger vehicles is greater than 10 mph.

3.1.5 DEFICIENCIES

Among the 289 entrance ramps along the corridors studied, 151 of those entrance ramps (52 percent) do not meet the minimum acceleration length given in the RDM. On I-35 in Laredo, the mainlane posted speed limit is 65 mph and the advisory speed limit of the entrance ramp is 45 mph. If the design speed of the mainlanes and entrance ramp were the same as the posted/advisory speed limits, the minimum acceleration length should be 600 feet for this criteria, according to the RDM. In one location on I-35 in Laredo, as shown in Exhibit 10, the acceleration lane length provided is less than the recommended 600 feet minimum. There is 54 feet provided for two cars adjacent to each other and then the traffic is forced to merge with a 360-foot-long taper.

Exhibit 9: Acceleration Lane Length Does Not Meet Minimum Recommended by Texas Roadway Design Manual

Exhibit 10: Existing Southbound I-35 Entrance Ramp with Insufficient Acceleration Lane Length (North of W Mann Road/I-35 in Laredo, TX)

3.1.6 ABOVE MINIMUM

Among the 289 entrance ramp locations studied, 138 of these locations (48 percent) have acceleration lanes that meet or exceed the minimum length given in the RDM. For example, on US 287 in Fort Worth, the highway posted speed limit is 60 mph and the entrance ramp advisory speed limit is 45 mph. Assuming the design speeds for the mainlanes and ramp are the same as the posted/advisory limits, according to the RDM, the minimum acceleration length for this location is 420 feet. Exhibit 11 demonstrates that this entrance ramp matches the minimum acceleration
length as given in the RDM. Exhibit 12 shows an example where an acceleration lane matches minimum guidance.

*Exhibit 11: Acceleration Lane Length Meets Minimum Recommended by Texas Roadway Design Manual*

*Exhibit 12: Existing Northbound US 287 Entrance Ramp with Acceleration Lane that Matches Minimum Length (South of E Maddox Avenue/US 287 Intersection in Fort Worth, TX)*
3.1.7 ABOVE OPTIMAL

Of the studied entrance ramps, 94 (33 percent) exceed the optimal length of 1,200 feet for acceleration lanes. For example, on I-45 in Rice, the highway posted speed limit is 75 mph and the entrance ramp advisory speed limit is 45 mph. According to the RDM, the minimum acceleration length for this location is 1,040 feet. However, the desirable value is 1,200 feet. Exhibit 13 shows that the acceleration lane length, which also serves as an auxiliary lane, for this entrance ramp is exactly 1,200 feet as recommended in the RDM. At these locations, trucks will have additional space to accelerate and merge with mainline traffic.

Exhibit 13: Existing Southbound I-45 Entrance Ramp with Acceleration Lane that Matches Optimal Length (North of Calhoun Street/I-45 Intersection in Rice, TX)

3.2 VERTICAL GRADE

3.2.1 DEFINITION

The slope along the direction of travel.

3.2.2 EXISTING GUIDELINES

The RDM provides requirements for maximum vertical grades in terms of design speed, the functional classification of the roadway, and the type of terrain. According to the RDM, the maximum vertical grade for a freeway ranges from 3 percent to 5 percent. This criteria ranges from 3 percent to 12 percent for non-freeway roadways. The maximum vertical grade used to evaluate the studied THFN corridors is 3 percent.

3.2.3 RECOMMENDED CONSIDERATIONS

Consider regulating maximum vertical grade based on percentage of truck traffic. The recommended maximum vertical grade for freeways of 3 percent to 4 percent in the RDM require no change. Consider lowering maximum vertical grades to 5 to 6 percent for arterials with heavy truck traffic from the current 8 to 9 percent in RDM. The Florida DOT limits the maximum grade to 4 percent for all roadway classifications with more than 10 percent heavy truck traffic; however, the relatively flat terrain in Florida makes it easy to meet this guidance. Exceptions to recommendation could be implemented in significant rolling terrain or mountainous areas of the state where achieving recommended grades is costly.
3.2.4 JUSTIFICATION
Trucks generally increase speed by up to 5 percent on downgrades and decrease speed by 7 percent or more on upgrades as compared to their operation on level terrains. On upgrades, the maximum speed that can be maintained by a truck is dependent primarily on the length and steepness of the grade and the truck’s weight-to-power ratio.

3.2.5 DEFICIENCIES
No major deficiencies were found. Of the 304 locations studied, 298 (98 percent) were found to have vertical grades less than 3 percent. However, these locations were typically found in urban freeway facilities with more than two lanes in each direction. In most cases, these steeper grades do not have a large negative effect from slower moving heavy truck traffic. The statewide network is likely to meet the flatter vertical grades due to the primarily flatter terrain in Texas. Further study should consider the grades in areas of significant rolling terrain and freeways where known congestion exists as a result of vertical grades, length of grade and truck volume. Exhibit 14 shows a roadway with a 3 percent maximum upgrade.

Exhibit 14: Roadway with 3 Percent Maximum Upgrade
3.3 CLIMBING LANE

3.3.1 DEFINITION
Roadway lane design that allows slower travel for large vehicles ascending a steep grade.

3.3.2 EXISTING GUIDELINES
The RDM encourages consideration of providing a climbing lane when one of the following three conditions exists:

- 10 mph or greater speed reduction is expected for a typical heavy truck
- Level-of-service E or F exists on the upgrade
- A reduction of two or more levels of service is experienced when moving from the approach segment to the upgrade

The RDM also recommends the consideration of providing a climbing lane if the following traffic conditions exist:

- Upgrade traffic flow rate in excess of 200 vehicles per hour
- Upgrade truck flow rate in excess of 20 vehicles per hour

The climbing lane should be introduced near the foot of the grade, preceded by a tapered section desirably with a ratio of 25:1, at least 150 feet long, extended to a point beyond the crest where a typical truck could attain a speed that is within 10 mph of the speed of other vehicles, followed by a tapered section desirably with a ratio of 50:1 and should not end just prior to an obstruction such as a restrictive width bridge.

3.3.3 RECOMMENDED CONSIDERATIONS
Consider expanding RDM guidance on climbing lanes so they are warranted in more locations throughout the THFN. A full analysis and calculations per the Highway Capacity Manual should be followed, and allowances could be added for roads with high truck volumes. Several peer states have expended guidance on the subject, especially those in mountainous parts of the country (some of this guidance might only be instructive in mountainous areas of Texas). Peer state California notes, “Regardless of traffic volumes, the requirement of a climbing lane should be implemented when a roadway has a sustained upgrade greater than 2 percent and the total rise is greater than 250 feet.” This guidance will generally result in more climbing lanes than suggested by the Highway Capacity Manual. Peer state Arizona has expanded guidance on climbing and passing lanes that could provide additional guidance for the RDM.
3.3.4 **JUSTIFICATION**

Grades greater than 2 percent may affect truck traffic depending on the length of grade. On two-lane highways, this reduction in truck speed will slow traffic traveling behind a truck and potentially cause unsafe driving situations from those attempting to pass a truck. Providing an adequate climbing lane will allow the slower moving truck to use this lane and faster moving vehicles to safely pass a truck.

3.3.5 **DEFICIENCIES**

In the selected locations of the THFN studied, no climbing lanes were found for the purposes of measuring taper lengths and length of climbing lane. Exhibit 15 shows the benefit of a climbing lane, which separates slower moving trucks from through-traffic as the roadway ascends a steep grade.

*Exhibit 15: Climbing Lane for 3 Percent Upgrade*
3.4 LANE WIDTH

3.4.1 DEFINITION
The width of the travel lanes.

3.4.2 EXISTING GUIDELINES
The TxDOT design standards uses 12-foot lanes on rural and urban interstates and other freeways/expressways, as well as Rural Principal and Minor Arterials. The TxDOT design standards call for a minimum lane width of 11 feet on Urban Principal and Minor Arterials, a minimum lane width of 10 feet on Urban Major and Minor Collectors and a minimum of 10- to 12-foot lane widths for Rural Major and Minor Collectors. AASHTO Green Book recommends lane widths of 9 to 12 feet, with a 12-foot lane predominantly used on most high-speed, high-volume highways.

3.4.3 RECOMMENDED CONSIDERATIONS
The recommended value for lane widths on all roadway types along the THFN is 12 feet. This will help accommodate trucks, even on lower classification roads. Priority for improvements could be given to roads with high truck volumes.

3.4.4 JUSTIFICATION
The lane width of a roadway influences the comfort of driving, operational characteristics, and, in some situations, the likelihood of crashes. Several peer states recommend wider lanes than in national guidance, especially on freight routes. For example, Florida DOT requires a minimum lane width of 11 feet for freight corridors or where truck volume is more than 10 percent regardless of functional classification. NCHRP Report 943 states, “It is desirable to provide 12-ft lanes on truck routes or to use differential lane widths with a 12-ft outside or curb lane and narrower center or left lanes.” This echoes the recommendation for this attribute.

3.4.5 DEFICIENCIES
According to the TxDOT roadway inventory database, 6 percent of the total on-system mileage on the THFN does not meet minimum design criteria for lane width. See Exhibit 16 for a breakdown of how the THFN meets lane width guidance for different roadway types.
## Exhibit 16: Comparison of TxDOT Design Standards and Existing Lane Widths on the Texas Highway Freight Network

<table>
<thead>
<tr>
<th>Roadway Type</th>
<th>TxDOT Design Standards (feet)</th>
<th>THFN Mileage Percentage of Subtotal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Greater</td>
<td>Less</td>
</tr>
<tr>
<td>R1-Rural Interstate</td>
<td>12</td>
<td>0%</td>
</tr>
<tr>
<td>R2-Rural Other Freeway and Expressway</td>
<td>12</td>
<td>0%</td>
</tr>
<tr>
<td>U1-Urban Interstate</td>
<td>12</td>
<td>1%</td>
</tr>
<tr>
<td>U2-Urban Other Freeway and Expressway</td>
<td>12</td>
<td>1%</td>
</tr>
<tr>
<td>Subtotal (Freeways)</td>
<td>2%</td>
<td>6%</td>
</tr>
<tr>
<td>R3-Rural Other Principal Arterial</td>
<td>12</td>
<td>9%</td>
</tr>
<tr>
<td>R4-Rural Minor Arterial</td>
<td>12</td>
<td>5%</td>
</tr>
<tr>
<td>U3-Urban Other Principal Arterial</td>
<td>11</td>
<td>22%</td>
</tr>
<tr>
<td>U4-Urban Minor Arterial</td>
<td>11</td>
<td>3%</td>
</tr>
<tr>
<td>Subtotal (Arterials)</td>
<td>40%</td>
<td>4%</td>
</tr>
<tr>
<td>R5-Rural Major Collector</td>
<td>10, 11, 12</td>
<td>29%</td>
</tr>
<tr>
<td>R6-Rural Minor Collector</td>
<td>10, 11, 12</td>
<td>1%</td>
</tr>
<tr>
<td>U5=Urban Major Collector</td>
<td>10</td>
<td>5%</td>
</tr>
<tr>
<td>U6=Urban Minor Collector</td>
<td>10</td>
<td>0%</td>
</tr>
<tr>
<td>Subtotal (Collectors)</td>
<td>35%</td>
<td>13%</td>
</tr>
</tbody>
</table>

Note: Values might not sum to totals because of rounding.

### 3.4.6 ABOVE MINIMUM

According to the TxDOT roadway inventory database, 63 percent of the total on-system mileage on the THFN meets TxDOT design standards and 31 percent exceeds the design standards.

### 3.4.7 ABOVE OPTIMAL

According to the TxDOT roadway inventory database, 70 percent of the THFN mileage on Principal and Minor Arterials and Major and Minor collectors meet the 12-foot optimal lane width.

Exhibit 17 through Exhibit 19 illustrate the lane widths on the THFN, which range from 10 feet on Rural/Urban Major and Minor Collectors to 12 feet on Rural/Urban Freeways and Principal and Minor Arterials.
3.5 OUTSIDE SHOULDER WIDTH

3.5.1 DEFINITION

The width of the right shoulder.

3.5.2 EXISTING GUIDELINES

The TxDOT design standards requires 10-foot minimum outside shoulders for Rural and Urban Interstates and Freeways/Expressways, 4- to 10-foot outside shoulders on Rural Principal and Minor Arterials, 4-foot minimum outside shoulders on Urban Principal and Minor Arterials, 2- to 10-foot...
outside shoulders on Rural Major and Minor Collectors, and 3-foot minimum outside shoulders in Urban Major and Minor Collectors.

### 3.5.3 RECOMMENDED CONSIDERATIONS

Optimally, increase outside shoulder width on Freeways and Expressways to 12 feet. Increase outside shoulder width on Rural Principal and Minor Arterials and Rural Major and Minor Collectors to 10 feet. Increase outside shoulder width on Urban Principal and Minor Arterials and Urban Major and Minor Collectors to 8 feet. Locations where these shoulder widths are provided could be further identified based on truck traffic volumes.

### 3.5.4 JUSTIFICATION

Large trucks can have widths up to 8.5 feet. Providing a wider outside shoulder allows for a recovery area for trucks that breakdown or need to stop for other reasons. This is especially important for higher speed roadways so passing vehicles do not have to slow down or are forced to change lanes to safely pass the truck. Peer states have adopted higher guidance on shoulder widths. For example, peer state Arizona increases shoulder width from 10 to 12 feet for a freeway with six or more lanes if truck traffic Direction Design Hourly Volume is more than 250. NCHRP Report 943 recommends paved shoulders of at least 10 feet on truck routes in rural areas. In addition, the report states that shoulders are desirable on urban roadways with design speeds of 50 mph or higher.
3.5.5 DEFICIENCIES

According to the TxDOT roadway inventory database, one percent of freeways, 32 percent of arterials and 70 percent of collectors do not meet the minimum RDM requirements for outside shoulder width. Exhibit 20 illustrates a roadway segment that does not have any shoulder. This roadway is FM-2181 in Corinth, TX.

*Exhibit 20: Roadway with Outside Shoulder Width Less Than Minimum of 10 Feet (Teasley Dr. in Corinth, TX)*
See the Exhibit 21 for a breakdown of how outside shoulders on the TFHN match existing TxDOT guidance.

**Exhibit 21: Outside Shoulder Width Comparison with TxDOT Design Standard**

<table>
<thead>
<tr>
<th>Roadway Type</th>
<th>TxDOT Design Standards (feet)</th>
<th>THFN Mileage Percentage of Subtotal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Greater</td>
<td>Less</td>
</tr>
<tr>
<td>R1-Rural Interstate</td>
<td>10</td>
<td>11%</td>
</tr>
<tr>
<td>R2-Rural Other Freeway and Expressway</td>
<td>10</td>
<td>1%</td>
</tr>
<tr>
<td>U1-Urban Interstate</td>
<td>10</td>
<td>11%</td>
</tr>
<tr>
<td>U2-Urban Other Freeway and Expressway</td>
<td>10</td>
<td>7%</td>
</tr>
<tr>
<td><strong>Subtotal (Freeways)</strong></td>
<td></td>
<td>29%</td>
</tr>
<tr>
<td>R3-Rural Other Principal Arterial</td>
<td>4, 8, 10</td>
<td>6%</td>
</tr>
<tr>
<td>R4-Rural Minor Arterial</td>
<td>4, 8, 10</td>
<td>4%</td>
</tr>
<tr>
<td>U3-Urban Other Principal Arterial</td>
<td>4</td>
<td>16%</td>
</tr>
<tr>
<td>U4-Urban Minor Arterial</td>
<td>4</td>
<td>2%</td>
</tr>
<tr>
<td><strong>Subtotal (Arterials)</strong></td>
<td></td>
<td>28%</td>
</tr>
<tr>
<td>R5-Rural Major Collector</td>
<td>2, 4, 8, 10</td>
<td>4%</td>
</tr>
<tr>
<td>R6-Rural Minor Collector</td>
<td>2, 4, 8, 10</td>
<td>0%</td>
</tr>
<tr>
<td>U5-Urban Major Collector</td>
<td>3</td>
<td>3%</td>
</tr>
<tr>
<td>U6-Urban Minor Collector</td>
<td>3</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Subtotal (Collectors)</strong></td>
<td></td>
<td>7%</td>
</tr>
</tbody>
</table>

Note: Values might not sum to totals because of rounding.

**3.5.6 ABOVE MINIMUM**

According to the TxDOT roadway inventory database, 98 percent of freeways, 57 percent of arterials and 17 percent of collectors meet or exceed the minimum requirements for outside shoulder width. Exhibit 22 illustrates an outside shoulder width that meets the minimum of 10 feet.
Exhibit 22: Roadway with Outside Shoulder Less than Minimum of 10 Feet

Exhibit 23: Roadway with Outside Shoulder Width Equal to Recommended Width of 12 Feet

3.5.7 ABOVE OPTIMAL

According to the TxDOT roadway inventory database, 23 percent of freeways meet the optimal criteria of 12 foot outside shoulders. Exhibit 23 illustrates an outside shoulder width that equals the recommended outside shoulder width of 12 feet.
3.6 INTERSECTION TURNING RADIUS

3.6.1 DEFINITION

The radius of the smallest circular turn that the vehicle can make.

3.6.2 EXISTING GUIDELINES

The RDM provides guidance on the minimum turning radii that should be provided for trucks at intersections. For a WB-62 design vehicle (see Exhibit 24) on an arterial-arterial urban intersection, the RDM recommends a turning radius of 75 feet.

Exhibit 24: Dimensions of WB-62 Design Vehicle

3.6.3 RECOMMENDED CONSIDERATIONS

Consider providing intersection turning radii for WB-67 design vehicle (see Exhibit 25) for THFN corridors where practical and where high truck turning movements are known or expected.
3.6.4 JUSTIFICATION

Providing turning radii for a larger design vehicle will provide for safer intersection conditions by minimizing the potential for the turning truck and other traffic from colliding. Damage to curbs and/or causing rutting behind the curb can be minimized as well. Florida DOT provides comprehensive tables for turning radii in their roadway design guidance. Some of these values are significantly higher than those in the RDM, especially for sharper turn angles.

3.6.5 DEFICIENCIES

Among the 440 intersections studied, 346 (79 percent) do not meet the minimum intersection turning radius of 75 feet. As shown in Exhibit 26, the intersection of US 90 (Veterans Boulevard) and E Cantu Road does not provide enough space for a truck turning maneuver with a radius of 75 feet.
3.6.6 ABOVE MINIMUM

Among the 440 intersections studied, 94 (21 percent) meet or exceed the minimum intersection turning radius of 75 feet. Exhibit 27 shows an intersection with sufficient turning radius.
3.7 INTERSECTION CHANNELIZATION

3.7.1 DEFINITION

The separation or regulation of conflicting traffic movements into definite paths of travel by traffic islands or pavement markings.

3.7.2 EXISTING GUIDELINES

TxDOT’s RDM revisions from January 2020 added Appendix D which provides guidance for right turn “slip lane” design including raised channelization islands. Exhibit 28 shows an intersection with channelized left and right turns.
3.7.3 RECOMMENDED CONSIDERATIONS

Consider developing guidance on storage lengths and channel widths at intersections that see significant truck volumes, particularly during congested periods of the day, as recommended in NCHRP Report 943. This would reduce the risk of truck-involved crashes and improve traffic operations.

3.7.4 JUSTIFICATION

The presence of trucks during peak traffic hour can reduce the amount of storage available for passenger cars. If there is a higher volume of trucks during peak traffic hour, the intersection should be designed in such a way as to accommodate both the passenger cars and trucks simultaneously.

Both Arizona and California suggest if peak-hour truck traffic is 10 percent or more of total, queue length should provide space for one passenger and one truck (85 feet minimum). Specific to channelizing for right-turn lanes, NCHRP Report 943 recommends channelization with larger curb return radii, which is advantageous for trucks without negatively affecting pedestrian crossings. The report also recommends extra storage length for left turns to accommodate truck storage and a turn
lane width of 12 feet where substantial truck traffic turns left. These recommendations are sensible and should be considered in Texas.

3.7.5 DEFICIENCIES

No data collected on channelization on the TFHN.

3.8 WORK ZONE LANE WIDTH

3.8.1 DEFINITION

The width of the travel lanes during a work zone. Exhibit 29 through Exhibit 31 illustrate work zone lane widths ranging from 10 feet to 12 feet with a reduced outside shoulder.

*Exhibit 29: 12-Foot Lanes and Limited Outside Shoulder in Work Zone*

*Exhibit 30: 11- to 12-Foot Lanes and Limited Outside Shoulder in Work Zone*
3.8.2 EXISTING GUIDELINES

There is no existing guidance in the RDM for work-zone lane widths. The *Texas Manual on Uniform Traffic Control Devices*, Part 6, is used for developing project-specific traffic control plans, including lane widths. (See Appendix A for a detailed review of existing work zone practices in Texas.)

3.8.3 RECOMMENDED CONSIDERATIONS

It is recommended that TxDOT consider truck volumes when determining appropriate lane widths in work zones. Maintaining 12-foot lanes is preferred to preserve safety.

3.8.4 JUSTIFICATION

In some cases, lane widths are narrowed in work zones due to construction activities. The minimum lane width should be limited, especially in areas with high truck volumes, in order to maintain freight mobility. Vehicles driving next to trucks in narrow lanes may tend to slow down and be reluctant to pass the truck potentially causing additional congestion. Some peer states provide work zone lane-width guidance for freight mobility:

- One of Michigan’s best practices in areas with narrowed lane widths due to construction is to provide one lane wider than another (e.g., one 12-foot lane and one 10-foot lane rather than two 11-foot lanes) to provide room for larger vehicles.

- New York sets “clear widths” for freeways with significant truck traffic at 14 feet (16 feet desirable) for one-lane operation. For two-lane operations, 22 feet clear width is recommended, with 11 feet for each added lane.
• Washington state’s manual recommends consideration for how work zone operation will affect truck traffic. Consideration of truck volumes when determining lane widths through work zones is noted. Total roadway widths less than 16 feet for one-lane/one-way traffic are discouraged in order to maintain freight mobility.

• NCHRP Report 943 states, “Work zones on truck routes should be designed to accommodate the appropriate truck design vehicle, selected based on the vehicle mix expected to travel through the work zone.”

3.8.5 DEFICIENCIES
No data collected on deficiencies.

3.9 WORK ZONE SHOULDER WIDTH

3.9.1 DEFINITION
The width of the right or left shoulder during a work zone. See Exhibit 29 through Exhibit 31 for outside shoulder widths illustrated alongside the lane widths in a work zone.

3.9.2 EXISTING GUIDELINES
There is no existing guidance in the RDM or in peer-state manuals for work zone shoulder widths.

3.9.3 RECOMMENDED CONSIDERATIONS
Provide full-width outside shoulders where possible when truck traffic is significant, and work zones are expected to last more than a week.

3.9.4 JUSTIFICATION
Outside shoulders can be used as a refuge area for trucks that breakdown allowing for all lanes to remain operational.

3.10 WORK ZONE STRATEGY

3.10.1 DEFINITION
Best practices to implement in the preparation of traffic control plan development. Exhibit 32 shows a work zone strategy that implements signage, no passing zone, and speed limit reduction to improve safety and mobility through the work zone.
3.10.2 EXISTING GUIDELINES

The RDM does not address work zone strategies. The Texas MUTCD and Traffic Control Plan (TCP) standards are used for guidance. Most TxDOT districts perform safety review meetings during the early development of the traffic control. (See Appendix A for a detailed overview of work zone strategies in Texas.)

3.10.3 RECOMMENDED CONSIDERATIONS

Some peer states discuss suggested work zone strategies for freight-heavy corridors. TxDOT should consider if these strategies could be beneficial:

- Michigan DOT often specifies a lane for truck use to minimize conflicts between truck and car traffic on corridors with high freight volumes. Washington state implements this strategy as well.
- As discussed in NCHRP Report 943, California and New York place warning signs farther upstream from a work zone than normal if hazardous conditions exist.
- Work zone or reduced regulatory speed limits should be implemented when lane transitions with minimum lengths are required.
- Lane closure and transition lengths above the minimum values shown in Traffic Control Plan Standards should be used when considerable truck volumes are present or expected.
- Through the transition areas the skip stripes can be replaced with solid striping to help traffic stay within lane assignments. Some TxDOT districts currently implement this strategy.

3.10.4 JUSTIFICATION

Freight traffic traveling through work zones can negatively affect traffic flow when traffic control plans are developed without considerations for accommodating large trucks.
3.11 WORK ZONE BRIDGE VERTICAL CLEARANCE

3.11.1 DEFINITION

The height of bridges, structures and signs over the roadways during a work zone. Exhibit 33 shows reductions in bridge vertical clearance in a work zone.

Exhibit 33: Reduced Bridge Vertical Clearance in Work Zone

3.11.2 EXISTING GUIDELINES

The RDM provides guidance on bridge vertical clearance along the THFN. The minimum vertical clearance requirement for applicable structures on the THFN project is 18.5 feet. However, the previous bridge vertical clearance requirement of 16.5 feet exists on the majority of the THFN corridors.

3.11.3 RECOMMENDED CONSIDERATIONS

It is critical to maximize the vertical clearance on all construction projects.
• Bridge clearance in work zone areas should be consistent with the THFN minimum requirement of 18.5 feet where this clearance already exists. A clearance of 16.5 feet should be considered acceptable.

• As noted by Michigan DOT, vertical and horizontal clearances should be evaluated on shoulders as well as the mainline, when shoulders remain open (vertical clearances in Texas are measured at the lowest point across the pavement, including shoulders).

• NCHRP Report 943 addresses a work zone condition where trucks may be prohibited from traveling through a work zone because of vertical clearance restrictions. Providing a suitable detour route that will accommodate truck traffic should be established and clearly signed.

3.11.4 JUSTIFICATION

Potential impacts to bridges must be avoided at all costs.
4 Assessment of Key Freight Design Attributes where Major Changes are Not Recommended

This section provides a summary of the assessment of each freight design attribute for which no changes are recommended. In these cases, roadway design practices in Texas match or exceed national best practices, and therefore no changes are recommended.

4.1 DECELERATION LANES LENGTH

4.1.1 DEFINITION
A speed change lane consisting of added pavement at the edge of through-traffic lanes to permit drivers to diverge from through-traffic flow without reducing speed until after the diverging maneuver is completed.

4.1.2 EXISTING GUIDELINES
The RDM provides requirements for deceleration lane lengths for various highway design speeds and includes adjustments to the deceleration lane lengths based on roadway vertical grades. According to the RDM, the minimum deceleration lane length for a highway with a design speed of 65 mph and an entrance curve design speed of 40 mph is 390 feet.

4.1.3 RECOMMENDED CONSIDERATIONS
Values provided in the RDM are similar to peer states, and no changes are recommended.

4.1.4 JUSTIFICATION
Some large trucks require more time and distance to slow down to merge safely with vehicles on the intersection roadway. A deceleration lane with sufficient length allows the truck to slow down without negatively impacting the vehicles on the mainline.

4.1.5 DEFICIENCIES
Among the 295 exit ramp locations studied, 145 (49 percent) have deceleration lanes shorter than the minimum length given in the RDM. On US 287 in Fort Worth, the mainline speed limit is 60 mph and the entrance curve design speed is 45 mph. The minimum deceleration length for this criterion is 300 feet, according to the RDM. There is no deceleration lane provided at this location, as shown in Exhibit 34.
Exhibit 34: Northbound US 287 Exit Ramp with Insufficient Deceleration Lane Length (North of E Vickery Boulevard Underpass, Fort Worth, TX)

Exhibit 35 shows a deceleration lane length that does not meet the minimum recommended in the RDM.

Exhibit 35: Deceleration Lane Length Does Not Meet Minimum Recommended by Texas Roadway Design Manual
4.1.6 EXAMPLES ABOVE MINIMUM/OPTIMAL

There are 150 locations with deceleration lane lengths equal to or greater than the minimum length given in the RDM. In this case, given that RDM criteria were judged to be adequate, the minimum criteria were found to be optimal. Exhibit 36 shows an exit ramp location with a deceleration lane length that meets RDM minimum criteria. On southbound I-45 in Rice, the mainline speed limit is 75 mph and the entrance curve speed limit is 45 mph. According to the RDM, the minimum deceleration lane length for a roadway with this criterion is 440 feet. The deceleration lane length provided at this location is 1,200 feet, which is greater than the minimum deceleration lane length provided in the RDM. This deceleration lane is shown in Exhibit 37.

Exhibit 36: Deceleration Lane Length Meets Minimum Recommended by Texas Roadway Design Manual

Exhibit 37: Existing Southbound I-45 Exit Ramp with Deceleration Lane Length That Exceeds Minimum Length (North of Calhoun Street/I-45 Intersection in Rice, TX)
4.2  RAMP LENGTH

4.2.1  DEFINITION
The length of entry or exit ramps to an access-controlled roadway. This length is measured from the painted nose of a gore to the painted nose of a gore in the case of freeway connections. In the case of ramps connecting to an at-grade intersection, this would be measured from the painted nose of gore to intersection curb line.

4.2.2  EXISTING GUIDELINES
There is no specified minimum ramp length for entrance ramps. The RDM provides guidance on certain types of exit ramp lengths depending on roadway configuration. For example, the minimum ramp length for exit ramps that are two-lane connecting roadways is 200 feet. The minimum ramp length for exit ramps that are ramp intersections is 800 feet.

4.2.3  RECOMMENDED CONSIDERATIONS
No changes to the current RDM guidelines are suggested. The RDM ramp length guidelines are generally the same as those provided by AASHTO. Peer states also follow similar guidelines for freeways. Ramp lengths and “taper” acceleration and deceleration lengths are defined as the same geometric feature.

Exhibit 39 and Exhibit 40 illustrate truck ingress and egress movements at an entrance and exit ramp, respectively.

4.2.4  DEFICIENCIES
Among the 584 ramp locations studied, only 27 of them have minimum ramp lengths specified by the RDM. Of these 27 ramps, 4 of them have lengths less than the minimum lengths provided in the RDM. On I-27 in Amarillo, the exit ramp from I-27 to I-40 is a ramp intersection, as shown in Exhibit 38. According to the RDM, the minimum ramp length for an exit ramp that becomes a ramp intersection is 800 feet. The ramp length provided at this location is 510 feet.
Exhibit 38: Existing Northbound I-27 Exit Ramp to I-40 in Amarillo, TX with Insufficient Ramp Length

Exhibit 39: Entrance Ramp Illustration
4.3 CRITICAL LENGTH OF GRADE

4.3.1 DEFINITION

Maximum length of a designated upgrade on which a loaded truck can operate without an unreasonable reduction in speed.

4.3.2 EXISTING GUIDELINES

The RDM shows the relationship of the percentage upgrade, length of grade, and truck speed reduction for an entering speed of 70 mph. Where critical length of grade is exceeded for two-lane highways, climbing lanes should be considered as discussed in the Transportation Research Board (TRB) *Highway Capacity Manual, Sixth Edition: A Guide for Multimodal Mobility Analysis* (HCM). The maximum length of grade for a loaded truck on a 6 percent upgrade with a speed reduction of 30 mph is roughly 2,250 feet.
4.3.3 **RECOMMENDED CONSIDERATIONS**

The existing guidelines for critical length of grade in Texas are the same as those provided by AASHTO and peer states. There are no changes recommended for this attribute.

4.3.4 **DEFICIENCIES**

There are no deficiencies in the critical lengths of grade in the studied locations of the THFN. Exhibit 41 shows the impacts to traffic along the critical length of grade as the truck is climbing a steep grade at lower rate of speed.

*Exhibit 41: Critical Length of Grade for Upgrade Greater Than Maximum of 3 Percent*

Exhibit 42 shows how traffic mobility improves along the critical length of grade as the truck is able to climb without reducing the operating speed.
4.4 PASSING SIGHT DISTANCE & PASSING/NO-PASSING ZONES

4.4.1 DEFINITION

The length of roadway that the driver of the passing vehicle must be able to see to make a passing maneuver safely.

4.4.2 EXISTING GUIDELINES

The RDM provides minimum passing sight distances for vehicles traversing two-lane rural highways with crest vertical curves. The minimum passing sight distance for a two-lane rural highway with a design speed of 60 mph is 2,135 feet. According to the AASHTO Green Book, research has shown that longer sight distances are often needed for “passing maneuvers when the passed vehicle, the passing vehicle, or both, are trucks,” although passing distances are usually not designed for this possibility.
4.4.3 RECOMMENDED CONSIDERATIONS

There are no recommended changes to the existing passing sight-distance guidelines.

4.4.4 JUSTIFICATION

Texas guidance requires passing sight distances that are the same or more conservative than the peer states (roughly double what they are in Michigan and Washington state). There is no warranted change to the existing guidelines.

4.4.5 DEFICIENCIES

In the studied locations, no areas with Passing/No-Passing Zones were found for measuring purposes. Exhibit 43 and Exhibit 44 illustrate unsafe passing maneuvers by truck and passenger vehicles, respectively, which attempt to pass slower traffic without a passing lane provided.

*Exhibit 43: Truck Passing Truck Without Passing Lane Provided*

![Exhibit 43](image)

*Exhibit 44: Truck Passing Passenger Car Without Passing Lane Provided*

![Exhibit 44](image)
4.5 INTERSECTION SIGHT DISTANCE

4.5.1 DEFINITION
The distance required for a driver to recognize a hazard or potential threat during challenging driving conditions for intersections.

4.5.2 EXISTING GUIDELINES
AASHTO’s Green Book provides guidance on minimum intersection sight distance, which is followed in the RDM. Providing the correct sight distance requires determining various conditions and inputting appropriate formula values. As an example, a traffic signal-controlled Urban Arterial with a maximum speed of 30 mph is required to have a minimum intersection sight distance of 600 feet.

4.5.3 RECOMMENDED CONSIDERATIONS
No changes to the RDM are recommended for consideration since AASHTO’s Green Book accounts for truck traffic for various types of intersection control, eye height, and time gaps. NCHRP Report 943 cites the Green Book’s use of a gap-acceptance model where the value of the accepted gap is increased by 4 seconds above the passenger-car value for combination trucks. Some peer states (such as Florida and Arizona) make additional allowances for the effect of grades on sight distances.

4.5.4 JUSTIFICATION
The sight triangle for a truck is dependent on the driver eye height above the road. In addition, large trucks accelerate from a stopped condition slower than cars and therefore need a larger gap in traffic to cross safely.

4.5.5 DEFICIENCIES
Among the 440 intersections studied, 49 (11 percent) do not meet the minimum criteria for intersection sight distance. The intersection of US 287 (N Dumas Avenue) and N 8th Street in Dumas is a stop-controlled Urban Arterial with a maximum speed of 45 mph (see Exhibit 45). The minimum intersection sight distance for an intersection with this criterion is 900 feet. The sight distance for a right or left turn from the minor road are blocked due to obstructions. The effects of the obstructions can be seen in Exhibit 46 by how far the truck must encroach past the stop bar to obtain sufficient sight distance to make the turning maneuver.
4.5.6 ABOVE MINIMUM

Among the 440 intersections studied, 391 (89 percent) meet the minimum intersection sight distance required. Exhibit 46 shows the unobstructed view of traffic approaching an intersection with adequate sight distance. Since intersection sight distance is a calculated value based on driver eye height, the locations studied would have to be recalculated based on a truck driver's assumed eye height to determine if optimal conditions are met.
Exhibit 47 shows how the line of sight could be obstructed at an intersection with insufficient sight distance.
4.6 TRAFFIC OPERATIONS

4.6.1 DEFINITION

Key attributes for traffic operations involve engineering the roads with appropriate design elements and control measures to ensure traffic safety and traffic management. This includes signage and pavement markings.

4.6.2 EXISTING GUIDELINES

Traffic operations is a complex area; therefore, practices in Texas cannot be summarized succinctly in this section. Many of the key attributes are already covered elsewhere in this section. Appendix A describes in greater detail existing approaches in the state. Operational considerations are generally holistic, which include all types of vehicles typical for the corridor including freight traffic. The RDM provides guidance on the vertical clearance of signals on the THFN project.
4.6.3 RECOMMENDED CONSIDERATIONS

No major changes are recommended. Existing practices generally fall in line with peer states and national guidance. However, two considerations were identified that could improve the operations of intersections with major truck activity:

- The design of traffic signal phasing should coordinate with the storage length provided in the intersection based on the peak-hour truck traffic. Because of their lengths, trucks often have insufficient storage lengths in intersections to prevent through-traffic from being affected. Longer phasing should be accompanied with longer storage lengths, particularly if significant truck-turning movements are expected.

- Supplemental far-side protected left-turn displays are recommended for long left turns. Vehicles behind trucks stopped at intersections can have difficulties seeing the traffic lights. This recommendation echoes the recommendations made in NCHRP Report 943.

4.6.4 JUSTIFICATION

Due to the greater length of trucks compared to passenger cars, queue times at traffic-signal controlled intersections will be greater if a higher volume of trucks are present. The storage length at the intersection should accommodate the peak-hour truck traffic, and the clearance time of the traffic signal should accommodate the queue length during peak-hour traffic. Also, trucks will frequently block visibility of overhead displays for drivers who are following trucks. Placing supplemental far-side displays will maintain signal display visibility to passenger cars when trucks are present in the intersection. Exhibit 48 shows the minimum vertical clearance for a traffic signal.
4.6.5 DEFICIENCIES

Almost all of the 440 intersections reviewed had adequate pavement markings. No data were collected on signal phasing or traffic operations.

4.7 BRIDGE VERTICAL CLEARANCE

4.7.1 DEFINITION

The height of bridges and structures over the roadways.

4.7.2 EXISTING GUIDELINES

The RDM provides guidance on bridge vertical clearance along the THFN. The minimum vertical clearance requirement for applicable structures on a new or reconstruction project is 18.5 feet. The bridge vertical clearance for pedestrian bridges and overhead sign bridges is 19.5 feet.

4.7.3 RECOMMENDED CONSIDERATIONS

There is no recommended change to the existing guidelines for required bridge vertical clearance within the THFN project.
4.7.4 JUSTIFICATION

TxDOT recently implemented higher vertical clearance requirements for all THFN corridors. Bridges with this new minimum clearance are where recent projects were completed. As new projects are constructed, it can be expected that the percentage of bridges with 18.5 feet or more clearance will increase.

4.7.5 EXISTING DEFICIENCIES EXAMPLE

According to the TxDOT roadway inventory database, 88 percent of the highway and railroad underpasses on the on-system portion of the THFN do not meet the 18.5-foot minimum bridge vertical clearance. Exhibit 49 shows a breakdown of the percentage of bridges with different clearances. Exhibit 50 maps the locations with deficient clearances.

Exhibit 49: Vertical Clearance for Highway and Railroad Underpasses on the Texas Highway Freight Network

<table>
<thead>
<tr>
<th>Vertical Clearance</th>
<th>Total</th>
<th>Percentage of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.5 feet or Greater</td>
<td>379</td>
<td>12%</td>
</tr>
<tr>
<td>Between 16.5 feet and 18.4 feet</td>
<td>1,533</td>
<td>48%</td>
</tr>
<tr>
<td>Between 15 feet and 16.4 feet</td>
<td>1,012</td>
<td>32%</td>
</tr>
<tr>
<td>Less than 15 feet</td>
<td>251</td>
<td>8%</td>
</tr>
<tr>
<td>Total</td>
<td>3,175</td>
<td>100%</td>
</tr>
</tbody>
</table>
Exhibit 50: Existing Bridge Design and TxDOT Design Standards Comparison of Vertical Clearance Map

Existing Bridge Design and TxDOT Design Standards Comparison

Bridge Vertical Clearance on the THFN (2020)
- Red: Less than 15 ft.
- Orange: Between 15 ft. and 16.4 ft.
- Green: Between 16.5 ft. and 18.4 ft.
- Blue: 18.5 ft. or Greater
- District Boundaries

Source: TxDOT Bridge Inventory, 2020

Prepared by Cambridge Systematics. Data for planning purposes only. February 22, 2021
Exhibit 51 shows the insufficient bridge vertical clearance of 14 feet 3 inches on eastbound I-10 under Houston Avenue in Houston.

Exhibit 51: Insufficient Bridge Vertical Clearance on Eastbound I-10 Under Houston Avenue (Houston, TX)

4.7.6 ABOVE MINIMUM

According to the TxDOT roadway inventory database, 12 percent of the highway and railroad underpasses on the on-system portion of the THFN meet or are greater than the 18.5-foot minimum bridge vertical clearance. Exhibit 52 shows the minimum vertical clearance for a highway underpass. The minimum value recommended by the RDM is considered to be the optimal value in the FIDC study.
4.8 PAVEMENT STRENGTH

4.8.1 DEFINITION

The type, structure, and design of the pavement used (see Exhibit 53 for examples).

Exhibit 53: Pavement Structure

4.8.2 EXISTING GUIDELINES

The type of pavement used, and its technical characteristics is ultimately determined by TxDOT’s district engineers. Designing pavements is a complex process that follows statewide conventions while considering many local factors. (See Appendix A for a detailed review of existing pavement
design processes.) Peer states such as Florida and Washington consider lane restrictions when calculating variations in loading on the pavement. Exhibit 53 shows the difference in surface material for rigid and flexible pavements.

4.8.3 RECOMMENDED CONSIDERATIONS

No major changes recommended to how pavement types and strengths are determined, based on local soil conditions, traffic volumes, percentage truck traffic, etc. Minor recommended considerations include:

- Develop guidance for considering type and volume of truck activity when selecting type of pavement (rigid vs flexible).
- Study the use of Mechanistic-Empirical pavement designs as a way of better capturing the differential impact of trucks on pavement deterioration and developing designs that are more cost effective from a life-cycle point of view.

For more detail on these recommendations, see Appendix A.

4.8.4 DEFICIENCIES

No significant deficiencies identified for pavements.
5 Design Needs Prioritization

The system-level and corridor need assessment identifies potential design deficiencies on the THFN, highlighting areas of the network where the existing design does not meet recommended minimum or optimal criteria. In this section, the impact of design deficiencies on system performance is analyzed to assess whether the application of freight-centric design criteria is related to the performance observed in terms of safety and mobility. Based on an assessment of the outcomes, key design criteria that appear beneficial to freight operations could then be prioritized for consideration as guidance for improving the THFN.

5.1 IMPACT OF DESIGN DEFICIENCIES

The performance metrics used to measure impacts of design deficiencies are based on datasets used for various TxDOT freight planning efforts. The metrics and data sources are summarized in Exhibit 54. Design deficiencies were examined at either a statewide level or along select segments, based on whether data was comprehensively available. As described in Section 2.3, the segments were selected along various criteria to achieve a representative sample of conditions and deficiencies on the THFN.

Exhibit 54: Performance Metrics and Data Sources Used in Analysis

<table>
<thead>
<tr>
<th>Performance Metric</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck Travel Time Reliability (TTTR)</td>
<td>Federal Highway Administration; National Performance Management Research Data Set, 2019</td>
</tr>
<tr>
<td>Truck Crash Density</td>
<td>TxDOT; Crash Record Information System, 2014–2016</td>
</tr>
<tr>
<td>Crash Rate per Hundred Million Traveled Miles</td>
<td>TxDOT; Crash Record Information System, 2014–2016</td>
</tr>
<tr>
<td>Average Annual Daily Traffic</td>
<td>TxDOT; Roadway Inventory, 2016</td>
</tr>
<tr>
<td>Truck Crash Points</td>
<td>TxDOT; Crash Record Information System, 2019</td>
</tr>
</tbody>
</table>

To quantify whether the impact is due to chance or some factor of interest, statistical significance testing was used at a 90 percent confidence interval. In this evaluation, a T-Test was utilized to test the hypothesis of whether the design deficiency had an impact. Sample sizes of the locations analyzed on the THFN were generally sufficient for the data that was collected. As such, comparing scenarios with deficient versus non-deficient criteria often yields an observed difference, such as a difference in average crash rate between corridors with deficient criteria (e.g., 11-foot lanes or less) versus corridors with optimal criteria (e.g., 12-foot lanes). However, these observed differences did
not always meet the statistical significance requirement, particularly in situations where the observations had high variations in sample size or standard deviation. Introducing statistical significance helps affirm—within the specific confidence limits—that a difference in performance outcomes exists between the two criteria groups.

In some instances, data was available but deemed to be not specific enough to draw conclusions. An example included crashes as a result of poor sight lines, which focused primarily on the quantity of angle crashes, but was not a data set available through the GIS inventory. Instead, a dataset of general truck-involved crashes was used for the analysis. Similarly, some data was available and showed statistically significant differences between criteria but was dismissed because another factor is likely at play. An example included two different types of designs that have statistically significant variations in crash rates but were dismissed because the higher crash group was more likely to be in environments where traffic volumes were also higher. These instances are documented herein where they apply.

5.1.1 LANE WIDTH

The THFN was examined at several levels to determine if notable variations existed for safety and mobility when factoring lane width. Deficient lane widths include widths of 11 feet or less. Non-deficient lanes were defined as measuring 12 to 14 feet wide. TTTR and the crash rate (i.e., all-vehicle crashes per hundred million traveled miles) were contrasted between deficient and non-deficient lane widths.

At a statewide level, which includes all THFN mileage (Freeways and Principal Arterials), a deficiency in lane width did not affect the crash rate in a statistically significant manner. However, for both Freeways and Arterials, TTTR is shown to improve in a statistically significant manner when lane widths are non-deficient. Based on these observations, it is possible that transitioning lane widths from deficient to non-deficient could result in an improvement in TTTR.

5.1.2 OUTSIDE SHOULDER WIDTH

The THFN was examined at several levels to determine if notable variations existed for safety and mobility when factoring outside shoulder width. Deficient outside shoulder widths include widths between 4 and 10 feet. Non-deficient widths were divided into two groups—11 to 12 feet and 13 to 15 feet—in order to contrast different recommendations. TTTR and the crash rate were contrasted between deficient and non-deficient outside shoulder widths.

At a statewide level, the crash rate had an observed, statistically significant reduction along segments with 13 to 15 feet as opposed to narrower outside shoulder width alternatives. Freeways
with relatively low- or medium-traffic volumes (relative to all THFN freeways) were observed to have an improved TTTR when utilizing 11- to 12-foot outside shoulder widths or 13- to 15-foot outside shoulder widths, as opposed to narrower shoulder widths, in a statistically significant manner. Along arterials, outside shoulder width did not have an observed impact on TTTR.

5.1.3 PAVEMENT TYPE

Pavement design parameters were limited in GIS data and available corridor research. The data in the TxDOT Roadbed Surface layer provides information only on whether the road surface is asphalt or reinforced concrete without providing any additional design information. Although pavement condition data was available, it was not deemed useful in this analysis because it is not a design factor. Instead, for this evaluation, the two types of road surface (asphalt and concrete) were contrasted to confirm if observable differences should be considered, noting that selection of one type over the other did not equate to a design deficiency.

The analysis did not find that pavement type had conclusive impacts on the measures. Among all statewide freeways and arterials on the THFN, TTTR is observed to be worse on roads built with concrete over roads built with asphalt; however, most concrete roads are found in urban areas, which carry higher traffic volumes and tend to have worse TTTR. When subdividing facilities between urban and rural environments, some differences were observed with statistical confidence, but again the causes for these differences are more likely the result of pavement being selected to accommodate the traffic conditions, not traffic conditions being the result of pavement type.

In the context of crash density among all statewide facilities, no statistically significant relationships were observed between asphalt and reinforced concrete.

5.1.4 PASSING SIGHT DISTANCE

Among the corridor locations that were analyzed, no segments were found to be deficient in terms of passing sight distance. No conclusions can be made for this attribute.

5.1.5 INTERSECTIONS

Intersections were examined at select locations to determine if variations existed for safety and mobility when factoring in intersection sight distances, turning radii, and/or pavement markings and signage. Observations were taken at select intersections to determine if the criteria were met or not met. For safety, the quantity of all truck crashes within 400 feet of the intersection was used. For mobility, TTTR was used.
Most results were not conclusive. Of all the attributes, the only one that showed a statistically significant impact was the intersection turning radii, where truck crashes within 400 feet were observed to be fewer in quantity. It is not clear if this is correlation or causation. All others had no observed impact. For pavement marking and signage, too few deficient intersections in this sample limited the ability to do any conclusive analysis.

5.1.6 ENTRANCE RAMPS (ACCELERATION LANES AND RAMP LENGTHS)

Entrance ramps were examined along select freeway segments to determine if variations existed for safety and mobility when factoring in acceleration lane length and ramp length. Observations were taken at entrance ramps along these segments to determine if the design attributes impacted these measures. For safety, the quantity of truck crashes within 500 feet of the entrance ramp was used. For mobility, TTTR along the mainline was used.

Impacts were not conclusive for the acceleration lanes. A statistically significant increase in truck crashes within 500 feet of the entrance ramp was observed for non-deficient acceleration lanes as opposed to deficient acceleration lanes, but upon further review, it was determined that non-deficient acceleration lanes biased heavily toward corridors with substantially higher traffic volumes. Segments were too short to generate an effective crash rate relative to traffic volumes. A statistically significant increase in TTTR was also observed near non-deficient acceleration lanes relative to deficient acceleration lanes, but for similar reasons, this is more likely an impact of being present in environments with substantially higher traffic volumes.

Impacts were also not conclusive for the ramp length. Between ramp lengths that were deficient and non-deficient, no discernable difference existed for quantity of truck crashes within 500 feet of the ramp or for TTTR.

5.1.7 EXIT RAMPS (DECELERATION LANES AND RAMP LENGTHS)

Exit ramps were examined along select freeway segments to determine if variations existed for safety and mobility when factoring in deceleration lane length and ramp length. Observations were taken at exit ramps along these segments to determine if the design attributes impacted these measures. For safety, the quantity of truck crashes within 500 feet of the entrance ramp was used. For mobility, TTTR along the mainline was used.
Impacts were not conclusive for the deceleration lanes. A statistically significant increase in truck crashes within 500 feet of the exit ramp was observed for non-deficient acceleration lanes as opposed to deficient acceleration lanes, but similar to the acceleration lane analysis, it was determined that non-deficient acceleration lanes biased heavily toward corridors with substantially higher traffic volumes. Segments were too short to generate an effective crash rate relative to traffic volumes. A statistically significant increase in TTTR was also observed near non-deficient acceleration lanes relative to deficient acceleration lanes, but for similar reasons, this is more likely an impact of being present in environments with substantially higher traffic volumes.

Impacts were also not conclusive for the ramp length. Between ramp lengths that were deficient and non-deficient, no discernable difference existed for quantity of truck crashes within 500 feet of the ramp or for TTTR.

5.2 PRIORITIZATION FRAMEWORK

The purpose of modifying design criteria is to help improve freight operations in the context of the goals identified in the 2018 Texas Freight Mobility Plan. While pursuing all design criteria recommendations would be advantageous for freight operations, it comes with a tradeoff of increased project impacts, most prominently increased costs that are incurred with implementing more conservative design criteria. Criteria that offer a good return on investment stand to be prioritized to the top of the consideration list, and the preliminary analysis done in this report can serve as a good starting point. Other criteria for prioritization include those that may not occur frequently, but have a substantial impact when they occur, such as bridge strikes.

Exhibit 55 shows the prioritization framework and the categories for consideration that separate the high, medium, and low prioritization rankings. These considerations centered around the results of the needs analysis, but also made allowances for existing deficiencies in the network.
Exhibit 55: Prioritization Framework

“HIGH” PRIORITIZATION

Definition
- Attributes that demonstrate improvement to mobility, safety, or other Texas Freight Mobility Plan goals.
- Attributes that ranked the highest by truck drivers in survey.

Qualifying Attributes
- Lane width
- Outside shoulder width
- Bridge vertical clearance
- Railroad-highway bridge clearance
- Intersection turning radius
- Sight distances
- Acceleration lane

“MEDIUM” PRIORITIZATION

Definition
- Attributes that do not demonstrate improvement in this analysis, but are supported by engineering judgment as being worthwhile investments.
- Attributes that are relatively low-cost investments to implement.

Qualifying Attributes
- Ramp length
- Climbing lane
- Intersection channelization
- Railroad-highway crossing sight distance
- Work zone lane width
- Work zone shoulder width
- Work zone strategy
- Work zone bridge vertical clearance
- Traffic-signal phasing/corridor operation
- Pavement strength/design strategy

“LOW” PRIORITIZATION

Definition
- Attributes that do not demonstrate improvement in the analysis of mobility or safety.
- Attributes for which no changes in design were recommended.

Qualifying Attributes
- Deceleration lane
- Passing/No-Passing Zones
- Vertical grade
- Critical length of grade
Attributes prioritized as “high” include ones that show an impact in the data analysis if the design criteria are not sufficient. Most prominently, bridge heights are highlighted as one attribute that comes with a high economic impact if a bridge strike occurs, even if uncommon. A “high” prioritization was also awarded to attributes that ranked highly in the survey of truck drivers. These were the attributes that cause concern for drivers, who have first-hand experience on how the THFN accommodates their needs and operations, and therefore should be prioritized accordingly.

Attributes prioritized as “medium” include those that did not show improvement in the needs analysis but are generally supported by engineering judgment as being worthwhile investments. Acceleration/deceleration lanes are widely understood to be instrumental in helping traffic transition to or from the mainline, and ramp length can reduce the chance of queue spillback onto the mainline during heavier traffic periods. Attributes prioritized as “medium” also include relatively low-cost investments, including work zone criteria, traffic-signal phasing and corridor operations, and upgraded signing and pavement markings.

Attributes prioritized as “low” include those that showed no observed impact to safety or mobility, but conceptually could be beneficial and may offer value upon further study. Vertical grade, for example, had too few situations among the locations that were examined to say that it affected freight performance; vertical grade may also not be as big of an issue for Texas as a whole, compared to more mountainous states, so restrictions on grade may not offer much improvement. The “low” priority also includes attributes for which the FIDC study recommended no change.
6 Conclusion

The FIDC study final report documents the efforts undertaken to identify operational challenges along the THFN and to recommend considerations that would improve roadway design criteria to better accommodate freight vehicles. Research was conducted to determine how national guidance and the practices of peer states address the functional and operational needs of freight operations in roadway design, including assessing whether these approaches apply to TxDOT's design practices. Feedback was gathered from TxDOT engineers and trucking industry stakeholders to identify and prioritize design attributes that should be enhanced.

Design needs on the THFN were assessed systemwide and on key freight corridors to examine how often minimum and optimal design criteria were met. A statistical analysis was also conducted to determine if observed impacts to safety or mobility may exist as a result of not meeting these criteria. With this analysis and feedback, a framework was established to identify high-, medium-, and low-priority considerations for design attributes that could be incorporated into TxDOT standard design practices.

6.1 Key Freight Attributes Where Major Changes Are Recommended

GEOMETRICS

The following recommendations will help design roads to better accommodate the large size and performance characteristics of trucks:

- **Acceleration Lane Length**: Consider increasing the length of acceleration lanes on roads that have significant truck traffic to reduce speed differentials with mainline traffic, which is associated with higher crash rates. Additional allowances are recommended for lanes on an upgrade or starting from ramp metering. Design values could be increased to match national best practices, which generally result in acceleration lanes that are longer than those recommended by the RDM. The THFN has a significant deficiency in this area, with over half of all the ramps studied not meeting existing RDM guidance, and a much higher proportion not meeting national best practices.

- **Vertical Grades**: Consider lowering maximum vertical grades on arterials with significant truck traffic to five or six percent, from current guidance in the RDM of eight percent to nine percent, to prevent significant slowdowns for loaded trucks and higher variability of speeds in the traffic stream. This would align the design criteria with leading peer states that reduce the maximum vertical grade when roads have a high truck percentage. Exceptions could be created for travel through mountainous areas in West Texas, where ensuring lower grades is costly. No change is
recommended to the maximum vertical grade on freeways, which is set at three to four percent in the RDM. Vertical grades were not found to be a pressing issue on the segments of the THFN analyzed.

- **Climbing Lane:** Consider expanding RDM guidance on climbing lanes so they are warranted in more locations throughout the THFN. Some peer states, particularly those in mountainous areas, have gone beyond the calculations recommended in national guidance to develop expanded criteria for the use of climbing lanes, in most cases prioritizing roads with significant freight volumes. TxDOT should study further the applicability of these recommendations to Texas.

- **Lane Width:** Consider increasing the minimum lane widths along the THFN to 12 feet, as recommended in the recently published NCHRP Report 943. The RDM recommends different lane widths depending on the functional classification of the roadway; however, trucks have difficulty operating on roads narrower than 11 feet, leading to encroachment into adjacent lanes and other safety risks. This change would fall in line with peer states that are increasing lane widths on roads with significant freight activity. A review of the THFN found that 70 percent of its mileage of principal and minor arterials and major and minor collectors are already 12 feet wide. On the other hand, this review also found that six percent of the mileage did not meet existing RDM recommendations.

- **Outside Shoulder Width:** Consider increasing the width of outside shoulders to 12 feet for freeways and expressways, 10 feet for Rural Principal and Minor Arterials and Rural Major and Minor Collectors, and 8 feet for Urban Principal and Minor Arterials and Urban Major and Minor Collectors. These changes would be significant increases relative to the current guidance on the RDM; however, they are intended to accommodate truck parking during emergencies. This change would fall in line with peer states that recommend wider shoulders on roads with significant truck activity. Currently, one percent of freeways, 32 percent of arterials and 70 percent of collectors do not meet the minimum requirements for outside shoulder width in the RDM.

- **Intersection Turning Radius:** Consider designating the WB-67 as the design vehicle on the THFN, where practical, and where high truck-turning movements are known or expected. This would reduce encroachment onto other travel lanes, improving safety and reducing damage to curbs and the pavement surface. This change would fall in line with peer states that are making greater allowances for truck turning movements. Turning radii is an area of systematic deficiency throughout the THFN, with 79 percent of the intersections reviewed not meeting the turning radii recommended for the smaller WB-62 design vehicle recommended in the RDM.

- **Intersection Channelization:** Consider developing guidance on storage lengths and channel widths at intersections that see significant truck volumes, particularly during congested periods of the day, as is recommended by NCHRP Report 943. This change would fall in line with peer states that include specific guidance for accommodating truck movements through intersections. The RDM does not include guidance for intersection channelization.
WORK ZONES

The U.S. Department of Transportation has published extensive rules and guidance on designing roadway construction work zones; however, each state ultimately implements this guidance per local conditions and practices. In Texas, this guidance has been operationalized in the Texas Manual on Uniform Traffic Control Devices, Part 6, although this guidance does not include any significant consideration of truck traffic. TxDOT should consider including truck-specific guidance like several peer states have done. This could include maintaining 18.5-foot clearances, limiting the narrowing of lanes, preserving adequate shoulders, and other geometric recommendations mentioned previously, especially when high truck volumes are present. The needs of work zones will vary from project to project; however, statewide guidance on work zones involving high truck volumes would be useful. This echoes the recommendations of NCHRP Report 943.

It is recommended that TxDOT continue deploying Intelligent Transportation Systems that warn truck drivers about disruptive work zone activities, as done in the I-35 Connected Work Zone Project.

6.2 KEY FREIGHT ATTRIBUTES WHERE MAJOR CHANGES ARE NOT RECOMMENDED

The following design attributes were reviewed as part of the FIDC study, however no major changes were recommended because existing practices in Texas matched national guidance or leading practices. Minor recommendations are provided for some of these attributes.

GEOMETRICS

- **Deceleration Lane Length**: No specific changes are recommended. The design criteria in the RDM aligns with the national guidance and the guidance from peer states. While some older trucks might take significantly longer to come to a stop, especially when heavily loaded, most trucks have braking systems that allow them to slow down at comparable rates similar to passenger vehicles. However, a review of the THFN found that almost half of the deceleration lanes reviewed were shorter than recommended by the RDM, which could be causing issues for the operations of trucks and other vehicles.

- **Ramp Length**: No specific changes are recommended. Even though the RDM provides guidance only on the lengths of ramps that have a specific configuration, this is not uncommon relative to national guidance and peer states. Most ramps reviewed in the THFN where not of the configuration that had length guidance. Of the few that were, only four did not meet RDM guidance; therefore, this is not an area of significant deficiency on the THFN.

- **Critical Length of Grade**: No specific changes are recommended. Existing design criteria in the RDM are compatible with national guidance and are similar to peer states.
• **Passing Sight Distance & Passing/No-Passing Zones**: No specific changes are recommended. Existing design criteria in the RDM are compatible with national guidance and are similar or more conservative than peer states.

• **Intersection Sight Distance**: No specific changes are recommended, as the RDM already follows national guidance. However, TxDOT is encouraged to study further how the sight distances of trucks might differ from those of passenger vehicles, particularly on downgrade situations. Some peer states recommend truck-specific criteria in this area that go beyond national guidance. Of the intersections reviewed on the THFN, 11 percent do not appear to meet the minimum sight distance recommendations of the RDM. While not a systematic deficiency, this could elevate crash risks at deficient intersections.

**PAVEMENT**

The pavement design process in Texas is similar to that of peer states. While a structured process is in place, the ultimate decision about the type of pavement used and its technical characteristics is made by either local engineers in TxDOT’s districts or municipal governments. Statewide guidance provides a basis for design methods but leaves ultimate responsibility to the local level. Truck impacts are considered as a percentage of traffic through Equivalent Single-Axle Load calculations.

In Texas, the decision whether to use flexible pavements (unreinforced asphalt on gravel) or rigid pavements (steel-reinforced concrete) does not appear to depend on the truck uses of the road, even though this has a critical impact on pavement performance and life-cycle costs. In general, flexible pavements deteriorate quicker under heavy axle loads, but withstand overweight trucks better, where the weight is distributed among many axles. Rigid pavements are more expensive to build initially but have a much longer service life.

The decision regarding pavement type could be made in a systematic way that reduces costs and improves freight serviceability on the THFN. Moreover, the adequacy of pavement design methods used should be reviewed to ensure that they accurately represent the deterioration caused by trucks of different configurations, capturing the higher frequency of overweight trucks, the changes in truck technology, and the strength characteristics of current pavements. Some peer states have made specific adaptations to their pavement design process for roads with high truck volumes. While most peer states rely on Equivalent Single Axle-Load calculations in pavement design, Michigan relies on the Mechanistic-Empirical method for designing pavement, which addresses some of the limitations of Equivalent Single-Axle Load designs and has the potential to better account for the impacts of truck loadings. TxDOT should consider how these and other approaches could be used to improve pavement designs throughout the THFN.

**TRAFFIC OPERATIONS**

Texas, like its peer states, does not design differently for intersections that have high truck volumes. Opportunities exist for improving this, while balancing driver expectancy and maintaining fluid
operations for all traffic. The design of traffic-signal phasing could coordinate with the storage length provided in the intersection based on truck volumes during congested times of the day. The storage length at the intersection should accommodate the peak-hour truck traffic, and the clearance time of the traffic signal should accommodate queue length during peak hours. Also, trucks frequently block the visibility of overhead displays for drivers behind the truck. Placing supplemental far-side displays would maintain signal visibility when trucks are present. No change is recommended to RDM guidance on vertical clearance of signs, overhead sign bridges, and signals. TxDOT should explore making greater use of Intelligent Transportation Systems applications for managing truck traffic, like in some peer states. This includes warnings for trucks entering crossings, warnings for oversized vehicles, and warnings of potentially dangerous conditions, such as strong winds.

**BRIDGES AND STRUCTURES**

TxDOT recently increased guidance on bridge vertical clearance from 16.5 feet to 18.5 feet on the THFN for new and reconstruction projects. Although none of its peer states or national guidance have recommended such a change, this change has the long-term potential to improve safety, reduce the probability of bridges being struck and damaged by truck collisions, and facilitate the movement of oversize cargo. No change is recommended to this guidance.

The THFN presently has a moderate deficiency with regard to bridge clearances. Of the 3,175 bridges on the THFN, 251 bridges have clearances lower than 15 feet, which might represent a bottleneck for truck operations (conventional trucks have a height limit of less than 14 feet), and 1,263 have clearances lower than 16.5 feet, the previous standard. Only 379 bridges on the THFN clear the recent 18.5 feet standard.

**6.3 IMPLEMENTATION CONSIDERATIONS**

With the prioritization framework, TxDOT can begin a conversation internally regarding which attributes should be advanced and incorporated into future project designs. Some of the beneficial attributes—those with observed impacts, those supported through engineering judgment, or those with low implementation cost—are more promising to be advanced, possibly through a time-phased approach of implementing groups of design attributes at a time in alignment with updates to standards.

Ongoing discussions between Transportation Planning and Programming and the Design Division will aid in determining an informed approach to implementation, but it is also advisable to seek feedback from the TxDOT districts, as well as the engineering community at large. The recommended design criteria and framework in the FIDC study could facilitate and add value to this collaboration. Forums related to updating standards are useful opportunities for identifying the feasibility of implementing a new design standard and will help build support for the attributes that are in TxDOT’s best interest. By pursuing these investments to improve freight movement on the THFN, TxDOT
stands to meet a key policy goal of the Texas Freight Mobility Plan that puts Texas on a path toward achieving the overarching goals of improving highway safety and mobility and maintaining the state’s economic competitiveness.

The FIDC study also serves as a conversation starter for understanding how the actual characteristics of the THFN compare to the latest design guidance. The THFN has been built over the years following contemporaneous practices and design standards that might differ significantly from current guidance. Given that only a few of its characteristics are documented systemwide in existing databases, a data collection effort across the THFN, for all the key design attributes, would help to better understand its characteristics and deficiencies. While none of the peer states have databases that cover all these informational needs, some do keep track of more attributes than in Texas. A process could be started in Texas to digitize this information following the rubric outlined in the manual data collection conducted as part of the FIDC study. Once the characteristics of the THFN are more well known, it is possible to conduct a more detailed and accurate identification of deficiencies and prioritization of design needs than conducted in the FIDC study. This information could also help structure a program for updating the deficient infrastructure that is causing the most significant impacts for freight and passenger vehicles.

Not only can recommended changes be implemented in new and reconstruction projects, but a program can be created to proactively improve segments of the THFN that are deficient. This could involve both segments that do not meet current design standards, and segments that where current design standards do not adequately accommodate trucks. In defining this program, deficiencies relative to current design standards should be prioritized, as these are likely causing significant issues for truck operation. This includes short to non-existent acceleration lanes, bridges with low clearances, and segments without shoulders or with narrow lanes. Once these pressing deficiencies have been addressed, the program could upgrade parts of the THFN where outdated standards have been met to better accommodate trucks.

An additional way that the recommendations of the FIDC study could be implemented is on a project-by-project basis. Flexibility could be given to designers to adopt higher truck-accommodating design standards where the case can be made that it will result in a significant improvement to mobility or safety. These design choices could be informed by the level of truck volumes on the road or the importance of the road in connecting to locations of freight generation or attraction (e.g., intermodal infrastructure, industrial land uses, etc.). TxDOT could provide “optimal” freight design guidance, that design engineers could choose to adopt depending on local circumstances.
Appendix A: Existing Conditions Report

Appendix B: Design Comparison Matrix

Appendix C: Systemwide Freight Design Needs Analysis