Texas Transportation Asset Management Plan

Texas Department of Transportation

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List of Acronyms

AASHTO	American Association of State Highway and Transportation Officials
ACP	Asphalt Concrete Pavement
BMIP	Bridge Maintenance and Improvement Program
BPM	Bridge Preventive Maintenance Program
BRG	Bridge Division
CRCP	Continuously Reinforced Concrete Pavement
DOT	Department of Transportation
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FO	Functionally Obsolete
GRID	Geospatial Roadway Inventory Database
HBP	Highway Bridge Program
HR	Heavy Rehabilitation
IH	Interstate Highways
IRI	International Roughness Index
LCP	Life Cycle Planning
LR	Light Rehabilitation
Maint Ops	Maintenance Operations
MAP-21	Moving Ahead for Progress in the 21st Century Act
MPO	Metropolitan Planning Organization
MR	Medium Rehabilitation
NBI	National Bridge Inventory
NBIS	National Bridge Inspection Standards
NHS	National Highway System
NOAA	National Oceanic and Atmospheric Administration
non-IH	Non-Interstate Highways
PA	Pavement Analyst
PM	Preventive Maintenance
SD	Structurally Deficient
SHF	State Highway Fund
SLRTP	Statewide Long Range Transportation Plan
SME	Subject matter expert
SOGR	State-of-Good-Repair
SR	Sufficiency Rating
STIP	Statewide Transportation Improvement Program
TAMP	Transportation Asset Management Plan
TTP	Texas Transportation Plan
TxDOT	Texas Department of Transportation
UTP	Unified Transportation Program

Executive Summary

Transportation Asset Management

The Texas Department of Transportation (TxDOT) has constructed, maintains, and inspects the largest state network of pavements, bridges, and other assets in the country. In that service, TxDOT is responsible for, among other things, ensuring the safety of the traveling public and the long-term operation of those assets. The latter of these two is often achieved through asset management. Transportation asset management can be summarized as using data to make informed decisions that, when implemented, sustain a desired level of network performance.

In its agency goals and objectives, TxDOT outlines several priorities that coincide with the goals of transportation asset management: Deliver the Right Projects, Foster Stewardship, Optimize System Performance, and Preserve our Assets. In pursuit of these goals and in accordance with federal requirements, TxDOT will continue to advance its use of transportation asset management. This document serves as TxDOT's Transportation Asset Management Plan (TAMP).

Federal Requirements and Guidelines

Through recent transportation funding bills (MAP-21 and the FAST Act), federal law requires each state to "develop and implement a Risk Based Asset Management Plan for the National Highway System (NHS) to improve or preserve the condition and performance of the system" (*1*). Promulgating this requirement into federal regulations, the Federal Highway Administration (FHWA) has provided states with requirements for TAMP development and implementation (*2*). At the core of this framework are Life Cycle Planning, Risk Management, Financial Planning, and Investment Strategies. Failure to comply with these regulations results in significant funding penalties.

FHWA has also adopted new performance measures for pavements and bridges (*3*). Some of these performance measures cannot be directly correlated with TxDOT's historic pavement and bridge performance measures. This gap, however, will close with time.

TxDOT's TAMP will be used by FHWA to verify that the transportation asset management processes certified in TxDOT's April 2018 document have been used to conduct the required analyses. For that reason, TxDOT has made use of federal requirements as the basis for the TAMP development.

Texas' Transportation Assets

The scope of TxDOT's TAMP consists of pavements and bridges that correspond to travel ways either on the NHS or on the State Highway System (On-System). Pavements and bridges corresponding to travel ways neither on the NHS nor On-System are excluded. The On-System inventory contains 190,000 lane-miles of pavements and nearly 37,000 bridges.

Pavement conditions are quantified using TxDOT's Distress, Ride, and Overall Condition performance indicators and FHWA's percent Good, Fair, and Poor performance measures. More than 87 percent of On-System pavements have an Overall Condition of Good or Very Good; only about 5 percent have an Overall Condition of Poor or Very Poor. Applying federal performance measures to the NHS, 57.5 percent of pavements are in Good condition and 10.7 percent are in Poor condition.

Bridge conditions are evaluated via routine visual inspections that follow national specifications, standards, and TxDOT policy. TxDOT and FHWA use data obtained from these inspections to calculate network performance measures and assess the health of Texas' bridge inventory. Applying FHWA performance measures to the NHS, 49.9 percent of bridge deck area is in Good condition, while 0.9 percent is in Poor condition.

Life Cycle Planning

Life Cycle Planning (LCP) is defined by FHWA as "a process to estimate the cost of managing an asset class, or asset subgroup over its whole life with consideration for minimizing cost while preserving or improving the condition" (*2*). LCP is a process that can be used to 1) forecast network-level funding needs to sustain performance of the inventory, and 2) recommend the most cost-effective project for a given asset to optimize long-term condition.

TxDOT uses Pavement Analyst software for retaining pavement condition data and life cycle planning analysis. The 2018 Unified Transportation Plan (UTP) funding levels are used as the baseline for the LCP analysis in TxDOT's TAMP. This planned funding level ($17.74 billion) is expected to sustain pavement conditions over the next 10 years with a slight increase in percent Good or Very Good. Reductions in funding or the use of worst-first investment strategies would cause a decline in network conditions.

TxDOT is currently advancing its bridge management system to include LCP capabilities. In lieu of a formal LCP analysis for TxDOT's TAMP, historic data sets are examined to predict short-term performance measure trends. These trends are used by TxDOT in developing targets for federal performance measures and in developing 10 year investment strategies.

Risk Management

Risk management is the process and framework through which TxDOT manages uncertainty related to system performance. Based on previous experience with natural weather events, it is widely accepted that flooding poses one of the greatest risks to Texas pavements and bridges. A geospatial analysis of TxDOT's pavement and bridge inventory using flood maps was performed to estimate the quantity of assets vulnerable to these events. By engaging stakeholders across Divisions and Districts, TxDOT has identified and prioritized additional risks, and developed preliminary management strategies for high-priority risks.

Financial Plan and Investment Strategies

Investment levels for pavement and bridge management are estimated through Fiscal Year 2027 in concurrence with TxDOT's 2018 UTP. A forecast of funding sources and revenue totals over this time period is also used to estimate additional funding through sources outside of the State Highway Fund. According to current cost replacement valuation methods, the value of NHS system pavement assets is $47 billion, and the estimated replacement value of NHS bridges is $33 billion.

Key Findings and Planned Enhancements

TxDOT has been able to maintain our assets in a condition above the national average due to successful funding programs. As our network of pavements and bridges continues to grow and our existing infrastructure ages, advanced programming becomes more critical.

TxDOT's performance on federal measures and current workflows largely satisfy the federal requirements. Further, the federal requirements are not anticipated to significantly alter TxDOT projects or procedures. Instead, TxDOT plans to leverage these requirements to help enhance cost-effective project selection and prioritization.

In the TAMP, a gap analysis highlights financial and technical gaps that TxDOT plans to minimize through progressive implementation of transportation asset management practices. Future enhancements include increased transparency and communication with non-TxDOT stakeholders, improved accuracy of funding forecasts, adoption of life cycle planning into TxDOT's bridge management system, and continued development of risk management practices.

Chapter 1: Introduction and Background

Overview

Transportation asset management has been defined by the Federal Highway Administration (FHWA) as a "strategic and systematic process of operating, maintaining, and improving physical assets with a focus on engineering and economic analysis based upon quality information to identify a structured sequence of maintenance, preservation, repair, rehabilitation, and replacement section that will achieve and sustain a desired state of good repair over the life cycle of the assets at minimum practicable cost" (*4*, *5*, *6*).

FHWA enabling legislation in Moving Ahead for Progress in the 21st Century Act (MAP-21) (*5*) and Fixing America's Surface Transportation Act (*6*) indicates the following:

- States will develop and implement a Risk Based Asset Management Plan for the National Highway System (NHS) to improve or preserve the condition and performance of the NHS.
- FHWA will establish minimum standards for states to use in developing and operating bridge and pavement management systems.
- States will conduct periodic evaluations to determine if reasonable alternatives exist to roads, highway, or bridges that repeatedly require repair and reconstruction activities.

Additional responsibilities of the states and FHWA are defined in 23 CFR 515 and 23 CFR 667 among other regulations (*7*). These regulations require states to develop a Transportation Asset Management Plan (TAMP). This document is the Texas TAMP required by this legislation and described by several referenced FHWA documents (*8*).

The Texas TAMP is governed by the Texas Department of Transportation (TxDOT) Administration and implemented by a steering committee with members from the Administration, Divisions (Bridge, Construction, Financial Management, Maintenance, Transportation Planning and Programming), and district representatives (Figure 1). A working group with membership from the Bridge and Maintenance Divisions is responsible for information gathering and report preparation. Subworking groups have been formed to develop information and prepare documents for each of the major chapters of the document. The Bridge Division is responsible for all information and reporting on bridges while the Maintenance Division is responsible for all pavement information and reporting, and providing the overall support for the development of the TAMP.

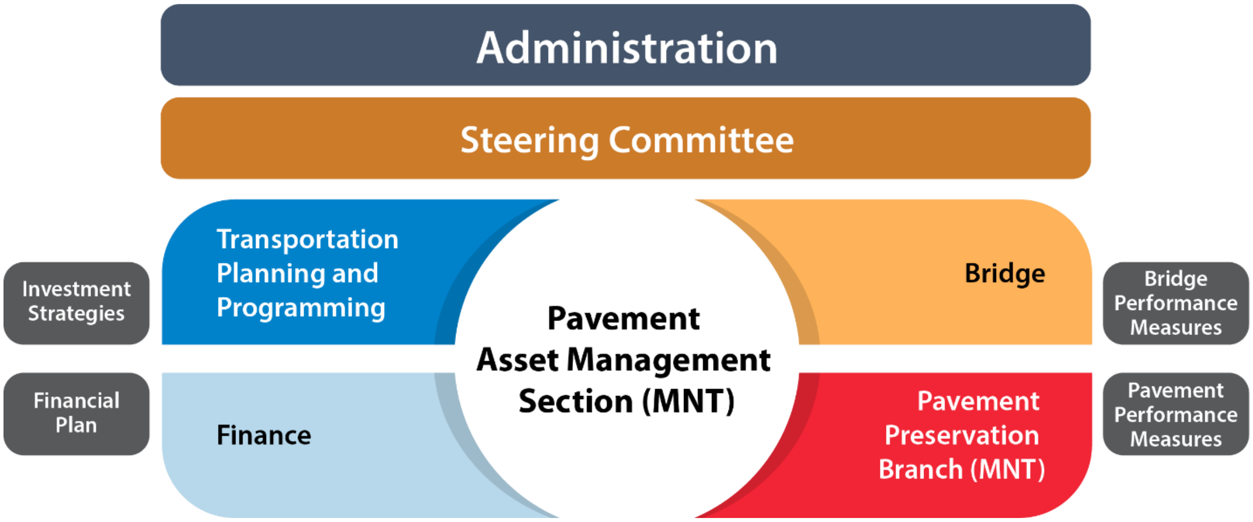


Figure 1. Texas TAMP Implementation.

Texas Highways Serving a Growing Economy and Population

Texas has the second largest state economy in the nation. If Texas was a nation, it would be the 10th largest economy in the world with a gross state product of more than $1.6 trillion in the year 2017. Six of the largest 50 Fortune 500 companies are headquartered in Texas. In addition, 54 of the 500 largest corporations as defined by Fortune are headquartered in Texas (*4*). In 2016, Texas moved more than 2 billion tons of freight. More than half of the freight is moved by trucks on the state's highways. Freight movement is expected to double by 2045 (Figure 2) (*9*).

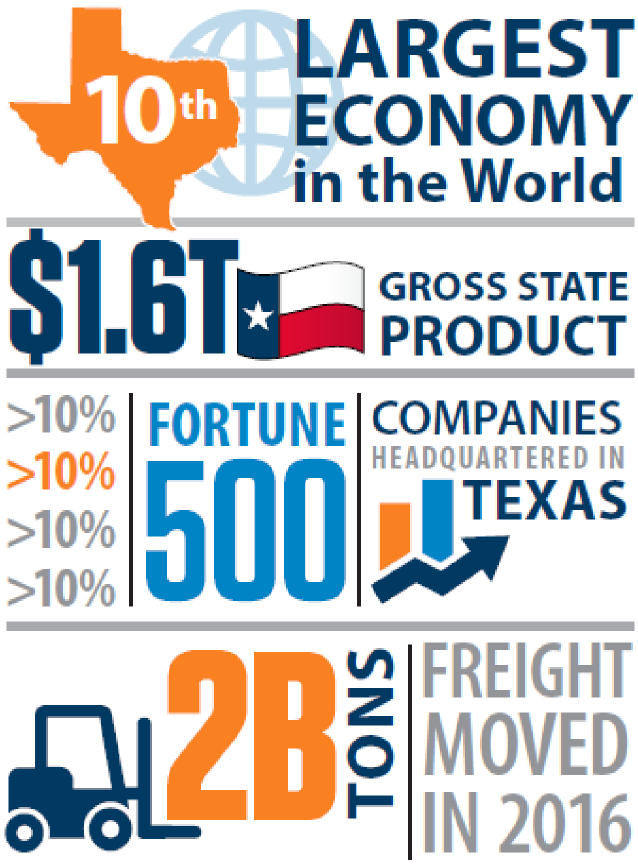


Figure 2. Texas Economy.

Texas is the second most populous state in the nation with about 28 million people in 2016. With continued urbanization, the state's population is expected to grow by 45 percent to 39 million by 2045 (9). The population has grown more than 50 percent over the last 25 years. During the same period, daily vehicle miles traveled have increased 70 percent and daily truck miles traveled have increased 110 percent on TxDOT maintained roadways, while roadway centerline miles have increased only 7 percent (Figure 3, Figure 4) (*10*).

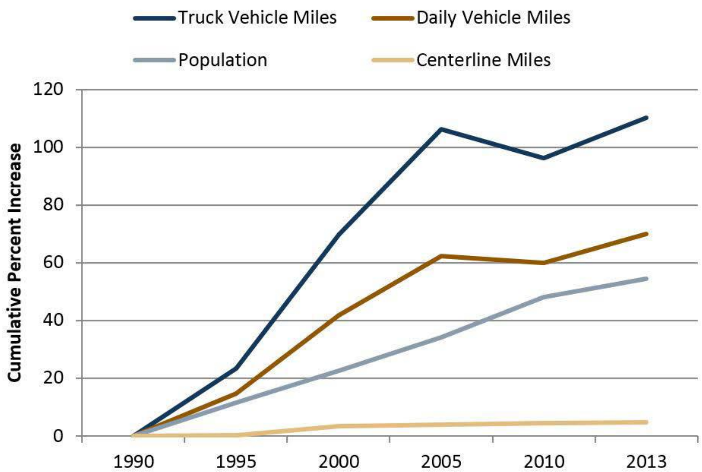


Figure 3. Texas Highway System and Historical Growth Trends (11).

It is important that the state continue to develop and maintain its system of highways to support the population, vehicle, and freight movement demand on its highways. Highways that are not maintained in a state-of-good-repair (SOGR) will increase transportation costs for people and goods. With increased congestion, the cost of travel and goods will increase as well. It is estimated that the trucking industry in Texas incurred 5.1 billion in congestion costs in 2016 (9).

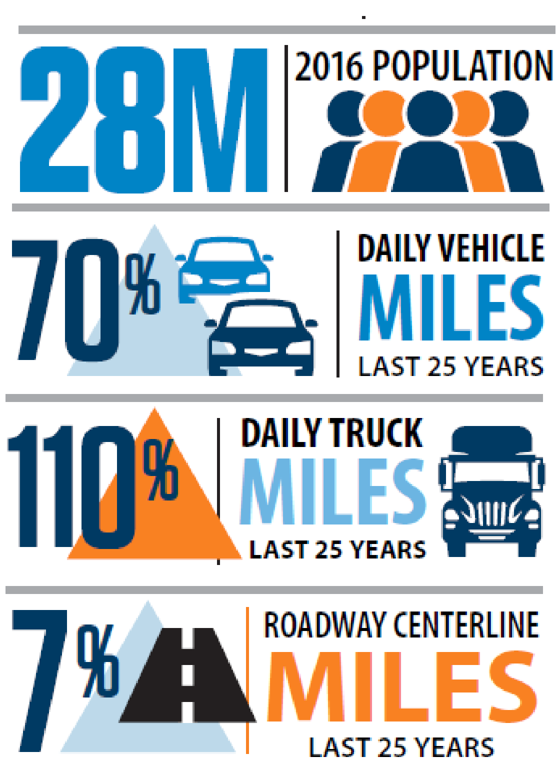


Figure 4. Changes in Texas Demographics and Transportation System.

TxDOT Transportation System

TxDOT maintains and operates approximately 72,657 centerline miles of pavements (or approximately 196,000 lane-miles of roads), which carry over 540 million vehicle-miles annually. The state highway system encompasses more than 35,000 bridges and about 450 million sq. ft. of bridge deck area. Deck area is estimated as the sum of all bridge's span length multiplied by their width (Figure 5).

TxDOT uses three different classifications of roadway miles: centerline miles, lane-miles, and roadbed miles:

- Centerline mile: A measure of length (in miles) of a highway along the centerline of the roadway.
- Lane-mile: A measure of the length of individual lanes on a highway in miles. A lane-mile is a centerline mile multiplied by the number of lanes.
- Roadbed mile: The same as a centerline-mile except on a divided highway where each direction of traffic is carried on a separate road structure.

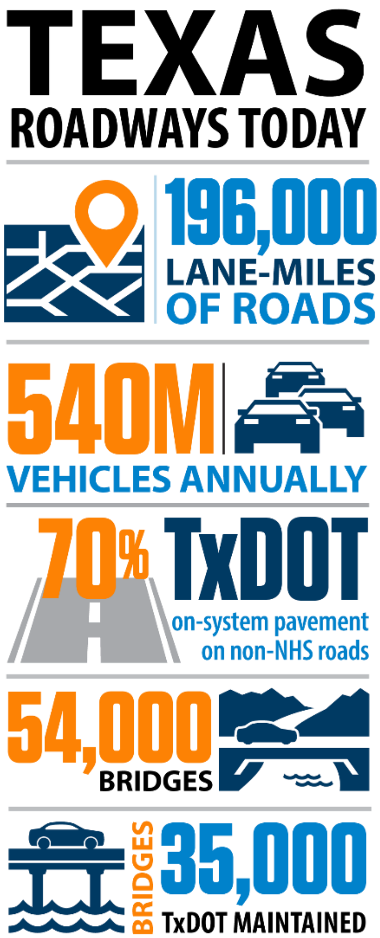


Figure 5. Texas Roadways Today.

National Highway System

NHS in Texas is designated by the U.S. Congress, through FHWA, in concert with TxDOT and other local governmental agencies. Figure 6 shows a map of NHS in Texas (*11*). NHS includes Interstate Highways (IH) and non-Interstate Highways (non-IH) (other principal arterials, and intermodal connectors) that are important to the national economy, defense, and mobility. The U.S. Department of Transportation in cooperation with state, regional, and local officials developed the NHS. MAP-21 expanded the system to include additional principal arterials, including those maintained by cities and counties. In addition, some highways owned, maintained, and operated by toll authorities and public/private partnerships are included in the NHS system. TxDOT is responsible for the design, construction, maintenance, and operation for the majority of the NHS.

The information contained in this document is reported in categories if existing databases are inclusive and allow this segmentation. The terms on-system, off-system, NHS, and non-NHS are used to define groups of data. These terms are defined as:

- NHS—all highways designed as on the NHS and include both IH and non-IH. Note that 91 percent of these highways are owned, maintained, and operated by TxDOT, and the remaining portion is owned by other entities including cities, counties, and toll road authorities.
- Non-NHS—all highways not designated as on the NHS.
- On-System—all highways owned, maintained, and operated by TxDOT.
- Off-System—all highways not owned, maintained, and operated by TxDOT.

Of the 69,142 NHS lane-miles of pavements in Texas, 61,219 lane-miles are on the TxDOT system (referred to here as on-system) and 7,923 lane-miles are maintained and operated by cities, counties, and toll authorities (referred to here as off-system).

The number of NHS bridges in Texas exceeds 17,000, with total bridge deck area near 340 million sq. ft. TxDOT maintains and operates more than 16,400 NHS bridges (320 million sq. ft. of bridge deck area) while other governmental agencies and toll road authorities maintain and operate around 1,000 NHS bridges (about 19 million sq. ft.).

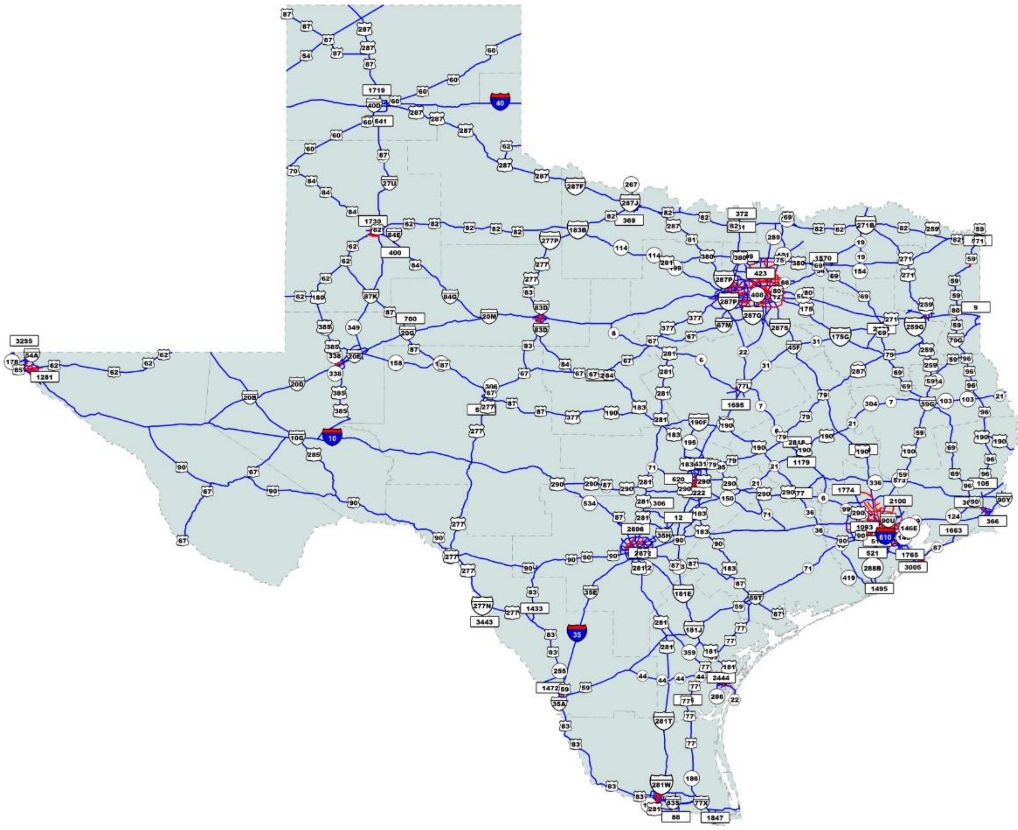


Figure 6. NHS in Texas.

Pavement and Bridge Asset Management Practices in Texas

Pavement management systems in TxDOT have evolved from a basic Pavement Evaluation System in the 1970s to a fully comprehensive Pavement Management System in the early 1990s. The methods for measuring the condition of pavements and predicting future performance have changed. The most recent change was initiated in 2016 with the implementation of a modern pavement management system and collection of semi-automated distress information.

Bridge management systems have been operational in Texas for nearly two decades. The methods of evaluation and management have changed over the years.

Methods to measure the condition of assets and the performance of the assets have changed and will continue to change in the future due to advancements in technology and development of new knowledge. However, historical data are valuable to obtain performance trends and develop predictive capabilities.

This Document

TAMP federal regulations (6) require that a document be prepared by the states that meets the following minimum requirements:

- Description of NHS pavement and bridge assets inventory.
- Statement of the asset management objectives and performance measures.
- Performance gap identification.
- Life cycle planning (LCP).
- Risk management analysis.
- Financial plan for a minimum of 10 years.
- Investment strategies.

This document describes the processes that are used or will be used for pavement and bridge management and presents the results of the analyses that were conducted. For more information on additional initiatives, readers are advised to review TxDOT publications titled *Project Selection Process* (*5*) and *Project Development Process Manual* (*6*).

Chapter 2: Asset Management Objectives

Overview

TxDOT views asset management as an important highway infrastructure management framework to improve and preserve the condition of assets and system performance. As identified previously, 23 CFR 515 of Federal Regulations (*7*) describes the requirement for an asset management plan that satisfies FHWA requirements. These federal requirements are discussed in more detail in Chapters 3 to 8 of this document. The general federal requirements for asset management are compatible with TxDOT's asset management priorities. However, details associated with TxDOT's current asset management processes are not identical to the requirements defined by FHWA. These differences will be identified in other parts of this document. TxDOT's values, vision, mission, and goals are discussed below to illustrate the compatibility between federal requirement and the state's guiding documents.

TxDOT Priorities

TxDOT operates under the guidance of a commission appointed by the governor of Texas. The commission has adopted rules requiring performance measurement and reporting, including the condition of bridges and pavements (*12*). The commission has also adopted seven goals for the agency, with specific objectives for each goal. These goals are as follows (*9*):

1. Deliver the right projects.
2. Focus on the customer.
3. Foster stewardship.
4. Optimize system performance.
5. Preserve our assets.
6. Promote safety.
7. Value our employees.

While all these goals deal with one or more elements of asset management, perhaps the most directly related one is Strategic Goal 5: Preserve our Assets:

- Deliver preventive maintenance for TxDOT's system and capital assets to protect our investments.
- Maintain and preserve system infrastructure to achieve a SOGR and avoid asset deterioration.
- Procure, secure, and maintain equipment, technology, and buildings to achieve a SOGR and prolong life cycle and utilization (*13*).

Several other goals (Deliver the Right Projects, Foster Stewardship, Optimize System Performance) also speak to the role of asset management in the provision of mobility.

In order to achieve a state of good repair (SOGR), it's necessary to define what that means for the public transportation assets in Texas. TxDOT defines SOGR as maintaining asset conditions and levels of service at a sustainable steady-state which meets or exceeds state performance measure targets for pavements and bridges over the next four years.

TxDOT further believes that preserving assets supports its five statewide objectives/traits, which maintain that the agency shall be (*14*):

1. Accountable to tax and fee payers of Texas.
2. Efficient such that maximum results are produced with a minimum waste of taxpayer funds, including through the elimination of redundant and non-core functions.
3. Effective in successfully fulfilling core functions, measuring success in advancing performance measures, and implementing plans to continuously improve these efforts.
4. Providing excellent customer service.
5. Transparent such that the agency can be understood by any Texan.

The Texas legislature, through Senate Bill 20, directed TxDOT to adopt a performance driven project selection process. This process has generated several performance targets internal to TxDOT that coincide with the National Performance Goals and the federal TAMP requirements. More emphasis is being placed at all levels to have projects that contribute more effectively and efficiently to the maintenance or increase of the system performance.

Asset Management as Expressed in TxDOT's Planning Documents

TxDOT's planning and programing activities are guided by four key documents (Figure 7): Texas Transportation Plan (TTP) 2040, Statewide Long Range Transportation Plan (SLRTP) 2035, Unified Transportation Program (UTP), and Statewide Transportation Improvement Program (STIP). These documents are described briefly as follows.

TTP 2040

The Texas Transportation Commission adopted the TTP 2040 to serve as TxDOT's long-range, performance-based transportation plan (*10*). The TTP 2040 guides planning and programming decisions for the development, management, and operation of the statewide, multimodal transportation system in Texas over 25 years (2015–2040). The TTP 2040 addresses the statewide planning requirements under the current federal surface transportation act, MAP-21, and Title 43, Texas Administrative Code, Chapter 16.

SLRTP 2035

The SLRTP is the 24-year blueprint for the planning process that guides the collaborative efforts between the department, local and regional decision-makers, and all transportation stakeholders to reach a consensus on needed transportation projects and services.

UTP

The UTP is a catalog of projects that are planned to be constructed and/or developed within the next 10 years (*9*).

STIP

The STIP provides a listing and detail of projects to be let over the next four years. The current version is for the years 2018–2021 (*9*). Figure 7 shows a diagram of how each planning document relates to others in the planning process.

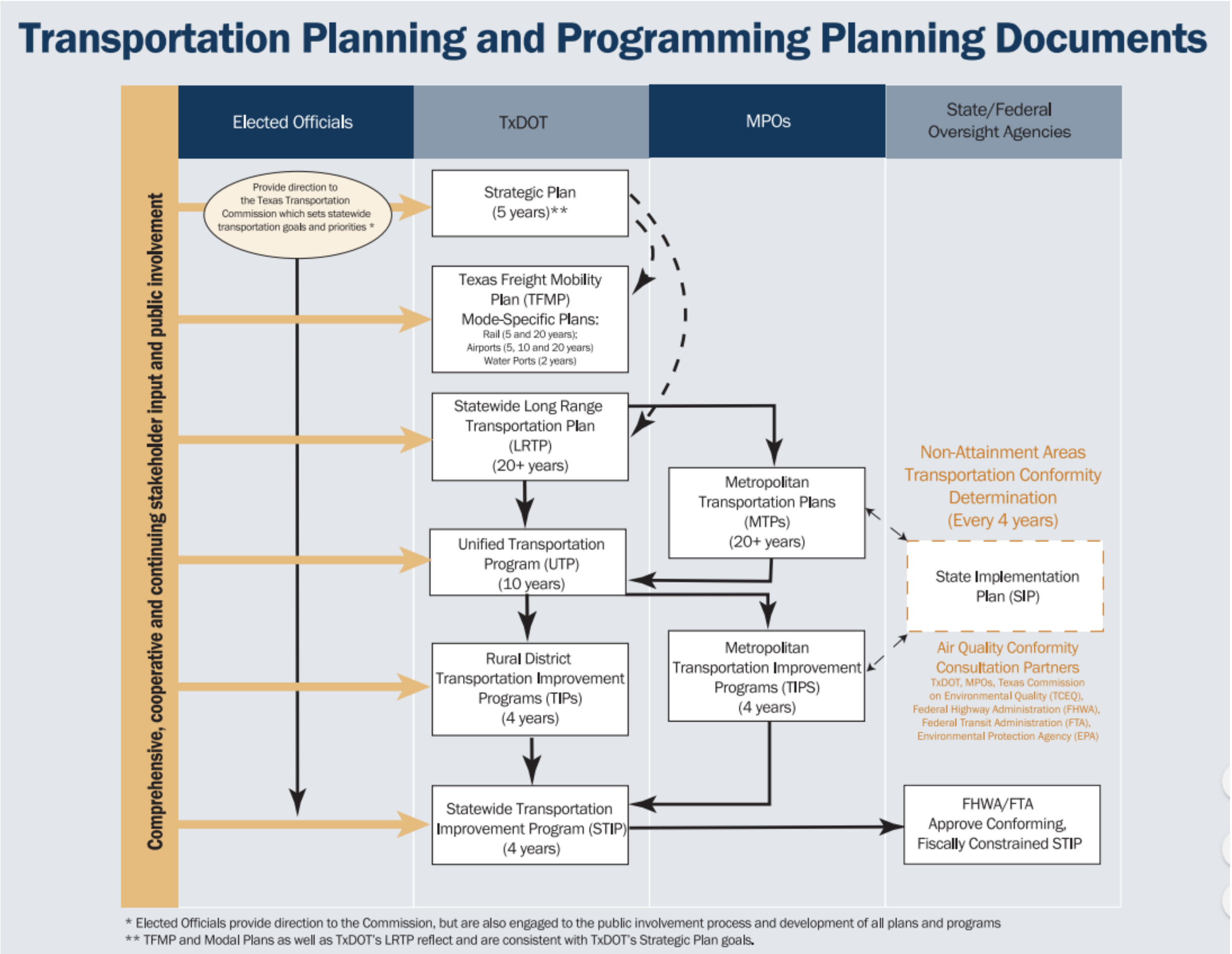


Figure 7. TxDOT's Transportation Planning and Programming Documents.

Chapter 3: Asset Inventory, Performance Measures, and Condition

Overview

Asset inventory and condition are key information that feed into transportation asset management systems and the establishment of transportation planning and programming documents (*9*). Key elements of an asset management plan such as LCP, financial plans and investment strategies, and risk analyses are all dependent on the asset inventory, condition, and performance information. Inventory information allows TxDOT to communicate the type and locations of assets; and condition information allows for measuring the current performance of the assets. Condition measurements are taken on individual assets and converted into condition indicators. This information is communicated in various forms to national, state, and local governments, while also providing the general public with valuable information.

FHWA requirements for network segmentation, asset condition evaluation, and performance measurements are not the same as those used by many states. Texas is not an exception to this statement. Differences between FHWA and TxDOT criteria will be identified, and when data are available, they will be presented in both formats.

The Texas highway transportation systems include assets owned and operated by several federal agencies, state agencies, tribal governments, cities, counties, toll authorities, and public/private partnerships. Highways on the NHS system are mostly owned, maintained, and operated by TxDOT; however, a portion of the NHS system is under the jurisdiction of cities, counties, and toll authorities. Assets identified in this document will be those on the NHS and the TxDOT system. Highways on the TxDOT system are owned, maintained, and operated by TxDOT.

Texas TAMP Assets

FHWA requires the TAMP to include a summary listing of the inventory and condition of the NHS designated pavement and bridge assets in that state. TxDOT has elected to report the pavement and bridge assets and their condition for the NHS and those on the state highway system. The Texas TAMP will report all pavements and bridges on the NHS and all pavements and bridges owned, maintained, and operated by TxDOT. Pavements and bridges have the highest value and annually expended dollars among all assets. In Texas, asset management for pavements and bridges has been active for several years and the data sets are robust and meaningful.

Inventory

Pavement Inventory

TxDOT maintains a current inventory of roadways through its internal Geospatial Roadway Inventory Database (GRID) (7). GRID contains information related to the extent, administrative designations, and physical characteristics of all state-owned highways at the roadbed level. This system documents the TxDOT-maintained on-system highway and roadway network. The TxDOT GRID database contains the following information:

- Mileage for every segment of the highway network.
- All secondary designations of any roadway segment.
- District responsibilities for any roadway segment.
- Highway segments that are part of the NHS.
- Highway segments that are part of the Texas Turnpike System.
- Physical properties of each highway and roadbed, including number of lanes, surface width, and traffic data.

TxDOT maintains and operates approximately 72,657 centerline miles or approximately 196,094 lane-miles of roads, which carry over 540 million vehicle miles annually. NHS inventory and condition information is reported on an annual basis to both FHWA and in the state of Texas on a lane-mile basis, and this is the inventory unit that will be used in this document. For informational purposes, the current TxDOT on-system inventory is as follows:

- 72,657 centerline miles (This number was calculated based on mainlanes only, not including frontage roads).
- 80,946 roadbed miles.
- 196,094 lane-miles.

Table 1 and Figure 8 show TxDOT's on-system pavement inventory information. TxDOT owns, maintains, and operates this system. The TxDOT on-system comprises around 196,100 lane-miles of which about 30 percent is on the NHS system and 70 percent is on the non-NHS system. Texas is one of a few states that has a relatively large portion of on-system pavements that are not on the NHS.

Table 1. TxDOT On-System Pavement Inventory-Lane Miles.

	NHS-IH	NHS-Non-IH	Non-NHS	Total
Lane Miles	16,343	44,876	134,875	196,094
Percent	8.3	22.9	68.8	100

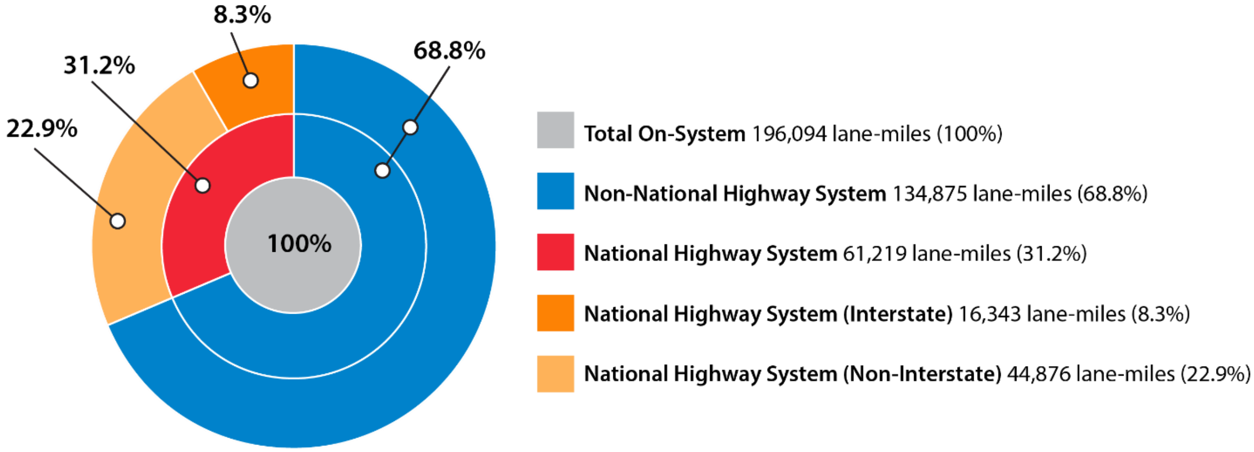


Figure 8. TxDOT On-System Pavement Inventory-Lane Miles.

Table 2 and Figure 9 show roadway or pavement lane miles for the NHS in Texas. TxDOT NHS on-system mileage totals 61,219 lane-miles. Off-system pavement mileage for the NHS in Texas is 7,923. Thus, about 11.5 percent of the NHS is owned, maintained, and operated by non-TxDOT entities including cities, counties, and toll authorities. Table 3 shows the lane miles of pavements owned and operated by non-TxDOT or off-system entities.

Table 2. Texas On-System and Off-System NHS Pavement Inventory-Lane Miles.

	On-System			Off-System	Total NHS Highways
	IH	Non-IH	Total On-System	Non-IH	
Lane Miles	16,343	44,876	61,219	7,923	69,142*
Percent	26.7	73.3	88.5	11.5	100

*This number was calculated excluding bridge miles on NHS.

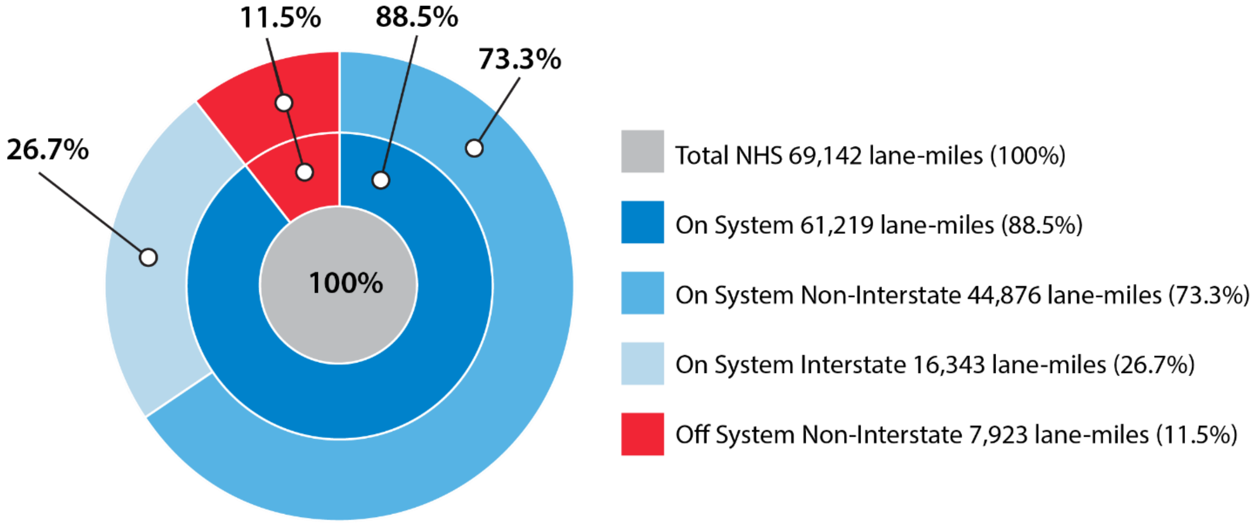


Figure 9. Texas On-System and Off-System NHS Pavement Inventory-Lane Miles.

Table 3. Off-System NHS Ownership.

Owner	Lane Miles
Cities	6,121
Counties	345
Toll Road Authorities	1,458
Total	7,923

Since pavement condition indicators for the federal requirements differ for various types of pavements, it is useful to inventory pavement lane-miles by pavement type. There are three broad pavement types commonly used in Texas, which include asphalt concrete pavement (ACP), continuously reinforced concrete pavement (CRCP), and jointed concrete pavement (JCP). Jointed concrete includes both reinforced and non-reinforced concrete pavements. Table 4 lists the NHS lane miles for the different pavement types.

Table 4. NHS Lane Miles and Percentiles for the Different Pavement Types.

Pavement Type	Lane Miles			Percentage of Lane Miles		
	On-System	Off-System	Total	On-System	Off-System	Total
ACP	48,318	4,649	52,967	91.22%	8.78%	76.61%
CRCP	10,676	3,229	13,905	76.78%	23.22%	20.11%
JCP	2,225	45	2,270	98.00%	2.00%	3.28%
Total	61,219	7,923	69,142	100.00%	100.00%	100.00%

Bridges

Texas has over 54,000 bridges in the state with about 35,000 owned and maintained by TxDOT. Table 5 shows the breakdown of on-system bridge inventory, and Table 6 shows the breakdown of NHS bridge inventory. Bridges are classified as structures having an end-to-end distance of 20 ft or greater. For this plan, bridges are defined as highway structures longer than 20 ft in clear span length open to public vehicular traffic. Bridges are comprised of the following primary components:

- Deck—The part of the bridge supporting traffic (including the riding surface).
- Superstructure—The part of the bridge that supports the deck (often composed of beams or girders).
- Substructure—The part of the bridge that supports the superstructure (columns, foundation elements, pier caps, etc.).
- Culvert—Culverts are drainage structures that, if 20 ft in width or wider along the direction of the roadway, are considered bridges. These structures are often considered as one integrated component.

Bridge data have been collected on the state's bridge inventory for decades. Defined in the National Bridge Inspection Standards (NBIS) (*9, 12*), the National Bridge Inventory (NBI) (*13*) is "the aggregation of structure inventory and appraisal data collected to fulfill the requirements of the National Bridge Inspection Standards." In accordance with federal policy, "Each State shall prepare and maintain an inventory of all bridges subject to the NBIS." TxDOT oversees the inspection of all Texas bridges open to public traffic to ensure that these requirements are met.

Table 5. TxDOT On-System Bridge Inventory.

	On-System NHS IH Bridges	On-System NHS Non-IH Bridges	On-System Non-NHS	Total On-System Bridges
Count of Bridges	4,644 (13.0%)	11,850 (33.2%)	19,232 (53.8%)	35,726 (100%)
Deck Area (million sq. ft.)	88.2 (19.1%)	238.1 (51.6%)	134.8 (29.2%)	461.1 (100%)

Table 6. Texas On-System and Off-System NHS Bridge Inventory.

	On-System NHS, IH Bridges	On-System NHS, Non-IH Bridges	Off-System NHS Non-IH Bridges	Total NHS Bridges
Count of Bridges	4,644 (26.5%)	11,850 (68.8%)	1,014 (5.7%)	17,508 (100%)
Deck Area (million sq. ft.)	88.2 (25.5%)	238.1 (68.8%)	19.6 (5.7%)	345.9 (100%)

Condition Measurement

TxDOT has long established methods to determine the condition of its pavements and bridges. Since the 1970s, TxDOT's pavement evaluation methods have evolved from visual evaluation methods conducted by a team of raters to the current semi-automated system using 3-D technology and other automated equipment. For pavement, the interpretation of these data by TxDOT and FHWA to determine pavement condition vary. For bridges, TxDOT's condition measurement system has followed the NBIS for several years. The measurement methods used to determine pavement and bridge condition and performance are presented below (*13*).

Pavements

Historically TxDOT has used a visual condition survey to determine the condition of pavements (*11, 14*). The visual condition surveys have been performed under contract by a consultant.

The visual condition surveys were performed on approximately 0.5-mile segments of roadway on all TxDOT on-system pavements and on samples for the NHS off-system pavements (owned, maintained, and operated by cities, counties, and toll authorities) on an annual basis.

In 2016, TxDOT began using an automated/semi-automated method for obtaining pavement condition information. A van mounted 3-D camera and a line laser is used to capture continuous images of the pavement. The images are used to determine the type and extent of pavement surface distress as defined in reference (*14*). The information is captured and reported in 0.1-mile increments. This transition of condition measurement systems was implemented to modernize TxDOT's pavement management practices and to meet the new federal requirements. The data are summarized on 0.5-mile roadway segments for TxDOT reporting and 0.1-mile segments for FHWA reporting. The pavement condition data for the off-system NHS are now collected for 100 percent of the roadbeds as a part of TxDOT statewide contract for automated/semi-automated pavement data collection.

Automated data collection is also used to determine rutting, ride quality, and faulting as briefly described below:

- **Rutting:** Automated pavement data collection equipment is used to establish transverse profiles for estimating rut depth and percentage of rutting levels for five rut categories in each wheel-path.
- **Ride Quality:** Certified Inertial Profilers are used in the data collection process to establish longitudinal surface profiles for computing the International Roughness Index (IRI), and the ride score.
- **Faulting:** Automated data collection equipment collects the faulting measurement on the JCP.

The semi-automated method to determine pavement condition is subject to a quality control procedure that uses TxDOT and TTI personnel to visually evaluate about 6 percent of the pavement sections. In addition, all measurement equipment is calibrated on a regular schedule. Pavement condition surveys are now performed on a 0.1-mile increment to satisfy the FHWA requirements.

Distress types and extent vary by pavement type. ACPs are evaluated for the presence of rutting, patching, failures, block cracking, alligator cracking, longitudinal cracking, transverse cracking, and total cracking percent. CRCPs are evaluated for the presence of spalled cracks, punch-outs, asphalt patches, concrete patches, and total crack percent. JCPs are evaluated for the presence of failed joints and cracks, failures, shattered slabs, slabs with longitudinal cracks, concrete patches, and total crack percent.

TxDOT Performance Indicators

TxDOT uses the data described above to determine the condition of their pavements. These data are used to determine three measures of pavement conditions as shown below:

- Distress Score.
- Ride Score.
- Condition Score.

The Distress Score represents the surface condition of the pavement in terms of type and extent of the different types of distress. The score ranges from 1 to 100 with 100 representing a pavement without distress (*14*). A Ride Score is determined from data collected by Inertial Profilers, which converts a pavement profile (roughness/smoothness) to an IRI. The IRI is converted to a Ride Score based on the 0 to 5 Serviceability Index developed at the American Association of State Highway and Transportation Officials (AASHTO) Road Test. The Condition Score is a combination of the Distress Score and Ride Score and represents the overall condition of the pavement. Condition Scores range from 1 to 100 with 100 being the best condition. TxDOT reports the condition of its pavements on an annual basis using these scores (*10*).

Table 7 provides a conversion from the Distress Score, Ride Score, and Condition Score to a descriptive class used by TxDOT to communicate the condition of pavements from a surface distress standpoint.

Table 7. Distress, Ride, and Condition Score by TxDOT Descriptive Class.

Descriptive Class	Distress Score	Ride Score	Condition Score
Very Good	90–100	4.0–5.0	90–100
Good	80–89	3.0–3.9	70–89
Fair	70–79	2.0–2.9	50–69
Poor	60–69	1.0–1.9	35–49
Very Poor	1–59	0.1–0.9	1–34

FHWA Methods

United States Code, Title 23, Sections 119, 144 and 150 (*8*) and 23 CFR 515 (*7*) provide general guides for states to use in developing and operating pavement and bridge management systems. These rules describe a process different than historically used by TxDOT.

FHWA indicates that the condition of pavements on the NHS is to be reported for both IH and non-IH. All IH are on the TxDOT system (on-system) while NHS non-IH are both on-system and off-system. Condition surveys are at 0.1-mile increments.

FHWA Performance Indicators

NHS Interstate System (on-system) pavements are evaluated based on ride quality and pavement surface distress. Table 8 shows criteria for pavements designated as being in Good, Fair, or Poor condition. A pavement section (0.1-mile in length) is classified as Good condition if all the metrics shown in Table 8 are good. The rating of a section will be Poor if two or more metrics are evaluated as poor. All other pavement sections are given a Fair evaluation.

NHS non-IH (both on-system and off-system) use ride quality only for evaluation. The criteria for ride quality is the same for NHS IH and non-IH (Table 8).

Table 8. Federal Requirements for Pavement Condition Thresholds.

Condition Threshold				
Metric		Good	Fair	Poor
IRI (inches/mile) (all pavement types)		<95	95–170	>170
Cracking (%)	ACP	<5	5–20	>20
	JCP	<5	5–15	>15
	CRCP	<5	5–10	>10
Rutting (inches) (ACP)		<0.20	0.20–0.40	>0.40
Faulting (inches) (JCP)		<0.10	0.01–0.15	>0.15

Targets for Federal Pavement Performance Measures

NHS Interstate system pavements are evaluated based on ride quality and pavement surface distresses (i.e. rutting and cracking). FHWA methods are used to classify each pavement section and then to summarize statewide percentage of the Interstate System pavements in Good condition and Poor condition, respectively. The most recent five years of pavement condition data are used as the basis for the target setting. The moving-average method is used to set up the target for the 2018–2021 Performance Period. Using this methodology, interstate targets reflect the expected condition by the end of 2021.

NHS Non-Interstate pavements are evaluated based on IRI data only for the first performance period. Subsequent performance periods will be evaluated based on ride quality and surface distress. FHWA methods are used to classify each pavement section and then to summarize the statewide percentage of the Non-Interstate pavements in Good condition and Poor condition, respectively. The most recent five years of pavement condition data are used as the basis for the target setting. The moving-average method is used to set up the two-year and four-year targets for the 2018–2021 Performance Period.

Table 9. FHWA Pavement Performance Targets

Performance Measure		2020 Target	2022 Target
Pavement on IH	% in good condition		66.4%
	% in poor condition		0.3%
Pavement on non-IH NHS	% in good condition	52.0%	52.3%
	% in poor condition	14.3%	14.3%

Bridges

Inspection and Condition Rating Methods

All bridges in Texas are subject to standardized and regularly scheduled inspections. The inspections are conducted according to the TxDOT Bridge Inspection Manual and the NBIS (*13*, *15*, *16*). Bridge inspections serve two primary purposes: 1) to ensure the safety of the public and 2) to catalog accurate data reflecting each bridge's physical attributes and current condition.

Bridge inventory and condition data are collected through the following inspection types:

1. Initial Inspection—Performed on new bridges or when the bridge is first recorded in the inventory.
2. Routine Inspections—Performed on all bridges according to a regular schedule (also referred to as routine safety inspections). These are the most common form of bridge inspection and typically occur on a 24-month inspection frequency.
3. Event Driven Inspections—Performed in response to an incident that might threaten bridge stability (i.e., collision, fire, flood, significant environmental changes, loss of support). These inspections are sometimes called Emergency Inspections and are performed on an as-needed basis.
4. In-Depth Inspections—Performed typically as follow-up inspections to better identify deficiencies found in any of the above three types of inspection. Detailed Underwater Inspections and Fracture Critical Inspections are both considered a type of In-Depth Inspection; although these two inspection types are not necessarily performed as a follow-up to previous inspection findings.

5. Special Inspections—Performed to monitor a particular feature, deficiency, or changing condition. Unusual bridge features (such as external, grouted, or post-tensioned tendons) may compel TxDOT to pursue a Special Inspection.
6. Condition Assessment Surveys/Damage Assessment Surveys—Performed to evaluate, to a heightened level of detail, the features and defects that should be addressed by future work. These inspections are typically conducted in preparation for a bridge repair, rehabilitation, or replacement project.

In Texas, bridge inspection policies have remained relatively constant over the past several decades. This stability has produced a rich set of historic data—a tremendous benefit to asset management efforts. Of the many data items collected through bridge inspections, the following are most relevant to the Asset Management Plan:

- Facility carried by the bridge.
- Feature crossed by the bridge.
- Bridge location (TxDOT district, county, latitude and longitude, etc.).
- Length and width of the bridge.
- Which entities own and maintain the bridge.
- Deck condition (on a 1–9 scale with 9 being best).
- Superstructure condition (on a 0–9 scale).
- Substructure condition (on a 0–9 scale).
- Culvert condition (on a 0–9 scale, if the bridge is a bridge-class culvert).
- Channel condition (on a 0–9 scale, if the bridge crosses a water feature).
- Element conditions (quantity in conditions states 1, 2, 3, and 4 for each bridge element).

While the first 10 of these have been collected consistently for decades, only recently have element condition data been considered for asset management in Texas. Furthermore, bridge element specifications have recently changed from AASHTO Commonly Recognized elements to AASHTO National Bridge Elements, making it problematic to rely on past data to forecast future trends. Because of those reasons, this asset management plan will focus on bridge conditions on a component-level only. Bridge component condition scores fall within a 0–9 numeric scale (Table 10). Technical definitions and additional details on each inspection item are available in TxDOT's Coding Guide (*17*).

Table 10. Bridge Component Condition Rating.

Condition Value	Description
9	**Excellent Condition.**
8	**Very Good Condition**—no problems noted.
7	**Good Condition**—some minor problems.
6	**Satisfactory Condition**—structural elements show some minor deterioration.
5	**Fair Condition**—all primary structural elements are sound but may have minor section loss, cracking, spalling, or scour.
4	**Poor Condition**—advanced section loss, deterioration, spalling, or scour.
3	**Serious Condition**—loss of section, deterioration, spalling or scour have seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present.
2	**Critical Condition**—advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken.
1	**Imminent Failure Condition**—major deterioration or section loss present in critical structural components or obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic, but corrective action may put back in light service.
0	**Failed Condition**—out-of-service beyond corrective action.
N	**Not Applicable.**

In accordance with NBIS, TxDOT annually reports statewide bridge inspection data to FHWA in support of the NBI. FHWA regulations require NBI reporting be done in a standardized fashion, specified by the Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges (*12*). NBI data are compiled by FHWA and made available to the public (*18*).

Additionally, a summary of network-level bridge information is published on TxDOT's website biennially (*19*). Each Report on Texas Bridges contains bridge conditions and funding information on a biennial basis.

Bridge conditions are typically discussed as a function of all primary bridge components. For span-type bridges, this includes deck, superstructure, and substructure. For bridge-class culverts, only the culvert condition rating is considered. Based on the minimum condition rating for each of its primary components, a bridge is assigned an overall condition score. Table 11 shows a bridge is classified as good, fair, or poor based on the criteria.

Table 11. Bridge Condition Groups.

Most Severe Component Rating	Condition Group
7 or greater	Good
5 or 6	Fair
4 or less	Poor

TxDOT Performance Indicators

TxDOT and FHWA both use numerous performance measures for assessing the health of Texas' bridge network. Network-level performance evaluations in Texas are typically executed by TxDOT's Bridge Division and are used to communicate with several key stakeholders including FHWA, state policymakers, the Texas Transportation Commission, TxDOT's Administration, TxDOT Districts, and the public. Network performance assessments are generally scoped to include Texas' statewide inventory (on- and off-system bridges, NHS, and non-NHS).

Prior to 2017, TxDOT's primary network performance measure was the statewide percent of good or better bridges. This measure had been used for several years as the principal decision-making aid to evaluate funding alternatives on a planning scale. A good or better bridge is one that is not classified as structurally deficient (SD), functionally obsolete (FO), or substandard for load only. The good or better bridges performance measure score is simply the percent of bridges (by count) classified as good or better. Historically, much of TxDOT's bridge funding has been directed toward improving this measure through replacing bridges not classified as good or better.

Table 12 shows statewide totals of SD bridges for 2016 as compared to 1992. TxDOT has significantly lowered the percent of SD bridges from nearly 13 percent in 1992 to less than 2 percent in 2016. TxDOT has made substantial inroads at replacing or improving SD bridges. Reliance on bridge replacement projects has served TxDOT well. As TxDOT's bridge inventory continues to grow and more bridges approach the end of their service life, TxDOT is pivoting toward condition-based asset management. The transition to condition-based network performance measures is being furthered by FHWA. FHWA no longer classifies bridges as SD or FO. Bridges historically classified as SD are now referred to as poor per recent federal regulations, and the FO designation has been retired altogether by FHWA.

Table 12. SD Bridge Quantities, 1992 versus 2016.

Year	Total Inventory	SD*	
		Number of Bridges	Percent of Total Inventory
1992	47,762	5,964	12.5%
2016	54,719	867	1.6%

*Historical classification; replaced by poor condition group

Recently, the percent of good or better bridges has been replaced by a new measure based on condition criteria rather than service level. For TxDOT's Administration and the Texas Transportation Commission, the Bridge Division has developed a new bridge network performance measure called the Bridge Condition Score. This new performance measure is intended to capture overall network health more directly than the percent of good or better bridges. However, the percent of good or better bridges is still reported annually to the Legislative Budget Board.

The Bridge Condition Score is based on the most severe primary component condition rating. A composite score for the network is calculated as the average of each individual bridge's numeric score, weighted by deck area. Table 13 defines each condition group, their minimum component rating, and their corresponding numeric score.

Table 13. TxDOT Bridge Condition Score Groups.

Most Severe Component Rating	Letter Grade Score	Numeric Score
7 or greater	A	95
6	B	85
5	C	75
3 or 4	D	65
2 or less	F	50

This new measure has been used to forecast network performance and explore funding levels beginning with the 2018 UTP, primarily applied to the statewide bridge inventory. To best capture TxDOT's bridge management policies, the TAMP considers this composite bridge condition score for the total TAMP inventory—NHS and Non-NHS, On-System bridges. By using this network performance measure to guide funding and asset management decisions, TxDOT is simultaneously supporting the federal performance measures (percent good deck area and percent poor deck area).

Although TxDOT's bridge management decisions are decentralized across several stakeholders, bridge network performance reporting is executed centrally by the Bridge Division. Performance reporting is used to inform five key stakeholders of network bridge performance: TxDOT's Administration, the Texas Transportation Commission, TxDOT districts, FHWA, and the public. Typically, network performance assessments are scoped to include Texas' statewide bridge inventory.

FHWA Performance Indicators

FHWA, through recent regulations, has introduced performance measures to be evaluated for each state's NHS bridge inventory—all bridges carrying NHS roadways. Similar to TxDOT's bridge condition score, FHWA's two federal performance measures are only a function of NBI ratings for primary bridge components: deck, superstructure, substructure, or culvert. Based on the most severe NBI component condition for each of these four items, a bridge is assigned an overall condition score. Dependent on its overall condition score, a bridge is classified as good, fair, or poor. Federal performance measures include 1) the percent of NHS bridge deck area in good condition, and 2) the percent of NHS bridge deck area in poor condition.[1] By inference, these measures can be used to calculate the share of NHS on bridges in fair condition. Alongside TxDOT's Bridge Condition Score measure, these two federal performance measures will be taken into consideration as condition-based bridge management strategies continue to be developed.

Targets for Federal Bridge Performance Measures

The new FHWA performance measures focus on bridge assets that carry the NHS. These new performance measures focus on Percent Deck Area of the NHS in Good Condition and Percent Deck Area of the NHS in Poor Condition.

Linear trend and crosswalk methodologies were used to develop two- and four-year targets for these measures. As TxDOT adopts a more sophisticated bridge management system, more advanced methods will become available for setting targets. Targets for the NHS performance measures were also set using trend line analysis and agency-developed crosswalk methodology (to predict the influence of various funding categories on bridge conditions).

Below are the suggested targets for the bridge performance measures. The target for "Percent of NHS Deck Area in Poor Condition" has been set at 0.80 percent for 2020 and 2022. This is regarded as the lowest practical value given the time it takes from when a structure becomes Poor to when it is replaced or rehabilitated.

[1] 23 CFR 490

Table 14. FHWA Bridge Performance Targets for the NHS

Performance Measure	Baseline (March 2018)	2020 Target	2022 Target
Percent of NHS Deck Area in Poor Condition (Federal Measure)	0.88%	0.80%	0.80%
Percent of NHS Deck Area in Good Condition (Federal Measure)	50.63%	50.58%	50.42%

Bridge and Pavement Current Condition

TxDOT reports the performance data for pavements and bridges on an annual basis (*11*, *19*). The reports present the historical condition of the pavements and bridges for the highway system and asset type. The pavement annual report also presents the maintenance level of service information.

Pavements

Condition of Pavements Based on TxDOT Indicators

The condition of the NHS Interstate (on-system) and NHS non-Interstate (on-system and off-system) pavements are shown in Table 15 for the five performance score classes used by TxDOT. These data indicate that nearly 92 percent of the Interstate pavements on the NHS system are performing at a very good or good level with about 4 percent performing at the poor or very poor level. The non-IH NHS system for on-system and off-system has about 86 percent of their lane miles at a good or very good classification while about 6 percent are at a poor and very poor level. Typically, the IH pavements are expected to be at higher condition level.

Table 15. NHS Pavement Condition Based on TxDOT Performance Indicators.

Measure	Condition	Interstate On-System	Non-Interstate On-System and Off-System	Total
Distress	%Very Good	76.30	70.11	68.49
	%Good	10.37	13.36	15.66
	%Fair	6.30	7.52	7.44
	%Poor	2.48	3.50	3.58
	%Very Poor	4.55	5.50	4.83
Ride	%Very Good	65.88	47.64	29.82
	%Good	30.34	41.31	49.32
	%Fair	3.65	9.96	19.24
	%Poor	0.10	1.01	1.53
	%Very Poor	0.02	0.07	0.08
Overall Condition	%Very Good	74.25	64.48	64.48
	%Good	17.54	21.59	23.44
	%Fair	4.66	7.57	7.25
	%Poor	1.96	3.15	2.54
	%Very Poor	1.60	3.21	2.29

Table 16 to Table 18 show historic TxDOT on-system pavement performance with TxDOT measures of distress, ride, and overall condition.

Table 16. TxDOT On-System Historic Performance Based on TxDOT Performance Indicators for Distress.

Fiscal Year	Percent of Very Good Lane Miles	Percent of Good Lane Miles	Percent of Fair Lane Miles	Percent of Poor Lane Miles	Percent of Very Poor Lane Miles
2007	78.53	7.66	4.75	4.37	4.68
2008	78.25	7.07	4.88	4.66	5.14
2009	78.76	6.86	4.92	4.74	4.73
2010	78.63	6.84	5.06	4.87	4.59
2011	78.42	7.18	5.07	4.89	4.44
2012	80.28	6.61	5.00	4.48	3.63
2013	76.70	9.20	5.34	4.51	4.24
2014	76.75	9.19	5.20	4.52	4.34
2015	77.69	8.81	4.74	4.25	4.52
2016	66.37	16.20	8.12	4.36	4.94
2017	68.49	15.66	7.44	3.58	4.83

Table 17. TxDOT On-System Historic Performance Based on TxDOT Performance Indicators for Ride Quality.

Fiscal Year	Percent of Very Good Lane Miles	Percent of Good Lane Miles	Percent of Fair Lane Miles	Percent of Poor Lane Miles	Percent of Very Poor Lane Miles
2007	24.36	50.64	22.97	1.95	0.08
2008	24.98	50.07	23.06	1.82	0.07
2009	26.59	50.06	21.76	1.53	0.06
2010	25.32	50.69	22.2	1.68	0.1
2011	24.91	49.92	23.09	2	0.08
2012	25.9	51.46	21.07	1.5	0.07
2013	27.32	50.38	20.54	1.68	0.09
2014	27.36	50.52	20.48	1.57	0.08
2015	27.46	50.73	20.2	1.54	0.06
2016	27.13	49.79	21.48	1.57	0.03
2017	29.82	49.32	19.24	1.53	0.08

Table 18. TxDOT On-System Historic Performance Based on TxDOT Performance Indicators for Overall Condition.

Fiscal Year	Percent of Very Good Lane Miles	Percent of Good Lane Miles	Percent of Fair Lane Miles	Percent of Poor Lane Miles	Percent of Very Poor Lane Miles
2007	71.65	14.62	8.57	2.79	2.37
2008	71.81	14.13	8.98	2.78	2.3
2009	73.18	13.79	8.76	2.39	1.88
2010	72.64	14.02	8.84	2.44	2.06
2011	71.78	14.69	8.96	2.52	2.05
2012	74.59	13.74	7.84	2.15	1.68
2013	71.15	16.04	8.32	2.41	2.08
2014	70.85	16.07	8.46	2.55	2.08
2015	72.02	15.3	7.98	2.55	2.15
2016	61.49	24.81	8.72	2.92	2.06
2017	64.48	23.44	7.25	2.54	2.29

Condition of Pavements Based on FHWA Definition of Performance

Table 19 and Figure 10 show the condition of the NHS pavements based on FHWA performance indicators. These data are reported on a lane mile basis and exclude miles missing or invalid data. Data are available for on-system IH, on-system non-IH, and off-system non-IH. Data are aggregated as well.

Table 19. FHWA Performance Indicators—Texas On-System and Off-System NHS Pavement Condition-Lane Miles Basis-Percent.

Condition	On-System		Off-System	On-System & Off-System	Total NHS System
	IH	Non-IH	Non-IH	Non-IH	
Good	10,920 (67.23%)	27,307 (61.69%)	916 (12.02%)	28,223 (54.39%)	39,143 (57.45%)
Fair	5,307 (32.67%)	13,973 (31.57%)	2,456 (32.21%)	16,429 (31.66%)	21,736 (31.90%)
Poor	16 (0.10%)	2,987 (6.75%)	4,252 (55.77%)	7,239 (13.95%)	7,255 (10.65%)
Total*	16,243	44,267	7,625	51,892	68,134 (100.00%)

*These numbers were calculated excluding pavement miles missing or invalid condition data on NHS

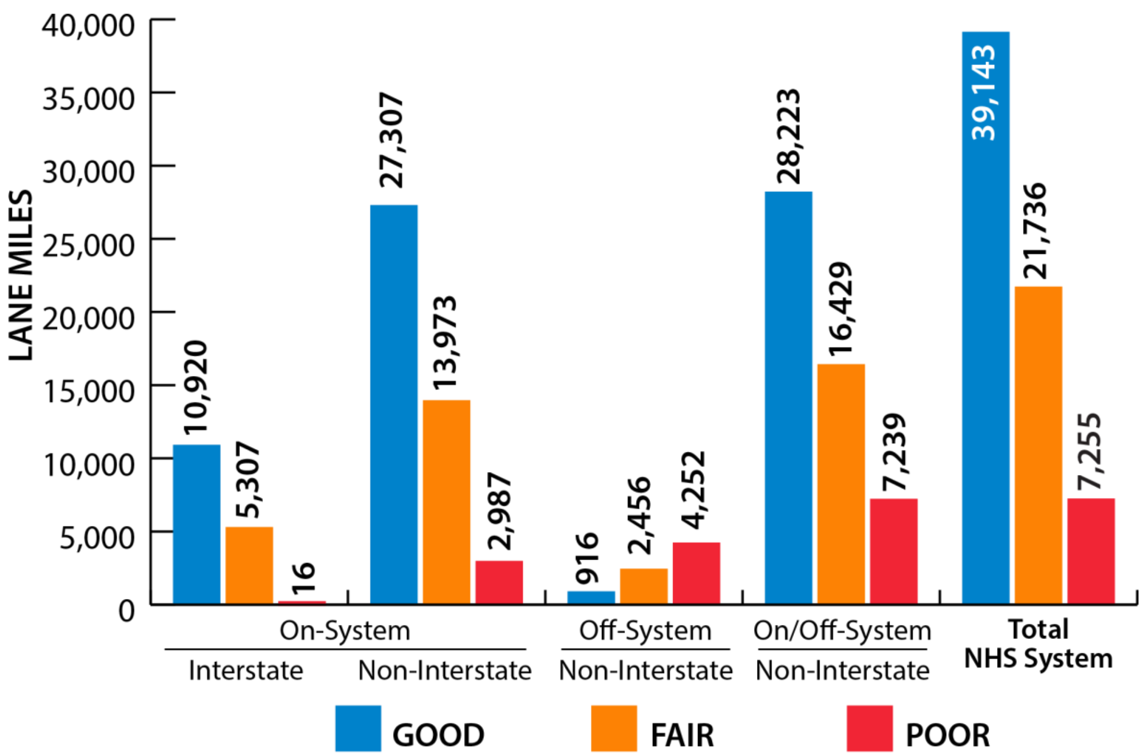


Figure 10. FHWA Pavement Performance Indicators—Texas On-System and Off-System NHS Lane Mile Basis.

This data set indicates that when using the FHWA methods to determine pavement conditions, about 45 percent of the NHS IH pavement lane miles are considered in good condition and less than 1 percent are

Less than 1 percent of NHS IH lane miles are classified as poor condition using the federal measure.

classified as poor condition. Non-IH NHS pavements (both on-system and off-system) have about 50 percent operating in the good classification and about 15 percent in the poor category.

Bridges

The maximum allowable NHS deck area in poor condition when determined by FHWA methodology is 10 percent according to FHWA regulations. Texas' bridge condition falls well below this threshold as measured by the TxDOT methodology of determining bridge condition, with only about 1 percent of deck area classified as poor. There is no required minimum percent of NHS deck area in good condition. For both of these performance measures, FHWA requires that 1) TxDOT establish future targets, and 2) that TxDOT demonstrate progress toward achieving its targets. To best capture TxDOT's bridge management policies, the TAMP presents information that defines the percent good and poor for the NHS and Non-NHS, On-System bridges.

Table 20 to Table 23 and Figure 11 to Figure 14 show the condition of bridges on the NHS system and on the TxDOT system (on-system). Table 20 (Figure 11) and Table 21 (Figure 12) show the information based on number of bridges for the NHS (Table 20) and the condition of the bridges on the TxDOT system (Table 21).

Table 20 indicates that the NHS system has about 52 percent of its bridges in good condition with less than 1 percent in the poor condition. The TxDOT NHS on-system bridges are in slightly better condition than the off-system bridges. Table 21 shows the condition of the TxDOT system, which includes part of the NHS bridges. Fifty-three percent of TxDOT owned and operated bridges are in good condition while less than 1 percent are in poor condition. Only a small difference in performance classification level is noted between NHS and non-NHS bridges in the Texas system. Traditionally, TxDOT has not explicitly considered NHS designation when programming bridge preservation activities.

Table 20. Texas On-System and Off-System NHS Bridge Condition-Based on Number of Bridges.

Condition Group	On-System NHS, IH Bridges	On-System NHS, Non-IH Bridges	Off-System NHS Non-IH Bridges	Total NHS Bridges
Good	1,950* (42.0%)	6,698 (56.5%)	503 (49.6%)	9,151 (52.3%)
Fair	2658 (57.2%)	5,113 (43.2%)	508 (50.1%)	8,279 (47.3%)
Poor	36 (0.8%)	39 (0.3%)	3 (0.3%)	78 (0.5%)
Total	4,644 (100%)	11,850 (100%)	1,014 (100%)	17,508 (100%)

*Count of Bridges

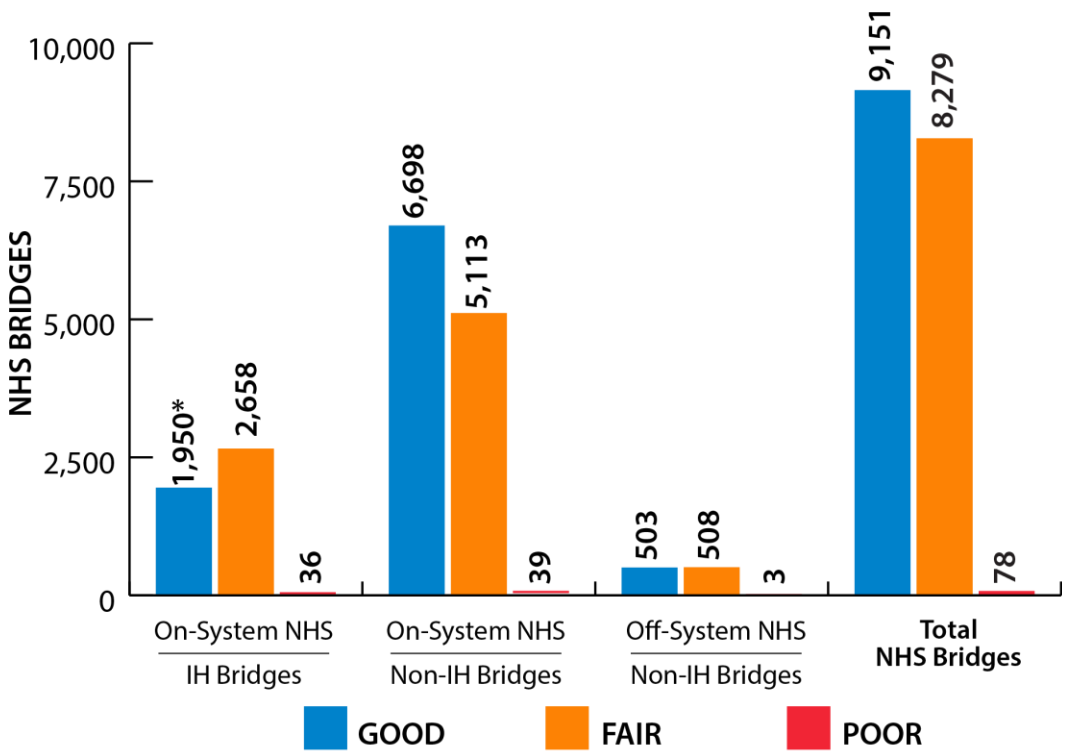


Figure 11. Texas On-System and Off-System NHS Bridge Condition-Based on Number of Bridges.

Table 21. TxDOT On-System Bridge Condition-Based on No. of Bridges.

Condition Group	On-System NHS IH Bridges	On-System NHS Non-IH Bridges	On-System Non-NHS	Total On-System Bridges
Good	1,950* (42.0%)	6,698 (56.5%)	10,114 (52.653.0%)	18,762 (52.5%)
Fair	2,658 (57.2%)	5,113 (43..2%)	8,978 (46.7%)	16,749 (46.93%)
Poor	36 (0.8%)	39 (0.3%)	140 (0.7%)	215 (0.6%)
Total	4,644 (100%)	11,850 (100%)	19,232 (100%)	35,726 (100%)

*Count of Bridges

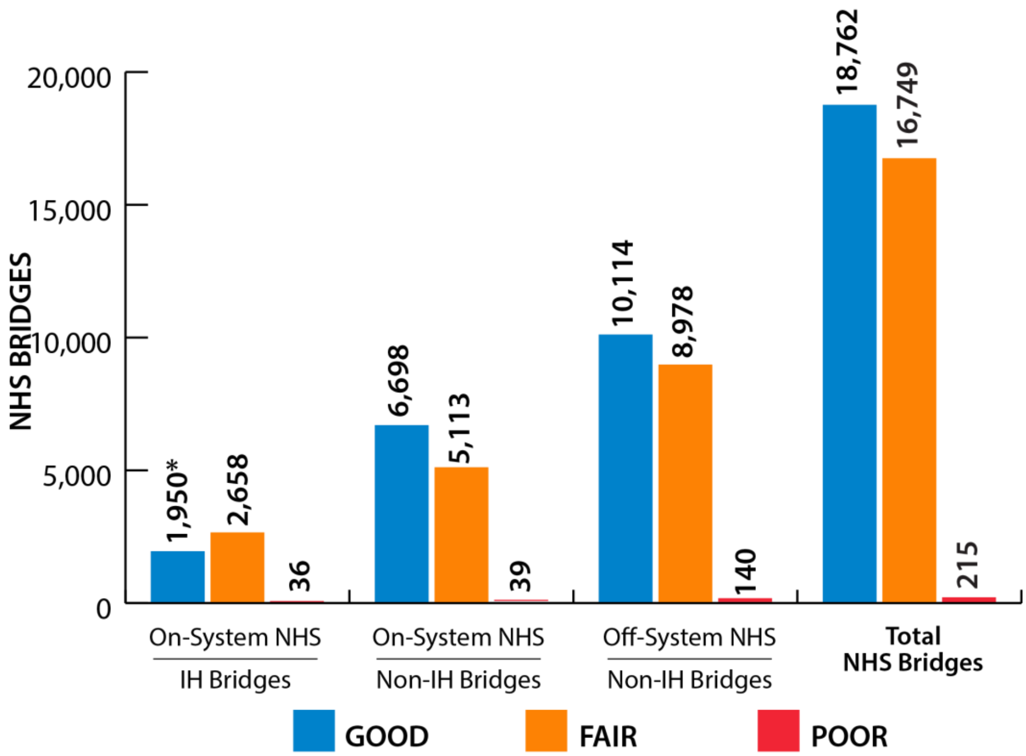


Figure 12. TxDOT On-System Bridge Condition-Based on No. of Bridges.

Table 22 (Figure 13) and Table 23 (Figure 14) show condition information based on bridge deck area for the NHS system (Table 22) and the TxDOT (on-system). About 50 percent of the NHS bridges are in good condition and less than 1 percent are in poor condition. On-system NHS bridges are performing at a somewhat higher level than off-system NHS bridges.

Table 23 shows the performance level based on bridge deck area for TxDOT system bridges. About 51 percent of TxDOT bridges are classified as in good condition while about 1 percent are in poor condition.

Table 22. Texas On-System and Off-System NHS Bridge Condition-Based on Bridge Deck Area (Millions of sq. ft.).

Condition Group	On-System NHS IH Bridges	On-System NHS Non-IH Bridges	Off-System NHS Non-IH Bridges	Total NHS Bridges
Good	33.9 (38.4%)	129.7 (54.5%)	8.9 (45.5%)	172.5 (49.9%)
Fair	52.2 (59.2%)	107.4 (45.1%)	10.7 (54.5%)	170.3 (49.2%)
Poor	2.1 (2.4%)	1.0 (0.4%)	0.01 (0.0%)	3.1 (0.9%)
Total	88.2 (100%)	238.1 (100%)	19.6 (100%)	345.9 (100%)

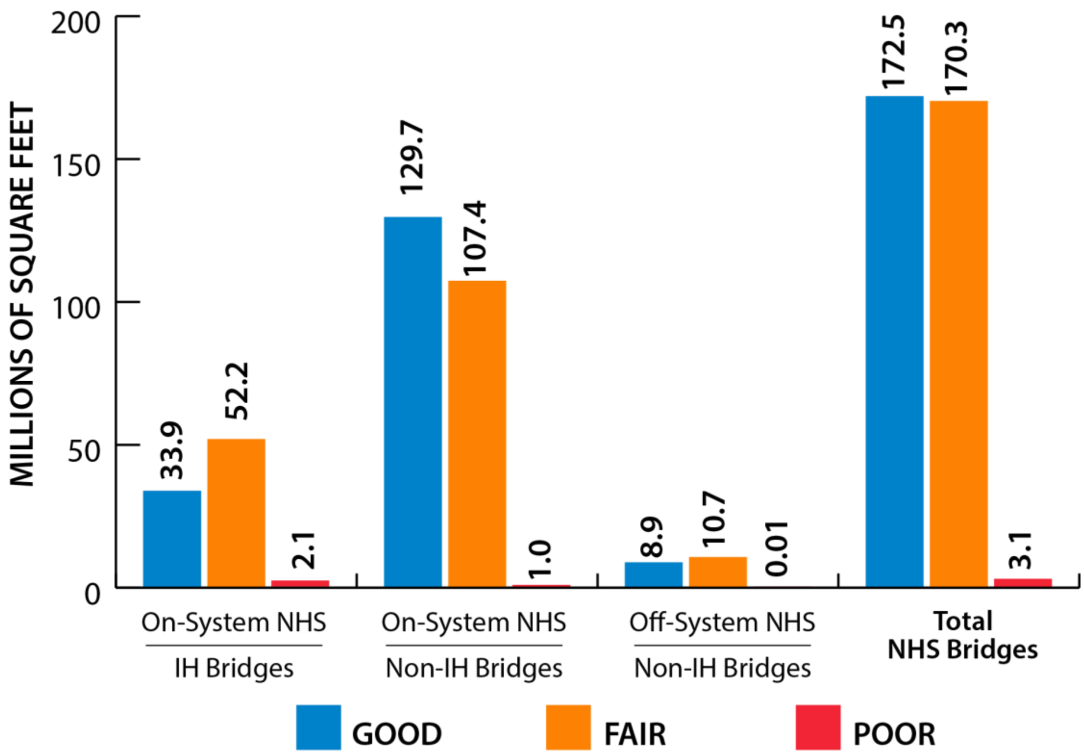


Figure 13. Texas On-System and Off-System NHS Bridge Condition-Based on Bridge Deck Area (Millions of sq. ft.).

Table 23. TxDOT On-System Bridge Condition-Based on Bridge Deck Area (Millions of sq. ft.).

Condition Group	On-System NHS IH Bridges	On-System NHS Non-IH Bridges	On-System Non-NHS Bridges	Total On-System Bridges
Good	33.9 (38.4%)	129.7 (54.5%)	73.0 (54.1%)	236.5 (51.3%)
Fair	52.2 (59.2%)	107.4 (45.1%)	60.2 (44.6%)	219.8 (47.7%)
Poor	2.1 (2.4%)	1.0 (0.4%)	1.7 (1.3%)	4.8 (1.0%)
Total	88.2 (100%)	238.1 (100%)	134.8 (100%)	461.1 (100%)

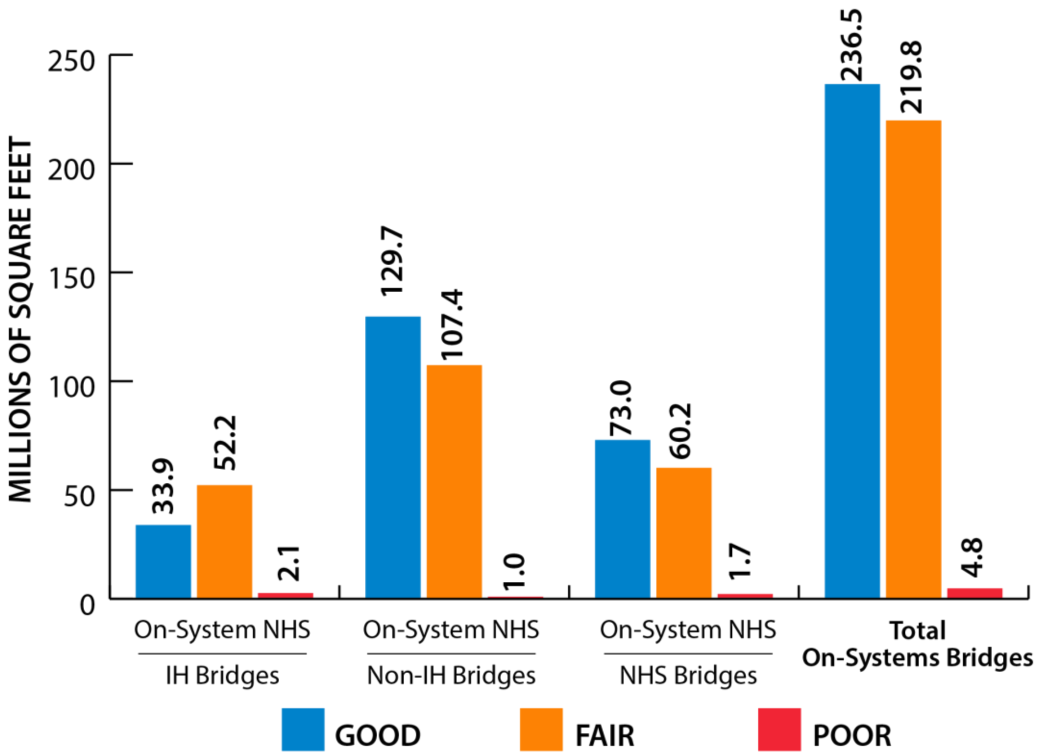


Figure 14. TxDOT On-System Bridge Condition-Based on Bridge Deck Area (Millions of sq. ft.).

Chapter 4: Life Cycle Planning

Overview

LCP is defined by FHWA (*7*) "as a process to estimate the cost of managing an asset class, or asset sub-group over its whole life with consideration for minimizing cost while preserving or improving the condition." LCP is a process that can be used to 1) identify performance gaps in the planning cycle and 2) determine the best life cycle scenarios to minimize any performance gaps between the current and desired SOGR. The objectives of LCP include the following:

- Establishing a long-term focus for improving and preserving the system.
- Estimating the condition that can be achieved with different alternative funding levels.
- Providing support for investment decisions with a thorough, data-driven analysis process.

Reference (*20*) provides an overview of LCP and the methodology used by TxDOT. The life cycling planning implications performed with TxDOT's methodology and bridge condition historic trends for TxDOT on-system assets are included. The LCP process does not include consideration for project duration and the associated user and non-user costs.

LCP for Pavements

LCP is conducted to maximize the performance of an asset over its lifetime through strategic and systematic planning of a well-planned reconstruction, rehabilitation, and maintenance strategy. Figure 15 shows an example of a typical life-cycle cost scenario of a highway without a preventive and routine maintenance strategy versus a scenario with a preventive and routine maintenance strategy (*10*).

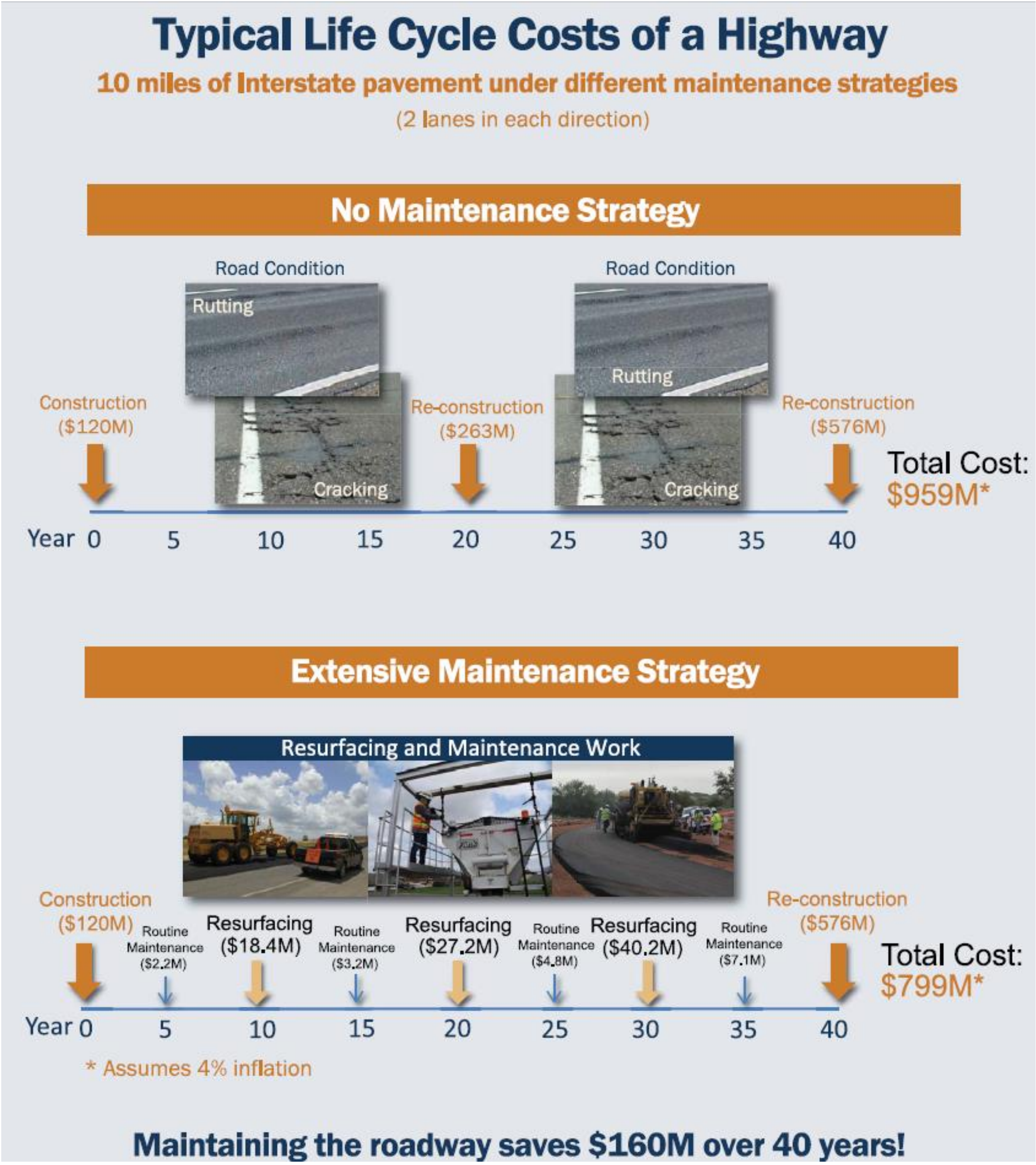


Figure 15. Typical Life Cycle Costs of a Highway (20).

Figure 16 shows an example of pavement conditions under three different strategies: reconstruction, rehabilitation, and maintenance. Through the process of LCP, alternative strategies such as those shown on Figure 16 can be compared to identify the lowest life cycle cost over a selected analysis period.

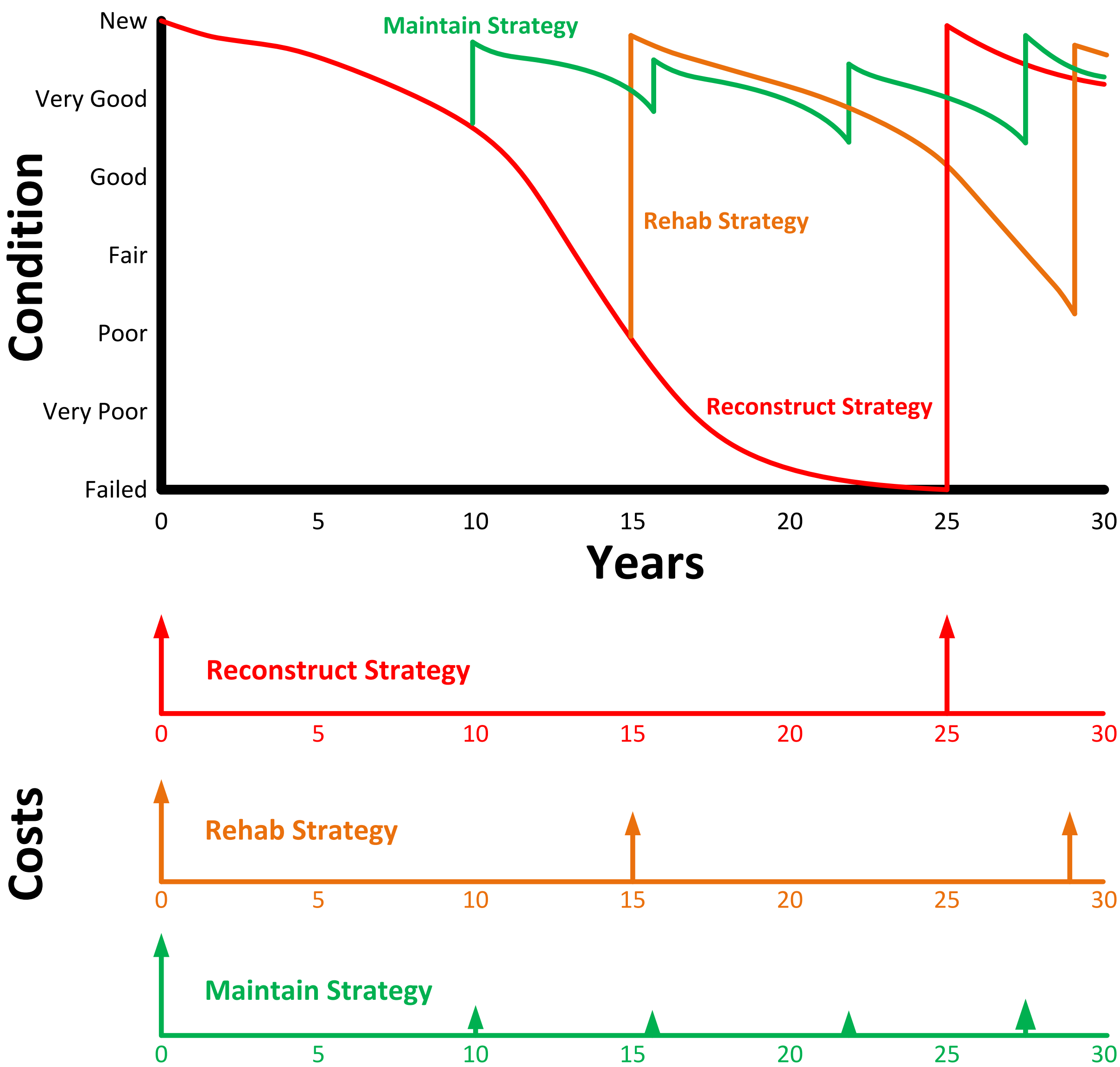


Figure 16. Life Cycle Strategies.

Asset managers can use LCP on an asset level to help inform programmatic decisions that affect their network of assets as a whole. LCP can help answer questions for asset owner decision makers including:

- Which strategy provides the best level of service or condition of an asset given budget constraints?
- What level of funding is needed to achieve a desired level of service or condition for a particular asset or for the network?
- What are the consequences of funding alternatives to a particular asset or on the network?

Key elements of LCP include the following:

- Asset inventory information.
- Condition data over a period of time or performance data.
- Deterioration or performance models.
- Repair or treatment options.
- Decision trees, which allow the selection of repair alternatives.
- Repair alternatives costs.
- Life cycles of repair alternatives.
- Economic analysis approach based on engineering economic principles.

TxDOT's LCP Process for Pavements

In 2016, TxDOT implemented a new pavement management system, Pavement Analyst (PA). PA provides the ability to forecast pavement condition, perform advanced analysis to answer what-if scenarios, and recommend optimized pavement work plans for preventive maintenance and rehabilitation to maximize the condition of the network based on constrained funding. PA also provides easy access to data including right of way images, the ability to create maps, and reports. The system supports network-level pavement decisions at the Division, District, Area Office, and Maintenance Section level.

TxDOT uses a comprehensive engineering and economic approach for conducting the LCP process: TxDOT's Pavement Management System (*21*) and the PA (*20*). The PA Program applies the treatment rules through decision trees and predicts the performance of the pavement network with the use of performance models. During an analysis period, the performance models predict the distresses and ride scores of each pavement section, in each year.

Decision trees are used to recommend treatments for each pavement section based on the predicted conditions. Whether the recommended treatment is selected will be further determined by its treatment cost and the available funding. As a result, a set of different treatments for preventive maintenance (PM), light rehabilitation (LR), medium rehabilitation (MR), and heavy rehabilitation (HR) can possibly be adopted for each given section in a 10-year period. The Optimization Algorithm will pick the best treatment strategies from a network perspective. If a treatment is applied to a section for a given year, its condition will be reset, and a deterioration or performance model will be applied to predict the condition in the subsequent years. In each year during the analysis period, the conditions of all sections will be summarized to generate the network-level condition statistics.

The types of maintenance and rehabilitation alternatives available in the decision tree include four broad categories. These broad categories include:

- Preventative maintenance
- Light rehabilitation
- Medium rehabilitation
- Heavy rehabilitation

Table 24, Table 25, and Table 26 describe the treatment definition for ACP, CRCP, and JCP, respectively. The performance and cost of all specific maintenance and rehabilitation alternatives within each one of the four groups (PM, LR, MR, and HR) are assumed to be the same.

Table 24. Treatment Definitions for Flexible Pavements.

Treatment Level	Description
Preventive Maintenance	Seal Coat
	Thin Overlay 2" Thick or Less
	Mill and Inlay 2" or less
	Hot In-Place Recycling
	Microsurfacing/Slurry Seal
	Scrub Seal
Light Rehabilitation	Overlay Greater than 2" Thick but Less than 4"
	Mill and Inlay between 2" to 4"
Medium Rehabilitation	Overlay between 4" and 6"
	Mill and Inlay Greater than 4" but Less than 6"
	Whitetopping
Heavy Rehabilitation	Overlays Greater than 6"
	Mill and Inlays Greater than 6"
	Full Reconstruction
	Full Depth Reclamation (Pulverization and stabilization) new HMA surface
	Full Depth Reclamation (Pulverization and add new base) new seal coat surface

Table 25. Treatment Definitions for CRCP Pavements.

Treatment Level	Description
Preventive Maintenance	Half Depth Repair/Full Depth Repair
	Diamond Grinding and Grooving
	Thin ACP Overlays 2" thick or less
Light Rehabilitation	ACP Overlay Greater than 2" and Less than 4"
Medium Rehabilitation	ACP Overlay Greater than 4" and Less than 6"
Heavy Rehabilitation	Reconstruction
	Rubblization & Overlay Greater than 6"
	Bonded Concrete Overlay
	Unbonded Concrete Overlay

Table 26. Treatment Definitions for Jointed Concrete Pavement-Concrete Pavement Contraction Design (JCP-CPCD) Pavements.

Treatment Level	Description
Preventive Maintenance	Diamond Grinding and Grooving
	Joint and/or Crack Sealing
	Half Depth Repair
	Slab Replacement
	Thin ACP Overlays 2" thick or less
Light Rehabilitation	ACP Overlay Greater than 2" but Less than 4"
	Dowel Bar Retrofit and Grinding
Medium Rehabilitation	ACP Overlay Greater than 4" but Less than 6"
Heavy Rehabilitation	Full Reconstruction
	Rubblizing and ACP Resurfacing Greater than 6"
	Bonded Concrete Overlay
	Unbonded Concrete Overlay

Federal definitions for work types in 23 CFR 515 are slightly different from definitions for pavement treatment levels used by TxDOT. The relationship between federal and TxDOT work types is described in Table 27.

Table 27. Federal and TxDOT Work Types Crosswalk

23 CFR 515 Work Types	TxDOT Work Types
Initial construction	New construction
Maintenance	Routine maintenance
Preservation	Preventive maintenance
Rehabilitation	Light Rehabilitation, Medium Rehabilitation, Heavy Rehabilitation (excluding reconstruction)
Reconstruction	Heavy Rehabilitation (reconstruction)

Note: The detailed definition of classifications Preventive Maintenance, Light Rehabilitation, Medium Rehabilitation, and Heavy Rehabilitation are listed as treatment levels in Chapter 4. Routine Maintenance refers to the remaining treatment levels such as edge repair, joint repair, etc. Any TxDOT work type can be performed directly by a district or through the Unified Transportation Program.

Pavement deterioration or performance models have been developed considering numerous inputs for Texas. These inputs or factors that are considered include the following:

- Climate and subgrade zone-four climatic and subgrade zones.
- Pavement type and thickness-asphalt bound and Portland cement concrete pavements of different types and thicknesses.
- Treatment types or alternatives-preventive maintenance and light, medium, and heavy rehabilitation.
- Traffic loading levels-based on a truck traffic indicator (low, medium, and high level).

Within each of the families defined above, a sigmoidal curve is used to project the pavement distress or ride quality loss, which are combined, into a distress score, ride score, and combined condition score based on their utility or weight values.

The Texas LCP process is composed of five steps as shown in Figure 17 and briefly described below.

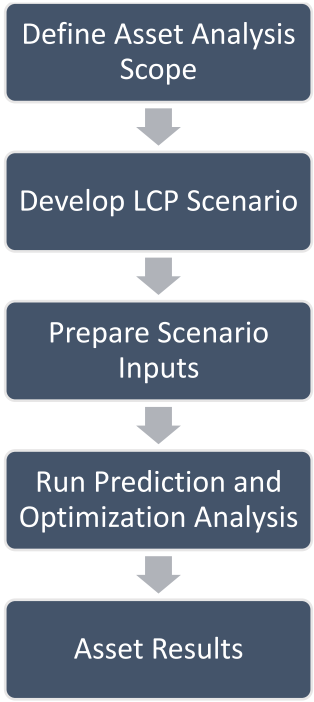


Figure 17. TxDOT LCP Process Flow Chart.

Step 1: Define Asset Analysis Scope

The scope covers the highway network to be considered in the analysis. The data set for the assets under consideration are located and imported into the program. As a minimum, the current condition and inventory information for each section in the selected network is required.

Step 2: Develop LCP Scenario

The LCP scenarios are heavily dependent on the funding levels in the planning period. TxDOT publishes the UTP annually (9). This document contains a funding scenario for a 10-year period for several funding categories. A portion of the UTP fund is dedicated for pavement preventive maintenance and rehabilitation. In addition, there is a maintenance budget allocated for pavements. These funds may vary considering the uncertainty/risk in the financial forecast. The TAMP used various 10-year UTP and maintenance funds in the LCP analysis as described in the Financial Plan and Investment Strategies (Chapter 6). The main LCP scenarios are listed below:

- Current planned investment levels.
- Reduced funding investment levels (e.g., 10 percent lower than planned).
- Increased funding investment levels (e.g., 10 percent higher than planned).

In addition, a scenario that sets the funding at a level to preserve the network is determined and included in this document.

Step 3: Prepare Scenario Inputs

For each LCP scenario, a series of factors is needed as input. These factors include network scope, start condition, analysis length, decision trees, financial parameters, etc. In addition, the most critical ones are the objective and constraints. In the LCP process, the objective is to maximize the performance of the network during the analysis period and the constraints are the available funding for each year.

Step 4: Run Prediction and Optimization Analysis

Once the inputs are prepared, each scenario can be run in the PA program to obtain the optimal solutions that meet the objective under the constraints. The optimal solutions include the right treatment at the right location and right time. As a result, the PA program will output the selected treatment and predicted condition for each section in the network in each year. It will also provide the summary statistics in condition, treated lane-miles, total treatment cost, etc. for the entire network.

Step 5: Assess Results

Based on the results in Step 4, the logical next step is to make an assessment from an engineering and economic perspective. This step typically involves answering the following questions:

- What is the impact of different funding levels on the network level performance?
- What is the gap between the projected condition of the system and the established criteria for defining the SOGR for any given funding level?
- How does the financial plan address the gap?

TxDOT Pavements

The LCP process for TxDOT on-system pavements used the following inputs to the PA program:

- **Analysis scope:** The analysis was performed on all TxDOT on-system pavements. This included NHS on-system pavements and on-system non-NHS pavements. At the current time, it is not possible to accurately segment funding for these highway categories. Thus, the LCP tool was used to reflect the operational reality at TxDOT (i.e., for the entire network).
- **Start condition:** The current condition of the network is based on information collected in 2017. The year 2017 was used as the start year in the prediction analysis.
- **Funding level:** Table 28 provides a series of funding levels. The planned funding level, or baseline funding, was obtained from information presented in Chapter 6, “Financial Plan and Investment Strategies.” On-system highways are estimated to

account for 95 percent of the total pavement funding. This percentage was applied to the UTP funding in Table 42 to determine the baseline 10-year funding level used in the LCP analysis. For funding variation, a fluctuation of plus or minus 10 percent from the baseline was used.

Table 28. Different Funding Scenarios for the 10-Year Analysis Period.

Scenario No.	Scenario Name	Funding Level ($Billion)
1	Planned Fund	$17.74
2	10% over Planned Fund (Planned Fund +10%)	$19.51
3	10% under Planned Fund (Planned Fund −10%)	$15.97
4	Worst-first	$17.74

- **Financial parameters:** A rate of return of 4 percent was used in the analysis. This is consistent with constant dollar economical life cycle approaches. The rate of return addresses the inflation rates associated with the time value of money. Material and labor inflation rates beyond the time value of money impacts are not considered in the analysis. The unit costs vary among different pavement types including CRCP, JCP, and ACP, and work types including PM, LR, MR, and HR. Each unit cost represents the cost required to treat one lane-mile of pavement and is shown in Table 29.

Table 29. Pavement Treatment Unit Costs.

Pavement Type	Treatment Type	Treatment Unit Cost per Lane Mile ($)
CRCP	PM	$81,703
	LR	$172,041
	MR	$210,144
	HR	$971,516
JCP	PM	$817,03
	LR	$172,041
	MR	$210,144
	HR	$971,516

ACP	PM	$534,62
	LR	$221,186
	MR	$296,023
	HR	$470,988

Figure 18 shows the results of the optimization analysis for the inputs described above for the funding scenarios described. For comparison, the historical percent of Good/Very Good pavement for the statewide network from FY2010 to FY2017 are shown.

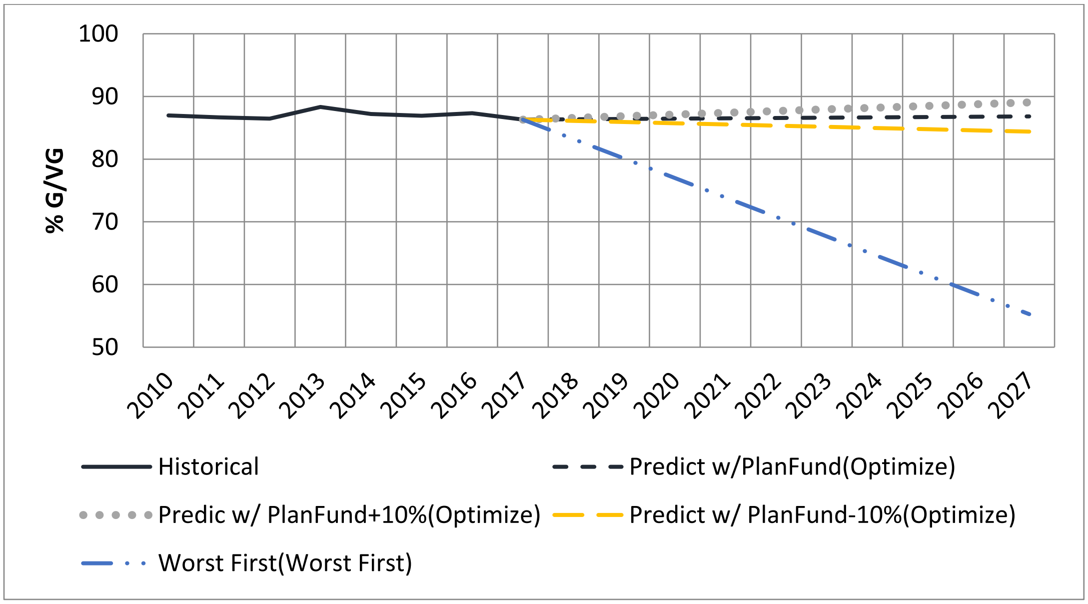


Figure 18. TxDOT On-System Statewide Historical and Predicted Percent Good/Very Lane Miles for Statewide Network in 10 Years of LCP Period.

As expected, the predicted performance varies with different levels of funding. The percent of Good/Very Good increases with the increase of funding. Overall, gaps exist for these funding levels to make the entire network reach the goal of 90 percent Good or better:

- With the planned funding level, the network can perform slightly better than the current condition (86.30 percent Good/Very Good) by the end of 10-year period (86.83 percent Good/Very Good).
- With a 10 percent budget increase, the network can reach very closely to the TxDOT statewide goal of 90 percent Good/Very Good by the end of 10-year period (89.04 percent Good/Very Good).
- With a budget at 10 percent below the expected funding level, 84.39 percent of the pavements will be classified as Good/Very Good at the end of the analysis period.

Another scenario analysis was conducted to establish a funding level that will keep/preserve the network at the current condition in terms of percent lane miles Good/Very Good in the 10-year analysis period. It is determined that as the funding reaches $17.39 billion, the network will remain in the current condition.

In addition to the above scenario runs based on the optimization algorithm, for comparison, Figure 18 shows the predicted network performance under a different strategy, the worst-first scenario. The predicted percent Good/Very Good with worst-first is lower than the optimization result (Figure 18).

LCP Process for Bridges

Through the TAMP document preparation, and in recognition of gaps in the TxDOT system, the LCP capabilities of TxDOT's bridge management system will be implemented. FHWA regulations stipulate that a LCP process for bridges must include the following components: the state department of transportation's (DOT's) performance measure targets, bridge deterioration models, bridge work types that preserve or improve assets, and strategies that lead to the managing of assets while minimizing costs during the whole life of assets (23 CFR 515.7(b)). One outcome of TxDOT's TAMP development process is the use of a bridge management system to satisfy these requirements. This section discusses bridge performance trends in consideration of LCP on a network level. Chapter 7 of this document describes the process TxDOT plans to take to implement a bridge management system in support of LCP.

Currently, TxDOT performs all of the federal work types defined in 23 CFR 515 (Initial construction, maintenance, preservation, rehabilitation, and reconstruction). Table 30 shows which categories of planned funding are typically used to fund each of these types of work.

Table 30. Planned Funds and Bridge Work Types

Funding Source	Bridge Work Type(s)
UTP Category 1	Maintenance, preservation, rehabilitation
UTP Category 2	Initial construction, reconstruction
UTP Category 3	Initial construction, reconstruction
UTP Category 4	Initial construction, reconstruction
UTP Category 5	None
UTP Category 6	Maintenance, preservation, rehabilitation, and reconstruction
UTP Category 7	None

UTP Category 8	None
UTP Category 9	None
UTP Category 10	None
UTP Category 11	Initial construction, reconstruction
UTP Category 12	Initial construction, reconstruction
In-House Maintenance Operations	Maintenance, preservation
District-Managed Contracts	Maintenance, preservation, rehabilitation

Although FHWA's good, fair, and poor performance measures have only recently been formally adopted, it is possible to apply these measures to previous years of bridge data. Doing so establishes a baseline for bridge performance in the state. Table 31 shows bridge condition information based on deck area and good, fair, and poor categories as defined by FHWA for NHS from 2007 to 2017. Table 31 shows bridge condition information for both NHS and other on-system bridges from 2007 to 2017. This table also includes anticipated values for percent good, fair, and poor deck area in the near future. TxDOT anticipates there will be a lag time between the development of condition-based bridge management processes and the actual impact on system performance measures. For that reason, it is expected that network performance measures will follow these linear trends in the short term.

Table 31. Bridge Conditions 2007–2017 (NHS and On-System Bridges).

	Deck Area (million sq. ft.)			
	Good	Fair	Poor	Total
2007	200.9 (53.9%)	164.1 (44.1%)	7.5 (2.0%)	372.4 (100.0%)
2009	203.6 (52.6%)	177.1 (45.7%)	6.7 (1.7%)	387.4 (100.0%)
2011	215.5 (52.9%)	185.2 (45.5%)	6.5 (1.6%)	407.2 (100.0%)
2013	232.4 (52.9%)	200.9 (45.7%)	6.1 (1.4%)	439.4 (100.0%)
2015	239.1 (52.5%)	211.2 (46.4%)	5.2 (1.1%)	455.5 (100.0%)
2017	242.3 (51.5%)	223.5 (47.5%)	4.4 (0.9%)	470.2 (100.0%)
Projected 2019*	255.4 (51.6%)	235.2 (47.6%)	4.0 (0.8%)	494.6 (100.0%)
Projected 2021*	264.8 (51.4%)	247.1 (47.9%)	3.4 (0.7%)	515.3 (100.0%)
Projected 2023*	274.2 (51.2%)	258.9 (48.3%)	2.9 (0.5%)	536.0 (100.0%)

*Projections for deck area in good, fair, and poor condition were developed via linear trend line analysis.

Based on these historic data, two distinct trends can be observed. First, the percent of poor bridges has decreased steadily to the lowest practical level. Second, the percent of good bridges is also decreasing. This offers an opportunity to shift focus away from addressing primarily bridges in poor condition and adopting a more holistic approach to bridge management.

Bridges in Texas have typically been replaced after 50 to 70 years of service, once they transition into a poor condition state. Although this management strategy has served TxDOT well in the past, there is reason to believe it may be economically unsustainable in the long term.

Figure 19 shows the distribution of bridge deck area by condition group and age, highlighting that TxDOT's bridge asset management strategy must take into account the large number of bridges constructed during the interstate era that are approaching the end of their intended service lives.

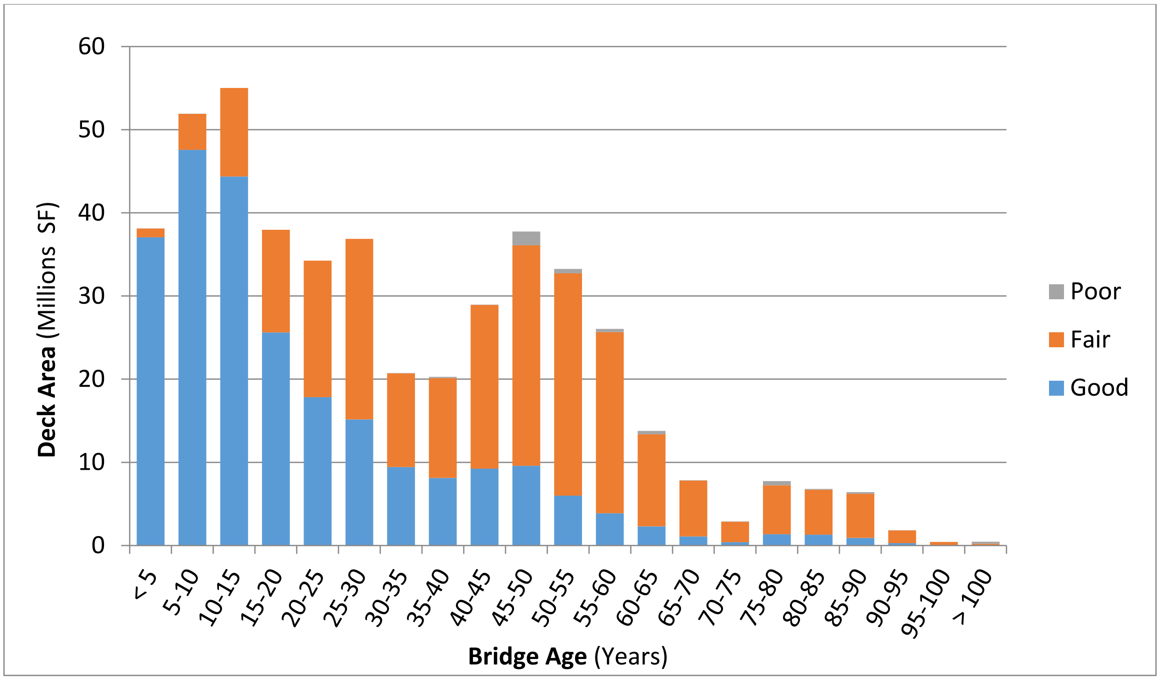


Figure 19. Deck Area by Age and Condition Group (NHS and On-System Bridges).

Category 6 of the UTP has been TxDOT's primary tool for funding bridge replacement projects. With typical funding levels, Category 6 has been able to improve bridges at a rate of less than 5 million square feet per year. Recognizing the large volume of bridges that are approaching the end of their service life, TxDOT will be evaluating historic practices along with new strategies to ensure sustainable long-term performance of the network.

As Texas' bridge inventory continues to age, condition deterioration rates are expected to accelerate. Given the vast size of Texas' bridge inventory and the reality that it will take time for changes in asset management strategies to be implemented and realized through better condition scores, TxDOT expects bridge conditions to closely follow these historic performance trends in the short term.

Chapter 5: Risk Management

Overview

Risk management is defined by FHWA as the processes and framework for managing potential risks, including identifying, analyzing, evaluating, and addressing the risks to assets and system performance. Risk management processes and considerations should be updated on a periodic basis.

TxDOT uses risk management in the TAMP to identify risk items that could impact performance of pavement and bridges. A risk management system will provide better, more informed decisions to address existing or potential risks. The use of risk management also provides an improved understanding of likely outcomes and results of actions taken in response to the risks.

TxDOT assumes and addresses risk with each transportation decision made at all levels within the agency. TxDOT, like many other transportation agencies, faces a range of general risks including the following categories:

- Public and agency safety.
- Human resources.
- Business systems performance.
- Legal and compliance.
- Fluctuations in funding.
- Project delivery.
- Emergency events.

FHWA regulations (7) require the development of a risk-based asset management plan. TxDOT adopted a risk analysis framework proposed by several industry experts (*22*, *23*). The framework incorporates the processes of risk assessment and management that addresses the risks identified (Figure 20).

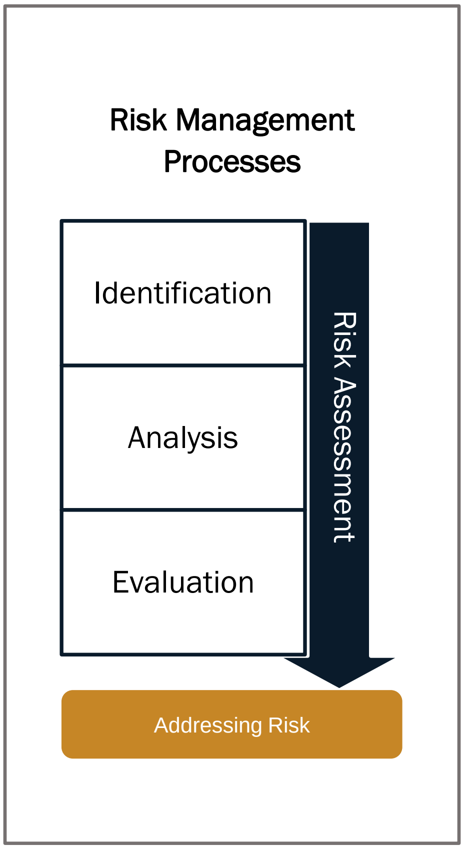


Figure 20. Risk Management Process.

Three analyses were conducted as part of the development of the risk based TAMP effort. These analyses are identified below:

- Environmental Impacts to Assets.
- Risk Management Processes.
- Facilities Repeatedly Requiring Repair and Reconstruction as a result of Emergency Events (recurring events).

The first two analyses are required by Part 515 of Federal Regulation 23 CFR (*7*), and the third is a result of Part 667 (*7*) of Federal Regulation 23 CFR. A discussion of the analyses conducted and the top risks identified through the risk management process follow.

Environmental Impacts

As a minimum, FHWA requires state DOTs to identify risks associated with NHS asset performance, including risks associated with current and future environmental conditions. This section identifies frequently occurring environmental risks and how TxDOT addresses them.

In the transportation context, and for the purposes of this TAMP, environmental stressors are natural events that impact highway assets. These are inclusive of climatological events and extreme weather, which are typically the most influential to the performance of Texas assets.

In addition to many rivers, streams, lakes, and reservoirs, Texas has approximately 367 miles of coastline exposure to the Gulf of Mexico (*24*). This exposure increases the vulnerability of transportation assets to tornado, hurricanes, and tropical storm winds as well as surging gulf waters pushed inland by hurricanes. Droughts also cause deterioration to highways because many Texas facilities are constructed on clay soils that change volume with changes in soil moisture content.

Texas recognizes and proactively prepares for changes to the transportation environment. The environmental review process provides early programmatic guidance on environmental considerations; whereas, the planning process and design phases are project level evaluations to specifically account for the most typical environmental stressors. TxDOT engineers design facilities considering the effects of flood, precipitation, storm surge, and winds. Data defining potential impacts of these events are used to design durable and resilient roadways; appropriate materials are used to address the local environment influence; and construction techniques are modified to account for climatological data and short-term fluctuations in weather. Except for extreme weather events, most climatological and environmental stressors are considered in advance of asset construction and the scheduling of asset reconstruction, rehabilitation, and maintenance operations.

Environmental Stressors

Like many other state agencies, TxDOT assets are impacted by several climate variables. Table 32 shows climate variables identified and discussed in a recent TxDOT study through the Environmental Affairs Division (*25*). Many of the commonly considered climate variables have little to no change associated with them; therefore, their influence, in the short term, is not anticipated to have an appreciable effect on the performance of Texas assets.

Table 32. Texas Climate Variables with Potential Asset Impacts.

Climate Variable	Environmental Events/Impacts	Variable Changes
Temperature	• Freeze Thaw Cycles • Heat Waves • Wildfire	3.08 to 6.25°F increase of annual maximum temperature in 50 years[2]
Drought	• Decreased Precipitation • Wildfire	Increase of 1 to 7 days of consecutive dry days
Sea Level Rise	• Increased Water Elevations (relative to land mass elevation)	1.9 to 6.6 mm/yr rise along the Texas coastline
Precipitation	• Drought • Flooding	No appreciable change

Historically, Texas has not been affected by large or frequent seismic activity. Recent increases in seismic activity appears to be associated with the large amounts of water disposal centered in areas of oil and gas drilling and production, and along natural fault lines. The United States Geological Survey predicts that most induced events are in lightly populated regions where they have only a 2 percent chance of damage in approximately a 50-year period (*26*).

Although TxDOT develops engineering solutions in response to environmental stressors, gradual climatological changes do not account for the occurrence of a single extreme weather event. Hurricane Harvey in 2017, for example, produced the largest historical rainfall from a single event in the state's history when no appreciable change in precipitation was anticipated. These extreme weather events pose the predominant threat to Texas infrastructure.

Extreme Weather Impacts

A quantification of assets within a given risk area is possible using geospatial analysis. These quantities are useful as a means of determining the locations, numbers and lengths of vulnerable pavement sections, and bridges that may be impacted by storms of various magnitudes. An asset located within risk prone areas may not experience physical damage. For example, the event may not occur at that location and the impacted structure may be hardened sufficiently to resist the event.

[2] United States Geological Survey, National Climate Change Viewer.

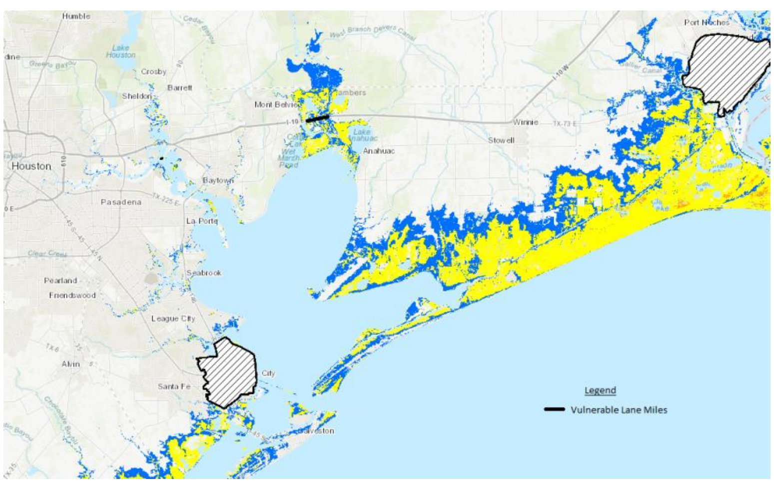
More frequent and more severe weather events are anticipated (*27*), which makes vulnerability considerations a statewide concern. Hurricane Harvey is an example of an extreme event that had a tremendous impact on Texas. In November 2017, the National Oceanic and Atmospheric Administration (NOAA) released updated frequency estimates for Texas, which included data from Hurricane Harvey. Note that data presented in this TAMP do not include data from Hurricane Harvey.

Pavements

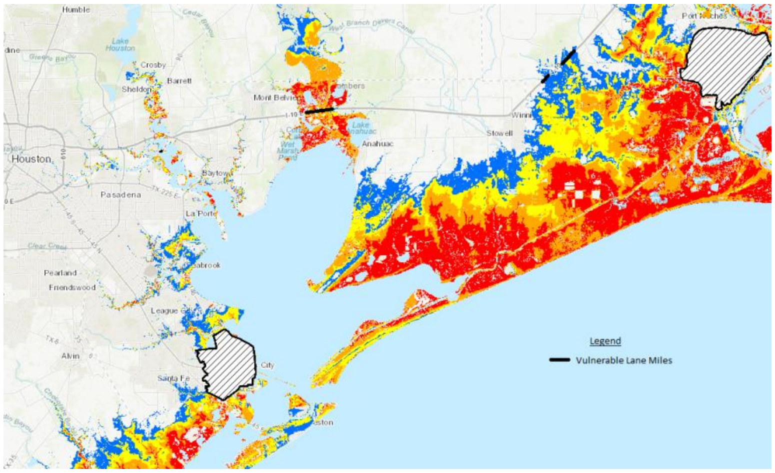
Extreme weather events such as major flooding and storm surges have historically impacted the state's transportation system. While it is difficult to predict the severity and frequency of future extreme weather events, historical information can assist in identifying areas of concern.

Storm Surge

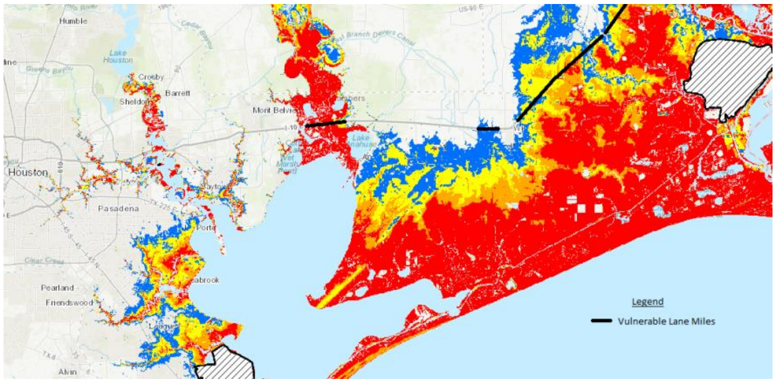
NOAA provides storm surge data for many coastal regions. Figure 21 shows the progression of predicted storm surge due to increased hurricane severity. The depth of water over land is shown as blue for 1 ft and red where more than 9 ft of inundation may occur. The length of vulnerable roadway segments gets progressively longer as the severity of storm increases. The length of roadway impacted by a Category 5 hurricane is substantially more than a Category 1 hurricane.



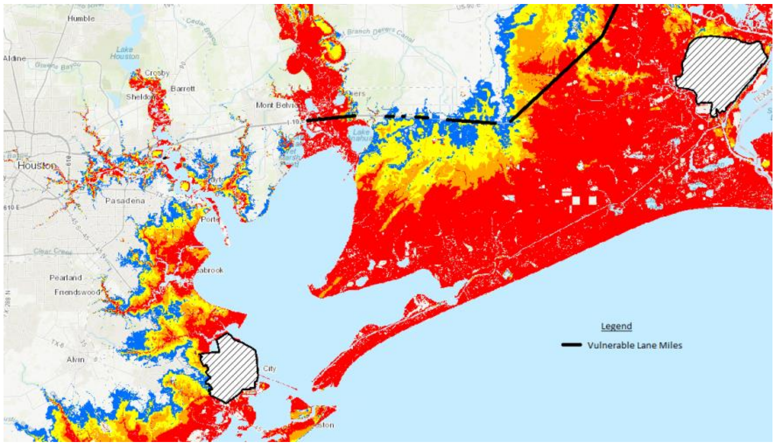
a. Category 1 Storm Impacts.



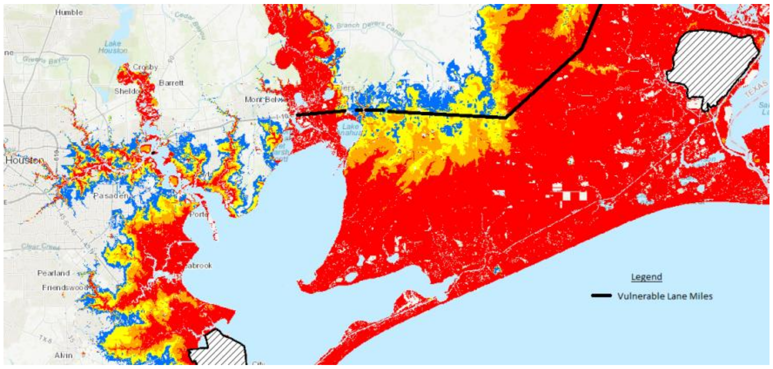
b. Category 2 Storm Impacts.



c. Category 3 Storm Impacts.



d. Category 4 Storm Impacts.



e. Category 5 Storm Impacts.

Figure 21. Storm Surge Resulting from Different Category Hurricanes in the Houston Area.

To determine statewide vulnerability to storm surge, the geospatial analysis is repeated for all areas in the state. Figure 22 shows the number of vulnerable NHS lane miles for each hurricane category. This mileage is determined by applying the storm surge data overlay on all regions of the state; therefore, the mileage is larger than what is likely to be affected by a single event. For example, a hurricane striking Port Arthur, Texas, may not cause any storm surge in Brownsville, Texas, but highway mileage is identified in both areas to document the potential for each to be impacted at some time.

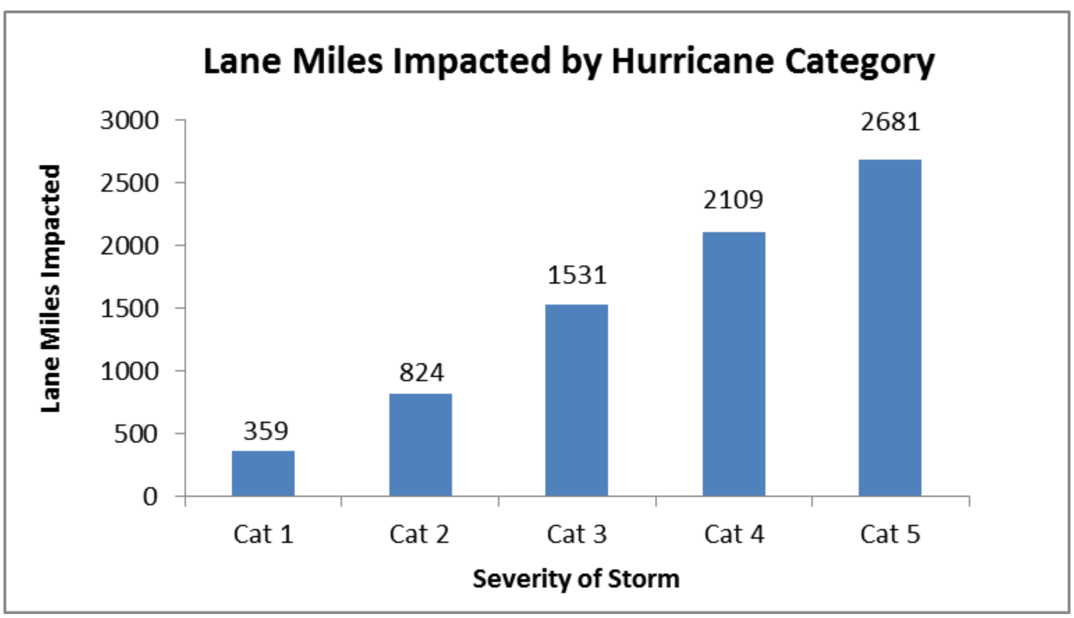


Figure 22. Vulnerable Lane Miles due to Storm Surge by Hurricane Category.

Flooding

Assets vulnerable to flooding were identified using Federal Emergency Management Agency (FEMA) flood plain data (Figure 23). Currently, statewide flooding data are not available that defines 100-year and 500-year flood plains. In many cases, there is not a 500-year flood plain corresponding to a 100-year flood plain. Where the data were absent, a 500-year flood plain was synthesized proportional to the areal increase calculated between the 100 and 500-year data where the two flood plain maps exist.

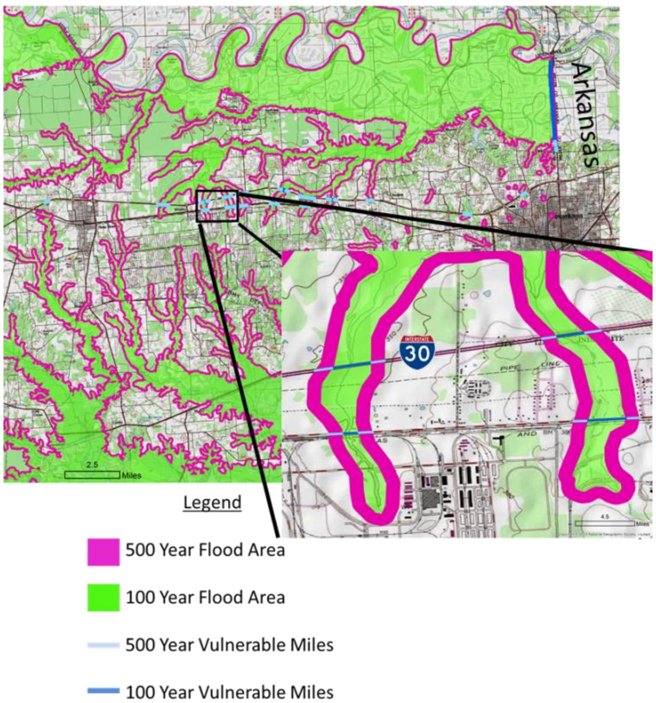


Figure 23. Example FEMA Flood Plain Map.

A geospatial analysis was performed using FEMA and synthesized flood plain data. Highway segment lengths were determined where they crossed or were contained in the 100-year flood plain. Similarly, the additional length of vulnerable roadway was determined for the 500-year flood plain.

Figure 24 shows the number of NHS lane miles that are geographically located in the 100-year and 500-year flood plains. These roadway segments are said to be vulnerable to flooding events. Since these are total lengths, the 100-year mileage is a subset of the 500-year mileage. Like storm surge, an asset may not experience physical damage if it is within the vulnerable area; rather, the areal extent identifies assets to be assessed for the probability of damage.

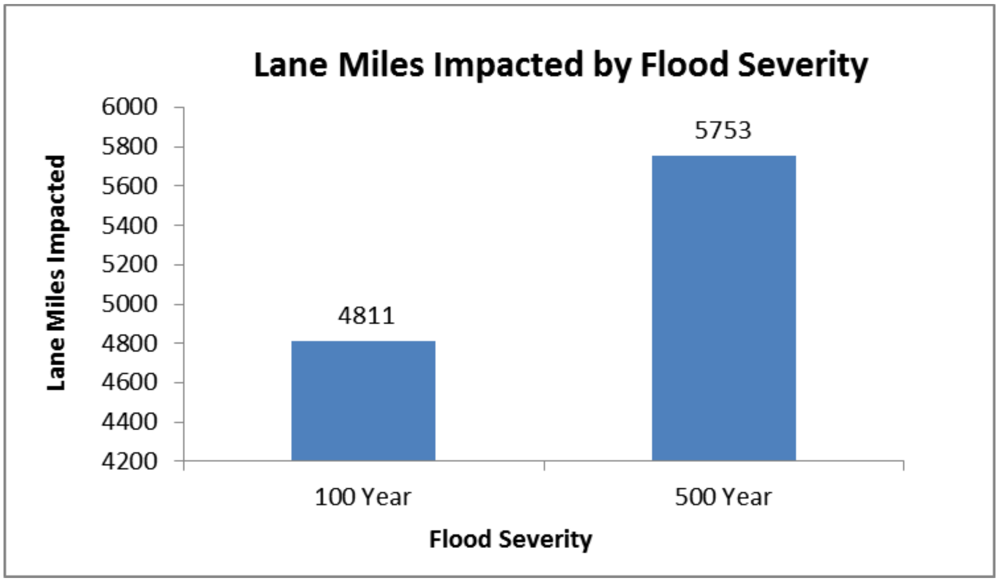


Figure 24. NHS Lane Miles Affected by Flood Severity.

Bridges

Based on available data, it is also possible to calculate via geospatial analysis the portion of Texas' bridge inventory that lies within estimated flood plains for 100-year and 500-year events. While many bridges may fall within these flood plains, not all are necessarily at risk of flood damage. Actual susceptibility to erosion and hydraulic forces is determined through engineering analyses, taking into account site-specific variables (such as soil properties, channel geometry, and substructure geometry).

TxDOT engineers perform scour evaluations for bridges that cross over water features. NBI Item 113, labeled "Scour Critical Bridges" is used to identify the current status of a bridge for its vulnerability to scour (*17*). Item 113 ratings are made by engineers with hydraulic, geotechnical, or structural expertise. Similar to primary component condition ratings, Item 113 values fall within a numeric scale between zero and nine (with nine being the least susceptible). Bridges with Item 113 values of four have foundations that are, by engineering assessment, stable for scour conditions; however, field review indicates action is required to prevent structural instability from developing. Bridges with Item 113 values lower than four are increasingly at risk of structural instability due to scour concerns.

For TAMP analysis, only bridges meeting each of the following criteria are considered potentially vulnerable to flood damage:

- The bridge is located within the 100-year or 500-year event flood plains.
- The bridge crosses over one or more water features.
- The bridge has an Item 113 rating of four or less.

Table 33 shows the quantity of Texas' bridges vulnerable to flooding for 100 and 500-year storms as of January 2018. Although scour and flood damage are some of the more common threats to Texas bridges, less than 2 percent of the state's bridge inventory is susceptible to damage. Over the past several decades, TxDOT has dedicated significant resources toward enhancing scour repair and other mitigation practices to reduce damage due to flooding.

Table 33. Bridge Assets Vulnerable to Flood Risk.

	NHS Total*				Total TAMP Inventory**			
	Number of Bridges		Deck Area (million sq. ft.)		Number of Bridges		Deck Area (million sq. ft.)	
Vulnerable to 100-Year and 500-Year Flood Event	132	0.8%	1.6	0.5%	522	1.4%	3.9	0.8%
Vulnerable to 500-Year Flood Event Only	112	0.6%	1.8	0.5%	176	0.5%	2.6	0.6%
Not Vulnerable	17,247	98.6%	339.0	99.0%	35,910	98.1%	463.7	98.6%
All Bridges	17,491	100.0%	342.4	100.0%	36,608	100.0%	470.2	100.0%

*Includes both On-System and Off-System bridges carrying NHS roadways

**Includes all vehicular bridges carrying or crossing roadways that are On-System and/or NHS

In the 1990s, TxDOT formed a statewide working group to establish best practices for remediating scour at bridge piers. This work group established pier remediation strategies that minimize long-term scour repair costs. Further, TxDOT's geotechnical and hydraulic engineers have been involved in several recent scour research projects, seeking to extend the long-term performance of stream-crossing bridges. The following research reports have been influential in TxDOT's development of scour protection measures:

- National Cooperative Highway Research Program Report 516: Pier and Contraction Scour in Cohesive Soils (*28*).
- National Cooperative Highway Research Program Report 568: Riprap Design Criteria, Recommended Specifications, and Quality Control (*29*).
- TxDOT/TTI Federal Aid Project 0-4378-1: Establish Guidance for Soils Properties–Based Prediction of Meander Migration Rate (*30*).
- TxDOT/TTI Federal Aid Project 0-5505-1: Simplified Method for Estimating Scour at Bridges (*31*).

In spite of the severe flood events that have occurred over the past several years, conservative strengthening practices have ensured that very few bridges have been damaged. Recent scour remediation projects generally involved only embankment and riprap repairs. Structural repairs to bridge foundation elements have been relatively rare the last several years. Figure 25 and Figure 26 show typical scour remediation projects. By identifying and improving embankment stability issues early, the need for more costly structural repairs to substructure elements is usually avoided.

Figure 25. Erosion Repair and Scour Protection (Gabion Mattresses).

Figure 26. FM 474 @ Guadalupe River in the San Antonio District—Erosion Repairs and Installation of Embankment Protection Measures (Gabion Mattresses).

Extreme Weather Summary

Extreme weather events may alter the design of TxDOT projects especially in areas subjected to excess flooding or storm surge. For example, TxDOT has already made changes to reduce bridge scouring from flood-prone areas and bridge heights have been increased to address potentially higher coastal storm surges. Future extreme weather events may result in additional changes to TxDOT transportation planning, design, emergency response, maintenance, and asset management operations. Maintenance and pavement design considerations currently address severe weather issues (heat, drought, and flooding).

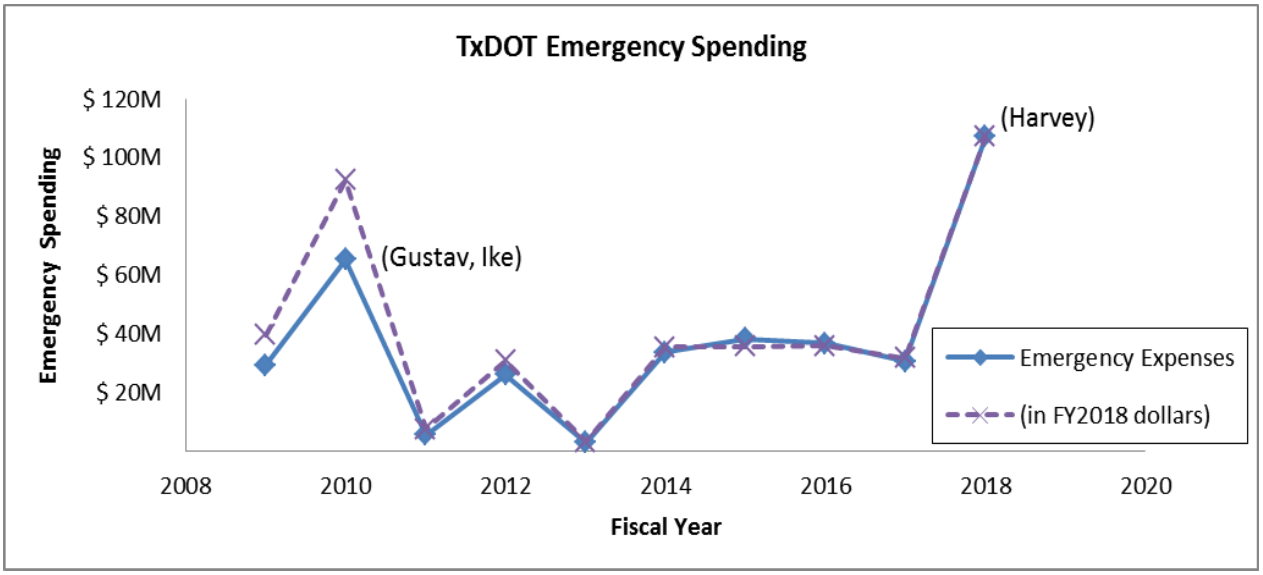
Programmatically, resiliency efforts, especially for riverine and coastal areas, are included in the planning and programming process when assets are in need of repair, rehabilitation, or reconstruction. The use of flood mapping, coastal surge data, and other relevant data will allow TxDOT to begin considering asset resiliency on a more strategic level. Consideration of resiliency projects may then be developed through the project programming process.

Economic Risks due to Emergency Response

Historical emergency expenditures provide insight into expected future costs and cost-variability of similar work. TxDOT has consistently recorded and tracked emergency expenditures over several years. Summarized as an economic risk, emergency response costs detract from resources available for preservation activities.

Emergency funds are typically identified only as contingency expenditures. Figure 27 shows annual emergency work expenditures for the fiscal years 2009 to 2018.

Funds for large repair, reconstruction, and replacement projects, if needed, are identified through the normal project funding mechanisms discussed in Chapter 6, Financial Plan. The effect of proceeding with these activities is to defer the letting of some projects to accommodate the funding required. This represents a risk to the timely delivery of relevant project to accomplish TxDOT objectives.



Dotted line indicates correction by Highway Cost Index.

Figure 27. Emergency Expenditures over Time.

NHS roadways in Texas require far less emergency maintenance and repair than other Texas roadways. Following severe weather events, emergency spending on the NHS does not spike as dramatically as for the rest of the system. About 31 percent of the lane mileage managed by TxDOT is on the NHS, which requires only 15 percent of emergency spending.

Emergency expenses have averaged about $42 million per year on the TxDOT system with a high degree of variability. From a budgetary perspective, it is prudent to identify funds that might be needed to address these events. Table 34 indicates the likelihood of emergency funds needed in any particular year based on historic expenditure levels.

Table 34. Estimated Emergency Expenses in a Given Year.

Likelihood	Projected Expenditure
50%	$42M
15%	$76M
10%	$84M
5%	$96M

Risk Management Process

The TxDOT TAMP risk management processes were developed under the guidance of the TAMP Steering Committee and followed the framework shown in Figure 20. Final selection of the high priority risk items and their mitigation was also performed by the TAMP Steering Committee.

Subject matter experts (SMEs) used workshops to identify risk items that might impact the performance of pavement and bridge assets. Risks deemed important to other state agencies were used in addition to risks identified by TxDOT. Risks identified through this process were used to construct a risk register for further analysis and evaluation.

The TAMP risk register items were examined and were grouped into seven categories:

- System condition and performance.
- Health and safety.
- Environmental.
- Economic.
- Agency function.
- Legal and compliance.
- Stakeholder interest.

SMEs generated several risk items for each risk category. SMEs identified the cause and potential impacts for each risk item. Approximately 120 risks were initially identified and placed in the categories identified above. A balloting and discussion process described below was used to reduce the 120 risks to about 40 risks of high importance. The 40 high priority risks were then considered by the TxDOT TAMP Steering Committee and a similar process was used to further reduce the leading risk items.

Risks were analyzed using a rating system that considered the likelihood of occurrence and the impact of the risk item to the system performance. Likelihood and impact of risks were qualitatively evaluated using a 1 to 5 scale as shown in Table 35. The product of the likelihood and impact ratings produced an overall rating. The overall rating of an individual risk was used to rank the risk items among others.

A risk, qualitatively, may be identified as a low, medium, or high risk or mission critical. The average products of likelihood and impact, as balloted by Steering Committee member, were used to identify risk priority. A risk with a product falling within a range of values identifies the risk priority as follows:

- Low 1–4.
- Medium 5–10.
- High 11–19.
- Critical 20–25.

An example risk rating determines a risk with a moderately impactful risk (rating of 3) that has a possibility of occurrence (rated as 3) as a Medium risk identified by the product of the impact and likelihood ratings equal to 9.

Table 35. Risk Analysis Matrix.

			Impact				
			Insignificant	Minor	Moderate	Major	Devastating
		Rating	1	2	3	4	5
Likelihood	Rare	1	Low	Low	Low	Low	Medium
	Unlikely	2	Low	Low	Medium	Medium	Medium
	Occasional	3	Low	Medium	Medium	High	High
	Likely	4	Low	Medium	High	High	Critical
	Almost Certain	5	Medium	Medium	High	Critical	Critical

Steering committee members determined the leading risks during a meeting by using the risk analysis process discussed above together with open discussion. The discussions allowed the Steering Committee to propose preliminary mitigation strategies to address each risk. Table 34 shows the results of the risk management analysis and how each risk is addressed through this process.

Future risk management workshops will be used to refine, reassess, and reprioritize risks and mitigation strategies that support TxDOT goals and objectives. Once risk assessment tasks are complete, the Steering Committee will discuss and identify the Owner or office most appropriate to manage the risk identified. Through this process, the status and disposition of each risk may be determined to allow the Steering Committee to reevaluate the appropriateness of the Risk Register.

Table 36. TAMP Risk Register.

Risk Register: High-Priority Risks		
Risk Description	**Mitigation Strategy**	**Rating**
Variability in revenue and funding priorities causes large variations in realized project delivery	1. Develop funding scenarios accounting for possible funding variability. 2. Develop and maintain a list of prioritized projects that may be developed to accommodate funding scenarios and level letting volumes commensurate with funding. 3. Develop a contingency plan that identifies project priorities if the budget is cut or increased suddenly. 4. Establish robust targets for each key phase of project development authority to assure portfolio health and flexibility. 5. Provide accurate and timely feedback/testimony to legislators and policy-makers on decisions that affect funding for asset management.	High
Decline in asset performance due to programming decisions	1. Evaluate effectiveness of current asset management processes and systems. 2. Review programming processes to increase highway system performance. 3. Track status of asset (e.g., inspection schedule, condition of asset) to plan optimal time and type of repair or replacement. 4. Establish robust development of projects within all stages of the planning process. 5. Develop a contingency plan that identifies project priorities if the budget is cut or increased suddenly.	High

Risk Register: High-Priority Risks		
Risk Description	**Mitigation Strategy**	**Rating**
Declining asset performance due to reduced emphasis on maintenance	1. Emphasize importance of maintenance for assets through TAMP and performance impact modeling. 2. Enhance the asset preservation program by continuing Best Practices processes such as Peer Reviews and the 4 yr. Pavement Management plan reviews. 3. Refine the use of asset management systems to assist with project prioritization and selection.	High
Accelerated asset (pavement and bridge) deterioration because of unexpected heavy truck traffic from the energy sector or freight-intensive industry	1. Study the issue and look to other states for potential guidance. 2. Refine ability to predict performance with the presence of traffic increases. 3. Track and make adjustments to traffic prediction models so that management systems reflect impacts on infrastructure. 4. Develop a management strategy for prioritization of energy sector corridors.	High
Occurrence of an unanticipated weather event or natural disaster such as a hurricane resulting in system damage	1. Update hydraulic design criteria and guidance. 2. Continue ongoing resiliency efforts. 3. Develop contingency funding scenarios.	High
Ability to maintain or develop staff knowledge and use of technology for asset management	1. Develop contingency funding scenarios. 2. Develop plans for implementing replacement systems.	High

The risk management process will be revisited periodically. An evaluation of the risk management process is warranted to ensure TxDOT identifies the most appropriate risks for assets on the state highway system and on the NHS. Periodic evaluations of this process will allow identification of risks that reflect current Texas transportation policy, available funding, and other considerations.

Recurring Events

As part of a separate FHWA rule (23 CFR 667), state DOTs must identify assets repeatedly damaged by emergency events. Specifically, states transportation agencies “shall conduct statewide evaluations to determine if there are reasonable alternatives to roads, highways, and bridges that have required repair and reconstruction activities on two or more occasions due to emergency events.” The process and criteria used to determine whether any such assets were identified is discussed below. Applying this process, TxDOT does not presently have an NHS asset considered to have been repaired more than once in the period reviewed.

TxDOT routinely considers recurring events in the planning, project development, and detailed design phases of their operations. These recurring events are reported for NHS highways and bridges in this TAMP.

Criteria used to identify qualifying assets are shown below. Numerous data sources were used to determine whether a highway or bridge asset should be identified in the TAMP and for reporting in accordance with 23 CFR 667, or “Part 667.” The following evaluation criteria were used:

- Asset is part of the NHS.
- Asset damage resulted from a natural disaster or other emergency declared by the governor or U.S. president.
- Asset was damaged on two or more occasions.
- Repeated damage occurred at the same location.
- Mode of asset failure or cause of repeated damage was similar.

TxDOT’s Maintenance Division submits damage reports and reimbursement requests for projects and other expenses to FHWA following a declared disaster. FHWA determines reimbursement eligibility and a project’s disposition. For the analysis in this TAMP, a table of emergency repair projects spanning from 1997 to 2018 was used to determine if any met any, a portion, or all criteria discussed. The FHWA table contains where and when projects containing work addressing damaged assets pertaining to Part 667 and the amount reimbursed to the state. These projects were narrowed to instances where work performed on a NHS asset, and additional steps were taken to determine whether each pavement or bridge asset had been included in prior emergency repair projects. Further filtering of projects was performed to determine if projects addressing the same asset are in response to separate events and whether the mode of failure was similar. An asset exhibiting failure more than once would be a candidate for reporting in accordance with Part 667.

Occasionally, more than one project are performed in response to the same event. For example, following the collision and damage to the Queen Isabella Causeway in 2001, primary bridge elements were replaced immediately. In 2003, a collision prevention system was installed. These are not considered recurrences because the projects were necessitated by the same event.

The TxDOT Maintenance Division leads the efforts to identify assets addressed by Part 667. Other divisions are contacted when there are assets meeting the evaluation criteria. Maintenance Division staff will review emergency repair projects for NHS assets when data are available after the occurrence of a qualifying event. Data sources are the FHWA table of reimbursed projects and other TxDOT identified assets requiring emergency repair.

As asset damage recurrences appear, Division and District personnel responsible for project programming and development will be notified so that the appropriate project level design criteria and resiliency actions may be considered. This will afford the District the opportunity to program and potentially construct feasible solutions to reduce the probability of future damage.

Chapter 6: Financial Plan

Overview

FHWA requires states to "establish a process for the development of a financial plan that identifies annual costs over a minimum period of 10 years." To meet these requirements, the following information must be presented:

- The estimated cost of expected future work to implement investment strategies contained in the TAMP.
- Estimated funding levels expected to be reasonably available to accomplish future work.
- Identification of anticipated funding sources.
- An estimate of the value of the agency's NHS pavement and bridge assets and the needed investment to maintain the value of those assets.

TxDOT identifies its revenue sources and expected revenue available for transportation projects annually through its UTP. The UTP is authorized annually by the State Transportation Commission covering a 10-year period. The purpose of the UTP is to guide the development of and authorize construction and transportation projects. The UTP contains information on revenue forecasts and investment strategies relevant to the funds available to maintain pavements and bridges in a SOGR. The available funding for the 10-year period of the UTP is known as the planning scenario.

Because the UTP addresses statewide transportation projects of all types, (pavement, bridge, safety, mobility, connectivity, and congestion), funds available for pavement and bridge work have to be disaggregated from each category of funding. Each category contributes some amount to both pavement and bridge. To calculate how much, historical information on the percentage of each category is determined and amount of the annual UTP funding is identified proportional to the percentage of pavement or bridge represented. This disaggregation of funding is based on many assumptions, not the least of which is that the percentage representation remains the same from year to year.

The planning scenario identifies projections of funding sources, which then allow the forecast of funds available to distribute through the processes documented in the UTP and described in this TAMP. The information relevant to the TAMP and funds projected to address pavement and bridge needs is further discussed in this chapter.

Sources of Revenue

Funding for transportation in Texas is generated from several federal, state, and other sources. Table 37 and Figure 28 list the revenue sources available for transportation related TxDOT expenses. Future revenues are projected based on financial analysis that includes historical trends, current statutes, the Comptroller's most current revenue estimates provided in the Biennial Revenue Estimate or Certification Revenue Estimate, current events, and other sources as appropriate (*19*).

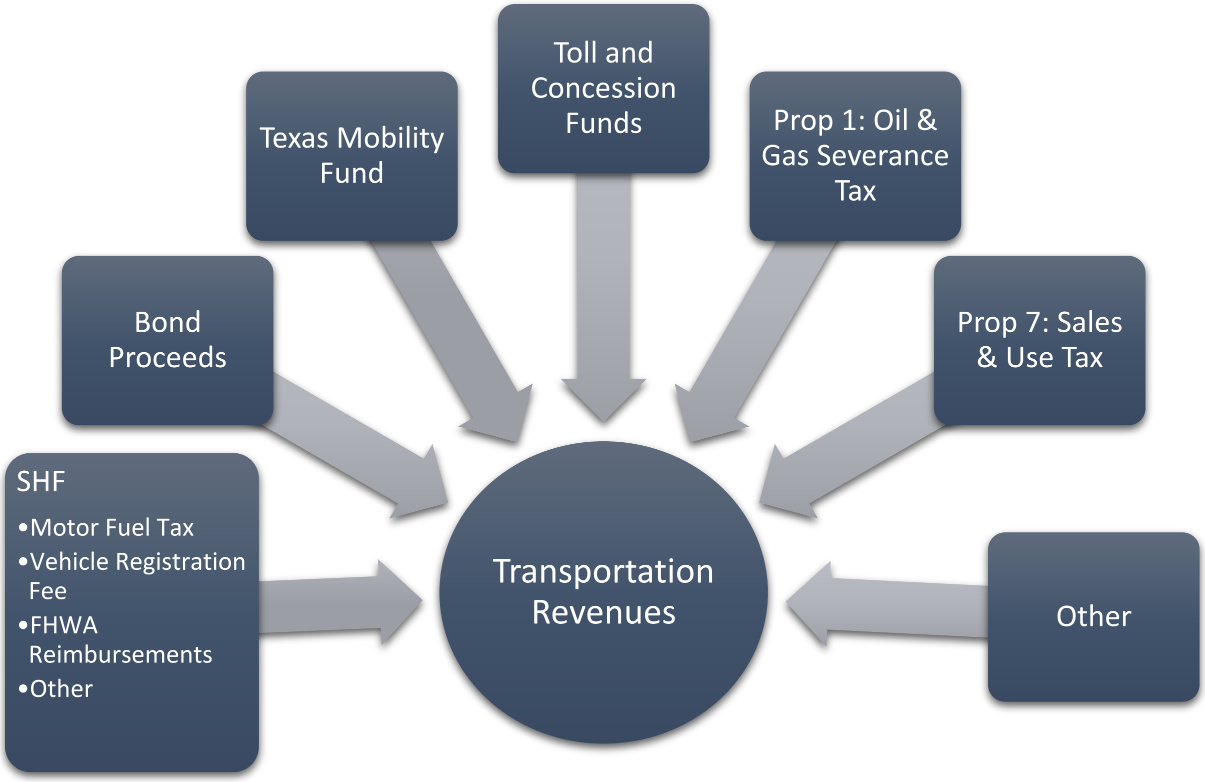


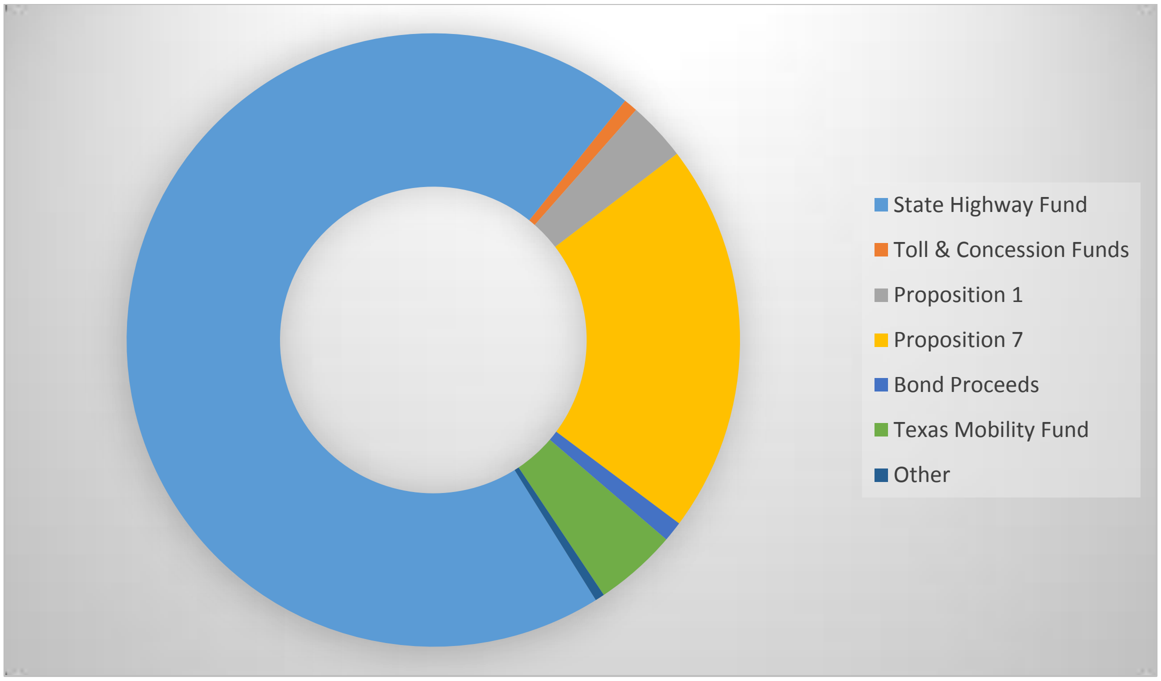
Figure 28. Sources of Revenue: Total Transportation.

Table 37. Estimated Total Transportation Available Revenues (in Billions$).

	State Highway Fund (SHF)	Bond Proceeds	Texas Mobility Fund	Toll & Concession Funds	Prop 1: Oil & Gas Severance Tax	Prop 7: Sales & Use Tax	Other	Total Funds
FY18	$9.5	$1.2	$0.8	$0.2	$1.4	$0.0	$0.4	$13.5
FY19	$9.3	$0.1	$0.6	$0.2	$0.5	$1.8	($0.2)*	$12.3
FY20	$8.5	$0.0	$0.5	$0.1	$0.6	$2.0	$0.1	$11.7
FY21	$8.7	$0.0	$0.5	$0.1	$0.5	$2.5	$0.1	$12.4
FY22	$8.4	$0.0	$0.5	$0.1	$0.4	$2.8	$0.1	$12.2
FY23	$8.0	$0.0	$0.5	$0.0	$0.2	$3.0	$0.1	$11.8
FY24	$7.9	$0.0	$0.5	$0.0	$0.1	$3.1	$0.1	$11.7
FY25	$8.0	$0.0	$0.5	$0.0	$0.0	$3.2	$0.1	$11.8
FY26	$8.2	$0.0	$0.5	$0.0	$0.0	$3.3	$0.1	$12.1
FY27	$8.5	$0.0	$0.5	$0.0	$0.0	$3.4	$0.1	$12.4
Total	**$84.9**	**$1.3**	**$5.3**	**$0.9**	**$3.8**	**$25.1**	**$0.6**	**$121.9**

*In 2019, a one-time payment to the General Revenue Fund is made for debt service on Proposition 12 GR Bonds.

Figure 29 depicts the revenue sources for the total 10-year planning horizon. The State Highway Fund (SHF) comprises 70 percent of the total revenues available for transportation.



Source: Data from TxDOT Long-Range Revenue Forecast FY 2018

Figure 29. Total Transportation Revenues.

State Highway Fund

The SHF is the largest source of revenue for transportation in Texas. It consists of revenues from the gas and diesel fuel tax, vehicle registration fees, federal reimbursements, and a few other miscellaneous fees (Table 38).

Table 38. Estimated SHF Revenues (in Billions$).

	State Motor Fuel Tax	Registration Fees	FHWA Reimbursements	Other Fed Reimbursements	Other	Total
FY18	$2.7	$1.5	$4.2	$0.2	$0.6	$9.2
FY19	$2.7	$1.5	$4.5	$0.4	$0.6	$9.7
FY20	$2.8	$1.6	$4.2	$0.2	$0.5	$9.2
FY21	$2.8	$1.6	$4.2	$0.2	$0.3	$9.1
FY22	$2.9	$1.7	$3.8	$0.2	$0.3	$8.8
FY23	$2.9	$1.7	$3.2	$0.2	$0.3	$8.3
FY24	$2.9	$1.8	$3.0	$0.2	$0.3	$8.2
FY25	$3.0	$1.8	$3.0	$0.2	$0.3	$8.3
FY26	$3.0	$1.9	$3.0	$0.2	$0.3	$8.4
FY27	$3.1	$1.9	$3.1	$0.2	$0.3	$8.6
Total	**$28.7**	**$17.1**	**$36.3**	**$2.1**	**$3.7**	**$87.8**

Note: Total varies from available revenue balance in Table 37 due to balance carry-over from year-to-year.

The state motor fuel taxes consist of a 20 cents per gallon tax on both gasoline and diesel fuel. Vehicle registration fees vary based on the vehicle type, weight, and age. Passenger cars and light trucks up to 6,000 lb are assessed a $50.75 fee annually. Texas receives federal funds from the Highway Trust Fund to be used on eligible projects.

FHWA Reimbursements

Federal highway reimbursement projections take into account the current highway bill, continuing resolutions, rescissions on obligation authority and apportionment, and other requirements made by FHWA and the federal government for the use of those funds (*19*).

Other Federal Reimbursements

Other federal funds are reimbursement programs for aviation, public transportation, and traffic safety. Because those funds are tied to specific existing program levels, which are expected to remain constant the next few years, there is no assumption of growth. Other federal funds also include federal assistance in the form of loans through the Transportation Infrastructure Finance and Innovation Act expected to be received FY 2017–FY 2019 (*32*).

Other Revenues

In addition to the SHF, the state of Texas authorized several bond issues beginning in 2006. The remainder of those issues contribute to the available funds in FY18 and FY19. Revenue from the Texas Mobility Fund (taxes and fees) is used to service the debt on Texas Mobility Fund Bonds. The taxes and fees consist of:

- Driver's license fees.
- Driver's record info fees.
- Vehicle inspection fees.
- Certificate of title.
- Other.

Additional revenues are also generated from various toll and concession projects around the state.

Proposition 1—Oil and Gas Severance Taxes

Proposition 1 is an amendment to the State of Texas Constitution, approved by the public in November 2014. The amendment directs a portion of the oil and gas severance tax from the Economic Stabilization Fund to the SHF at the beginning of each fiscal year. For planning purposes, 80 percent of assumed transfers are made available, and while the transfers will end in 2025 without further legislative action, the planning scenario assumes they will continue through 2027.

Proposition 7—Sales and Use Taxes

Proposition 7 is another constitutional amendment passed by the Texas Legislature and approved by the public in November 2015. The Comptroller is directed to deposit $2.5 billion of the net revenue derived from the state sales and use tax in excess of $28 billion to the SHF each year. This provision is set to expire in FY 2032. Beginning in fiscal year 2020, the Comptroller is directed to deposit 35 percent of the revenues collected from the tax imposed on the sale, use, or rental of a motor vehicle that exceed $5 billion to the SHF each year. This provision is set to expire in FY 2029 (*19*).

Revenue for Planning Projects

The UTP (*9*) uses revenues from the SHF, Oil and Gas Severance Taxes, Sales and Use Taxes, available concession and toll revenues, and funds from local entities. These funds are reserved for planning future projects as described in the UTP (Figure 30). While the UTP is an essential planning tool that guides long-term transportation project development, it is not a budget and does not guarantee that a project will be built.

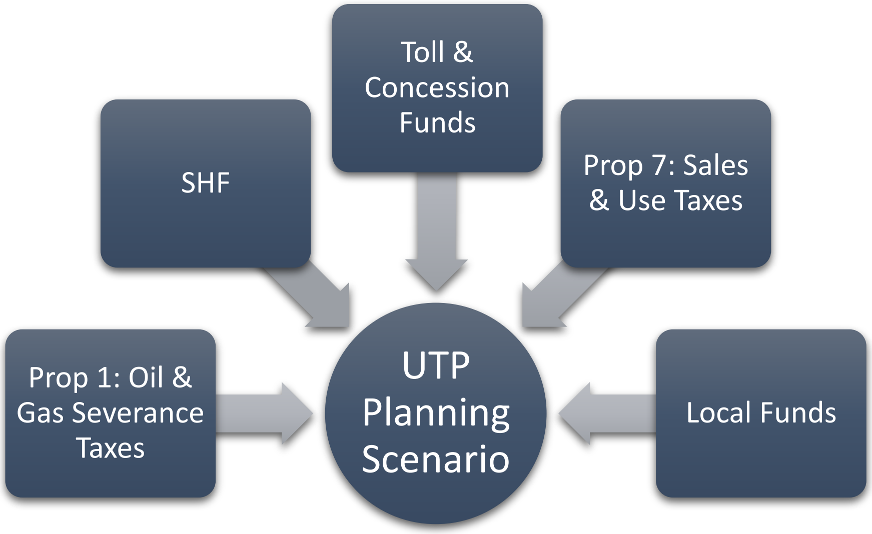


Figure 30. Sources of Funds for Planning Projects.

Table 39 lists the annual estimated state and federal funds allocated for planning projects designated in the UTP. The UTP also includes additional local funds that local entities plan to contribute in addition to the state and federal funds. Table 39 does not include these additional local contributions. A total of $5.2 billion in local funds are estimated over the 10-year planning period.

Table 39. Estimated Revenues Available for Planning Projects (in Billions$).

	SHF	Toll/ Concession Funds	Prop 1: Oil & Gas Severance Tax	Prop 7: Sales & Use Tax	Total
FY18	$3.0	$0.0	$0.3	$1.7	$5.1
FY19	$3.1	$0.0	$0.6	$2.0	$5.7
FY20	$3.4	$0.0	$0.7	$2.3	$6.4
FY21	$3.5	$0.0	$0.7	$2.4	$6.6
FY22	$3.4	$0.0	$0.7	$2.5	$6.6
FY23	$3.6	$0.0	$0.7	$2.5	$6.9
FY24	$3.7	$0.0	$0.7	$2.6	$7.0
FY25	$3.8	$0.0	$0.7	$2.7	$7.1
FY26	$3.8	$0.0	$0.7	$2.7	$7.3
FY27	$3.8	$0.0	$0.7	$2.8	$7.3
Total	**$35.2**	**$0.1**	**$6.5**	**$23.7**	**$66.0**

Alongside these revenue forecasts, the UTP contains a discussion of each project and program TxDOT intends to pursue during the UTP period. Additionally for each project and program, the UTP identifies the applicable funding category or categories from which the project or program is funded. TxDOT is required to distribute funds into the 12 prescribed funding categories listed in Table 40.

A project's funding may be assigned from multiple funding categories, based on the type of project and its characteristics (*9*). Table 40 lists the total funding authorizations for the 2018 UTP plan by funding category over 10 years.

Table 40. 2018 UTP Funding Authorizations (in Billions$).

Funding Category	2018 UTP 10-Year Funding Authorizations
1 - Preventive Maintenance and Rehabilitation	$14.1
2 - Metro and Urban Area Corridor Projects	$12.3
3 - Non-Traditionally Funded Transportation Projects	$5.2
4 - Statewide Connectivity Corridor Projects	$11.6
5 - Congestion Mitigation and Air Quality Improvement	$2.2
6 - Structures Replacement and Rehabilitation	$3.4
7 - Metropolitan Mobility and Rehabilitation	$4.3
8 - Safety	$3.3
9 - Transportation Alternatives Program	$0.8
10 - Supplemental Transportation Projects*	$0.6
11 - District Discretionary**	$3.2
12 - Strategic Priority***	$10.1
Total UTP Funding: Categories 1–12	**$71.2**

Source: (9)

*Category 10 includes Federal Earmark Match

**Category 11 includes $1.0 billion district discretionary and $2.1 billion of energy sector funding.

***Category 12 includes $5 billion congestion funding for HOU, FTW, DAL, AUS, and SAT

The impact of UTP funding categories can be sorted into six areas: maintenance (includes pavement and bridges), bridge, mobility, connectivity, safety, and other. Most categories of the UTP affect multiple impact areas. Figure 31 illustrates the progression of funds through the UTP.

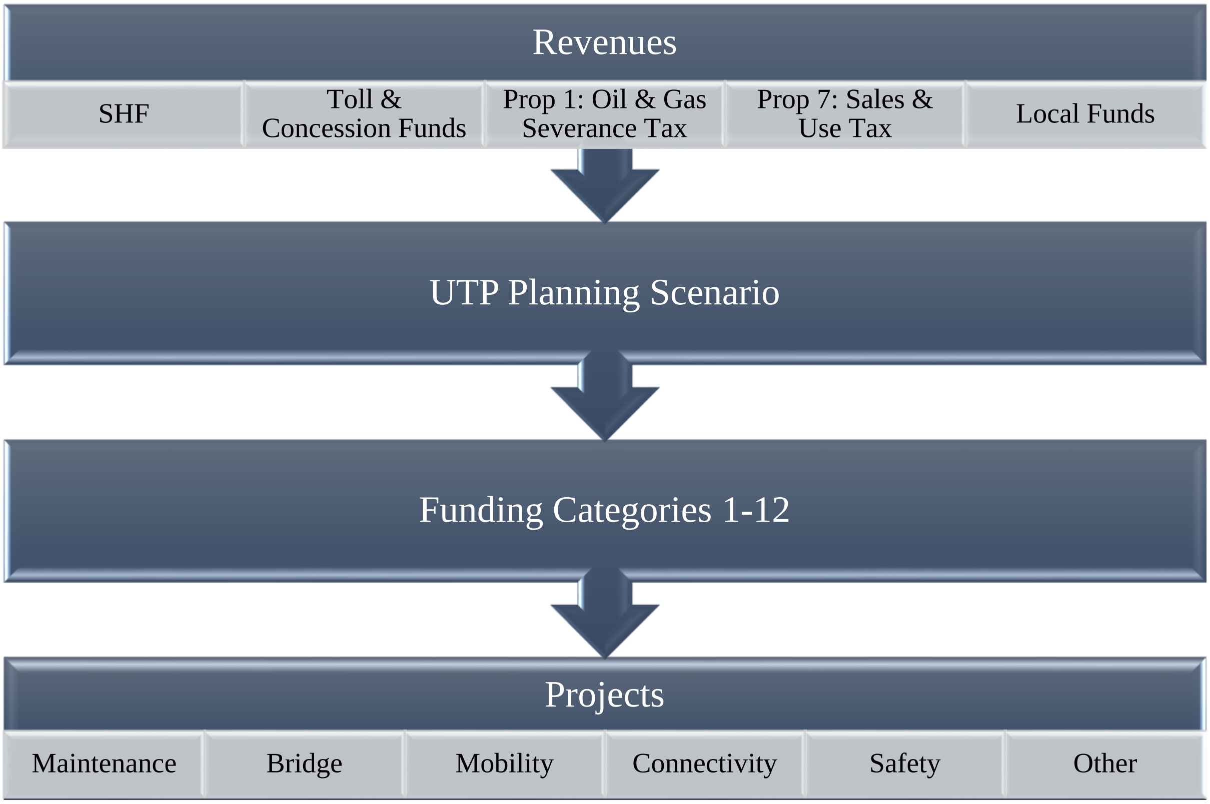


Figure 31. Project Funding Process.

Of the total funds available for use in the UTP, nearly half are allocated for pavements and bridges. The remaining funds are planned for mobility, connectivity, safety, and other projects (Figure 32).

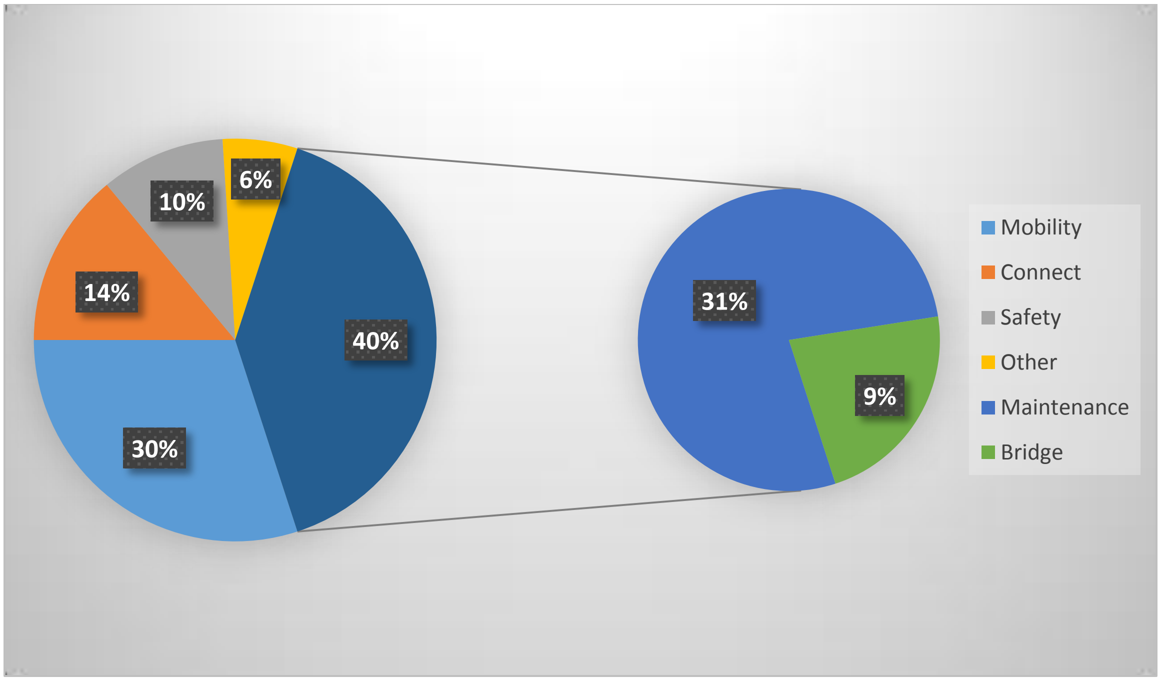


Figure 32. Estimated Percent of 10-Year Funding Allocation, by Impact Area.

Table 41 details the total funds planned for pavement and bridges for the 10-year planning period. Pavement funds total $25.5 billion while bridge funds total $5.6 billion over the 10-year horizon.

Table 41. Pavement and Bridge Funding (in Billions$).

	Pavement Total	Bridge Total	Pavement and Bridge Total
FY18	$2.3	$0.5	$2.8
FY19	$2.5	$0.5	$3.1
FY20	$2.9	$0.7	$3.6
FY21	$2.9	$0.7	$3.6
FY22	$2.4	$0.6	$3.0
FY23	$2.5	$0.5	$3.0
FY24	$2.5	$0.5	$3.0
FY25	$2.5	$0.5	$3.0
FY26	$2.6	$0.6	$3.2
FY27	$2.4	$0.5	$2.9
Total	**$25.5**	**$5.6**	**$31.1**

Pavement

Pavement projects are funded either through the revenues allocated for UTP planning or through the maintenance program. Table 42 illustrates the revenue allotted to pavement projects in the UTP and the revenue allotted to pavement projects and work performed through the maintenance program (referenced as Maintenance Operations [Maint Ops]).

Table 42. Pavement Funds (in Billions$).

	UTP	Maint Ops	Total
FY18	$1.7	$0.6	$2.3
FY19	$2.0	$0.6	$2.5
FY20	$2.3	$0.6	$2.9
FY21	$2.2	$0.6	$2.9
FY22	$1.7	$0.7	$2.4
FY23	$1.8	$0.7	$2.5
FY24	$1.8	$0.7	$2.5
FY25	$1.7	$0.8	$2.5
FY26	$1.9	$0.8	$2.6
FY27	$1.6	$0.8	$2.4
Total	**$18.7**	**$6.8**	**$25.5**

Revenues allotted for pavement projects can be further disaggregated to denote revenues available for NHS and Non-NHS pavement projects, both on- and off-system. Table 43 and Figure 33 demonstrate these divisions of funds over a 10-year period.

Table 43. Pavement Funding FY 2018 to FY 2022 (in Millions$).

	NHS			Non-NHS			Pavement Total
	On-System	Off-System	Total	On-System	Off-System	Total	
FY18	$871	$1	$872	$1,288	$116	$1,404	$2,276
FY19	$964	$1	$965	$1,427	$128	$1,555	$2,521
FY20	$1,100	$1	$1,101	$1,628	$146	$1,774	$2,876
FY21	$1,099	$1	$1,100	$1,626	$146	$1,772	$2,872
FY22	$916	$1	$917	$1,355	$122	$1,476	$2,393
FY23	$971	$1	$972	$1,437	$129	$1,566	$2,538
FY24	$958	$1	$959	$1,417	$127	$1,544	$2,503
FY25	$955	$1	$956	$1,413	$127	$1,540	$2,497
FY26	$1,007	$1	$1,008	$1,490	$134	$1,624	$2,632
FY27	$919	$1	$920	$1,359	$122	$1,481	$2,401
Total	**$9,760**	**$10**	**$9,770**	**$14,440**	**$1,297**	**$15,736**	**$25,509**

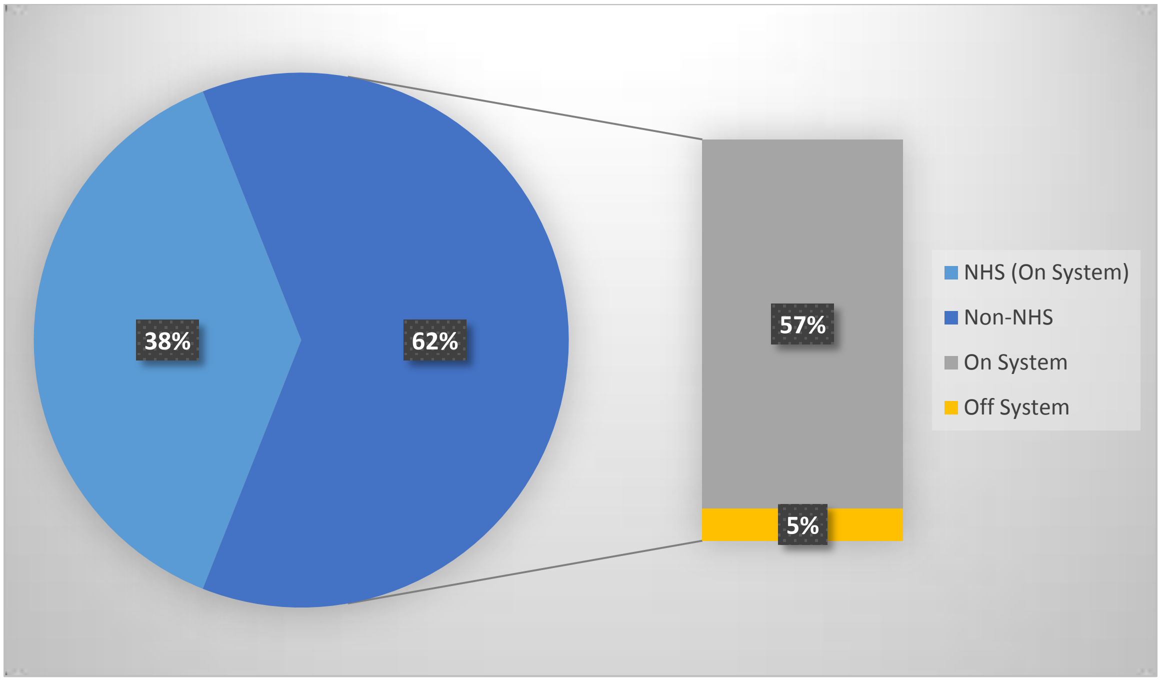


Figure 33. Pavement Funding: NHS and Non-NHS, On- and Off-System.

Bridge

Bridge projects are funded through the revenues allocated for UTP planning or through the Maintenance Division's maintenance operations budget. Table 44 illustrates the revenue allotted to bridge projects in the UTP and the revenue allotted to bridge projects through the maintenance program. Bridge funding through the UTP is primarily from Category 6: Structures Replacement and Rehabilitation. Several other categories within the UTP are often used to wholly or partially fund bridge projects although their exact level of bridge funding and impact on network performance vary from year to year.

Table 44. Bridge Funds (in Millions$).

	UTP	Maint Ops	Total
FY18	$479	$32	$511
FY19	$502	$32	$534
FY20	$689	$32	$720
FY21	$660	$32	$692
FY22	$534	$32	$566
FY23	$480	$32	$512
FY24	$498	$32	$529
FY25	$490	$32	$522
FY26	$520	$32	$551
FY27	$425	$32	$457
Total	**$5,279**	**$315**	**$5,594**

As with pavement projects, revenues allotted for bridge projects can also be disaggregated to specify revenues available for NHS and Non-NHS bridge projects, both on- and off-system. Table 45 and Figure 34 present these divisions of funds over a 10-year period.

Table 45. Bridge Funding FY 2018 to FY 2027 (in Millions$).

	NHS			Non- NHS			Bridge Total
	On-System	Off-System	Total	On-System	Off-System	Total	
FY18	$334	$5	$340	$131	$40	$171	$511
FY19	$348	$5	$353	$139	$42	$181	$534
FY20	$440	$7	$446	$209	$65	$274	$720
FY21	$439	$6	$445	$184	$62	$247	$692
FY22	$318	$6	$324	$179	$63	$242	$566
FY23	$270	$6	$276	$172	$64	$236	$512
FY24	$285	$7	$292	$172	$65	$237	$529
FY25	$273	$7	$279	$176	$67	$243	$522
FY26	$267	$5	$272	$206	$73	$279	$551
FY27	$192	$4	$196	$189	$72	$261	$457
Total	**$3,166**	**$58**	**$3,223**	**$1,757**	**$613**	**$2,371**	**$5,594**

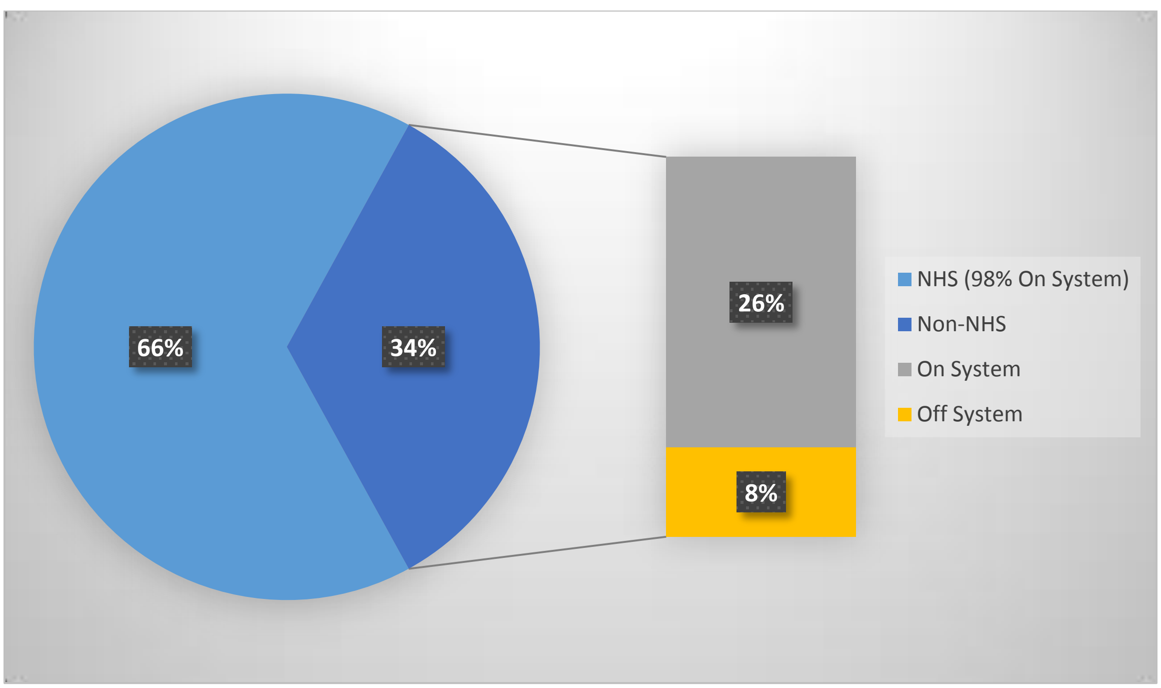


Figure 34. Bridge Funding: NHS and Non-NHS, On- and Off-System.

Bridge work planned via the UTP is primarily funded through Category 6: Structures Replacement and Rehabilitation. Several other categories within the UTP are often used to wholly or partially fund bridge projects; although their exact level of bridge funding and impact on network performance vary from year to year.

The following programs are those most relevant to bridge management and network performance. Bridge projects funded outside of these programs are typically intended to improve congestion, mobility, or safety; though they may incidentally improve conditions on a case-by-case basis.

Highway Bridge Program

Most bridge replacement projects are funded through the Highway Bridge Program (HBP) within TxDOT's UTP, under Category 6: Structures Replacement and Rehabilitation. The HBP is managed by TxDOT's Bridge Division (BRG) and was developed to comply with the now-retired federal HBP. Additional information on the HBP can be found in the TxDOT Bridge Project Development Manual, Section 2.3 (*33*). The HBP has an annual allocation of approximately $230 million.

A list of projects eligible for the HBP is identified by the BRG Project Development group and then provided to each of TxDOT's Districts for review. Districts respond with their priority ranking of HBP-eligible projects. The districts develop cost estimates for each eligible project identified by the district. As described in the TxDOT Bridge Project Development Manual, projects qualify according to the following eligibility requirements:

1. Bridge must be considered either FO or SD; and
2. Bridge must have a sufficiency rating (SR) equal to or below 80:
    a. If SR ≤ 80, the bridge is eligible for rehabilitation.
    b. If SR < 50, the bridge is eligible for replacement.

After developing cost estimates, BRG allocates funding for bridges from the list of district-prioritized projects. Projects are ultimately prioritized by deficiency category and sufficiency rating. Allocations are made to SD bridges first and then FO. The list of potential projects is ranked by the lowest SR being top priority and so on. This project selection process is in most cases emblematic of a worst-first approach to asset management.

On-system projects and off-system projects are budgeted and selected separately within the HBP. Approximately 75 percent of HBP funds are dedicated toward on-system structures, with the remaining 25 percent going toward off-system. There is no preference assigned to NHS structures or interstate structures—all are considered for HBP funding based on the sufficiency rating and whether the bridge is SD or FO. From an initial list of eligible projects, BRG and Districts work together to determine an optimal collection of projects to program, taking into account life-cycle costs on a project-by-project level.

Life-cycle planning is used within the HBP to determine the best alternative for a structure at the end of its service life. When bridge assets approach the end of their service life, a life-cycle cost analysis is performed to estimate the cost-benefit ratio of each project alternative. Typical alternatives include replacement, rehabilitation, or preservation. A large majority of structures are replaced, with economics being the driving factor. With low construction costs in Texas, the cost-benefit ratio of replacing a bridge is typically high compared to improving it once the bridge reaches this point.

Bridge Maintenance and Improvement Program

The primary source of funding for bridge maintenance and repair work is TxDOT's Bridge Maintenance and Improvement Program (BMIP). Similar to the HBP, this program is administered by TxDOT's Bridge Division and funded through Category 6 of the UTP. The BMIP is relatively new and has been developed with the intent of deviating from the typical worst-first asset management. The program addresses bridge condition needs through repair and preventive maintenance projects that reduce life-cycle costs. Additional information on BMIP can be found in the Bridge Project Development Manual, Section 2.4 (*33*). The BMIP has an annual allocation of approximately $45 million.

To be eligible for the BMIP, a bridge project must address structural issues resulting in a condition rating of 5 or 6 for the deck, superstructure, substructure, culvert, or channel NBI components. Additionally, the bridge is not eligible for BMIP if it is eligible for HBP funding. Specific work categories are listed below as examples of projects included and excluded by the BMIP. Figure 35, Figure 36, and Figure 37 show typical projects executed through TxDOT BMIP.

Figure 35. Application of Polymer Overlay Deck Surface Treatment Project (SH 31 WB over Trinity River in the Tyler District).

Figure 36. Typical Concrete Substructure Repair Project to Remediate Severe Column Spalling.

Figure 37.Typical Steel Painting Project, Showing Localized Defects (Left), the Bridge during the Painting (Top Right), and the Bridge after Being Reopened (Bottom Right).

BMIP-eligible project types include:

- Re-decking.
- Bridge raisings if the bridge has damage due to over-height impacts.
- Relief joints in concrete pavement and/or approach slab (limit of 40 ft from end of bridge).
- Approach guard fence, safety end treatment, and transition (up to 100 ft per bridge corner).
- Steel protective coatings.
- Post-tension repairs.
- Retrofits of two-column bents with installation of vehicle deflection/crash walls.
- Rail improvements/upgrades.

BMIP-excluded project types include:

- Widening projects that require installation of additional substructure elements (though minor widening in conjunction with deck replacement that can be accommodated using the existing substructure are be eligible).
- Bridge replacement.
- Debris removal-only projects (though debris removal when addressing other structural defects may be eligible).
- Projects to address critical findings (the BMIP Committee may make exceptions to this rule in limited circumstances).

BMIP funding is allocated for on-system structures only. There is no explicit preference for NHS or interstate structures, although Districts may prioritize high-volume corridors, which tend to be interstate and NHS projects. Crash wall improvement projects are generally identified for bridges that cross interstates or other major highways.

The Bridge Preventive Maintenance Program

The Bridge Preventive Maintenance Program (BPM) is managed by the Maintenance Division. Additional details on BPM scope and eligibility can be found in the Maintenance Management Manual, Section 4.9 (*33*). The BPM has an annual allocation of approximately $15 million.

The Bridge Division is typically asked to assist in reviewing BPM projects, allowing for coordination of funds between programs and ensuring the following: 1) that no projects are being double-programmed; and 2) that each project is using the most appropriate funding program(s). For some large maintenance projects identified as BPM-eligible, those projects may be recommended for funding through the BMIP.

The following are examples of BPM-eligible projects:

- Joint cleaning and sealing.
- Joint repairs.
- Steel piling repairs.
- Bearing and/or bearing pad replacement.
- Bearing supplements for T-Girders.
- Cap repairs for spalling.
- Pan and T-Girder bridges deck repairs.
- Concrete repairs for corrosion damage.
- Concrete deterioration treatments for pre-stressed beams.
- Asphalt plug joint.
- Bridge rail retrofits and transitions.
- Adjustment of steel shoes.

- Installation of channel protection.
- Bridge painting.

BPM funding is allocated toward on-system bridge projects only. As with TxDOT's HBP and BMIP, there is no explicit preference for NHS or interstate structures.

Asset Valuation

FHWA requires an estimate of asset value for NHS and any other pavement and bridge assets included in the TAMP. This TAMP includes all NHS and all other non-NHS state highway system pavement and bridge assets. A replacement cost method is used to derive asset valuations.

As of September 2018, estimated replacement costs include only material in place and do not include right of way, non-bridge drainage structures, and other appurtenances. The estimated replacement value of NHS system pavement assets is $46.9 billion, and the estimated replacement value of NHS bridges is $33.4 billion. Table 46 also includes pavement and bridge non-NHS valuations.

Table 46. Asset Valuation.

System	Bridge ($B)	Pavement ($B)
On the State Highway System		
IH	$9.3	$16.7
Non-IH NHS	$22.4	$26.4
Non-NHS	$12.2	$40.6
Off the State Highway System		
Non-IH NHS	$1.7	$4.0
Total		
IH	$9.3	$16.7
Non-IH NHS	$24.1	$30.2

Pavement Valuation

Table 46 shows a distribution of pavement asset values within the scope of this TAMP. Replacement values were determined through a process incorporating FY 2017 material and construction pavement layer costs and the inventory information. Representative pavement structures were synthesized, corresponding to the amount of traffic the pavements must bear. Accumulated costs for the lane-mileage of each pavement structure was calculated using average pavement layer costs recorded in TxDOT's bid cost database. The value of shoulders was similarly appraised. Total pavement asset valuation is the summation of roadway pavement replacement costs, and where present, shoulder replacement costs.

It is difficult to accurately quantify the value of off-system pavement assets, due to the lack of available data. Although the inventory is populated with these roadways, the replacement costs for many of these pavements are unknown. Off-system NHS pavements are assumed to be of similar structure (and cost) TxDOT roadways. For the TAMP, off-system inventory valuations were calculated using TxDOT layer costs and synthesized structures similar to TxDOT roadways.

Bridge Valuation

Bridges, like all public goods, provide a tangible value to stakeholders. While there are several ways to estimate the value of a bridge, perhaps the most widely used is replacement cost—the equivalent amount of money needed to construct a new bridge exactly like the one being considered. Although there are limitations to this methodology, replacement cost is straightforward to understand and provides an account of the true value lost by TxDOT if preservation is neglected for too long, making reconstruction necessary.

Table 46 shows the value of bridge assets in Texas based on non-depreciated replacement cost in current dollars. These estimates consider the total deck area in each inventory class (NHS/non-NHS and On-System/Off-System) and superstructure class (culvert, weathering steel, conventional steel, reinforced concrete, pre-stressed concrete, timber, and other). Unique construction costs per square foot were used for each superstructure class and aggregated to obtain network-wide estimates.

ASSET CATEGORIES
IH

Non-IH NHS On-system

Non-IH NHS Off -system

Non-NHS state highways

Investment Strategies

The UTP contains a catalog of projects that are planned to be constructed and/or developed within the next 10 years. This document is used to identify projects leading to the STIP. Preliminary engineering work, environmental analysis, right-of-way acquisition, and design work are all included as project development activities. While the UTP is an essential planning tool that guides long-term transportation project development, it is not a budget and does not guarantee that a project will be built (*9*). The investment strategies identified in this section support all department objectives but in particular those to, "Deliver the Right Projects," "Optimize System Performance," and "Preserve Our Assets." FHWA requires states to "discuss how the plan's investment strategies collectively would make or support progress toward":

1. Achieving and sustaining a desired SOGR over the life cycle of assets.
2. Improving or preserving the condition of the assets and the performance of the NHS assets.
3. Achieving the state DOT targets for asset condition and performance of the NHS.
4. Achieving the national goals identified in statute.

The investment strategy approach TxDOT has taken is one of fiscal constraint. Based on the funding projected to be available for pavement and bridges, scenarios are modeled to determine the ones most feasible to maximize performance of the assets at a minimum practicable cost. This statement is important since, as has been discussed, there are numerous competing priorities such that asset performance is not always the highest priority. Because of this, other desirable projects may be funded prior to very high ranking bridge and pavement projects to accomplish a competing objective.

Each annual UTP adoption uses updated revenue forecasts and investment strategies that are based on past system performance and system key performance objectives. These forecasts guide funding distribution, project selection, and formation of the new UTP. After the UTP is adopted, the performance of the state's system is monitored and evaluated to help adjust the next update. Each year, this continual improvement process is used to identify the 10-year list of projects. Figure 38 illustrates this process.

As a result of TxDOT planning and programming processes instituted many years prior, TxDOT has identified its investment strategies in many documents including:

- TTP 2040.
- SLRTP 2035.
- UTP.
- STIP.
- Annual Letting Schedule.

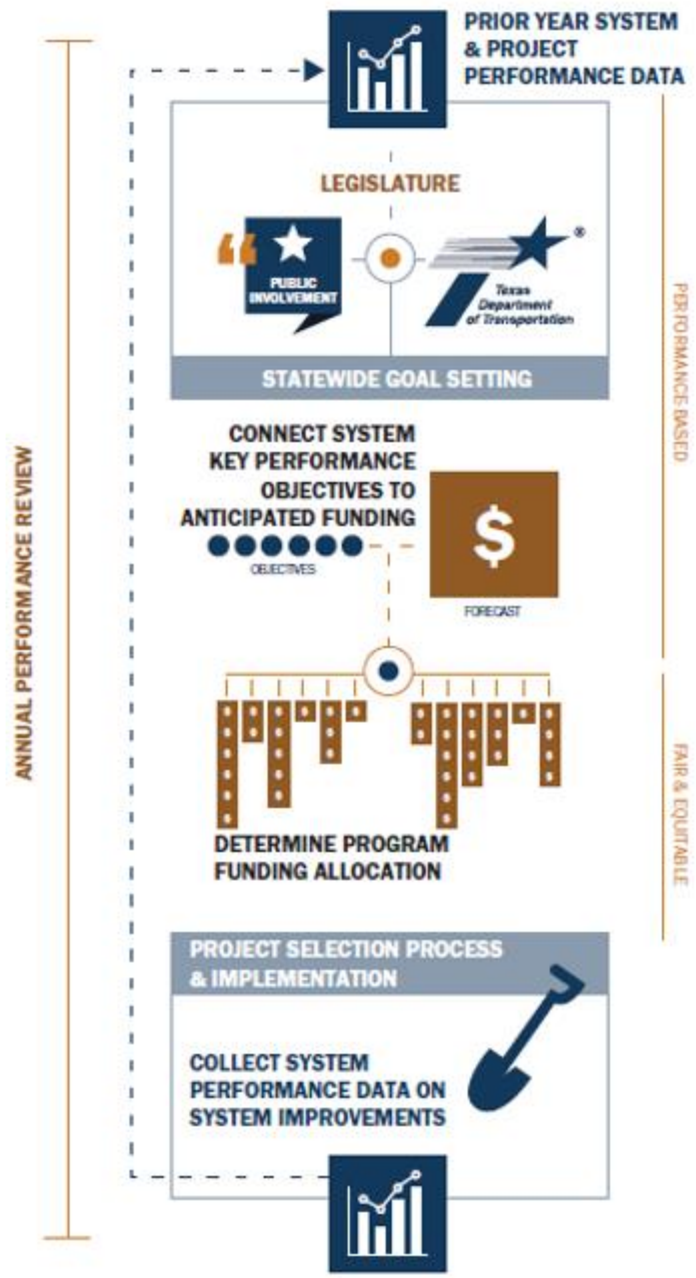


Figure 38. TxDOT System Performance Management Process.

Each of these documents contains products or explanations of the planning and programming processes that represent TxDOT investment strategies. Figure 39 illustrates the timing of investment strategy development and the products delivered. Figure 40 and Figure 41 further elaborate on the planning process and identify how MPOs and other roadway owners participate in this process. The unique document for Texas that defines many of the investment strategy considerations is the UTP. This document identifies information with which analyses will be made and decision makers will have available to ensure the most effective projects are delivered to meet the many state and federal objectives, including provisions for maintaining NHS asset in “a state of good repair.”

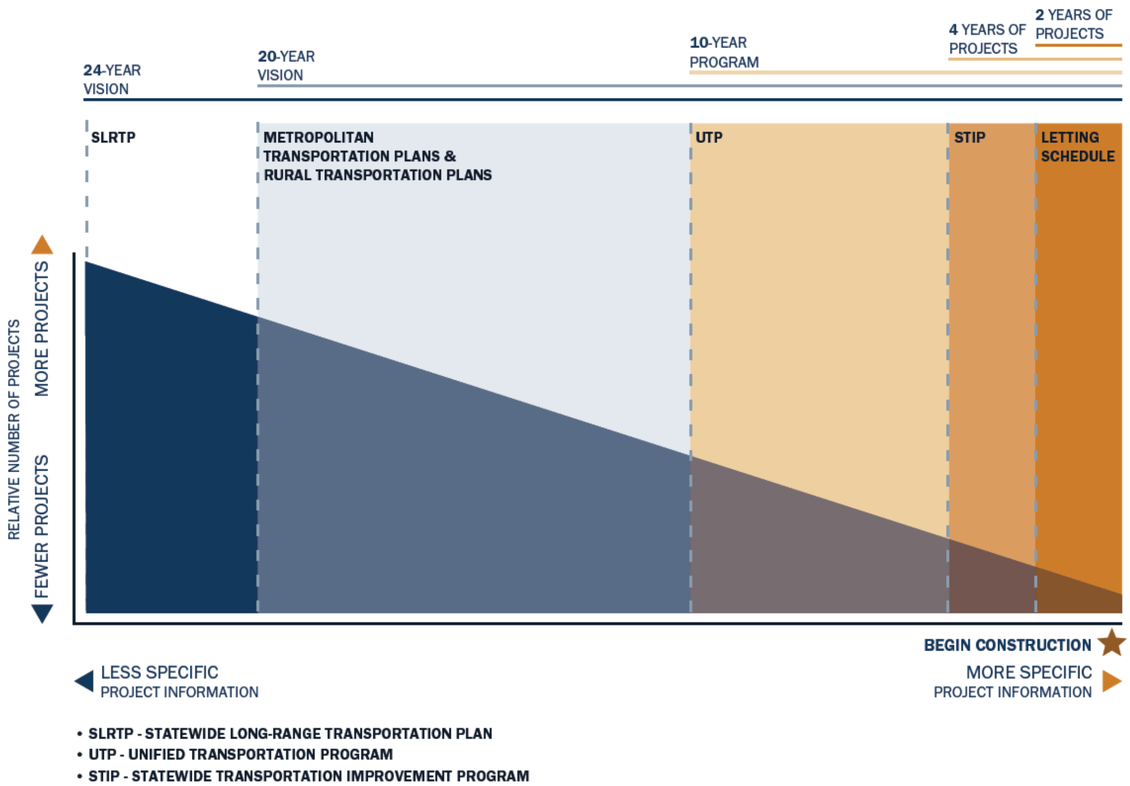


Figure 39. Planning and Programming Documents and Products.

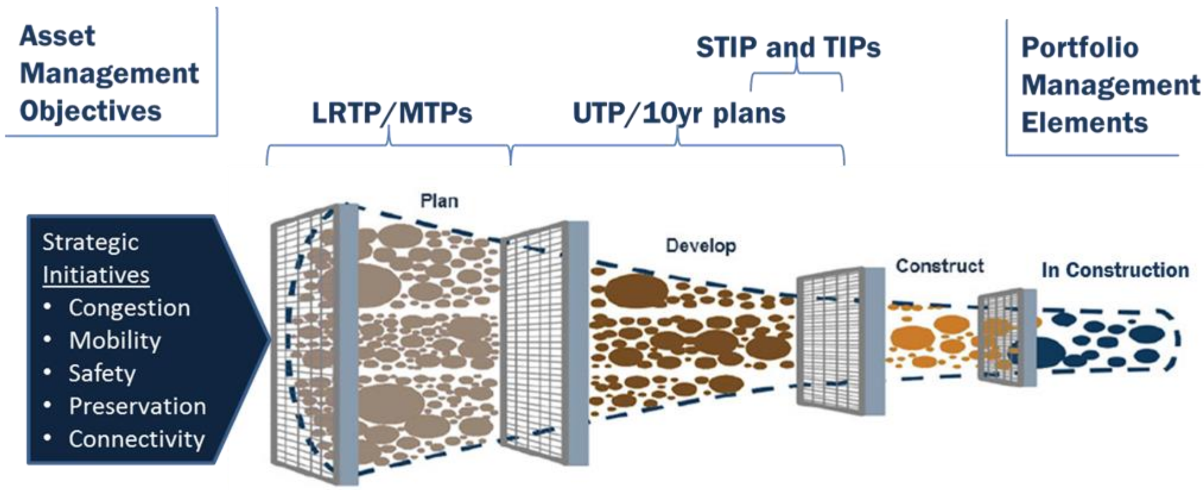


Figure 40. Planning, Development, and Construction Process.

The UTP is a standalone document created annually and requires the Transportation Commission approval. Texas Transportation Code provides that TxDOT shall develop the UTP covering a 10-year period to “guide the development of and authorize construction and transportation projects.”

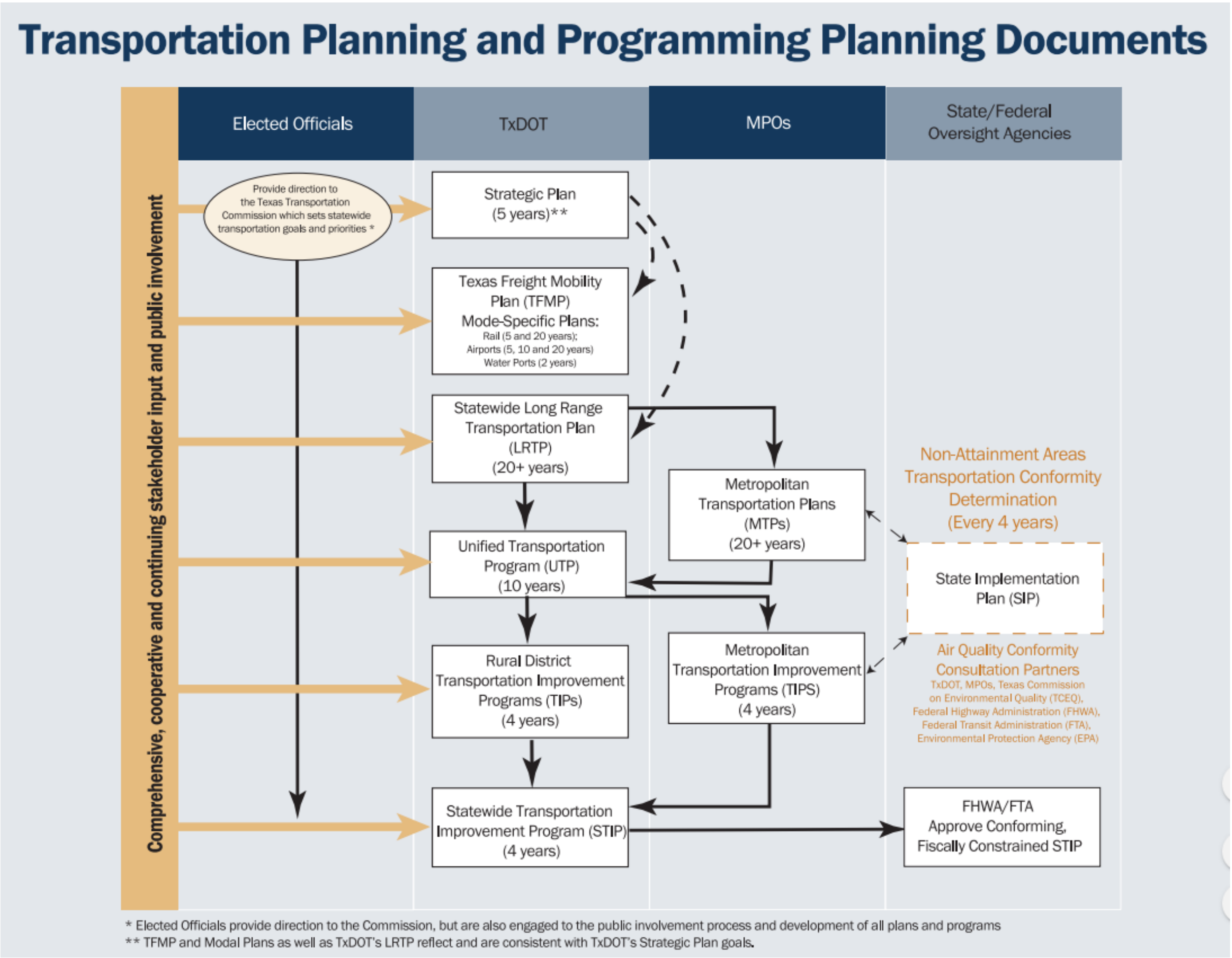


Figure 41. Transportation Planning and Programming Processes.

As presented in the Financial Plan and Figure 31 and Figure 42, funding sources available for projects are distributed into 12 separate funding categories. From these 12 categories, funding, shown in Table 43 and Table 45, for constructing, maintaining, and preserving pavement and bridge assets is made available.

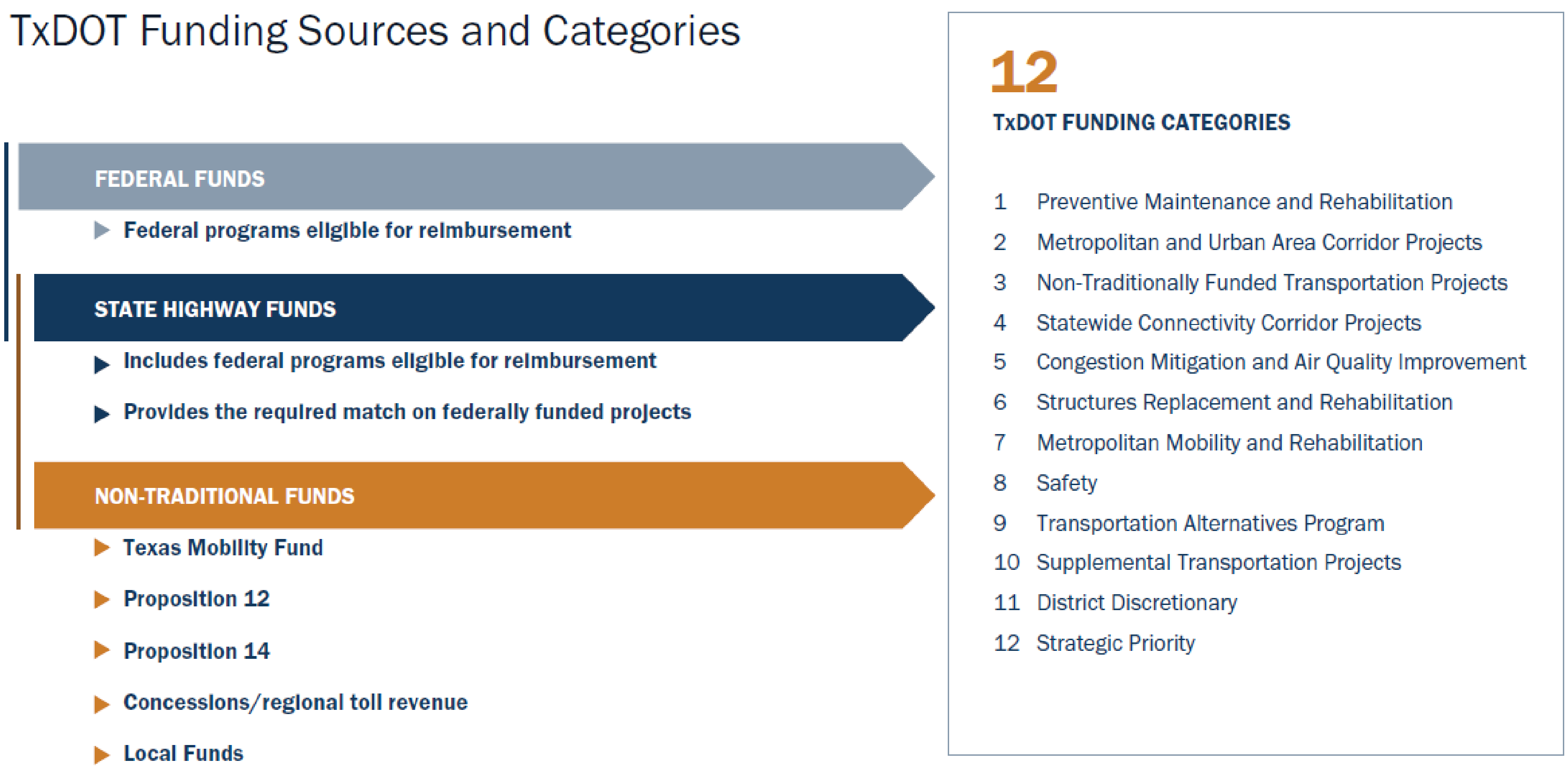


Figure 42. TxDOT Funding Sources and Categories.

Specific projects for pavement and bridge work are identified at the local TxDOT district level addressing district priorities including maintaining the condition of roadways and bridges. Districts may analyze the impact of project prioritization to determine the optimal mix of project cost and impact on their region's or statewide roadway system performance. The optimization routines available through TxDOT's pavement management system, identified in Chapter 4, Life Cycle Analysis, are used to determine these impacts.

Prioritized projects are submitted for funding consideration though TxDOT's Transportation Planning and Programming Division. Once projects are accumulated from all districts, a scoring process is used to rank and identify projects proposed to be funded. Fund expenditures are optimized to make the most use of leveraged federal and local funds by identifying combinations of projects that satisfy multiple TxDOT objectives. Technologies that use an Analytical Hierarchical Process are being piloted to assist with the optimization of funds and system performance.

The UTP is a collaborative process between TxDOT, MPOs, the public, and other local transportation partners (9) that evaluates system performance and directs resources where they are needed most. There are two approaches to development: a top-down or a bottom-up approach. Historically, funding has been distributed through the 12 categories in a top-down process. To be a purely performance-driven program, the project selection process would work from the bottom up assessing a financially unconstrained list of projects and selecting projects with the highest performance scores and return on investment, without regard to project type or location. However, to be fair and equitable to the entire state and meet the funding category mandates, TxDOT uses a hybrid approach. An evaluation tool is used to implement an iterative top-down and bottom-up approach to select projects that provide the best value, both statewide and locally.

Identifying project-specific data that align a project's performance benefits with the statewide objectives is critical to this process. Data-driven criteria are established for each system key performance objectives used to quantify each project's contributions to system performance. This process helps objectively evaluate projects to be included in the plan. As input into the evaluation tool, each project's performance data are estimated for the relevant criteria. The evaluation tool combines the performance metric data with input from stakeholders on the relative weights of the system key performance objectives, and a performance-metrics scoring matrix, to predict the overall performance of the system of projects (9). The tool provides a performance score for each project. According to the UTP, this process allows a fair comparison of the relative importance of each project. Using this tool, a program of projects can be analyzed, sensitivity analyses can be run, and projects can be selected and prioritized based on their performance scores.

Investment Strategies and National Performance Goals

TxDOT's Transportation Asset Management Plan seeks to improve and enhance Texas' transportation assets in furtherance of national and state goals. As discussed in Chapter 2, the TAMP and TxDOT's focus on asset management are in concurrence with several of the Department's agency goals and objectives. With regard to national priorities, the following table highlights how the TAMP supports each of the goals established in 23 USC 150(b). Pivotal in the pursuit of each of these goals is TxDOT's ability to achieve a state of good repair for public transportation assets in Texas.

Table 47. Investment Strategies and National Goals

National Performance Goal	Description of TAMP Strategies to Achieve Each Goal
(1) Safety To achieve a significant reduction in traffic fatalities and serious injuries on all public roads.	Strategies included in the TAMP support the goal of promoting safety outlined in TxDOT's Goals and Objectives, the UTP, the STIP, and other planning documents. Maintaining pavements and bridges in a state of good repair ensures that the public will encounter fewer roadway segments with poor friction, deep rutting, or other forms of deterioration that reduce safety. With these improved conditions, drivers are less likely to be involved in collisions where roadway condition was a contributing factor.
(2) Infrastructure condition To maintain the highway infrastructure asset system in a state of good repair.	The primary goal of TxDOT's investment strategies is to keep transportation assets in a sustainably acceptable condition throughout their lifecycle. This goal coincides with one of TxDOT's strategic goals to preserve our assets as well as the federal goal; both of which are also supported by the UTP, STIP, and other planning documents. Using data-informed performance management planning techniques, TxDOT is able to manage transportation assets with a focus on long-term conditions.
(3) Congestion reduction To achieve a significant reduction in congestion on the National Highway System.	Through these strategies, TxDOT expects to reduce the long-term costs of maintaining assets while sustaining the same level of network performance. These strategies correspond to those used in TxDOT's UTP which balances the need for funds aimed at asset management with the need for funds aimed at congestion reduction.
(4) System reliability To improve the efficiency of the surface transportation system.	Strategies included in the TAMP aim to minimize the hazards resulting from adverse weather conditions and reduce the number of collisions where road conditions were a factor. A reduction in collision-related and weather-related traffic diversions will improve system resiliency and reliability, improving the quality of service provided to the traveling public and the freight industry.
(5) Freight movement and economic vitality To improve the National Highway Freight Network, strengthen the ability of rural	Sustaining asset conditions in a steady state of good repair ensures the quality of assets in the long-term, preventing unexpected cases of advanced deterioration which might

National Performance Goal	Description of TAMP Strategies to Achieve Each Goal
communities to access national and international trade markets, and support regional economic development.	otherwise require detours for roadways with heavy truck traffic. Strategies in the TAMP aim to make asset conditions more predictable for rural communities and the freight industry and reduce the need for closures and lengthy detours.
(6) Environmental sustainability To enhance the performance of the transportation system while protecting and enhancing the natural environment.	TxDOT's investment strategies included in the TAMP aim to improve asset conditions through an optimal focus on preservation and maintenance. Properly balancing preservation and maintenance with replacement projects will decrease the need for excess construction materials. Additionally, minimizing partial closures and detours to consistently maintain highway throughput will reduce the amount of idle time spent on public roadways, reducing vehicle-related emissions.
(7) Reduced project delivery delays To reduce project costs, promote jobs and the economy, and expedite the movement of people and goods by accelerating project completion through eliminating delays in the project development and delivery process, including reducing regulatory burdens and improving agencies' work practices.	Strategies outlined in the TAMP will help to make more predictable the needs for more extensive rehabilitation and replacement projects which tend to have a larger impact on the public when delayed. Having additional time for planning these projects will allow for increased coordination between TxDOT and other stakeholders. With some of the most-common reasons for significant project delays being utility coordination, environmental coordination, and change orders, increased planning time should help to mitigate these hurdles.

Investment Strategies—Pavements

For pavements, TxDOT implemented the requirement for a Four-Year Pavement Management Plan. Every district is required to develop a comprehensive pavement management plan for all pavement related activities that is fiscally constrained. The plan covers all the routine maintenance, PM, LR, MR, and HR work for all the pavements within the district. The plans are reviewed annually by a committee established by TxDOT administration to ensure that the maximum maintenance resources are directed toward pavement operations and roadway related work to provide the maximum benefit to the agency.

As a part of the STIP in the transportation planning and programming process, the Four-Year Plan for the pavement provides investment strategies on an annual basis. The planned number of lane miles treated for each work type/treatment level is reported in each of the four planning years. It is suggested that PM is the predominant work type used to preserve the network's performance. In the meantime, the rehabilitation work is used to maintain or reduce the lane miles in the poor condition. Both strategies jointly contribute to the SOGR of TxDOT pavement network. This also is directly tied to the national Infrastructure Condition goal: to maintain the highway infrastructure asset system in an SOGR.

The Four-Year Plan allows the district to appropriately allocate resources through long-term planning to meet their management objectives. From the plan, a district may identify their highest priority projects and work.

For example, in the four-year pavement plan, the planned number of lane miles treated for each treatment type and planning year is reported, as shown in Figure 43. This suggests that Preventive Maintenance is the predominant work type used to preserve the network's SOGR at TxDOT.

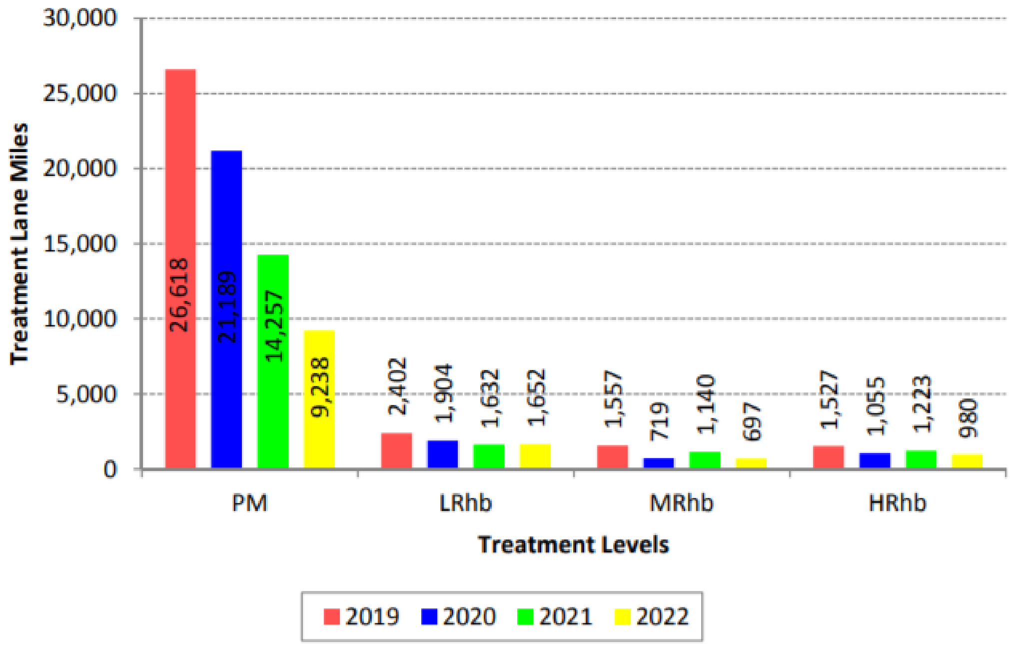


Figure 43. Quantity of Lane Miles by Treatment Type

Investment Strategies—Bridges

TxDOT places bridge management responsibilities primarily in the hands of its 25 districts. Traditionally, this has enabled each district to balance their specific needs with available funding and serve their community in a more responsive manner compared to a highly centralized management structure.

One shortfall of this strategy is a lack of centralized analysis necessary for data-driven asset management on a system-wide level. Because asset management strategies vary from district to district, significant time and resources are necessary to sufficiently catalog usual management strategies and improve them. Tangible bridge management strategies will be included in successive versions of the TAMP.

Table 48 shows TxDOT's planned funding levels for the Department's primary bridge programs and the corresponding work types associated with those programs. Table 44 (shown previously in this chapter) includes planned levels of funding for total bridge work in Fiscal Years 2018 through 2027. Bridge work funded through the UTP can include any of the following work types: initial construction, maintenance, preservation, rehabilitation, and reconstruction. Typically, a majority of these funds are utilized for initial construction, replacement, and rehabilitation work. In-house maintenance operations funds are typically utilized for maintenance and rehabilitation work.

Table 48. Planned Bridge Investment Funding

TxDOT Programs & Funding Sources	TxDOT Work Types	23 CFR 515 Work Types	Anticipated Annual Funding Levels
Bridge Preventive Maintenance Program (BPM)	Preventive Maintenance, Minor Repair	Preservation, Rehabilitation	$15M
Bridge Maintenance and Improvement Program (BMIP)	Major Repair, Rehabilitation	Preservation, Rehabilitation	$45M
Highway Bridge Program (HBP)	Replacement	Reconstruction	$230M
In-House Maintenance	Preventive Maintenance, Minor Repair	Maintenance	$32M
Total			***$322M***

Bridge Management and Planning

In developing and implementing the TAMP, TxDOT's Bridge Division will continue to bolster its understanding of bridge network performance and develop comprehensive investment strategies for future years. Ultimately, this development process will be supported using a bridge management system solution as a primary LCP and network management tool. With the assistance of the Texas A&M Transportation Institute, TxDOT will develop a supplementary LCP tool. The Life Cycle Planning section of this plan describes this tool and its methodology in more depth.

Implementation of a bridge management system in Texas has been a multi-year effort and will continue to require significant resources going into the next several years. The timeline TxDOT foresees with regard to meeting minimum system capability requirements is described in Table 49.

Table 49. Bridge Management System Implementation Timeline

Requirement: TxDOT's bridge management system must be capable of...	Target Date
(a) Collecting, processing, storing, and updating inventory and condition data for all NHS pavement and bridge assets	1/1/2020
(b) Forecasting deterioration for all NHS pavement and bridge assets	3/1/2020
(c) Determining the benefit-cost over the life cycle of assets to evaluate alternative actions (including no action decisions), for managing the condition of NHS pavement and bridge assets	5/1/2020
(d) Identifying short- and long-term budget needs for managing the condition of all NHS pavement and bridge assets	7/1/2020
(e) Determining the strategies for identifying potential NHS pavement and bridge projects that maximize overall program benefits within the financial constraints	8/1/2020
(f) Recommending programs and implementation schedules to manage the condition of NHS pavement and bridge assets within policy and budget constraints	9/1/2020

Bridge Management through Construction

Historically, TxDOT has invested significant resources toward bridge construction (new construction and replacement projects). As a result, TxDOT has developed and maintained a robust set of design manuals, policies, practices, and standards, which all contribute toward relatively low construction costs and lengthy asset service lives. These and other economic factors have contributed toward TxDOT's conventional wisdom—that it is more expensive to rehabilitate a bridge than replace it. As the economic landscape of the state changes and the inventory grows older, this strategy may not be the most cost-effective for the whole network.

Bridge Management through Preservation and Rehabilitation

Consistent with other states and national efforts, TxDOT will be investigating additional investment strategy alternatives aimed at improving bridge preservation policies and reducing network deterioration trends. More specifically, TxDOT's Bridge Division will be quantitatively investigating overall project costs and service life benefits of various preservation and rehabilitation activities identified in the Life Cycle Planning Section of this plan. These activities include:

- Full-depth deck replacement.
- Deck concrete spot repairs (partial-depth or full-depth).

- Protective deck overlays.
- Expansion joint cleaning and sealing.
- Expansion joint replacement.
- Drainage system cleaning.
- Superstructure steel coatings (paint and/or metalizing).
- Superstructure concrete spot repairs.
- Superstructure replacement.
- Bearing cleaning, resetting, and/or replacement.
- Substructure concrete spot repairs.
- Substructure steel coatings (paint and/or metalizing).
- Substructure resiliency improvements (i.e., encasements, foundation retrofits, CFRP wrapping).
- Riprap and drainage improvements.
- Backwall and/or wingwall repairs.
- Channel stabilization.
- Bridge replacement.
- Culvert replacement.

Along the initial analysis of these preservation alternatives, TxDOT will be exploring opportunities to incorporate findings into its decentralized asset management business structure. TxDOT will determine strategic funding levels to dedicate toward each of the above efforts in subsequent versions of the TAMP.

Chapter 7: Gap Analysis and Enhancements

Overview

FHWA requires that state DOTs "establish a process for conducting performance gap analysis to identify deficiencies hindering progress toward improving or preserving the NHS and achieving and sustaining the desired state of good repair" (*7*). The states are asked to identify the gaps and develop strategies to close or address the gaps.

This document will address two types of gaps: financial and technical. Financial gaps are those gaps that relate to TxDOT's ability to meet its asset performance goals as impacted by available funding. If insufficient funding is available to achieve or maintain the assets in a SOGR as defined by state performance criteria or FHWA criteria, a gap exists between present funding levels and the funding levels necessary to maintain the assets at the desired performance level. Asset performance is not only impacted by available funds but also by the effectiveness of its internal operations including allocation of funds to various operating units, project selection criteria, project level repair alternatives, repair operations, and the integration of technology into its operations, among other factors. Financial gaps are summarized below.

Technical gaps are those gaps that are related to operational date sets, performance measurement systems, performance prediction models, management systems, LCP, risk analysis, communications, and other technical activities that allow TxDOT information and processes to be used to satisfy the requirement of the TAMP as defined by FHWA in various regulations.

The gap analysis was primarily performed at the TAMP Working Group and SME Working Group level of the organization structure used to develop the TAMP (Figure 44). TAMP Working Group meetings were held every two weeks and a part of their agenda was devoted to the identification of gaps in the various elements of the TAMP as they were discussed. A list of these gaps was maintained as part of the meeting notes (minutes). SME Working Groups were also used to identify gaps that were reported during the TAMP Working Group meetings.

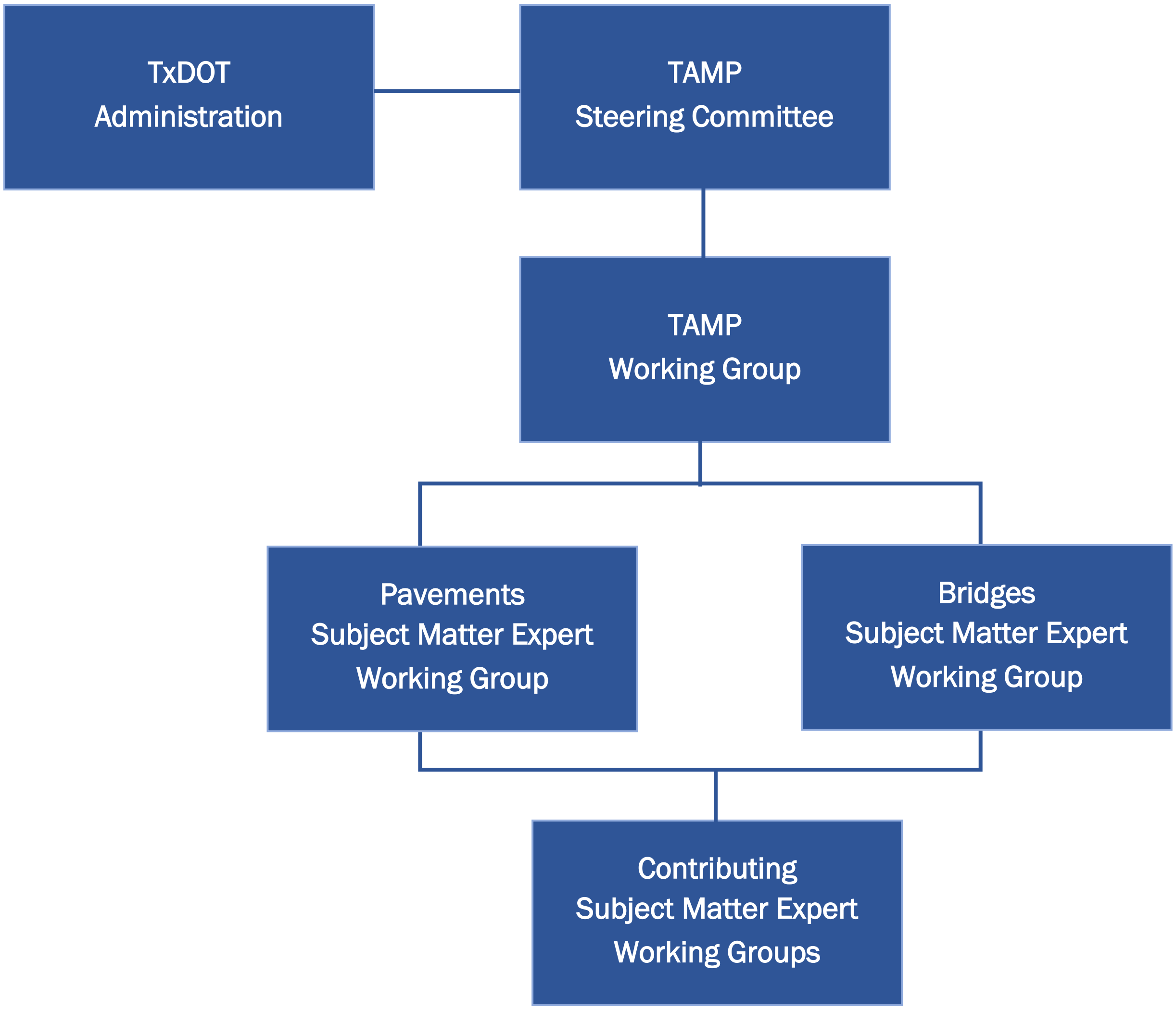


Figure 44. Organizational Structure for TxDOT TAMP Preparation.

Financial Gaps

Pavements

Chapter 4 on LCP used TxDOT's PA (*34*) to estimate the future performance of pavements with different funding levels. Figure 45 shows the results of this analysis. Note that this is the same figure as Figure 18 but repeated in this chapter for ease of reference. PA used TxDOT methods for measuring pavement condition, performance models, and decision trees.

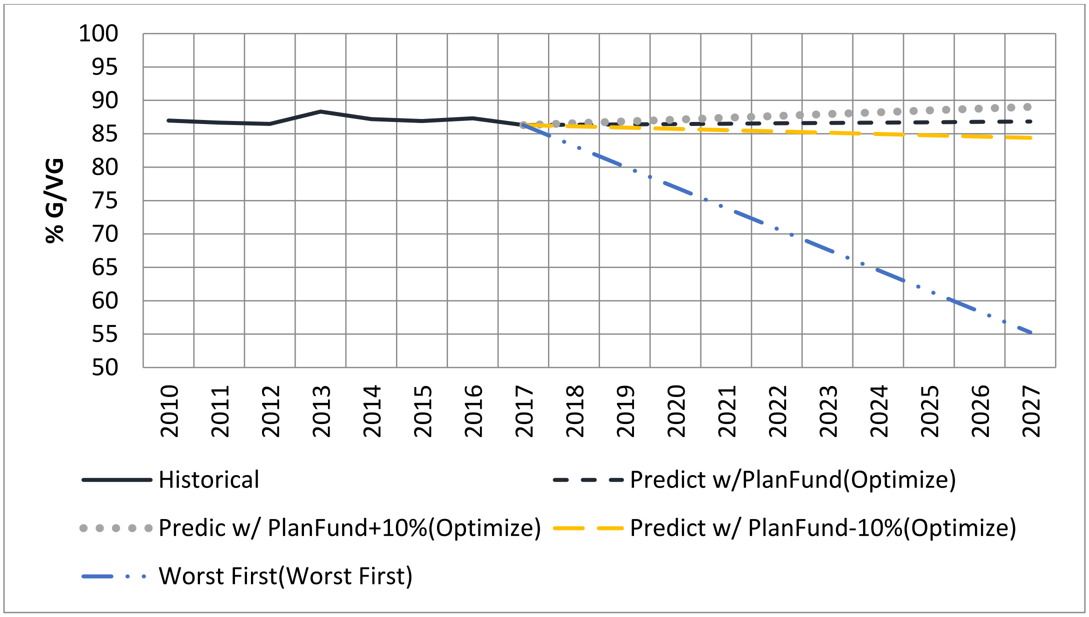


Figure 45. Predicted Pavement Condition for TxDOT On-System Pavements.

TxDOT's UTP (9) and the maintenance operations budget were used as the bases for determining expected funding on pavements ($25.5 billion) over the next 10 years. For this planned funding scenario, $17.7 billion is expected to fund on-system pavements. The TxDOT on-system pavements are expected to gradually improve to a level such that 86.83 percent of the pavements will be in good or very good condition as defined by current TxDOT criteria (Table 50).

Table 50. Predicted Performance of TxDOT On-System Pavements.

Funding Scenario	Expected Percent Good or Very Good
Planned* ($17.7 billion)	86.83%
10% Increase ($19.5 billion)	89.04%
10% Decrease ($16.0 billion)	84.39%

*Based on 2018 UTP for a 10-year period

If an additional 10 percent funding were available to TxDOT for on-system pavement over this 10-year period ($19.5 billion), the percent of pavements in good and very good condition is forecast to increase to 89.04 percent at the end of the period. The TxDOT goal for on-system pavements is 90 percent good and very good.

If available funding was reduced by 10 percent ($16.0 billion) for TxDOT on-system pavements over the 10-year period, the percent good and very good pavements would be reduced to 84.39 percent.

Funding levels will need to be increased to meet TxDOT's desired pavement performance level for its pavements. The process used to estimate the available funds is discussed in Chapter 6 and is based on several assumptions as identified in that chapter. Additionally, performance predictions for NHS interstate, NHS non-interstate (on-system and off-system), and non-NHS on-system will need to be developed.

The pavement performance will continue to be monitored on an annual basis, and this information will be used by TxDOT Districts, Divisions, and Administration to allocate funds to ensure that pavement performance meets the desired targets.

TxDOT is aware of the challenges of the maintenance needs of current and planned capacity improvements. TxDOT is planning to increase the budget for maintenance operations to address these needs. In general, the maintenance needs for newly added capacity is very minimal for the next 10 years since most of these pavements are designed for 30 years and constructed using Continuous Reinforced Concrete Pavements (CRCP) that have a history of excellent performance with minimal maintenance expenditures.

Bridges

Federal requirements for a Transportation Asset Management Plan include provisions for using a bridge management system that has the following minimum capabilities (23 CFR 515):

- Collecting, processing, storing, and updating inventory and condition data for all NHS bridge assets.
- Forecasting deterioration for all NHS bridges.
- Estimating benefits and costs of alternative work candidates over bridge life cycles.
- Forecasting short-term and long-term budget needs.
- Identifying strategies for NHS bridge projects that maximize overall program benefits given financial constraints.
- Recommending programs of work that manage bridge assets given policy and budget constraints.

Currently TxDOT does not have a bridge management system that can perform all these tasks. TxDOT is in the process of procuring and implementing components of a bridge management system that meet these requirements.

The Bridge Division is currently working with TxDOT's Information Management Division (IMD) to review possible solutions and identify the best option for meeting TxDOT's bridge management needs. The process used thus far and going into the future can be summarized as follows:

1. Assess TxDOT's business needs for desired features of a bridge management system.
2. Research possible solutions; review commercially available bridge management systems and evaluate against needs assessment.
3. Select and procure or implement the solution.

TxDOT anticipates that a bridge management system complying with all FHWA requirements will be in use no later than July 2020 and will be used for subsequent versions of the TAMP. In the meantime, TxDOT has begun developing deterioration models, work type candidate lists, and other input parameters that are necessary for configuration of a bridge management system regardless of whichever solution is implemented.

FHWA criteria state that no more than 10 percent of bridge deck area can be in poor condition as determined by FHWA condition measurement systems. Available TxDOT data indicate that about 1 percent of the bridge deck area on NHS bridges (both on-system and off-system) in Texas is in poor condition at the present time. At present and with future funding levels, TxDOT bridges are expected to be maintained with less than 10 percent of the bridge deck area in poor condition.

The bridge performance will continue to be monitored, and this information will be used by TxDOT Districts, Divisions, and Administration to allocate funds to ensure that bridge performance meets the desired targets.

Enhancements

TxDOT does not directly allocate funds to budget line items identified as "pavements" and "bridges." Funding for pavement and bridges is available in several categories as identified in the UTP (9). The uncertainty of the funding numbers selected for use in this analysis could easily be plus or minus 5 to 10 percent of their actual allocations in future years. In the short term, it is unlikely that budget line items will be developed for pavements and bridges. Budget allocations for pavements and bridges will continue to have uncertainty.

TxDOT budget allocation segmentation as described above is important for predicting performance and determining the SOGR. This budget segmentation can only be estimated at the present time. Some examples of additional budget segmentation that are of interest include the following:

- NHS on-system Interstate and on-system non-IH highways and bridges.
- NHS off-system highways and bridges.
- Non-NHS on-system highways and bridges.

Funding estimations for off-system NHS system pavement and bridges—from cities, counties, and toll authorities—are needed to provide accurate condition predictions for the future. This will require extensive coordination efforts with the MPO.

The need for the TAMP to have more accurate funding forecasts will be discussed with TxDOT Administration and its financial planning groups by the TAMP Steering Committee.

Technical Gaps

Table 51 and Table 52 contain gaps identified by the TAMP Working Group for pavement and bridge assets. The technical gaps are identified by general categories of inventory, condition measurements, management system, risk matrix, and communications. A brief description of a strategy to fill the gap is provided together with the responsible group or owner of the gap.

Table 51. Pavement Technical Gaps.

Item	Element	Strategy	Responsible Group
Pavement Management System	Develop performance models for pavement performance based on FHWA distress measurement	Harmonize data collection and develop models	Pavement SME Working Group
Risk Matrix	Refine the methodology for processing recurring events	Perform analysis	Pavement SME Working Group
Communications	Budgets from off-system NHS pavements are needed to forecast future performance	Continue to communicate with these entities and pursue needed information	Pavement SME Working Group
	Condition of system to interested stakeholders	Continue and enhance communication effort	Pavement SME Working Group

Table 52. Bridge Technical Gaps.

Item	Elements	Strategy to Close Gap	Responsible Group
Management System	Incorporate performance models, decision trees, life cycle costs, etc. into TxDOT's bridge management system	Establish research projects and implement deterioration and LCP models into TxDOT's bridge management system	Bridge SME Working Group
Risk Matrix	Refine the methodology for processing recurring events	Perform analysis	Bridge SME Working Group
Communication	Budgets from off-system NHS bridges are needed to forecast future performance	Continue to communicate with these entities and pursue needed information	Bridge SME Working Group
	Condition of system to interested stakeholders	Continue and enhance communication effort	Bridge SME Working Group

Chapter 8: Communications

Overview

A gap recognized in Chapter 7 (Gaps and Enhancements) is communication with interested stakeholders, including the public. This chapter recognizes the importance of communication associated with the development and implementation of the TAMP in Texas. Large amounts of information were collected, analyzed, discussed, synthesized, and placed in the document. Much communication across disciplines and operating units within TxDOT was necessary to accomplish these work tasks.

The acceptance, use, and implementation of the information contained in the TAMP will require focused communication activities. This communication will be with various public and private sector entities and internal to TxDOT.

Plans are needed to effectively communicate the TAMP document to the stakeholders. Communication efforts associated with information gathering and information dissemination are discussed below.

Information Gathering

Several Divisions within TxDOT provided the information in the TAMP. This active participation in exchanging data benefited TxDOT by opening new communication lines between the Divisions.

Key parts of developing the TAMP included:

- Defining the asset inventory and condition.
- Conducting LCP to determine future condition of the assets with available funding levels.
- Understanding the budgeting process to establish pavement and bridge funding levels on a 10-year horizon.
- Identifying risks and their mitigation.
- Performing a gap analysis.

Cities, counties, and toll authorities own, repair, and operate a portion of the NHS system in Texas. Pavement and bridge inventory and condition data have been obtained on the off-system NHS by TxDOT. Information on expenditures for the off-system NHS is not presently available from these entities without contacting each unit individually.

Contact has been made with MPOs in Texas to obtain funding level information for investment strategies, life cycle plans, and expected funding level for off-system NHS pavements and bridges. MPOs have responded that the information may be available from cities and counties. Some cities and counties do not have management systems that allow for the information to be collected since funding is not segmented by pavements and bridges that are on the NHS.

Toll authorities also own and operate a part of the off-system NHS. Financial data are needed to complete the TAMP for the NHS system. Funding levels needed to provide the desired level of service or SOGR will not be possible for the off-system NHS without these data.

At present, TxDOT has working agreements with MPOs but not the cities and counties. These working agreements allow for more effective communication and information flow. TxDOT will continue to work with these other owners to develop a more streamlined process for obtaining these data.

Information Dissemination

TxDOT will use the TAMP to provide information to its stakeholders to describe the present and future condition of its pavements and bridges as impacted by its financial resources. High risk items will be identified that can impact future performance of the pavements and bridges. Gaps in the asset management plan and planned enhancements for these gaps will be identified. Use and implementation of the information contained in the document will improve the pavement and bridge assets in Texas. Performance information is available for all TxDOT on-system pavements and bridges (*10*, *18*, *19*).

Chapter 9: Compliance Checklist

Overview

Federal Regulations 23 CFR 515 and 667 describe FHWA requirements for Asset Management Plans (515) and identification of recurring repairs due to emergency events (667) (7). This chapter lists these requirements, how the requirements are addressed, and a chapter reference to the location of the information in the TAMP. Sections of 23 CFR 515 and 667 that identify requirements are as follows (Figure 46):

- 515.5 Definitions.
- 515.7 Process for Establishing the Asset Management Plan.
- 515.9 Asset Management Plan Requirements.
- 515.17 Minimum Standards for Developing and Operating Bridge and Pavement Management Systems.
- 515.19 Organizational Integration of Asset Management.

These sections will be briefly review for compliance. Section 515.9 is addressed in more detail.

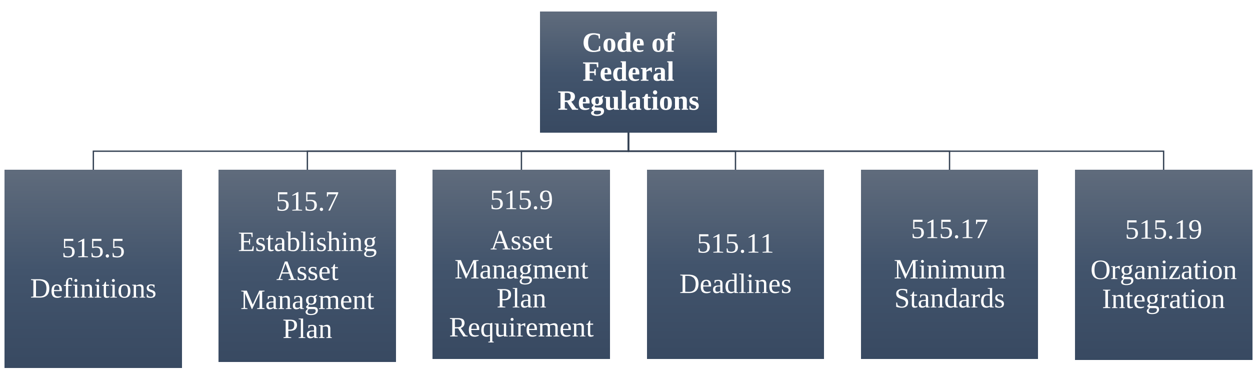


Figure 46. Compliance Requirements (23 CFR 515).

Definitions (515.5)

The definitions used in this section of the requirement are compatible with TxDOT definitions used for its pavement and bridge asset management systems.

Process for Establishing the Asset Management Plan (515.7)

This section of 23 CFR 515 indicates that “the state shall develop a risk-based asset management plan that describes how the NHS will be managed to achieve system performance effectiveness and state DOT targets for asset condition, while managing the risks, in a financially responsible manner, at a minimum practicable cost over the life cycle of its assets." The state is required to as a minimum, develop processes for the following:

- Performance gap analysis–Chapter 7.
- Life cycle planning–Chapter 4.
- Risk management–Chapter 5.
- Financial planning–Chapter 6.
- Investment strategies–Chapter 6.
- Obtaining information from other owners of the NHS–Chapter 8.

TxDOT has used the best available information to develop this TAMP. Processes were in-place in existing pavement and bridge management plans to satisfy some of these requirements. Other processes or approaches were developed to address these minimum requirements. Details are provided below.

Asset Management Plan Requirements (515.9)

The state "shall develop and implement an asset management plan to improve or preserve the condition of the assets and improve the performance of the NHS." The asset management plan developed by the state must describe/discuss, as a minimum, items identified in this section of the federal regulation. Table 53 identifies these items and addresses how the items were considered and where the item was discussed in the TAMP.

Deadlines and Phase-in of Asset Management Plan Development (515.11)

The TxDOT initial TAMP was submitted April 30, 2018, and a final TAMP will be submitted by June 30, 2019. The initial plan is required to describe the state's processes for the following:

- Development of a risk-based asset management plan.
- Measures and targets for asset condition.
- Investment strategies to meet 23 U.S.C. 150 (b) (safety, infrastructure condition, congestion reduction, system reliability, freight movement, environmental sustainability, reduced project delivery delays).
- NHS targets for pavements and bridges.

The TxDOT TAMP includes a risk management analysis that was considered in its asset management plan development (Chapter 5). Measures and targets for asset condition are included in the TxDOT TAMP (Chapter 3). Investment strategies are included in Chapter 6 of the TxDOT TAMP and as part of the budget development the items identified in 23 U.S.C. 150 (b) are considered in the process. NHS targets for pavements and bridges are those presently used by TxDOT.

Minimum Standards for Developing and Operating Bridge and Pavements Management Systems (515.17)

Minimum standards for pavement and bridge pavement management systems are defined in this section of the 23 CFR 515 and must contain documentation for the following:

- Collecting, processing, storing, and updating inventory and condition data for all NHS pavements and bridge assets—Chapter 3.
- Forecasting deterioration for all NHS pavements and bridges—Chapter 4.
- Benefit-cost over the life cycle of the assets—Chapter 4.
- Short-term and long-term budget needs—Chapters 6 and 7.
- Strategies for identifying NHS pavement and bridge projects that maximize overall program benefits with given financial constraints—Chapters 4 and 6.
- Recommending programs that manage pavement and bridge assets within policy and budget constraints—Chapters 6 and 7.

Organizational Integration of Asset Management (515.19)

This section defines how TxDOT will integrate asset management into its organizational mission, culture, and capabilities at all levels. The TAMP development Steering Committee has responsibility for the integration of asset management into TxDOT's business practices.

Asset management information is presently a key part of budget development at all levels of the TxDOT organization. TxDOT Districts use performance condition information as part of their selection process to develop their project needs lists. TxDOT Divisions and Administration use the condition forecasts at the network level to establish funding levels. Additional processes will continue to be developed that more formally integrate asset management into TxDOT's current processes.

Table 53. Compliance Check List for Section 515.7 of 23 CFR 515.

Item	Section	Requirement	How This Requirement Is Addressed in This Document	Requirement Addressed in Chapter
1	515.9 (a)	Develop and implement an asset management plan	Asset management plan for pavements has been developed. Asset management plan has been partially developed for bridges. Bridge performance or deterioration models and a bridge management system is being developed.	3, 4
2	515.9 (a)	How TxDOT will carry out asset management	TxDOT's Maintenance and Bridge Divisions have responsibility for the pavements and bridge asset management plan. Financial allocations	3 to 8

Item	Section	Requirement	How This Requirement Is Addressed in This Document	Requirement Addressed in Chapter
			are made by the Financial Management and Transportation Planning and Programming Division with input from the Districts and operational division with oversight from the Administration.	
3	515.9 (b)	NHS pavement and bridge inventory	Obtained from state databases for both on-system and off-system NHS.	3
4	515.9 (c)	Other assets	This document addresses all pavements and bridges owned by the TxDOT, not just those that are on the NHS.	3 to 8
5	515.9 (c)	If other assets are included in TAMP all elements of these requirements apply	Elements required by 23 CFR 515 for non-NHS TxDOT system pavements have been considered in the TAMP.	3 to 8
6	515.9 (d)(1)	Asset management objectives	FHWA and state objective for asset management were compared and contrasted and are in alignment.	2
7	515.9 (d)(2)	(2) Asset management measures and state DOT targets for asset condition	Asset measures, condition evaluation, and condition targets are those presently used by TxDOT for pavements and bridges. FHWA pavement measurement systems and targets for pavements have been used by TxDOT in this document for the NHS. FHWA bridge measurement systems and targets have not been used in this document.	3
8	515.9 (d)(3)	Summary description of the condition of NHS pavements and bridges, regardless of ownership	Condition of NHS on-system and off-system pavements and bridge information was obtained from TxDOT pavement and bridge management databases. TxDOT evaluates the condition of all NHS on-system and off-system bridges and pavements.	3
9	515.9 (d)(4)	Performance gap identification	Performance gaps for pavements with different funding levels has been determined using TxDOT pavement management software (PA). Performance gaps for bridges have not been developed as TxDOT is in the process of developing a bridge management system that will forecast bridge condition for various funding scenarios.	4

Item	Section	Requirement	How This Requirement Is Addressed in This Document	Requirement Addressed in Chapter
10	515.9 (d)(5)	Life cycle planning	LCP has been performed for pavements based on PA TxDOT software. A bridge management system is under development.	4
11	515.9 (d)(6)	Risk management analysis including recurring events	Risk management has been addressed through a formal process involving SMEs and the TAMP Steering Committee. A detailed procedure was used to identify recurring events as described in 23 CFR 667.	5
12	515.9 (d)(7)	Financial plan	This document provides a financial plan that describes the sources of asset management funding, the processes TxDOT uses to allocate these funds, the amount of funding expected to be available for asset management over the next 10 years, and the impact of these funding levels on system conditions.	6.
13	515.9 (d)(8)	Investment strategies	This document defines investment strategies that enable TxDOT to work toward desired asset management outcomes at a minimal practical cost while managing risks.	6
14	515.9 (e)	An asset management plan shall cover, at a minimum, a 10-year period	This document covers a 10-year period.	4 and 6
15	515.9 (f)(1)	Investment strategy supports progress toward achieving a SOGR over the life cycle of investment	LCP used the TxDOT's PA program to determine the SOGR over the life cycle of pavement assets. A bridge management system is under development.	4, 6
16	515.9 (f)(2)	Investment strategy supports progress toward improving the condition of the assets	TxDOT's PA program forecasted the condition of pavements with different funding scenarios to illustrate funding level requirement to improve the condition of pavements. A bridge management system is under development.	4, 6

Item	Section	Requirement	How This Requirement Is Addressed in This Document	Requirement Addressed in Chapter
17	515.9 (f)(3)	Investment strategy supports progress toward improving state targets for asset condition and performance	TxDOT's PA program forecasted the condition of pavements with different funding scenarios to illustrate funding level requirement to improve the condition of pavements. A funding increase of 10 percent will be needed to achieve the state target for pavement performance. Bridge performance history information indicates that state targets have been met historically and are expected to exceed state targets in the future. A bridge management system is under development.	4, 6
18	515.9 (f)(4)	Investment strategy supports progress toward improving the national goals	The national methods for determining pavement condition have been implemented on the Texas NHS for a one-year period. Performance prediction models have not been developed for pavement using these measurement parameters. Performance targets have not been established for pavements. Condition of pavements using the national standards have been reported for the NHS pavements. National bridge measurement systems have been used on TxDOT NHS system highways. These measurement systems are changing. A bridge management system is being developed.	3, 6
19	515.9 (g)	State developed analyses (life cycling planning, risk management, performance gaps, etc.) support the state TAMP investment strategies	Investment strategies are based on needs identified by the Districts, Divisions, and the Administration. These decisions are based in part on the condition of their pavements and bridges and the need to maintain pavements and bridges in a SOGR and budgetary constraints. The tools developed by TxDOT allow for not only pavement and bridge management system to provide input to the decision making but also allow TxDOT to consider risk and to identify areas of their management systems that need improvements.	4, 5, 6, 7

Item	Section	Requirement	How This Requirement Is Addressed in This Document	Requirement Addressed in Chapter
20	515.9 (h)	Integrate the asset management plan into its STIP transportation planning processes	The asset management tools developed by TxDOT are used at all levels of decision making to formulate the 10-year plan UTP and the 4-year STIP. Districts use the pavement and bridge management tools and information to establish their needs based UTP and STIP. Divisions and Administration–level input into these plans are based in part on asset management tools.	2, 3, 4, 6
21	515.9 (i)	Asset management plan available to the public	The TAMP has largely been developed in a non-technical format. The communication plan in Chapter 8 recognizes that various audiences will be interested in information provided in the TAMP and that a comprehensive communication plan needs development. Final TAMP will be made available online.	8
22	515.9 (j)	TAMP reporting of performance measures and state DOT targets does not satisfy requirements of other federal requirements for information reporting	TxDOT will continue to report information as required in 23 U.S.C. 150.	
23	515.9 (k)	The head of the state DOT shall approve the asset management plan	TxDOT's Executive Director has approved TxDOT's TAMP.	
24	515.9 (l)	If assets other than NHS pavements and bridges are included in TAMP detailed information is required	The TxDOT TAMP reports NHS pavement and bridge assets (on-system and off-system) and all other TxDOT on-system (non-NHS on-system) pavements and bridges. Complete information requirements are included for TxDOT on-system pavements and bridges.	3, 4, 6
25	515.9 (m)	Asset management plan may include consideration of off-system NHS	The condition of the off-system NHS is determined by TxDOT and reported in the TAMP. Funding levels for this segment of the NHS are not available at this time and not included in the financial analysis and performance prediction sections of the TAMP.	3, 6

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