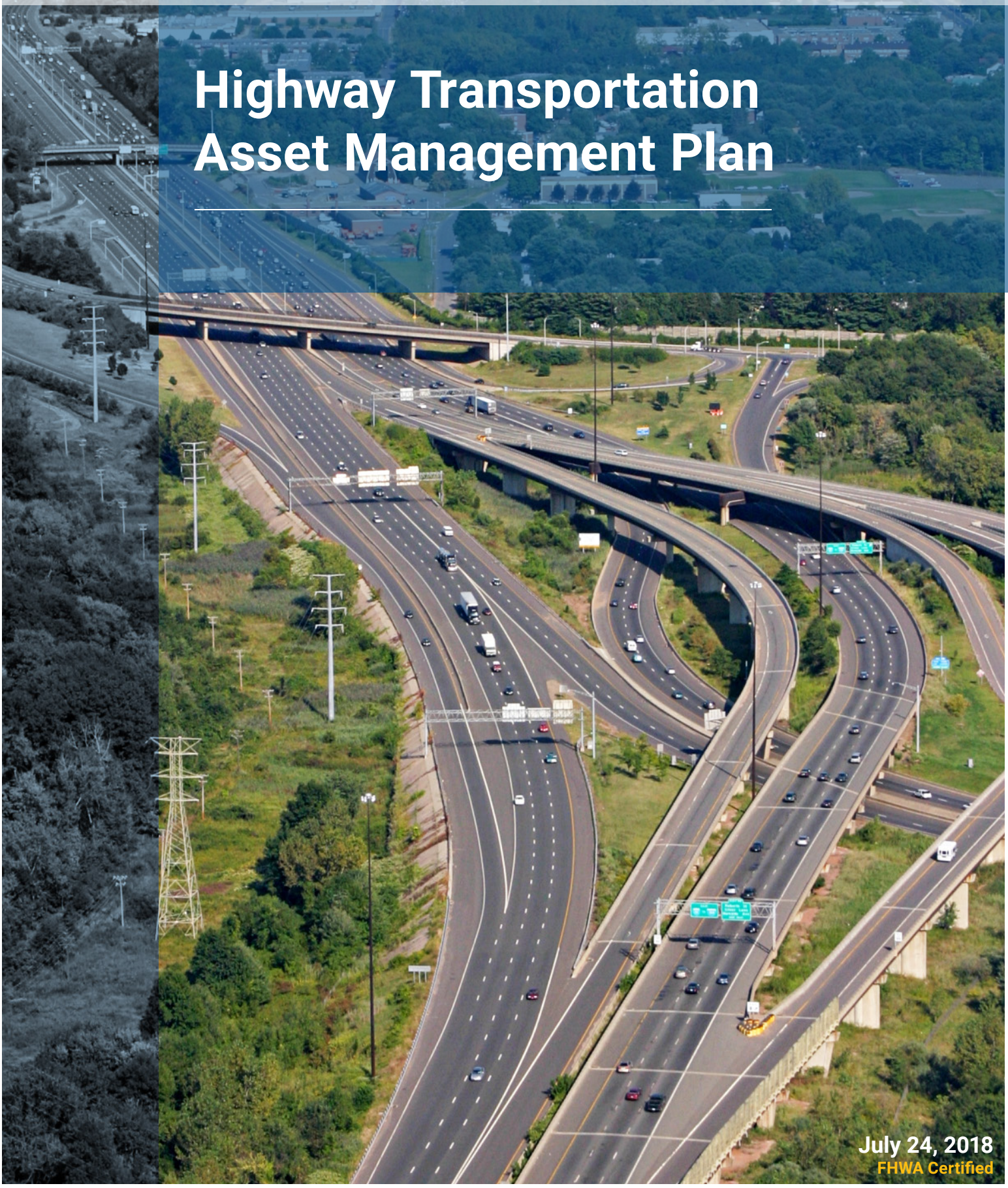
Connecticut Department of Transportation

Highway Transportation Asset Management Plan



July 24, 2018

FHWA Certified

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U.S. Department of Transportation
Federal Highway Administration

Connecticut Division

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July 24, 2018

Mr. James P. Redeker
Commissioner
Connecticut Department of Transportation
2800 Berlin Turnpike
PO Box 317546
Newington, Connecticut 06131-7546

Subject: Initial Transportation Asset Management Plan (TAMP) Certification Review

Dear Mr. Redeker:

This letter serves as the Federal Highway Administration (FHWA) Connecticut Division Office's process certification decision relative to the Connecticut Department of Transportation (DOT)'s initial TAMP.

The Connecticut DOT's initial TAMP dated April 2018 was received by the Division Office on April 25, 2018 and a revised submission received on July 23, 2018. The processes you followed to develop your TAMP comply with the minimum requirements set forth in 23 CFR 515.11(a) and 515.11(b). Therefore, Connecticut DOT's TAMP development processes are certified.

We would like to commend you and your staff for the broad participation in development of the initial TAMP, a risked-based asset management plan. The initial TAMP is the first required TAMP submission, which includes the State DOT's proposed TAMP development. The State-approved asset management plan meeting all the requirements of 23 U.S.C. 119 and 23 CFR Part 515 is to be submitted to FHWA by June 30, 2019.

Should you have any questions, please contact Kurt Salmoiraghi, Program Development Team Leader at 860-494-7561.

Sincerely,

Amy Jackson-Grove
Division Administrator

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Message from the Commissioner

It is my pleasure, as Commissioner of the Connecticut Department of Transportation, to present the State's initial Highway Transportation Asset Management Plan. This plan goes beyond federal mandates and demonstrates a strong commitment to achieving a State of Good Repair for our transportation system.

Connecticut's transportation system is multimodal and supports the economy by enabling the efficient movement of people, goods, and services. Connecticut is a vital transportation link between northern New England and New York, New Jersey and the Mid-Atlantic states. The transportation system also links our communities; helping connect neighborhoods, towns, and cities. In order for Connecticut's economy to function properly and grow, the transportation system must be maintained and updated.

This document presents a plan to manage six of Connecticut's important transportation assets, with detailed information about the processes for managing each of the assets.

Implementation of this plan aligns with the Department's priority to maintain and preserve the transportation system.

James P. Redeker

Commissioner

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Connecticut Department of Transportation
Highway Transportation Asset Management Plan

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Appendices

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List of Acronyms

AADT	Annual Average Daily Traffic
ARAN	Automatic Road Analyzer
CMAQ	Congestion Mitigation and Air Quality
CPD	Composite Project Database
CSR	Combined Stress Ratio
CTDOT	Connecticut Department of Transportation
FAST	Fixing America's Surface Transportation
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GIS	Geographic Information System
GPS	Global Positioning System
HI	Health Index
HMA	Hot Mix Asphalt
HPMS	Highway Performance Monitoring System
HTF	Highway Trust Fund
IBC	Incremental benefit Curve
IRI	International Roughness Index
ITS	Intelligent Transportation Systems
KML	Keyhole Markup Language
LCCA	Life Cycle Cost Analysis
LCP	Life Cycle Planning
LRS	Linear Referencing System
MAP-21	Moving Ahead for Progress in the 21st Century
MIRE	Model Inventory of Roadway Elements

MMS	Maintenance Management System
MPO	Metropolitan Planning Organization
MUTCD	Manual on Uniform Traffic Control Devices
NBE	National Bridge Element
NBI	National Bridge Inventory
NBIS	National Bridge Inspection Standards
NHPP	National Highway Performance Program
NHS	National Highway System
OBL	CTDOT's Capital Program Obligation Plan
PCI	Pavement Condition Index
PMS	Pavement Management System
RIS	Roadway Inventory System
ROW	Right-of-Way
RSR	Rehabilitation Study Report
SMS	Structure Management System
SOGR	State of Good Repair
STBG	Surface Transportation Block Grant
STF	Special Transportation Fund
STP	Surface Transportation Program
SQL	Structured Query Language
TAM	Transportation Asset Management
TAMP	Transportation Asset Management Plan
TED	Transportation Enterprise Database
TIR	Traffic Investigation Report
VIP	Vendor-in-Place
VMT	Vehicles Miles Traveled

Executive Summary
Highway Transportation Asset Management Plan

The Connecticut Department of Transportation (CTDOT) has developed its first Federal Highway Transportation Asset Management Plan (TAMP) to establish and document the agency's strategic and systematic process of managing its transportation assets. This Highway TAMP was also developed to meet Federal requirements of Moving Ahead for Progress in the 21st Century (MAP-21) and the Fixing America's Surface Transportation (FAST) Act. The penalty for not having a certified process results in a reduction of federal match from 80% or 90% to 65%. In Connecticut, this penalty could equate to approximately $100 million of additional State funds needed annually to utilize all federal dollars at the lower federal participation rate. CTDOT, a multi-modal agency, is also working on its first Transit Transportation Asset Management Plan to be completed for October 1, 2018 in accordance with Federal Transit Administration (FTA) requirements.

Each chapter of this Highway TAMP addresses a separate asset management process requirement and its federal legislative and regulatory context. The Federal Highway Administration's (FHWA) role is to certify the process and annually conduct a consistency review to ensure the processes are being implemented. CTDOT worked closely with staff from the FHWA Connecticut Division Office in developing this initial TAMP.

What's in the Plan

While Federal legislation requires reporting only on National Highway System (NHS) bridges and pavements, CTDOT has chosen to go beyond the NHS and has included all CTDOT-maintained bridges and pavements. The TAMP also includes four additional assets: traffic signals, signs, sign supports and pavement markings. These four additional assets were selected to be included in the initial TAMP based on their highway safety function. It is envisioned that more assets will be added in future TAMPs.

The TAMP development process included the following steps:

1. Compile asset inventory and condition summaries using best available data
2. Document procedure for collecting, processing, storing and updating inventory and condition data
3. Define a State of Good Repair
4. Determine performance measures
5. Perform the life cycle cost analysis for various funding scenarios and determine the strategies to develop the life cycle plan
6. Review available funding and investments to develop a financial plan and investment strategies

7. Set 2-year, 4-year and 10-year performance targets.
8. Develop a risk management plan that identifies, assesses and prioritizes risks along with potential treatments
9. Identify process improvements for future implementation

Quick reference Fact Sheets have been developed for each of the six assets and are available in Appendix B of the TAMP. The asset Fact Sheets include pertinent details in the following asset management areas: inventory and condition summaries, State of Good Repair definition, performance projections, targets and asset valuation.

Asset Management in Action

Building this TAMP involved educating and engaging staff throughout the Department in a coordinated effort. CTDOT formed a TAM Steering Committee, staffed a Transportation Asset Management Group, designated asset stewards, and identified asset working groups to support this effort. Valuable input was gained from these groups through active involvement at interviews, meetings and workshops. Asset Stewards were particularly instrumental in providing information to develop this TAMP.

This TAMP uses the best available data to compile asset inventory and condition data to perform life cycle analyses. This TAMP also assumes the current funding scenarios based on the funding available as of June 30, 2017.

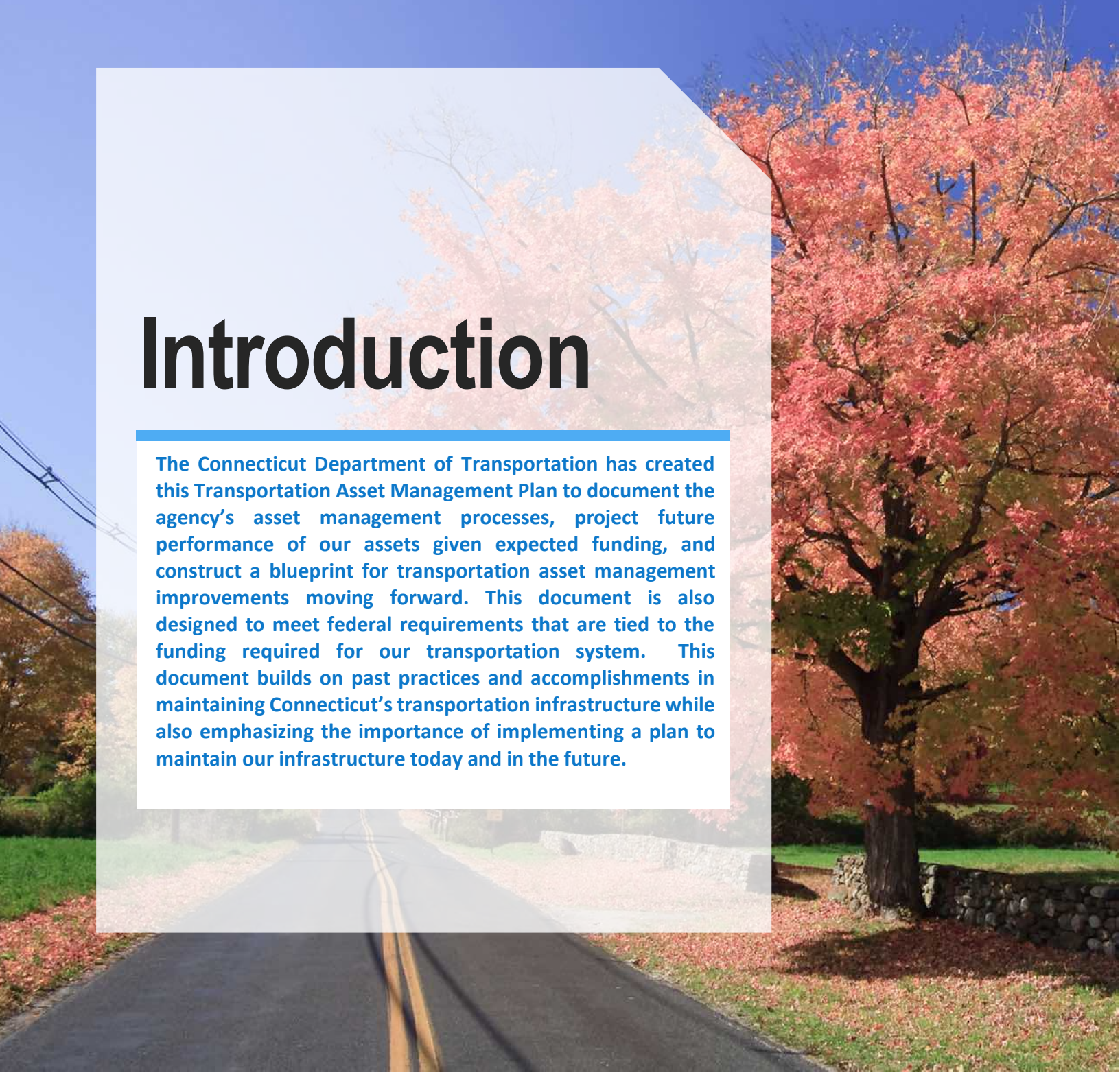
Although we have been summarizing performance each year on bridges and pavement since 2007, with the development of this TAMP, we have been able to project future performance for all six assets for the first time. These projections are proving to be useful in understanding and projecting transportation funding needs.

Moving Forward

At CTDOT, asset management is more than a document; it is a better way of doing business. Through the TAMP building process, CTDOT has made strides toward an enterprise asset management practice. As we strengthen the ability to employ asset management, next steps include implementing key process improvements:

- Develop a financial plan and capital planning process that is driven by asset management principles.
- Pursue methods to enhance performance in project selection, prioritization and cross-asset allocation.
- Better understand resource and industry capacity limitations to deliver at increased funding levels.
- Expand the asset management approach to other assets.

Timely investments and doing the right treatment at the right time, result in improved overall asset condition over a longer period of time at lower long-term costs. This TAMP sets the direction for enhanced business practices and a framework for effective management of Connecticut's infrastructure.



Introduction

The Connecticut Department of Transportation has created this Transportation Asset Management Plan to document the agency's asset management processes, project future performance of our assets given expected funding, and construct a blueprint for transportation asset management improvements moving forward. This document is also designed to meet federal requirements that are tied to the funding required for our transportation system. This document builds on past practices and accomplishments in maintaining Connecticut's transportation infrastructure while also emphasizing the importance of implementing a plan to maintain our infrastructure today and in the future.

CHAPTER 1

Connecticut Department of Transportation
TRANSPORTATION ASSET MANAGEMENT PLAN

Welcome

Transportation asset management (TAM) is a strategic and systematic process of taking care of our assets, with a focus on both engineering and economics and is based upon quality information that we collect. The TAM process identifies a structured sequence of work to better maintain assets in a State of Good Repair (SOGR) over their lifecycle at a minimum cost.

In Connecticut, the practices of asset management are needed to address the condition of our infrastructure as many of our assets have aged beyond their intended life expectancy. This aging infrastructure combined with increased demands on the transportation network and limited funding strongly substantiates the need to implement asset management practices.

The Connecticut Department of Transportation (CTDOT) has created this Highway Transportation Asset Management Plan (TAMP) to layout the agency's asset management processes and begin implementing improvements for the Connecticut road network. A separate document is being developed to address the transit assets maintained by CTDOT as mandated by the Federal Transit Administration. Eventually, CTDOT intends to merge the documents into a comprehensive asset management plan for the entire department.

Federal Legislative Context

Federal authorization (initially Moving Ahead for Progress in the 21st Century or *MAP-21* and more recently Fixing America's Surface Transportation or *FAST Act*) requires that each State Department of Transportation develop a risk-based TAMP to improve and preserve the condition of assets on the National Highway System (NHS), with the plan containing the following elements at a minimum:

- Summary listing of the bridge and pavement assets on the NHS in each State, including a description of the condition of those assets
- Asset management objectives and measures
- Performance gap identification
- Life cycle cost and risk management analysis
- Financial plan
- Investment strategies

This document provides all of these elements required for NHS bridges and pavements. The NHS is a federal designation for a system of roadways that are important to the nation's economy, strategic defense, and overall mobility and includes the following subsystems of roadways: Interstate, Other Principal Arterials, Strategic Highway Network (STRAHNET), Major Strategic Highway Network Connectors, and Intermodal Connectors. The NHS was developed by the US Department of Transportation in cooperation with the states, local officials and metropolitan planning organizations (MPOs).

As required in Title 23 Code of Federal Regulations Part 515, each state must develop an initial TAMP by April 30, 2018, for all bridges and pavements on the NHS. The next TAMP is due June 30, 2019 and then every four years following.

Agency Overview

CTDOT owns, operates and maintains a multi-modal transportation network comprised of highway assets and transit assets. CTDOT owns and maintains the entire Interstate System in Connecticut and approximately 95% of the non-Interstate NHS. CTDOT also owns and maintains all bridges and pavements on the State Highway System. CTDOT also owns or subsidizes nearly all of the Connecticut's public transportation services, including commuter rail, bus, bus rapid transit, paratransit, and ferry service.

According to the CTDOT Transportation Fast Facts 2015: 87% of Connecticut's labor force commuted to work as motorists while 5% used public transportation; 31.1 billion Vehicle Miles Traveled (VMT) on our roadways, of which 25 million miles (0.08% of the VMT) were traveled by buses. The breakdown of commuters by mode of travel is shown in Table 1-1.

Table 1-1. Connecticut Commuters by Mode

	% Use by Commuters	Number of Commuters
Motorists	87%	1,571,808
Bus	2.57%	46,432
Rail	2.43%	43,902
Other	8%	144,534

Agency Structure Regarding TAM

Organizational alignment and support for TAM is a key element for program success. The TAMP-building and updating process itself brings together the agency's stakeholders, disciplines, and business processes to work towards a common understanding of the TAM mission and objectives.

TAM Mission

CTDOT uses a risk-based, data-driven process to maximize transportation performance and user experience, to prioritize resources, and to optimize treatments and costs over the life cycle of an asset for the state's multimodal transportation system.

TAM Objectives

- Attain the best asset conditions achievable given available resources, while striving towards a State of Good Repair
- Deliver an efficient and effective program to optimize the life of our infrastructure
- Improve communication and transparency regarding decisions and outcomes
- Achieve and maintain compliance with Federal requirements regarding asset management

CTDOT is organized into five bureaus: Engineering & Construction; Finance & Administration; Highway Operations; Policy & Planning; and Public Transportation. The Bureau of Engineering & Construction leadership initiated this effort to implement TAM and develop a TAMP to improve decision-making processes throughout the agency. A memorandum from Commissioner James Redeker on February 26, 2013 outlined the organizational framework for an Asset Management System at CTDOT in Appendix A. Note that the memo references a draft organization chart for TAM development. The original draft organization chart is now obsolete; the current organization chart is included as Figure 1-1.

As part of this effort, CTDOT designated key TAM roles, formed a TAM Steering Committee, staffed a Transportation Asset Management Group, and identified asset stewards and asset working groups. The current agency structure for TAM is presented in Figure 1-1.

The Agency Sponsor for TAM is the Deputy Commissioner of Transportation and Chief Operating Officer. The Agency Chairperson for TAM is the Division Chief of Facilities and Transit.

The TAM Steering Committee includes representatives from the Commissioner's Office and all five bureaus: Engineering, Finance & Administration, Highway Operations, Public Transportation, and Policy & Planning. The role of each member of this committee is to support TAM and recognize the value of TAM for CTDOT and the state. The Committee acts as a liaison to bureaus and divisions to ensure that each area's interests are properly represented and to ensure each area is supporting the TAMP and TAM initiatives.

The Transportation Asset Management Group operates in the Office of Engineering in the Bureau of Engineering and Construction. The Transportation Asset Management Group was created as a result of the Commissioner's commitment toward implementing an asset management philosophy within CTDOT. The group includes a TAM Implementation Lead and three additional support staff to assist in developing an asset management strategy for each asset. The strategy is focused on obtaining and maintaining each asset in a SOGR. This group is responsible for:

- Developing and implementing the CTDOT's TAMP to ensure CTDOT's compliance with all Federal requirements
- Coordinating asset management activities with asset stewards
- Facilitating progress towards improving asset conditions, inventories and data sharing capabilities
- Acting as liaisons and facilitators for each Asset Working Group, in assisting the group in meeting its asset goals and objectives

An individual asset steward has been identified for each asset. The steward:

- Is a "Champion" for the Asset (defend, support and promote the asset)
- Leads the Asset Working Group
- Facilitates the exchange of information
- Supports development and implementation of the TAMP for their asset
- Serves as the asset's primary contact
- Responsible for compiling and submitting performance measure data on the asset
- Oversees internal and external asset data needs

Asset Working Groups for each asset were convened as part of the interview and workshop processes early on in the TAMP building process. Working Group members were designated based on their function, expertise and experience with regard to a particular asset. Within each working group, membership is targeted to include strategic, operational and data-oriented perspectives. These members play a vital role in providing technical guidance throughout the asset's life cycle. As the asset management process matures, it is envisioned that the working group

members will support the asset stewards in achieving and maintaining a SOGR and meet regularly (quarterly or semi-annually, depending upon the asset) to address:

- State of the asset
- Inventory and condition
- Performance targets
- Best practices to meet Connecticut needs
- Advancements in knowledge in life-cycle or technology

The Bureau of Public Transportation has a Public Transportation Asset Management Sub-Group internally within its organization that reports to the Public Transportation Transit Manager. The Public Transportation Asset Management Sub-Group is currently preparing the Federal Transit Administration (FTA) TAMP. The Transportation Asset Management Group in the Bureau of Engineering and Construction provides technical guidance and support to this unit.

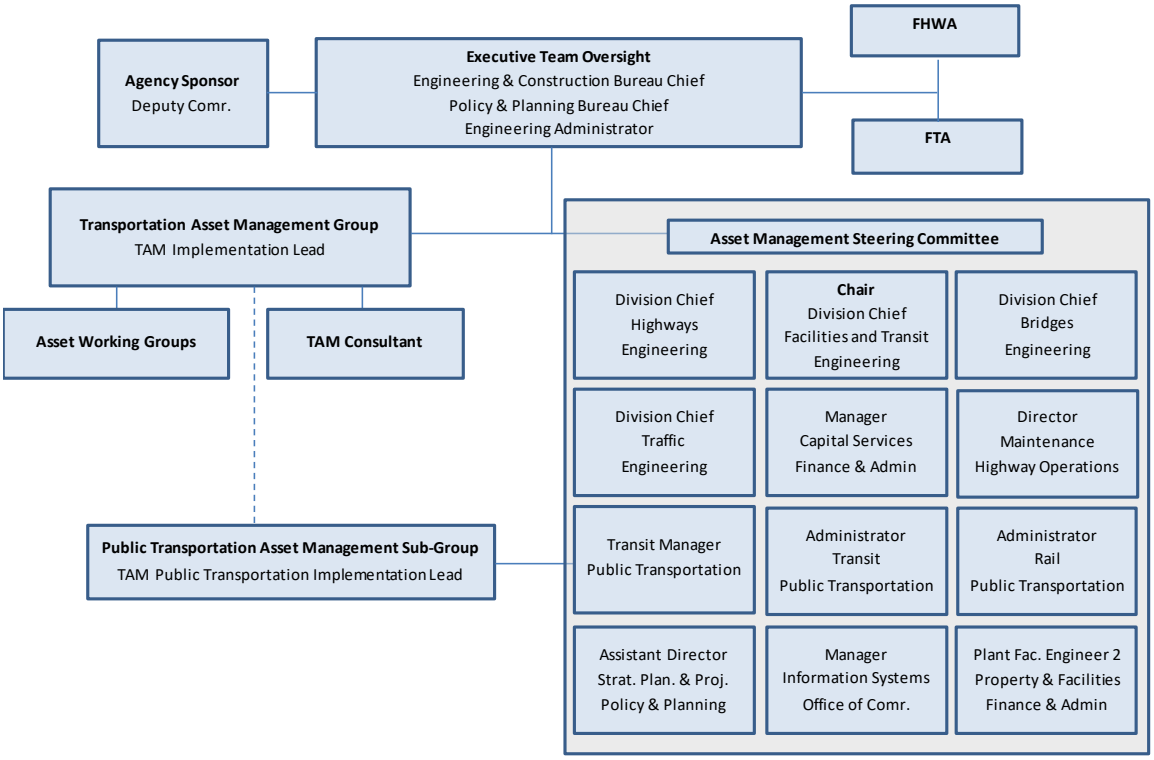


Figure 1-1. CTDOT TAM Organizational Structure

TAMP

Purpose of the TAMP

The TAMP is a federally-required document intended to document TAM practices and processes at CTDOT. A key TAM objective is making data-driven investment decisions to meet federal requirements and make progress towards state goals. TAM will help CTDOT maintain the transportation system in a SOGR with the most efficient use of financial resources.

Scope of the TAMP

While the FHWA TAMP rules outlined in MAP-21/FAST Act require reporting on NHS bridges and pavements, Connecticut's transportation system includes other assets. For this initial Highway TAMP, CTDOT is including traffic signals, signs, sign supports, and pavement markings in addition to all of its state-maintained network of pavement and bridges. These four additional assets were selected to be included in the initial TAMP based on their function in guiding motorists on the road. Additional assets will be added in future versions of CTDOT's TAMP, for example buildings, guiderail, illumination, etc. The inclusion of additional assets into CTDOT's TAMP will drive the collection and use of data for better business practices and investment decisions.

TAMP

A Transportation Asset Management Plan is not just a document, but a better way of doing business.

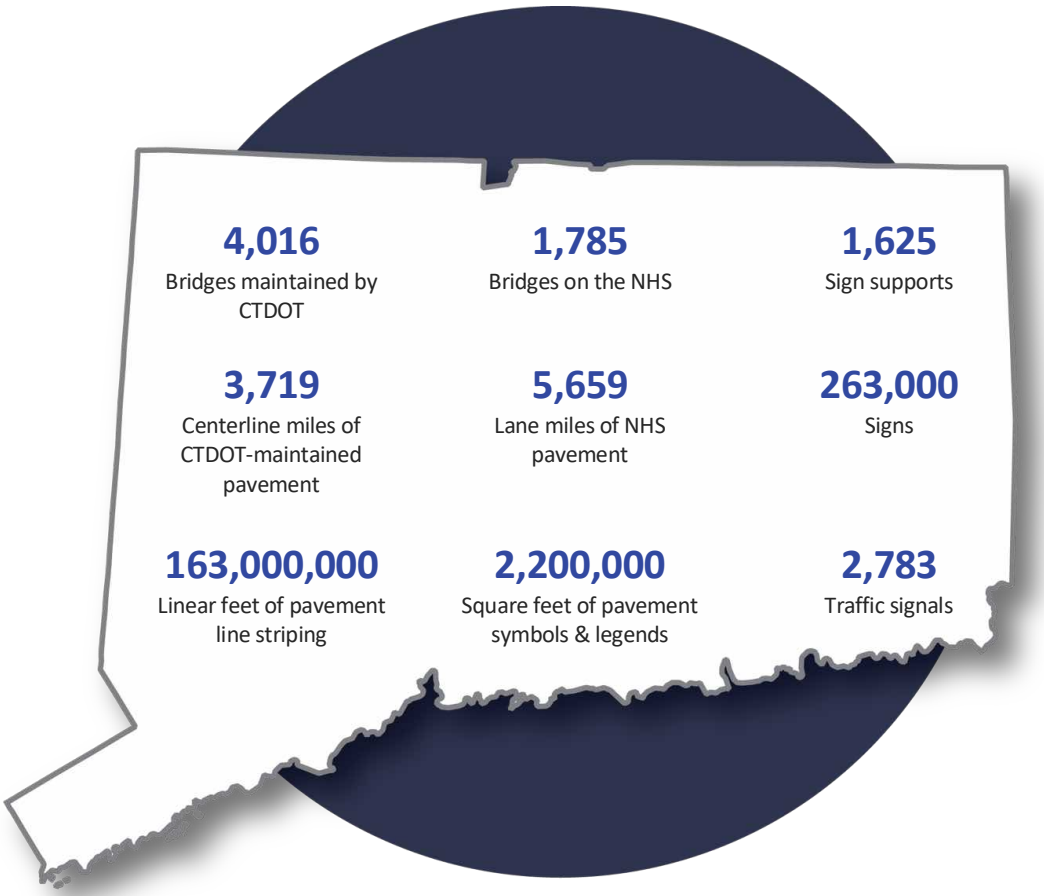


Figure 1-2. CTDOT TAMP Scope

CTDOT, a multi-modal agency, is also working on its first Transit Transportation Asset Management Plan to be completed for October 1, 2018 in accordance with Federal Transit Administration (FTA) requirements.

Awareness of other CTDOT plans, such as those listed below, is important for context and alignment with the TAMP.

Related CTDOT Plans

Transportation Infrastructure Capital Plan Report
http://www.ct.gov/dot/cwp/view.asp?a=1383&Q=454340

Let's Go CT!
http://www.transformct.info

Statewide Transportation Improvement Program
http://www.ct.gov/dot/cwp/view.asp?a=3529&q=447186

Statewide Long-Range Transportation Plan
http://www.ct.gov/dot/cwp/view.asp?a=1383&q=259760

Strategic Highway Safety Plan
http://www.ct.gov/dot/lib/dot/documents/dsafety/shsp.pdf

State Freight Plan
http://www.ct.gov/dot/cwp/view.asp?a=4719&Q=561266

State Rail Plan
http://www.ct.gov/dot/cwp/view.asp?a=1386&q=437648

Statewide Bike & Pedestrian Plan
http://www.ct.gov/dot/cwp/view.asp?a=1390&q=259656

Public Transportation Asset Management Plan
(under development)

TAMP Building Process

A wide range of CTDOT organizational units and the Federal Highway Administration (FHWA) were involved in the development of this TAMP. The TAMP building process began in April 2015. After documenting the TAM organizational framework and developing a detailed schedule of activities, the next step was to document the existing asset management-related business processes. A strategic series of interviews were conducted at the start of the process to gain understanding of the current state of TAM practice. This was followed by a set of interactive workshops that provided targeted input and guidance for key elements of the TAMP.

Six workshops were held and their subject matter was closely aligned with MAP-21 TAMP requirements. The TAMP workshop schedule is shown in Figure 1-3.

Figure 1-3. TAMP Workshops and Dates

Documents produced during these initial stages laid the foundation for the writing of the TAMP. Asset fact sheets were also developed as part of the TAMP building process to provide quick reference summaries for each asset highlighting the asset's inventory and condition, objectives and performance and life cycle planning. These asset fact sheets are in Appendix B.

TAM is an ongoing process that will be evaluated annually for targets and implementation progress. This TAMP is a living document that will be reviewed, updated and submitted to FHWA for certification every four years.

Plan Updates

A TAMP is a living document that will be reviewed, updated, and submitted to FHWA for certification every four years.

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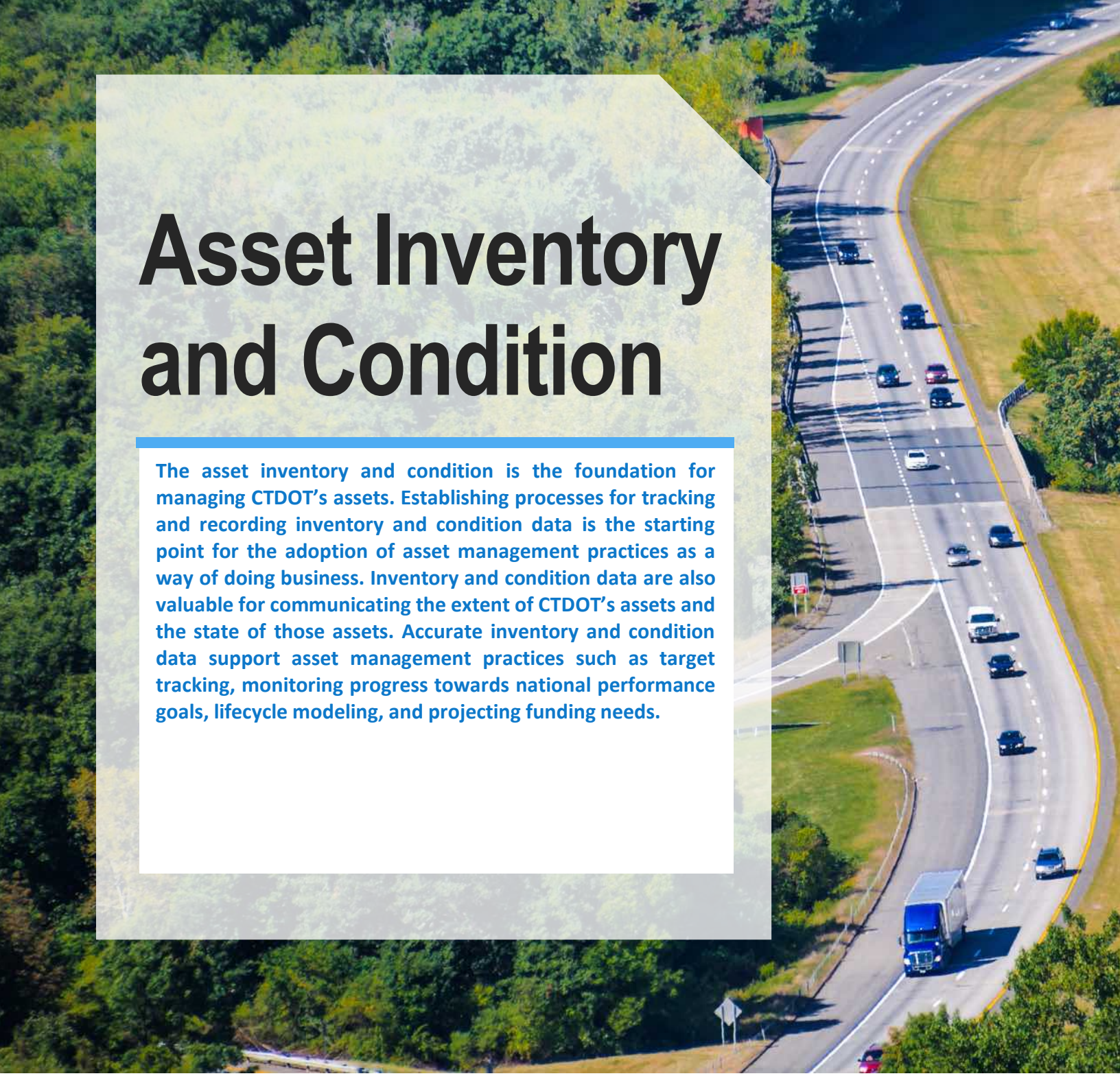


Asset Inventory and Condition

The asset inventory and condition is the foundation for managing CTDOT's assets. Establishing processes for tracking and recording inventory and condition data is the starting point for the adoption of asset management practices as a way of doing business. Inventory and condition data are also valuable for communicating the extent of CTDOT's assets and the state of those assets. Accurate inventory and condition data support asset management practices such as target tracking, monitoring progress towards national performance goals, lifecycle modeling, and projecting funding needs.

CHAPTER 2

Connecticut Department of Transportation
TRANSPORTATION ASSET MANAGEMENT PLAN

Overview

This chapter presents summary information on asset inventory and condition. Connecticut's TAMP addresses assets on state-maintained roads, as well as bridges and pavements on the NHS maintained by CTDOT and other entities. To comply with federal requirements, bridges and pavements will be reported separately for those on the NHS.

Federal Legislative Context

FHWA requires that a state's TAMP include a summary listing of NHS pavements and bridges, including a description of asset condition. FHWA identifies NHS pavements and bridges as Interstate System pavements; NHS pavements (excluding the Interstate System); and NHS bridges on the National Bridge Inventory (NBI) carrying the NHS. Interstate pavements are part of the Interstate Highway System, a highway network which is part of the NHS.

States may include other assets or systems in their TAMP. If a state chooses to include additional assets, those assets must be included in all of the TAMP processes: inventory and condition, performance measures, targets, performance gap analysis, life cycle planning, risk management, financial planning, and investment strategies.

In addition to providing inventory and condition data, states must also have documented procedures for collecting, processing, storing, and updating inventory and condition data for NHS pavement and bridge assets. States are required to use bridge and pavement management systems that, in addition to other capabilities, collect, process, store, and update inventory and condition data.

Connecticut TAMP Assets

Connecticut's transportation system consists of a wide variety of physical assets, as depicted in Figure 2-1. The most significant assets on the system (in terms of their cost and extent) are bridges and pavement. Connecticut's TAMP also includes the following CTDOT maintained assets: traffic signals, signs, sign supports, and pavement markings.

Note that many other assets are needed to improve safety and support mobility besides these. In many cases, replacement or rehabilitation of roads and bridges includes replacement or upgrades to other additional assets depicted in Figure 2-1. For instance, the cost of reconstructing or replacing a bridge includes the cost of guiderail, and pavement projects often include upgrades to associated traffic and safety assets.

National Highway System (NHS)

The NHS is a system of roadways which includes the Interstate Highway System and other roads important to the nation's economy, strategic defense and overall mobility.

The NHS was developed by the US Department of Transportation in cooperation with the states, local officials and metropolitan planning organizations (MPOs).

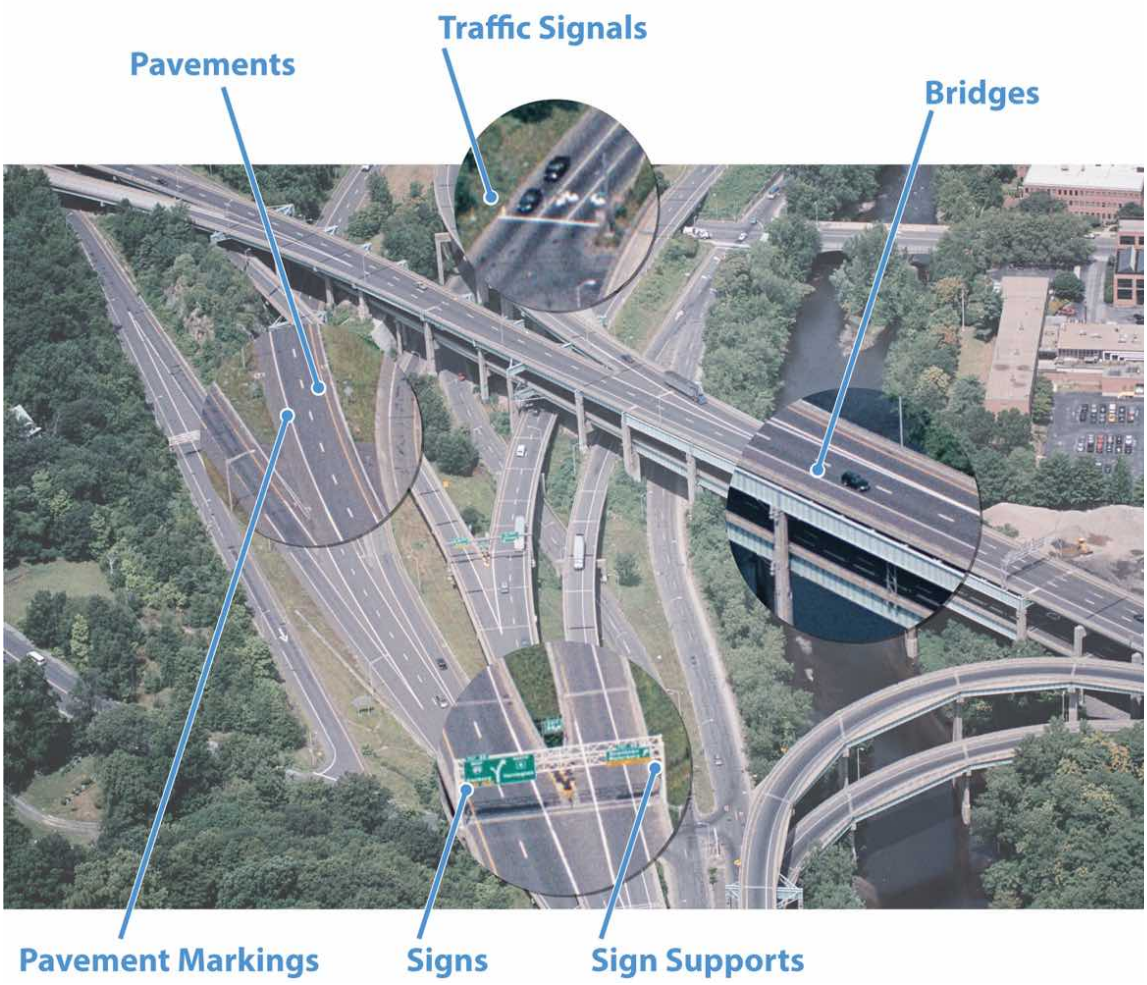


Figure 2-1. Highway Assets in the CTDOT TAMP

This plan addresses assets on two overlapping highway systems: CTDOT-maintained assets and the NHS. CTDOT-maintained assets include all assets within the state highway network. The NHS is primarily composed of CTDOT-maintained roads. However, 145 miles of the NHS is locally maintained. Table 2-1 summarizes the federal and state reporting included in the TAMP.

Table 2-1. Federal and State TAMP Reporting

Asset	NHS Assets Included To Meet Federal Requirements	Additional CTDOT-Maintained Assets Included
Bridges	✓	✓
Pavements	✓	✓
Traffic Signals		✓
Signs		✓
Sign Supports		✓
Pavement Markings		✓

Throughout the remainder of the TAMP document, asset information is summarized in two ways: for the entire CTDOT-maintained system (portions of which are on the NHS), and for the entire NHS (which includes a portion of the state system and a portion of the local system). For bridges and pavement, this means that both federal and state performance measures and data are included. For the four additional assets, only CTDOT performance measures and data are used. This approach is used to provide a complete picture of CTDOT-maintained assets, as well as to meet federal requirements for including all NHS bridges and pavement in the TAMP.

Connecticut's Transportation System Summary

The NHS in Connecticut consists of

- 1,442 centerline miles of pavement
- 1,785 bridges totaling 26,270,638 square feet of bridge deck area

Note: The other assets are not broken out by their NHS designation.

For the purposes of the TAMP, the CTDOT-maintained system consists of

- 3,719* centerline miles of pavement
- 4,016 bridges
- 2,783 traffic signals
- 263,000 signs
- 1,625 sign supports
- Pavement markings
  - 163,000,000 linear feet of pavement lines
  - 2,200,000 square feet of pavement symbols

*Note: The CT Public Road mileage is 4,136 centerline miles which includes 417 centerline miles of public roads that are not under CTDOT's purview for pavement condition.

The NHS in Connecticut is shown in Figure 2-2.

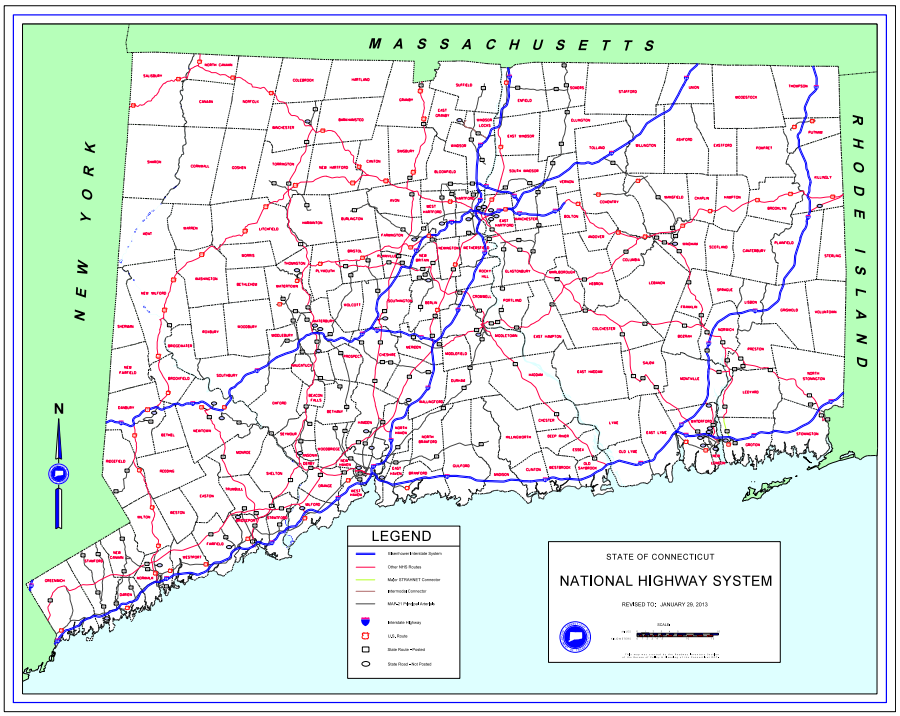


Figure 2-2. NHS in Connecticut

The State highway network is shown below in Figure 2-3.

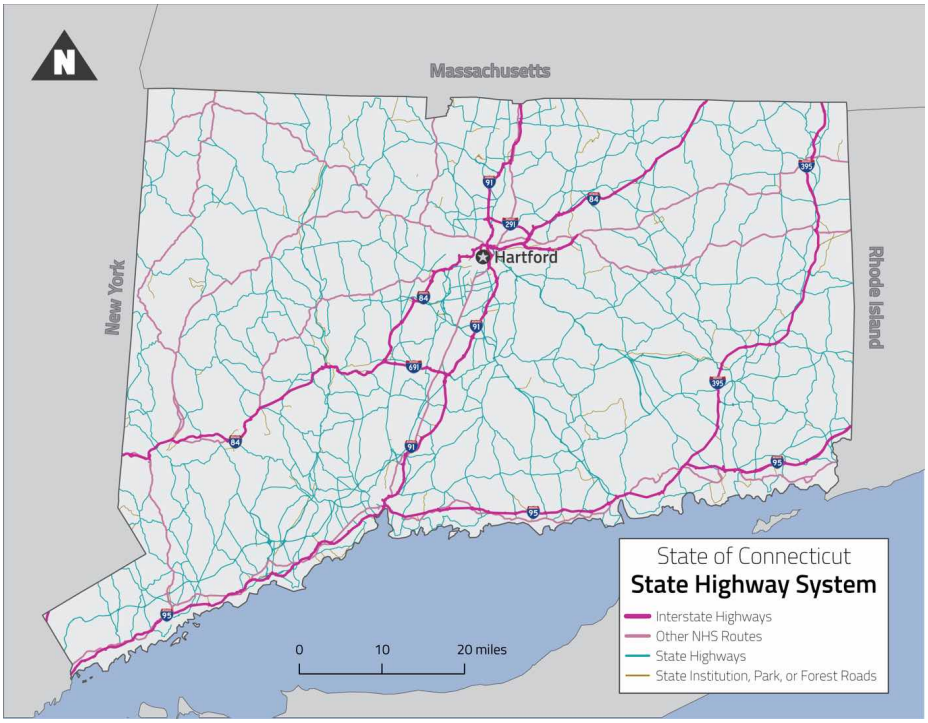


Figure 2-3. Connecticut's State Highway Network

Monitoring and measuring transportation asset conditions enables CTDOT to assess the performance of the transportation system, analyze deficiencies and predict future needs, allocate funding, and schedule projects in order to address the SOGR. Asset condition is also an important public-facing measure. Users of the transportation network notice and experience asset condition every day and recognize changes in asset condition. Further, public trust and confidence is bolstered when objective measurable results can be demonstrated from increased public investment. For depicting NHS conditions, this TAMP uses definitions of good, fair, and poor condition developed by the FHWA and required for use in the TAMP. CTDOT also tracks State performance measures on the CTDOT-maintained system for bridges, pavement, traffic signals, signs, sign supports, and pavement markings. Table 2-2 summarizes asset inventory and conditions in Connecticut for the six asset classes of this TAMP. The table is organized by system and by asset class. This TAMP uses bridge data reported by CTDOT to the NBI and NHS pavement data reported by CTDOT to the Highway Performance Management System (HPMS) for the NHS inventory and condition values.

Communication

The TAMP is a valuable tool to communicate needs and to advocate for resources.

Table 2-2. Inventory and Conditions for Assets in the TAMP

NHS	Inventory	Good	Fair	Poor
Bridges	26,270,638 Square feet of deck area	18.1%	66.9%	15.0%
Pavement *	5,514 Lane miles	48.4%	45.4%	6.2%
CTDOT-Maintained	**Inventory**	**Good**	**Fair**	**Poor**
Bridges	4,016 Bridges	27.4%	66.4%	6.2%
Pavement **	3,719 Centerline miles	60.6%	32.5%	6.9%
Traffic Signals	2,783 Assets	34.8%	36.8%	28.4%
Signs (approximate inventory)	263,000 Assets	31.1%	9.5%	59.4%
Sign Supports	1,625 Assets	46.2%	52.6%	1.2%
		State of Good Repair		**Poor**
Pavement Markings *** (estimated by assumptions)	163,000,000 Linear feet of pavement lines	29.8%		70.2%
	2,200,000 Square feet of pavement symbols	63.6%		36.4%

*Note: The Good, Fair, and Poor percentages were calculated using MAP-21/Fast Act. The percentages were based only on available pavement condition data and do not include NHS concrete pavements and less than 0.5% (~22 lane miles) of the NHS pavement condition data not available due to construction, etc.

**Note: These Good, Fair and Poor percentages were calculated using CTDOT's Pavement Condition Index. Less than 0.5% of the pavement condition data for CTDOT-maintained pavement was not available due to construction, etc. and for purposes of this TAMP, these 15 centerline miles were considered in Fair condition.

***Note: Pavement marking inventory and condition is simply reported in State of Good Repair and Poor based on age. Assumptions did not consider a detailed good and fair condition breakdown for this TAMP.

Bridge

The FHWA defines a bridge as a structure at least 20 feet in length or greater to be on the NBI. In addition to the FHWA designation, CTDOT has also expanded the bridge classification to include all structures 6 feet in length or greater, including culverts. For purposes of this TAMP, all NHS bridge references and measures use the FHWA NBI bridge designation; whereas all CTDOT bridge references and measures use the expanded bridge classification.

Bridges provide road network connectivity, spanning water bodies and other natural features, rail lines, and other roadways. New bridges are designed to last at least 75 years, and in practice, many bridges remain in service for much longer. However, bridges require periodic maintenance to replace individual components (such as decks) that have a shorter life than the bridge as a whole. If preservation work on a bridge is deferred, then deterioration may accelerate to the point where more costly repairs are needed. In some cases, deteriorated conditions may require restricting the loads the bridge can carry or closing the bridge until needed repairs are complete–which can mean extensive detours for road users. Thus, maintaining bridges in good condition pays off, resulting in the lowest long-term costs both to transportation agencies and road users. Bridges in good condition allow access to essential services and have a positive impact on the economy.

Bridge Performance Measures

FHWA has established two measures of bridge condition:

- Percentage of NHS bridges classified in good condition (weighted by deck area)
- Percentage of NHS bridges classified in poor condition (weighted by deck area)

FHWA requires that states use the above measures in their TAMPs to describe condition, set targets, and analyze performance gaps of NHS bridges. Note that if a bridge is not in good or poor condition, it is deemed to be in fair condition.

National Bridge Inventory (NBI)

The NBI is a database that includes all bridges longer than 20 feet and on a public road.

CTDOT follows FHWA NBI standards for inspecting all Connecticut bridges. Inspectors record overall ratings for a bridge's deck, superstructure and substructure on a scale from 0 (failed) to 9 (excellent). Structures classified as culverts are included in the NBI inventory if they span more than 20 feet. For these structures, a single culvert rating is recorded using the same 0-9 scale.

Bridge condition ratings are used to classify the bridge as being in good, fair or poor condition. The lowest of the three ratings for deck, superstructure and substructure (or a culvert rating for a culvert) determines the overall rating of the bridge. If this value is 7 or greater, the bridge is classified as being in good condition. If it is 5 or 6, the bridge is classified as being in fair condition, and if it is 4 or less, the bridge is classified as being in poor condition. A bridge in poor condition is considered Structurally Deficient. Thus, if any major component is classified as being in poor condition, the bridge will be considered Structurally Deficient. Note that the fact that a bridge is classified as Structurally Deficient does not imply that the bridge is unsafe, just that deficiencies have been identified that require maintenance, rehabilitation or replacement. A graphical depiction of the three bridge components is shown in Figure 2-4.

Bridge Condition: NBI Ratings and Good/Fair/Poor Classification		
9	Excellent	GOOD
8	Very Good	
7	Good	
6	Satisfactory	FAIR
5	Fair	
4	Poor	POOR
3	Serious	
2	Critical	
1	Imminent Failure	
0	Failed	

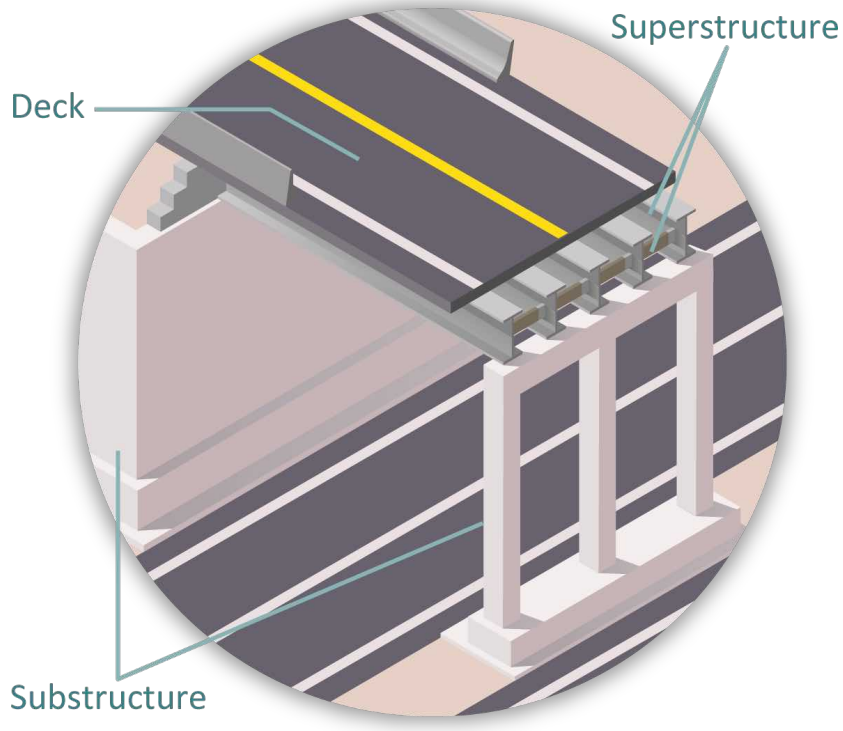


Figure 2-4. Bridge Components

In addition to the federal performance measures above, CTDOT has adopted a Good, Fair, and Poor condition rating system for state-maintained bridges using the same deck, superstructure, substructure, and culvert ratings described previously. CTDOT defines a bridge as a crossing of at least six feet in length, including culverts.

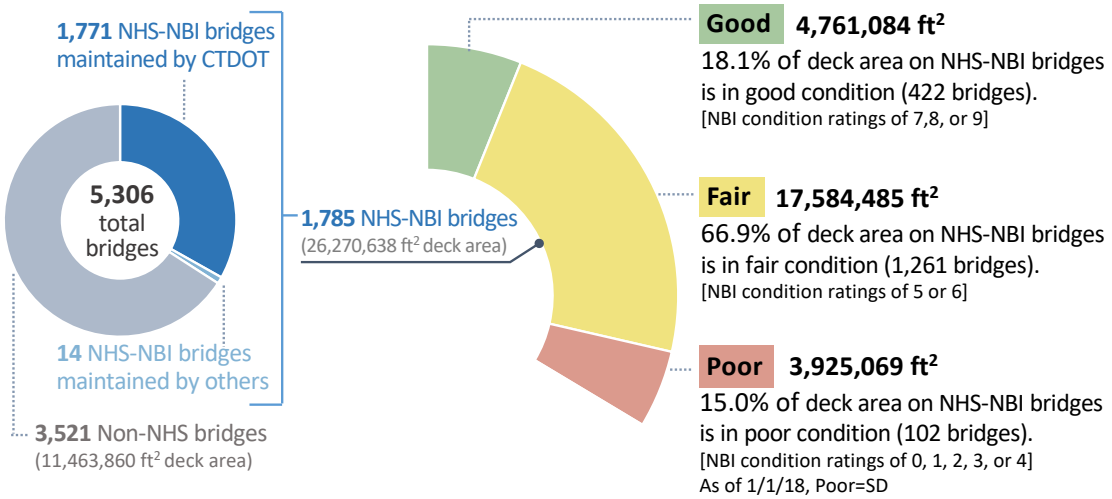
CTDOT's performance measure for CTDOT-maintained bridges is the percent of CTDOT-maintained bridges in a SOGR. A bridge for which the NBI rating is 5 or greater is classified by CTDOT as being in a SOGR. CTDOT's measure for 4,016 CTDOT-maintained bridges is based on the number of bridges, unlike FHWA's required measure which is based on total bridge deck area for 1,785 NHS bridges. CTDOT bases their measure by number of bridges rather than by deck area since the number of bridges is a more appropriate representation of the network condition. In Connecticut, a measure by deck area can disproportionately represent the network based on a few large sized bridges.

Bridge Condition: NBI Ratings and State of Good Repair	
9 Excellent	SOGR
8 Very Good	
7 Good	
6 Satisfactory	
5 Fair	
4 Poor	
3 Serious	
2 Critical	
1 Imminent Failure	
0 Failed	

Inventory and condition data for bridges are gathered through the bridge inspection process. The data are stored in the Structure Management System (SMS) using customized InspectTech software and updated based on inspections, which happen most commonly on a biennial cycle. CTDOT reports on the condition of the NBI to FHWA on an annual basis. Asset data management is discussed in greater detail in Chapter 3.

Bridge Inventory and Conditions

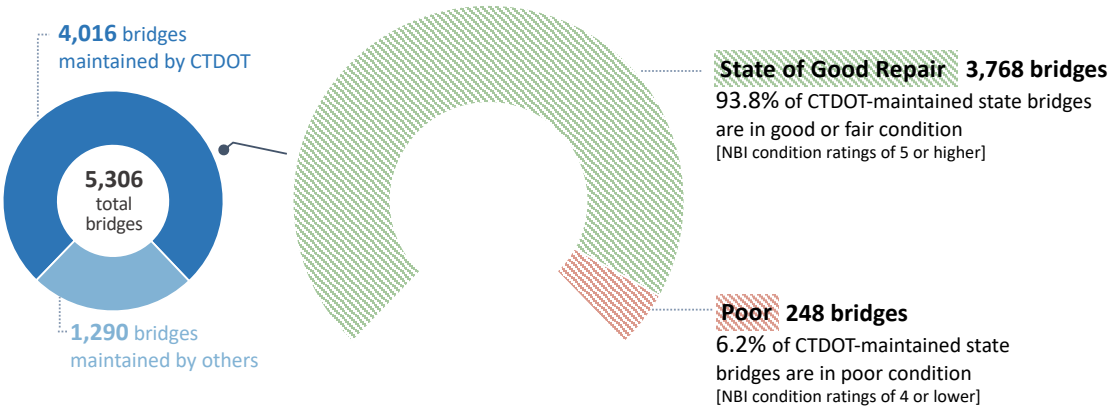
CTDOT inspects a total of 5,306 roadway bridges, including all of Connecticut's NBI bridges (20 feet or longer) and all of CTDOT's bridges (6 feet or longer). Of this total, 1,785 are NBI bridges on the NHS, and 4,106 are maintained by CTDOT. Figure 2-5 summarizes the NHS-NBI bridge inventory and its condition in Connecticut.



Based on CTDOT 3/31/17 NBI Submittal

Figure 2-5. NHS-NBI Bridge Inventory and Conditions

Figure 2-6 shows the inventory and condition of CTDOT-maintained bridges.



Based on CTDOT 3/31/17 Snapshot

Figure 2-6. CTDOT-Maintained Bridge Inventory and Conditions

Bridge Asset Valuation

For the purposes of this TAMP, the estimated value of the 5,306 CTDOT-inspected bridges is $15.9 billion. Asset valuation is discussed in further detail in Chapter 7.

Pavement

Pavement is the layered structure that forms the road. Pavements are designed to support anticipated traffic loads and provide a safe and relatively smooth driving surface. Maintaining pavements in good condition lengthens their life, enhances safety, helps reduce road users' operating costs, and reduces vehicle emissions. On the other hand, rough roads cause more wear and tear on vehicles, increasing user costs.

A typical pavement structure is shown below in Figure 2-7.

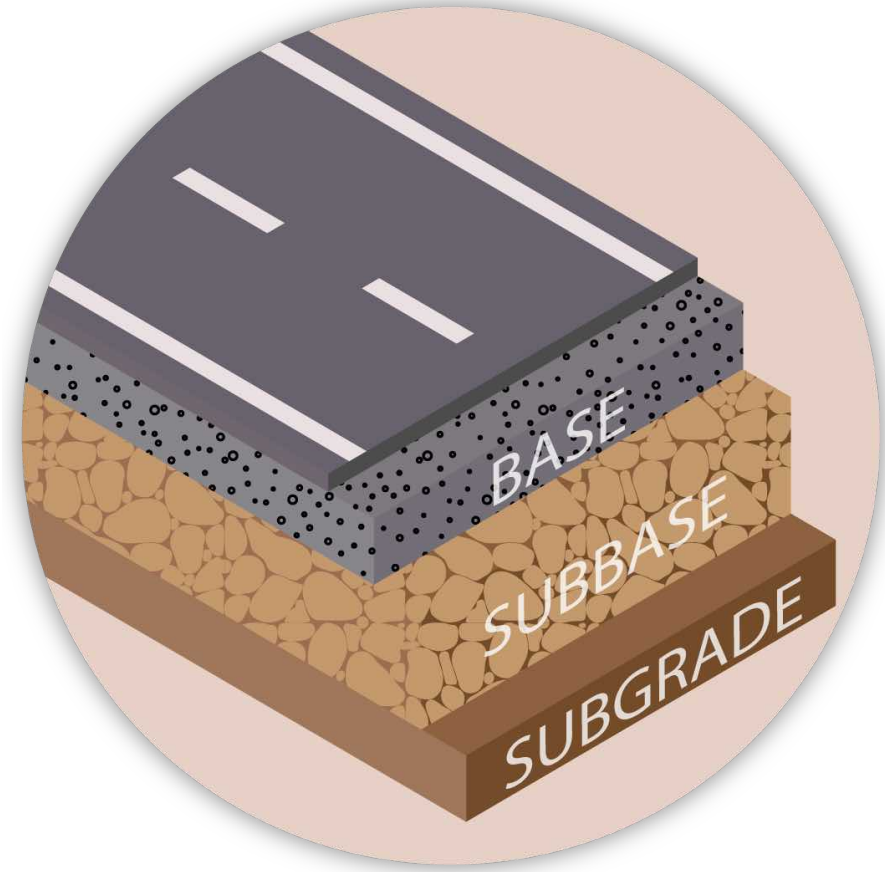


Figure 2-7. Pavement Structure

Centerline Miles vs Lane Miles

A centerline mile is a measure of the total length (in miles) of highway facility in-place or proposed, as measured along the highway centerline.

A lane-mile is a measure of the total length of traveled pavement surface.

Lane-miles equate to the center-line length (in miles) multiplied by the number of lanes.

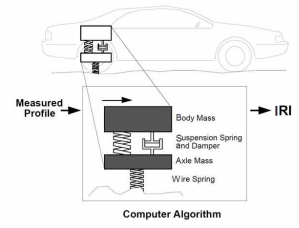
Pavement Performance Measures

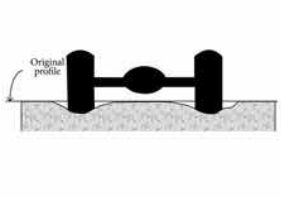
CTDOT has adopted FHWA's four pavement condition performance measures for NHS pavements:

- Percentage of pavements on the Interstate System in Good condition
- Percentage of pavements on the Interstate System in Poor condition
- Percentage of pavements on the NHS (excluding the Interstate System) in Good condition
- Percentage of pavements on the NHS (excluding the Interstate System) in Poor condition

Each of the performance measures are calculated based on data reported to the HPMS.

For asphalt pavements, the following metrics are used to calculate the pavement condition performance measures:





1

International Roughness Index (IRI) is an indicator of pavement roughness experienced by road users traveling over the pavements, and is computed from a single longitudinal profile.

Rutting is quantified for asphalt pavements by measuring the depth of ruts along the wheel path. Rutting is commonly caused by a combination of high traffic volumes, heavy vehicles and the instability of the pavement mix.

Cracking is measured in terms of the percentage of cracked pavement surface. Cracks can be caused or accelerated by aging, loading, poor drainage, frost heaves or temperature changes, or construction flaws.

For concrete pavements, in addition to IRI described for asphalt pavements, faulting and cracking are used to calculate the pavement condition performance measures. Faulting is computed as the average vertical misalignment of adjacent slabs. Cracking in concrete pavements is measured

1 The Little Book of Profiling, M. Sayers and S. Karamihas, University of Michigan, 1998

as the percentage of slabs in the section that exhibit cracking. Only 0.5% of pavements in Connecticut are concrete surface.

For each of the above metrics, FHWA has established thresholds for good, fair and poor condition. These thresholds are summarized in Table 2-3. The pavement condition metrics are used to calculate the FHWA performance measures for pavement condition. Conditions are assessed using these criteria for each 1/10-mile long pavement section. An individual section is rated as being in good overall condition if all of the metrics are rated as good, and poor when two or more are rated as poor. All other combinations are rated as fair. The lane miles in good, fair and poor condition are tabulated for all sections to determine the overall percentage of pavement in good, fair and poor condition.

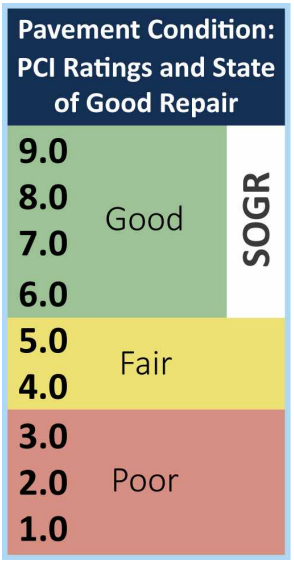
Table 2-3. Pavement Condition Thresholds

Metric	Good	Fair	Poor
IRI (inches/mile)	<95	95-170	>170
Rutting (inches)	<0.20	0.20-0.40	>0.40
Cracking (%)			
- Asphalt	<5	5-20	>20
- Jointed Concrete	<5	5-15	>15
- Continuously Reinforced Concrete	<5	5-10	>10
Faulting (inches)	<0.10	0.10-0.15	>0.15

In addition to using the above federally-required measures for NHS pavements, CTDOT uses a Pavement Condition Index (PCI) to measure the condition of all CTDOT-maintained pavements. PCI is calculated for each 0.1 mile segment based on five metrics, including three of the FHWA metrics noted previously. The overall PCI is a weighted average of the following metrics, with each metric weight shown in parentheses:

- IRI (10%)
- Rutting (15%)
- Cracking (25%)
- Disintegration (30%)
- Drainage (20%)

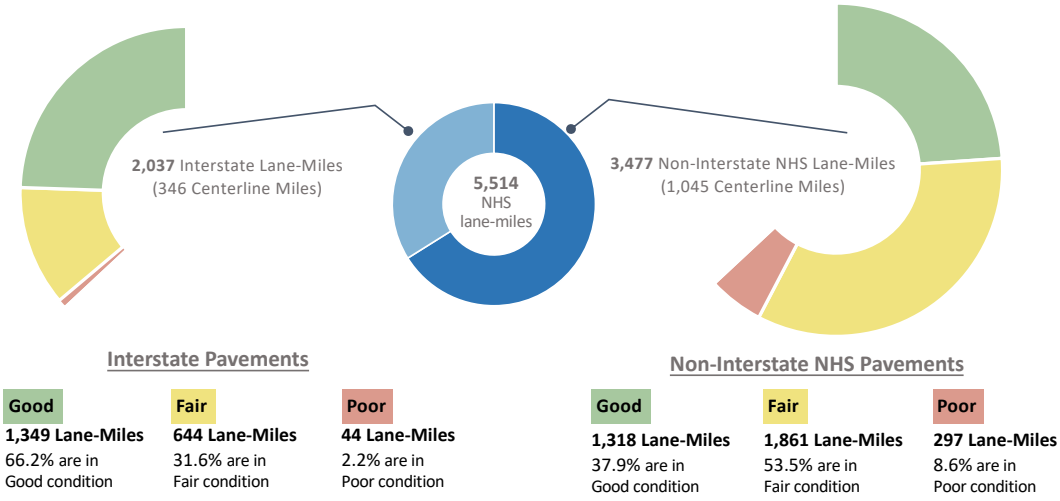
IRI, Rutting and Cracking are the same as the FHWA metrics described earlier in this section. Disintegration is the wearing away of the pavement surface caused by the dislodging of aggregate particles and loss of asphalt binder. The disintegration metric is estimated using the pavement age. Drainage refers to the ability of the surface of the roadway to drain and uses the collected cross slope and grade of the roadway to compute the drainage metric.



The PCI is scaled from 1.0 to 9.0, with 9.0 describing a pavement without defects. Within this scale, roadways with a PCI less than 4.0 are classified in "Poor" condition, those between 4.0 and less than 6.0 are in "Fair" condition, and 6.0 to than 9.0 PCI indicates "Good" condition. A pavement section for which the PCI is 6 or greater is classified as being in a SOGR. CTDOT's performance measure for CTDOT-maintained pavement is the percentage of centerline miles in a SOGR.

Pavement Inventory and Conditions

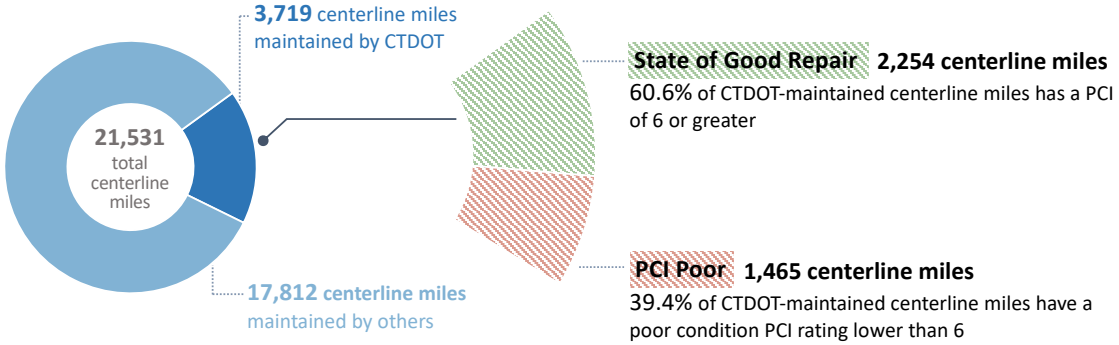
The pavement inventory is organized by system, divided into NHS and state highway network pavements. The NHS is further broken down into Interstate and Non-Interstate NHS pavements. Figure 2-8 shows current inventory and conditions on CTDOT-maintained NHS.



Based on CTDOT 6/15/17 HPMS Submittal

Figure 2-8. NHS Pavement Inventory and Conditions

Figure 2-9 shows current inventory and conditions of CTDOT-maintained pavements.



Based on CTDOT 6/15/17 Snapshot

Figure 2-9. CTDOT-Maintained Pavement Inventory and Conditions

Pavement Asset Valuation

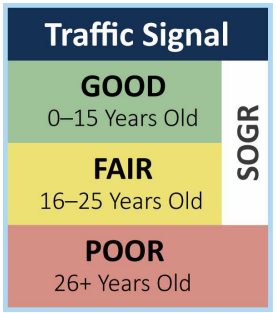
For the purposes of this TAMP, the estimated value of the 3,719 centerline miles of CTDOT-maintained pavement is $8.4 billion. Asset valuation is discussed in further detail in Chapter 7.

Traffic Signals

CTDOT defines a traffic signal unit as all traffic control equipment at a given intersection or location.

Traffic Signal Performance Measures

Traffic signal condition is currently approximated based on age. The life-cycle for a traffic signal is estimated to be 25 years based on expectations of traffic controller and signal head life with interim component replacements at varying intervals. For the purpose of the TAMP, traffic signals between 0 and 15 years old are considered to be in good condition, traffic signals between 16 and 25 years old are considered to be in fair condition, and traffic signals older than 25 years are considered to be in poor condition. A traffic signal installed within the past 25 years is classified as being in a SOGR. CTDOT intends to revise its management approach of this asset to a component level in the future.

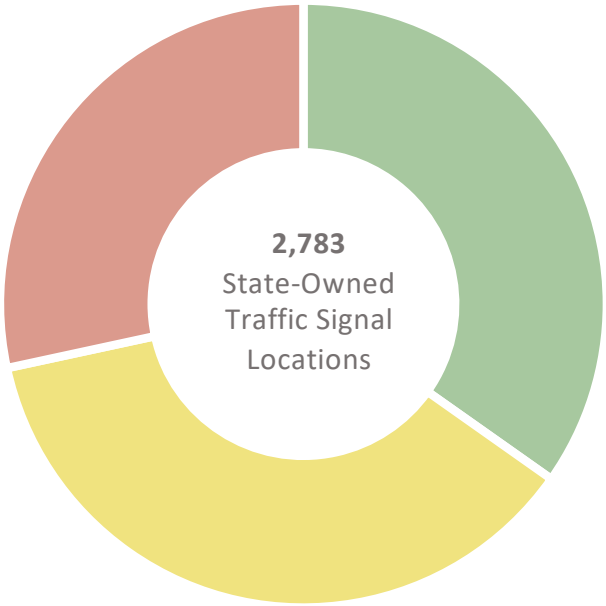


Traffic Signals Inventory and Condition

CTDOT is currently responsible for maintaining 2,783 state-maintained traffic signals:

- 2,551 traffic signals
  - 945 of the traffic signals are part of 107 computerized traffic signal systems
- 232 overhead flashing beacons
- An additional 285 signs with flashers are tracked in the traffic signal inventory. The associated signs are included under the sign asset

Figure 2-10 shows the current inventory and conditions of CTDOT-maintained traffic signals.



Good

968 Locations

34.8% are in Good condition (0-15 years old)

Fair

1,025 Locations

36.8% are in Fair condition (16-25 years old)

Poor

790 Locations

28.4% are in Poor condition (26+ years old)

Based on CTDOT 3/27/17 Snapshot

Figure 2-10. Traffic Signal Inventory and Conditions

Traffic Signal Asset Valuation

For the purposes of this TAMP, the estimated value of the 2,783 CTDOT-maintained traffic signals, including flashing beacons, is approximately $522 million. Asset valuation is discussed in further detail in Chapter 7.

Signs

CTDOT defines a sign as a panel attached to a post(s) or sign structure and a sign assembly as the combination of sign panel(s) and their post(s), support, or sign structure at a single location. For the purpose of the TAMP, the sign asset category includes all state-maintained sign panels (side-mounted and overhead) and the posts, supports and foundations for side-mounted sign panels located adjacent to a roadway. Overhead sign supports with their associated foundations are managed as a separate asset.

Signs Performance Measures

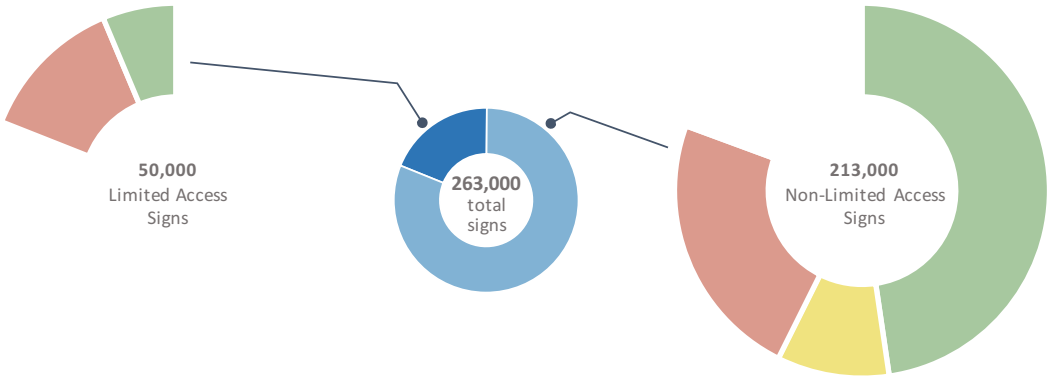
Sign condition is approximated based on age. A sign installed within the past 17 years is classified as being in a SOGR based on expectations of retroreflectivity life. Retroreflectivity is a measure of the amount of light reflected by a surface back to the source of the light.

Sign Condition		
GOOD 0–12 Years Old		SOGR
FAIR 13–17 Years Old		
POOR 18+ Years Old		

Signs between 0 and 12 years old are considered to be in good condition, signs between 13 and 17 years old are considered to be in fair condition, and signs older than 17 years are considered to be in poor condition.

Signs Inventory and Conditions

CTDOT is responsible for maintaining approximately 263,000 regulatory, warning, and guide signs that are located on state-maintained roadways. The sign asset is organized by signs located on limited access roadways and signs located on non-limited access roadways. Figure 2-11 shows the inventory and conditions of CTDOT-maintained signs.



Limited Access Signs

Good	Fair	Poor
16,667 Signs	**0 Signs**	**33,333 Signs**
33.3% are in Good condition (0-12 years old)	0% are in Fair condition (13-17 years old)	66.7% are in Poor condition (18+ years old)

Non-Limited Access Signs

Good	Fair	Poor
65,000 Signs	**25,000 Signs**	**123,000 Signs**
30.5% are in Good condition (0-12 years old)	11.7% are in Fair condition (13-17 years old)	57.8% are in Poor condition (18+ years old)

Based CTDOT 2013 Inventory

Figure 2-11. Sign Inventory and Conditions

Sign Asset Valuation

For the purposes of this TAMP, the estimated value of the 263,000 CTDOT-maintained signs is approximately $162 million. Asset valuation is discussed in further detail in Chapter 7.

Sign Support

CTDOT defines a sign support as the structure (horizontal member(s), post(s), vertical attachments and foundation) carrying sign panels or variable message boards at a single location. Overhead sign panels attached to the sign support are managed as part of the sign asset.

Sign Support Performance Measures

Sign support condition ratings are used to classify a sign support as being in good, fair or poor condition. The lowest of the ratings for the structure or the foundation determines the overall rating of the sign support. Sign support condition is measured using a 0-9 rating scale. If the overall rating is 7 or greater, the sign support is classified as being in good condition. If it is 5 or 6, the sign support is classified as being in fair condition, and if it is 4 or less, the sign support is classified as being in poor condition. Sign supports with an overall rating of 5 or better are classified as being in a SOGR. Sign support condition ratings are re-evaluated every 4 years.

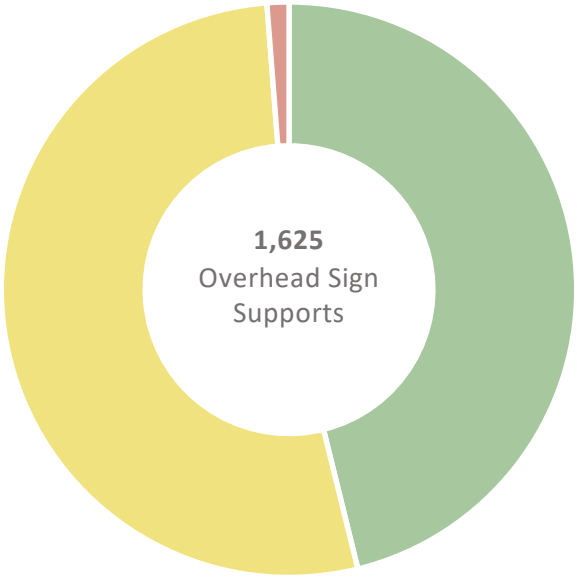
Sign Support Condition: State of Good Repair		
9	Excellent	SOGR
8	Very Good	
7	Good	
6	Satisfactory	
5	Fair	
4	Poor	
3	Serious	
2	Critical	
1	Imminent Failure	
0	Failed	

Sign Support Inventory and Conditions

CTDOT is responsible for maintaining 1,625 overhead sign supports on state-maintained roadways. The sign support inventory is made up of three categories:

- 609 Cantilevers
- 605 Full-Span
- 411 Bridge Mounted

Figure 2-12 shows the current inventory and conditions of sign supports.



Good
750 Sign Supports
46.2% are in Good condition

Fair
855 Sign Supports
52.6% are in Fair condition

Poor
20 Sign Supports
1.2% are in Poor condition

Based on CTDOT May, 2017 Snapshot
Figure 2-12. Sign Support Inventory and Conditions

Sign Support Asset Valuation

For the purposes of this TAMP, the estimated value of the 1,625 CTDOT-maintained sign supports is approximately $233 million. Asset valuation is discussed in further detail in Chapter 7.

Pavement Markings

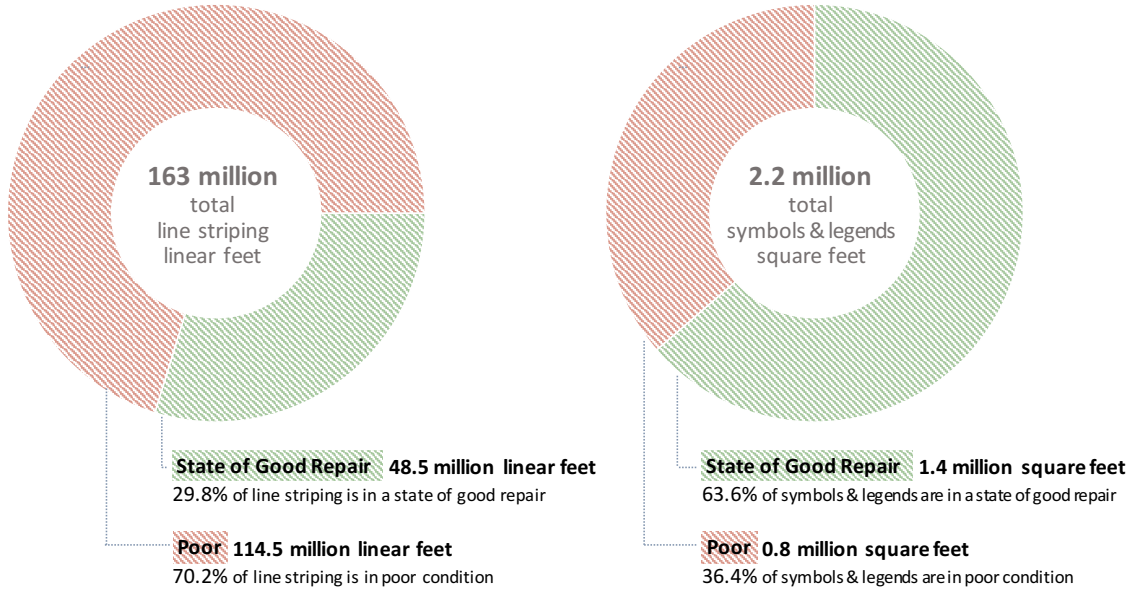
Pavement markings are organized into two categories: line striping, measured in linear feet; and symbols and legends (arrows, crosswalks, etc.), measured in square feet. Both types of pavement marking can be applied as water-based markings or epoxy markings. An additional type, in-laid pavement markings, has recently been applied. At this time, due to their limited use, they have not been broken out as a separate category in the inventory so they are assumed to be epoxy for purposes of this TAMP.

Pavement Markings Performance Measures

Epoxy pavement markings installed within the past 3 years are classified as being in a SOGR whereas water-based pavement markings installed within 1 year are classified as being in a SOGR. This is based on expectations of retroreflectivity life and wear. Epoxy pavement markings older than 3 years and water-based pavement markings older than 1 year are classified in a Poor condition. Fair condition is not defined for pavement markings.

Pavement Markings Inventory and Conditions

CTDOT is responsible for maintaining pavement markings on approximately 3,719 centerline miles of state-maintained roadways. Figure 2-13 shows the current inventory and conditions of both types of pavement markings. This inventory combines epoxy and water-based markings.



Based on CTDOT 2017 Snapshot

Figure 2-13. Pavement Markings Inventory and Conditions

Pavement Markings Asset Valuation

For the purposes of this TAMP, the estimated value of CTDOT-maintained pavement markings is approximately $90 million. Asset valuation is discussed in further detail in Chapter 7.

Summary

CTDOT is implementing TAM not only because it is federally required, but also because CTDOT recognizes that asset management is the right way to do business. Developing systems and processes to gather, record, process, and analyze asset inventory and condition data is a key initial step towards TAM. The inventory and condition data captured in this chapter helps to tell the Connecticut transportation story by outlining the extent and condition of the statewide system and NHS. Subsequent chapters complete the story by describing targets, gaps, plans, risks, and the financial details of the system.

Asset Data Management

In order to measure, analyze, track, and report asset inventory, condition, and performance, CTDOT needs consistent, high-quality, well-organized data. Data are used to support strategic and operational decision-making for TAM activities and project development. TAM activities are data reliant and include tracking performance, analyzing performance, and anticipating future needs. Developing and maintaining robust data management practices, processes, and systems will help CTDOT operate more efficiently and make progress towards state and national performance goals.

CHAPTER 3

Connecticut Department of Transportation
TRANSPORTATION ASSET MANAGEMENT PLAN

Overview

This TAMP reflects CTDOT's need for good asset data management to provide a strong foundation for transportation asset and performance management. Data management is a set of practices for specification, collection, quality assurance, standardization, integration, reporting and access to meet information needs and promote efficiency and consistency. Rather than relying on a decentralized approach in which individual units collect, store and report on data to meet their individual operational needs, CTDOT has been moving towards an enterprise approach in order to make best use of agency data for informed decision-making, as shown in Figure 3-1.

Figure 3-1. Data-Driven Decision Making

This chapter presents a summary of data management practices and processes for the six assets in the TAMP and an overview of TAM data systems used at CTDOT.

Federal Legislative Context

FHWA requires that State DOTs use the best available data to develop their asset management plans. In addition, states must use bridge and pavement management systems to support development of the asset management plan. Management systems used by State DOTs to support the asset management plan must include documented procedures for:

- Collecting, processing, storing, and updating inventory and condition data for NHS bridges and pavement
- Forecasting deterioration for NHS bridges and pavement
- Conducting life-cycle analysis of alternative strategies for NHS bridges and pavement
- Identifying short- and long-term budget needs for managing condition for NHS bridges and pavement

- Determining the optimal strategies for identifying potential projects for NHS bridges and pavement
- Recommending programs and implementation schedules to manage condition for NHS bridges and pavement

Practices and Processes

Data should be used within a well-defined set of practices and processes to maximize its value. This section summarizes asset data management practices at CTDOT such as data collection and updates.

An asset data readiness assessment was completed for each asset for the following categories and a blank sample assessment form is attached in Appendix C:

- Administrative Information
- Asset Definition and Identification
- Asset Data Requirements
- Data Ownership and Stewardship
- Asset Data Collection, Storage and Updating
- Derivative Data Set Creation and Management
- Asset Work History Tracking
- Data Access Points
- Additional Notes

Bridge Data

CTDOT Bridge Safety Unit performs bridge and culvert inspections in accordance with the National Bridge Inspection Standards (NBIS) as well as more detailed element-level inspections. Structures are inspected on a regular interval, typically every 24 months. Some structures in poor condition are inspected more often. As part of a bridge inspection, bridge inspectors rate a bridge's structural condition through careful inspection and evaluation of the three main components for a span bridge: (1) deck and wearing surface; (2) superstructure (structural supports beneath the deck); and (3) substructure (piers and abutments); or for a culvert: the structural condition. Element-level inspections supplement component inspections, providing detailed data on the condition of each structural element of a bridge. CTDOT reports on the condition of bridges that are part of the NBI to FHWA on an annual basis. CTDOT also reports element-level data for NHS bridges as part of its annual submittal.

National Bridge Inspection Standards

FHWA has specified data to be collected as part of a bridge inspection through the National Bridge Inspection Standards (NBIS) in accordance with 23 U.S.C. 151. The standards apply to all publicly owned highway bridges longer than twenty feet located on public roads.

Pavement Data

Data flows into the Pavement Management System (PMS) from several sources (see Figure 3-2). Pavement condition data are collected by the Bureau of Policy and Planning's Photolog Unit using specially equipped Fugro Roadware Automatic Road Analyzer (ARAN) vans. The entire CTDOT-maintained mainline and locally owned segments of the NHS are measured each year.

Starting with the 2015 data collection, the ARANs were updated to provide 3D imaging using Pavemetrics™ Laser Crack Measurement System, which includes two scanning lasers. This provides greater detail in the measurement of cracking, which will support future refinements to CTDOT's condition indices and PCI. The pavement images captured by the ARANs are processed to identify the presence of different types of pavement distress, including wheel path rutting, cracking, cross slope, potholes, raveling and faulting. Faulting is applicable to concrete pavements only, which makes up 0.5% of CTDOT's network.

Also starting in 2015 data collection, the ARANs were updated to include two Selcom RoLine sensors that feature laser line sensing (versus point laser sensing) located along each wheel path to collect longitudinal profiles to compute roughness measures.

The condition data are then processed by the Pavement Management Unit to calculate IRI (roughness), rutting (distortion), cracking (structural and environmental), disintegration (age), faulting, and drainage (cross slope and grade) indices, which are in turn used to calculate the PCI. Condition ratings are collected every five meters, aggregated by tenth-mile sections and then by pavement analysis sections and stored in a Structured Query Language (SQL) database. Finally, condition data are summarized by lane-miles for FHWA and State performance measures as well as Federal HPMS reporting.

Source: Provided by CTDOT, July 2015

Figure 3-2. Pavement Management System Data Flow Diagram

Traffic Signals Data

The traffic signal inventory contains location, ownership, maintenance, estimated energy use, pedestrian features, and other limited attributes. This database was developed years ago and was designed to meet operational rather than asset management needs. The data are stored in a SQL database with a Microsoft Access front end for data entry and viewing. The system was developed and is maintained by CTDOT's Office of Information Systems.

Signs Data

CTDOT currently has a sign inventory that was developed through a consultant contract in 2013 that involved capture of sign locations based on the CT Photolog images. CTDOT has imported that inventory into the Exor Linear Referencing System (LRS). Efforts are currently underway to improve the accuracy and quality of the sign inventory. Information has been assembled from maintenance work orders and construction contracts to support this process.

CTDOT is also working internally to implement a new process within Traffic Engineering, the Sign Shop, Office of the State Traffic Administration and District Maintenance to capture changes to the sign inventory as they occur, using information from the Maintenance Management System (MMS).

Sign Supports Data

Sign support condition data are collected during inspections by the Bridge Safety Unit, typically on a 48 -month basis.

Pavement Markings Data

Pavement markings data are based on assumptions for inventory and age. Methods to capture and track data for this asset are being explored. Baseline data could be compiled using the Photolog; information on work affecting pavement markings is captured in the TR-8 (paper) forms by district Signs and Markings Units.

TAM Information Management Systems

This section summarizes the key asset and project-related information systems used and the data held within them. This summary includes a description of how each type of data are collected, analyzed, managed, housed, and used within the CTDOT. Figure 3-3 shows the assets in the Connecticut TAMP and the systems used to manage those assets. The data within these systems are also used to generate annual Federal submittals for NBI and HPMS. Additional applications, such as ESRI Collector, are being used for other assets that may be included in future TAMPs.

	Bridges	Pavement	Traffic Signals	Signs	Sign Supports	Pavement Markings
InspectTech	●		-		●	
dTims	●	●			-	
EXOR	-	-	-	●	-	-
Traffic Signals Database			●			
Transportation Enterprise Database (TED)	●	-	●	●	-	-
CT ATLAS	●		●			-
ProjectWise (PW)	●	-	●		●	
Composite Project Database (CPD)	●	-	●	-	-	-
DigitalHIWAY	●	●				
Maintenance Management System (MMS)	-	-	-	●	-	-

- Considered for future deployment.

Figure 3-3. TAM Information Management Systems

InspectTech

TAMP Assets: Bridges, Sign Supports

Description:

CTDOT uses a customized version of InspectTech for its SMS to store and report information on CTDOTs highway bridges, sign supports, mast arms, and building facilities. The system was implemented in 2015 and consolidates a variety of structure information that was previously stored in multiple repositories. The system includes a link to ProjectWise, which is used as the repository for inspection reports.

Contents:

InspectTech includes inventory data and inspection results, with separate sections for highway bridges, town bridges less than 20 feet, railroad bridges mast arms, sign supports, and building facilities. For highway bridges over 20

feet in length, the system stores the federally required NBI and bridge element items.

InspectTech also includes a maintenance module that is being implemented to store inspector work recommendations and structure maintenance history.

InspectTech is also being integrated with project tracking data for bridges to identify work types and work codes for each bridge within a project.

Functions/Uses:

InspectTech is the authoritative database for structure inventory and inspection data. It is used to:

- Produce individual reports showing inspection condition and appraisal ratings, inspection schedules, CTDOT supervisor and engineer responsible for the structure, and other information
- Produce NBI and element level reports for FHWA
- Monitor bridge performance. InspectTech includes a dashboard view depicting bridge condition, bridge status, bridges posted for load restrictions, and structural deficiency. It also offers capabilities to drill down from aggregate performance data (e.g. Percent Structurally Deficient Bridges on the NHS) to individual bridge information
- Assign inspector work recommendations to state maintenance forces and design staff and track completion of these items

Data Sources:

The primary data source for InspectTech is structure inspections along with updates based on maintenance work performed.

Issues/Improvement Needs:

- The maintenance module of InspectTech has not yet been fully implemented for assets beyond bridges
- InspectTech is not currently intended to be used as CTDOT's network analysis system, therefore improved data transfer with bridge analysis systems is needed.

dTIMS

TAMP Assets: Bridges and Pavements

Description:

CTDOT uses a customized version of dTIMS to analyze and project condition of CTDOTs bridges and pavements. For bridges, the system was implemented in phases beginning in 2013 and is used solely for analysis. For pavements, the system was implemented in 1998 and provides capabilities for storing, reporting, and viewing pavement inventory and condition information. For

both bridges and pavements, dTIMS is capable of analyzing alternative investment scenarios and planning a program of projects.

Contents:

Bridge

The bridge portion of the application includes:

- Current NBI and element level condition data imported from InspectTech
- Treatment rules (a.k.a. decision trees) that specify what types of treatments are recommended for bridges based on their condition indices, and the condition improvements expected for each treatment type.
- Unit costs that are used to calculate costs for each of the bridge treatment types.
- Deterioration/performance curves for various bridge types are used to predict changes in bridge condition over time.
- Information on planned projects extracted from the Capital Plan.
- Budget scenarios which are used to constrain treatment selections.

Pavements

The pavement portion of the application includes:

- Pavement Inventory Data: width, number of lanes
- Road Inventory Data: Functional class, NHS designation, Overlaps (parent routes carried), Divided/Undivided Status, Administrative District, Annual Average Daily Traffic (AADT), and percent heavy trucks assigned based on functional class
- Pavement Construction History and Composition: year of original construction, pavement type and thickness, year of last resurfacing (initial data from Roadway Inventory System (RIS), updated based on completed paving work)
- Soil assessment by town
- Detailed (0.1 mile) pavement condition data: cracking (length and orientation by road zone; cross-slope, roughness (IRI), rutting. Faulting is collected for the five concrete sections on the network
- Summarized pavement condition data by analysis unit – including:
    - PCI: 1-9 scale, based on IRI, rutting, cracking, disintegration, and drainage
        - 8.0-9.0 Excellent
        - 6.0-<8.0 Good
        - 4.0-<6.0 Fair

        - <4.0 Poor
    - Structural Index, Environmental Index, IRI
- Pavement Activity Data-
    - Maintenance Vendor-in-Place (VIP) Projects (Initial, monthly, and final reports– includes milling and filling depth), VIP Projects are verified using DigitalHIWAY
    - Construction Projects with greater than 300 tons of Hot Mix Asphalt (HMA) – based on SiteManager queries for HMA pay items using locations based on stationing from project plans in ProjectWise
- Rules (a.k.a. decision trees) that specify what types of treatments are recommended for pavement sections based on their condition indices
- Unit costs ($/square yard) that are used to calculate costs for each of the of pavement treatment types for unconstrained needs or scenario analysis including direct pavement costs and markup for engineering and contract administration. Deterioration/performance models used to predict changes in pavement condition over time for each pavement family. Over 100 pavement families are defined in dTIMS according to climatic zone, pavement type, pavement thickness, traffic volume and soil condition.
- Planned or programmed pavement projects – used within scenario analysis to ensure scheduling of pipeline projects; also used to support development of resource-constrained work programs

Functions/Uses:

Bridge

For bridges, dTIMS is used to:

- Conduct strategic analysis that estimates future network bridge condition under various investment scenarios. This analysis includes a life cycle cost optimization function that selects a set of bridge treatments to maximize benefits for a given budget – where benefits are based on condition improvement relative to doing nothing
- Produce recommended bridge treatments

Pavement

For pavements, dTIMS is used to

- Store, summarize and report pavement condition data
- Conduct strategic analysis that estimates future network pavement condition (average PCI and percent of mileage in poor condition) under various investment scenarios. This analysis includes an optimization function that selects a set of pavement treatments to maximize benefits for a given budget – where benefits are based on

condition improvement relative to doing nothing (based on the area under the deterioration curve), weighted by traffic volume estimates

- Produce recommended pavement treatments and inform pavement project scoping and development

Data Sources:

Bridge

InspectTech is the authoritative database for bridge condition data for dTIMS. Planned project data will be extracted from the Composite Project Database (CPD) in the near future, currently it is within a spreadsheet maintained by the Bridge Management Group.

Pavement

Primary data sources for the PMS include basic road inventory data from the Road Inventory System, pavement condition data collected each year from the photolog vans, and pavement treatment history information. In addition, dTIMS includes soil classification information by town (poor or good) provided by the CTDOT Soils and Foundation Unit in 2007.

Issues/Improvement Needs:

Bridge

Deterioration Models: Continued efforts are needed in validating and updating the bridge deterioration models.

Component Ages: The age of most bridge components is not tracked in InspectTech. Deterioration modeling needs the age of a component to forecast future condition, but without tracking actual ages, the age of most components must be estimated from the year constructed, year reconstructed, or the year that an improvement was noted in that component's condition rating. These estimates may not be accurate and may cause condition forecasts to vary by a wide margin.

Tracking Work: Most maintenance-initiated work performed on a structure, except for major reconstruction, is not tracked in a central database, making it impossible to determine the effectiveness or existence of maintenance and minor rehabilitation work.

Committed Projects: An automated method to import lists of committed bridge projects is needed. The current method of using a spreadsheet involves extensive manual data entry and reformatting.

Budgeting: Most bridge projects involve expenditures over several years. However, dTIMS is not able to handle projects which involve costs distributed over several years, with all the benefits realized in the final project year. Multi-year projects involve extensive manual adjustments of available budgets, and

each schedule modification in the capital plan requires considerable manual effort.

Pavement

Pavement Sections: Work is required to eliminate short sections that have resulted from splitting existing sections based on maintenance project limits.

Inventory Data: Divided/undivided status in the PMS is tailored for analysis units but does not exactly match the LRS. An automated process to keep the pavement network in sync with the agency LRS has not yet been developed.

Condition Data: CTDOT collects information in both directions for all roads, but on divided roads CTDOT can only process the data in one direction in dTIMS. With the transition to 3D imaging in 2015, there is a need to ensure consistency and continuity with prior years' condition given that the new images may reveal more deficiencies than were previously discernable.

Pavement Structure and History Data: Improvements/validation needed for information on pavement type, thickness and year of last resurfacing.

Pavement Activity: There are challenges establishing locations on the LRS for construction projects from stationing information in plans. Information on pavement work associated with smaller construction projects, and with developer (encroachment permits) and other (e.g. emergency) projects is not readily available.

Traffic Data: Current system has AADT based on functional class. Improved traffic data (potentially to include truck traffic) to be added in the future once the new Traffic Monitoring System is complete and an interface can be developed. Also, volumes, truck classifications, and loadings should be included.

Exor

TAMP Assets: Signs

Description:

CTDOT uses Bentley's Exor, a software package for road network management that uses Oracle, for its LRS. Exor is used to maintain both spatial and attribute data for the road network, which has been expanded to cover both State and local roads. Exor includes reporting capabilities that enable aggregation of information about features stored using different sets of linear segments.

The Roadway Inventory System (RIS), which was originally developed as an in-house mainframe application, and was converted into an in-house Oracle-based system in 2004 is in the process of being phased out and eventually these data sets will be managed in Exor. RIS includes the official state highway mileage log, and stores data on road inventory features required for the HPMS submittal and a variety of other internal purposes.

Contents:

Exor stores information for multiple roadway features including:

- Descriptive information about route legal limits and intersections
- Basic road characteristics: facility type, number of lanes, surface width, median type
- Basic administrative characteristics: ownership, maintenance responsibility HPMS sections, functional classification, NHS status
- Other HPMS data items – for roadway full extent and sample sections
- Bridge locations
- AADT by sections (to be added soon)

Functions/Uses:

Exor enables storage and management of geospatial (GIS) representations of the road network, the routes, measures and reference points that make up the LRS, and characteristics of roadways required for a wide variety of purposes including HPMS reporting, safety planning and project scoping.

Data Sources:

Updates to spatial and LRS information are made based on completed construction projects. Annual field data collection of data using the photolog vehicles provide a source of information for updates to roadway characteristics.

Issues/Improvement Needs:

RIS data needs to be transitioned to Exor for updating and a field collection tool implemented.

Traffic Signals Database

Description:

The traffic signal database is a custom CTDOT application originally created to track power consumption of signals for Power Letters, letters sent to utility companies to serve as the basis for billing for power. This application is required because power for the majority of state-maintained signals is unmetered. Over time the database has been expanded to store additional information.

Contents:

The database contains inventory and power consumption information for over 2700 state-maintained traffic signals. Each signal is identified by a six-digit number in which the first three digits represent the town number (e.g., “017-201”). The database includes a record for the initial signal installation as well

as a record for each change that has impacted power consumption. The database includes, but is not limited to, the following types of information:

- Location
- Traffic Signal type/description (traffic control signal, flashing beacon, etc.)
- Status (pending, active, removed)
- Maintenance responsibility
- State Maintenance Level (priority for response to service issue)
- Ownership
- Energy "paid by" (i.e. who pays the bill)
- Traffic Investigation Report (TIR)/Office of the State Traffic Administration report that ties the signal back to the original warrant approval
- Project number/Service Memo number generating the revision
- Traffic Signal Coordination type (time based, closed loop, etc.)
- Pedestrian control information
- Pre-emption (system type, method)
- Mast arm/span pole – quantity, install years
- Vehicle detection information
- Lamp type, wattages, and other information needed to calculate estimated power consumption

Functions/Uses:

The primary function of the database is to generate power letters for the utility companies. The database is available for use by signal maintenance technicians in the Office of Maintenance and Highway Operations to provide reference information needed for effective response to service calls. It is also used to scope traffic signal improvement projects and plan replacement schedules, primarily based on age of span poles and mast arms.

The database includes a reports menu that allows users to make limited queries of traffic signal information within a given town and/or route.

Data Sources:

Data are maintained by staff within the Electrical Section of the Division of Traffic Engineering. When new signals are designed, information is manually entered from the signal plans to create a new "pending" record. A semi-final inspection by Traffic Engineering of the constructed signal provides additional information to complete the record. As changes to the signal are made that impact its power consumption, the original record is set to "Removed" status and a new record is created using information from the revision.

Issues/Improvement Needs:

The database is adequately serving its initial purpose of tracking power consumption to generate Power Letters, however now that the database serves a greater function for asset management, additional details will need to be collected and added. This may necessitate the need to eventually convert to a different database that will allow for easier updating and provide better functionality for the management of the assets. Additional detail is needed for certain traffic signal components so that tracking and managing life cycle replacement of signal components can occur, resulting in the timely replacement of major signal components.

The database also includes some information on Intelligent Transportation System (ITS) assets that consume power such as cameras and variable message signs. However, it is not currently the definitive system of record for these assets. Separate databases and different asset identifications are maintained by the Office of Maintenance and Highway Operations for these assets.

Transportation Enterprise Database

Description:

The Transportation Enterprise Database (TED) is a SQL Server data warehouse that contains geospatial information. TED is currently under development. The vision for TED is to: "create an accessible transportation safety and asset data enterprise system where authoritative data sets are managed by data stewards and formatted for consumption and analysis in a manner that allows stakeholders to use tools that are both effective and meet their business needs."

A TED Development Group was formed to provide oversight and governance for improvements to TED and related data gathering efforts. An initial priority focus of this group has been to support safety data and analysis capabilities. However, asset management needs are being considered as well. Specific responsibilities include:

- coordinate data management activities,
- oversee the development of a data business plan,
- monitor implementation tasks within the data business plan
- serve as a forum to review data issues,
- advise on data-related software procurement,
- develop an FHWA-compliant data capture plan for the Model Inventory of Roadway Elements (MIRE), and
- report and make recommendations to the Data Governance Council.

Contents:

TED contains the following data:

- Road Network and linear attribution
- Road inventory attributes including NHS, Functional class
- Projects, bridges, and signal control areas
- Crash
- Rights of Way, Monuments, and Geodetic Surveys
- Static reference data (districts, MPOs, towns, urbanized areas, etc.)
- Metadata

Functions/Uses:

TED is a high level linked roadway, asset, and safety data base with dashboard, reporting, and mapping capabilities that can serve the viewing, query and analytical needs of data stewards and external customers in a user-friendly manner. TED will offer the most current views and queries of resident data sets while also enabling in depth analysis of selected data attribute relationships for any defined period of time.

The geospatial information in TED can be consumed by any mapping or reporting tool that can connect to a SQL Server database, such as ESRI, QGIS, or Assetwise Publisher. Ad-hoc queries can be run against the database using query tools like SQL Server Management Studio or Bentley's Transportation Information Gateway (TIG) tool.

Data Sources:

TED data sources include:

- Exor
- ATLAS
- CPD
- InspectTech
- CAS2
- ESRI
- Town boundaries, legislative districts etc.
- Metadata

The authoritative data is updated nightly from the various data sources.

Issues/Improvement Needs:

Within the TED Development Group, six work groups have been established to provide a focus on different aspects of data and analysis improvements:

I. Field Data Collection Tool, Roadway Asset Development, MIRE Self-Assessment, and Gap Analysis

II. Exor and Other Authoritative Base Development, Roadway Data Migration and Asset Readiness Planning
III. System Architecture Work Flow, Extract-Transform-Load (ETL), and TED Data Warehouse Build Out
IV. ATLAS Project Geospatial Management Capabilities
V. Development of Network Screening and Safety Analysis Tools
VI. Data Visualization, Analytics, and Reporting for Geospatial Data

These work groups meet and report to the TED Development Group.

ATLAS

Description:

ATLAS is a custom Geographic Information System (GIS) application intended to serve as the agency's GIS data integration and display platform. It is being developed incrementally using the open source MapServer/GeoMoose framework.

Contents:

ATLAS incorporates the agency's spatial data foundation including base maps, LRS, and available GIS data layers – including layers for capital projects, proposed and completed VIP paving projects, structures, signals and traffic monitoring locations. It provides standard web feature services and web mapping services for exchanging data to use in other applications.

Functions/Uses:

The GeoMoose framework provides the following functions:

- Access to maps from: ArcGIS, MapServer, Google, VirtualEarth
- Publishing of spatial data layers
- Distributed data maintenance amongst multiple owners
- Configuration of multiple views of data sources
- Obtaining and filtering of data from data catalogs
- Multiple data navigation and exploration tools
- Integration with non-spatial systems
- Portable Document Format (PDF) printing

ATLAS is being used at CTDOT to view integrated spatial data on assets and projects. For example, a user can click on a section of roadway and view available AADT, project and asset data for that location. Users can also link to available documents located in ProjectWise pertaining to the selected projects and assets.

ATLAS is also being used to create and update spatial data records for assets and projects. For example, users can select a bridge or a signal from InspectTech or the Traffic Signals Database, draw a polygon on the map, and associate the new

spatial data with the asset. Users can also draw a polygon representing a new proposed or recommended project area and complete a form with information needed to create a Proposed Project Information(PPI) record for this new project. Route, milepoint, and length data for the assets or project are automatically identified within the limits of the polygon.

ATLAS is available only within the CTDOT firewall. In order to provide access to CTDOT's asset and project information to partners, ATLAS publishes data to ALIM, a web-based GIS publishing tool.

Data Sources:

Base map information and spatial data layers published to ATLAS are maintained using the open source GeoMoose tool.

Issues/Improvement Needs:

ATLAS is currently in a relatively early stage of development, and many future improvements are planned. A future process has been envisioned for utilizing ATLAS as part of a standard workflow process for adding new assets to the inventory:

- The designer uses computer-aided design (CAD) to locate a new asset with a spatially correct polygon and exports to keyhole markup language (KML)
- The designer submits KML to the asset steward in exchange for a new asset ID
- The asset steward obtains a new asset ID in the asset's authoritative inventory and imports the KML with a new ID into ATLAS
- ATLAS business attributes are updated nightly from the authoritative sources

ProjectWise

Description:

ProjectWise is a cloud-based engineering project collaboration and content management platform. CTDOT implemented ProjectWise in 2010.

Contents:

At CTDOT, ProjectWise is the source system of record for design plans, specifications and construction project as-built plans. CTDOT also uses ProjectWise as a document management system, storing a variety of project and non-project-related asset content. CTDOT has begun to use ProjectWise to tag specific assets associated with active projects – currently bridges and signals are tagged. This allows for documents associated with these assets (e.g. computations, shop drawings and reports) to be managed within ProjectWise.

Select asset attributes are also pulled into ProjectWise from the source asset management systems to provide visibility of asset information for users.

Functions/Uses:

ProjectWise stores and provides access to project and non-project-related content. It includes indexing, search, and versioning capabilities.

Data Sources:

ProjectWise is populated by a variety of internal and external CTDOT users. The system is currently managed by the CTDOT Architecture, Engineering and Construction Applications Unit within the Bureau of Design and Construction.

Issues/Improvement Needs:

Continued configuration and process improvements to facilitate additional asset integration with project data.

Composite Project Database

Description:

The CPD is a custom SQL database application that was created in 2015 to integrate data on capital projects from several different sources.

Contents:

Currently the CPD contains data for over 2,600 CTDOT projects, sourced from CTDOT's Capital Program Obligation Plan (OBL, Microsoft Access database), the State's financial management system (CORE-CT), CTDOT's construction project management system (SiteManager), and the Project Asset Form (in the CPD). CPD data are then joined with geo-located project work areas within ATLAS. Data in the CPD includes:

- Project description, schedule and budget information
- Payment and expenditure information
- Asset identification and limited work information
- Design and construction team information
- Current Project Phase (Final Design, Construction, etc…)

Functions/Uses:

CPD's purpose is to aggregate project information from several different sources into one convenient location for viewing. The CPD is located on a SQL server for internal agency use only.

Data Sources:

As previously listed, the CPD pulls in data from the OBL, CORE-CT, and SiteManager. Some information, such as asset and design team, are entered directly into a CPD form.

Issues/Improvement Needs:

Further development and build-out of the CPD to include additional asset classes and associated work to provide more thorough asset life-cycle information for asset management purposes.

DigitalHIWAY

Description:

The CTDOT DigitalHIWAY is a custom photolog application that is uploaded with images of the State highway system on an annual basis. CTDOT's photolog program was initiated in 1973, and DigitalHIWAY images are currently available for each year back to 1985.

Contents:

DigitalHIWAY includes:

- Forward-view Right-of-Way (ROW) images
- The corresponding set of pavement conditions, GPS, and geometric data

Engineering data include:

- Downward-facing high resolution pavement images
- Rut-depth measurements
- IRI
- Global Positioning System (GPS) coordinates
- Horizontal and vertical geometry
- Pavement cross slope
- Pavement grade

Functions/Uses:

Images are used for pavement analysis, safety analysis, project scoping, derivation of HPMS sample section data values, asset inventory data updates, fulfillment of special requests, and for a variety of reference purposes. Imagery is made available to FHWA, the University of Connecticut, the Connecticut State Library, and the State Police.

Data Sources:

CTDOT uses state-of-the-art ARANs to collect high resolution images and roadway condition, geometric and position data every 16.4 feet (5-meters) for the entire state-maintained roadway network and local-maintained NHS. Roadway images are taken at equal intervals to provide the appearance of continuous video. The ramp system is also captured periodically.

Issues/Improvement Needs:

The DigitalHIWAY is being continually enhanced based on user feedback. Future improvements under consideration include integration of point cloud data from LiDAR to enable increased use of information for engineering applications.

Maintenance Management System

Description:

The Maintenance Management System (MMS) is a custom CTDOT application used to track and manage maintenance activities performed by state forces.

Contents:

MMS includes several modules for tracking work accomplishments (quantities of work completed by activity code), tracking and reporting maintenance costs (labor, equipment and materials), tracking delivery and use of winter maintenance materials (sodium and magnesium chlorides), tracking temperature and snow accumulation during winter storm events, and ordering signs from the CTDOT Sign Shop. Specific data includes:

- Maintenance accomplishments by activity. Work locations are recorded on trip tickets and supervisor rundown sheets but are not entered into the MMS
- Labor hours by maintenance activity by crew – regular and overtime; crew size
- Sodium and magnesium chloride amounts delivered and used by each maintenance facility
- Costs by activity, type (labor, equipment, materials) and Interstate/non-Interstate. Maintenance activity codes indicate Interstate/Non-Interstate as well as type of crew
- For storm events, temperature and precipitation type and total amounts are collected at specific garages periodically throughout the event

Note: CTDOT fleet assets are managed in a separate system.

Functions/Uses:

The MMS is used to track and report on maintenance accomplishments and associated costs at each of the state's 48 maintenance garages (there are two maintenance sections in each of the four CTDOT districts, and 6 garages per section), 4 electrical and 4 signs & markings district specialty garages and 6 bridge maintenance garages. This information is used for budgeting. Work is not currently planned within the MMS – crews get their daily assignments on paper trip tickets.

Material usage for snow and ice control is tracked through internal reporting. This information is used for materials inventory purposes as well as application rate validation.

The MMS also includes a module used by Traffic Engineering and District Maintenance to order signs from the Sign Shop. The sign order information will be used to update the sign inventory.

Data Sources:

Maintenance accomplishments and time are logged on paper forms by crew members, provided to maintenance garage supervisors, and then entered into the MMS by clerks at the garages. During the winter, clerks track sodium and magnesium chloride inventory as well as patching materials and other associated tasks.

Issues/Improvement Needs:

Currently the MMS does not identify work done to a specific asset with the exception of the recently added Sign asset. In order to facilitate the use of the MMS for other asset management purposes, asset identification needs must be included in the tracking of work accomplished and the associated costs determined.

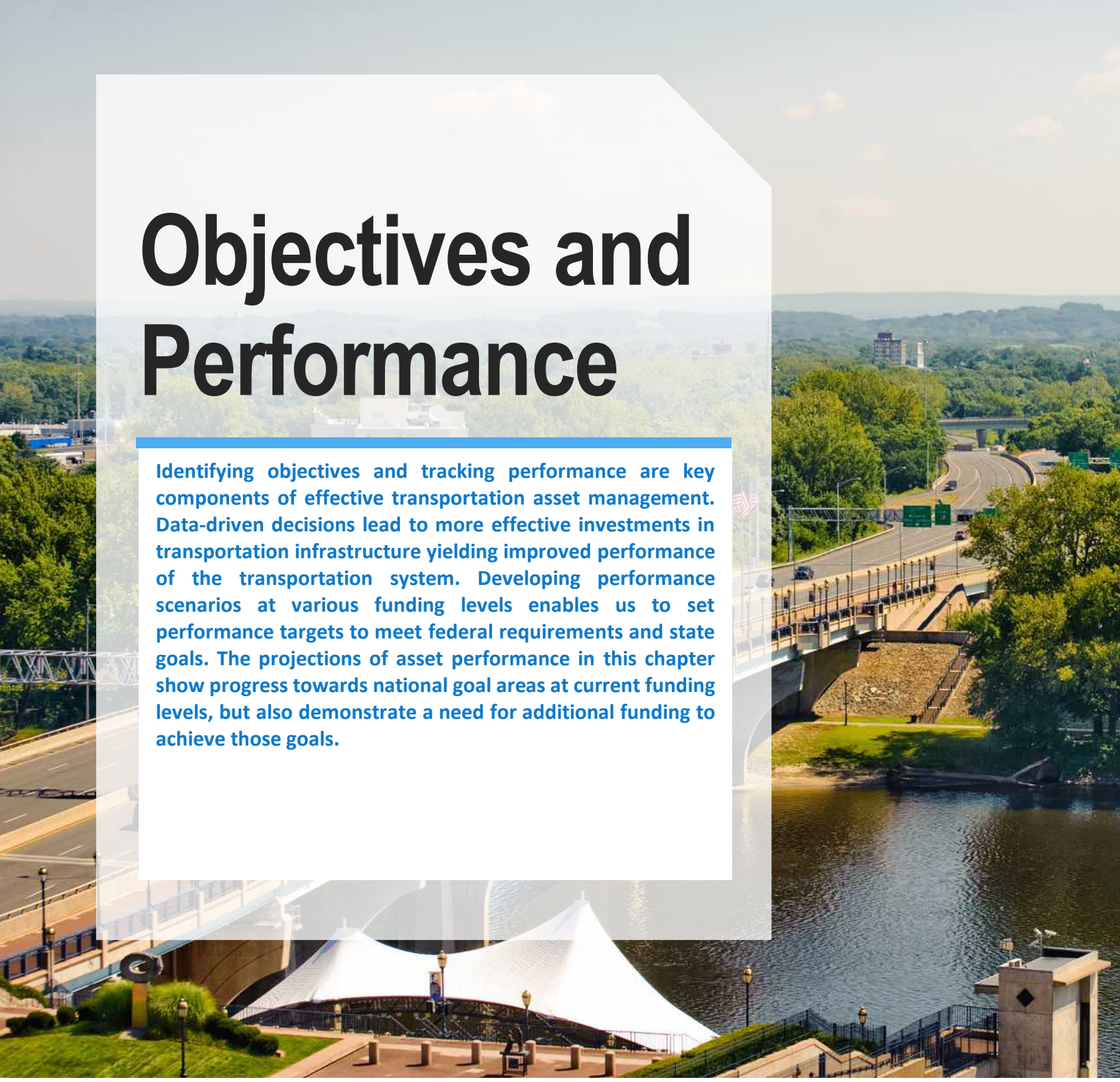
An initiative is being launched to scope the needs of a new electronic MMS. It is envisioned that this new system will address asset tracking as well as work tracking with associated costs using electronic field data collection capabilities.

Data Governance

CTDOT formed a Data Governance Council to build a framework of rules, policies, and procedures to regarding availability, usability, data quality and security. The Council includes representation from all 5 CTDOT Bureaus. The Data Governance Council is responsible for:

- Prioritize safety and asset data governance solutions to provide the foundational tools necessary to expand enterprise data participation across all disciplines within the agency
- Identify data being collected and maintained agency wide.
- Document data standards and coordinate development of new standards.
- Develop guidance for data dictionaries, user manuals, and training programs.
- Establish quality assurance /quality control (QA/QC) processes.
- Facilitate the integration and interoperability of information between authoritative roadway inventory databases and CTDOT's enterprise wide data system.
- Identify and inform the Executive Committee of emerging data priorities and how they best might be addressed
- Report to the Executive Committee as needed to make recommendations regarding data governance challenges or technology opportunities.

The Data Governance Council, in conjunction with the TED Development Group, have prioritized data to be loaded into TED, drafted data management guidance regarding definition of data assets, the assignment of asset data owners and asset data stewards as well as their roles and responsibilities, metadata requirements, and a process for establishing TED asset data readiness.



Objectives and Performance

Identifying objectives and tracking performance are key components of effective transportation asset management. Data-driven decisions lead to more effective investments in transportation infrastructure yielding improved performance of the transportation system. Developing performance scenarios at various funding levels enables us to set performance targets to meet federal requirements and state goals. The projections of asset performance in this chapter show progress towards national goal areas at current funding levels, but also demonstrate a need for additional funding to achieve those goals.

CHAPTER 4

Overview

Establishing targets, articulating strategies, linking agency processes to asset management and other performance strategies are all integral parts of the TAMP. The performance measures and targets included in this chapter are used to track progress and guide Connecticut towards our goals.

Connecticut is quantifying inventory, measuring condition and setting performance targets for six transportation assets. The targets that have been set are aligned with federal requirements and state goals and objectives, and are based on the projected funds available for transportation. The targets will help guide Connecticut in allocating its resources to projects and programs to make progress towards our goals.

This chapter presents CTDOT's goals and objectives, TAM performance targets, performance projections over a 10-year period, and a gap assessment comparing current performance, targets, and projected future performance.

Federal Legislative Context

The FHWA requires states to include measures and targets for asset condition for NHS bridges and pavements in their TAMP as defined in 23 CFR 490.313. States may choose to include additional assets. Any asset included in the TAMP must have accompanying measures and targets.

Using the measures of condition defined by FHWA, State DOTs must specify their desired "state of good repair" for the 10-year analysis period of the TAMP consistent with state asset management objectives. The desired SOGR must also support progress towards achieving goals. National goal areas include safety, infrastructure condition, congestion reduction, system reliability, freight movement and economic vitality, environmental sustainability, and reduced project delivery delays.

As part of the FHWA rule on performance management, 23 CFR Part 490, states must set two and four-year asset condition performance targets. These targets shall be included in the TAMP but will also be reported separately to FHWA. As part of this performance management rule, states are also required to maintain NHS pavements and bridges to meet federally-established minimum condition levels.

Federal Minimum Condition Levels

- **Bridges**: **Structurally Deficient$_{NHS}$ < 10%**
  States must maintain bridges on the NHS (greater than 20-ft in length) so that the percentage of deck area of bridges classified as structurally deficient does not exceed 10 percent of the overall deck area in a state. (Note that as of 2018 FHWA defines structurally deficient and poor condition to be the same – a bridge that is in poor condition is also considered structurally deficient).
  If FHWA determines a state DOT to be out of compliance, the state must obligate and set aside funding for eligible projects on bridges on the NHS. This funding requirement will remain in effect each year until the state is in compliance.

- **Pavements**: **Poor$_{Interstate}$ < 5%**
  States must ensure that no more than 5 percent of pavement lane miles on the Interstate system are in poor condition.
  If FHWA determines a state DOT to be out of compliance, the state must obligate funding to the National Highway Performance Program (NHPP) and transfer funds from the Surface Transportation Block Grant Program to the NHPP.

The FHWA also requires that states establish a performance gap analysis process for TAMPs. Specific requirements for the process are listed below.

Performance Gap Analysis Process Requirements

- Establish desired SOGR based on Federal requirements and State goals
- Establish state targets for asset condition
- Determine performance gaps
- Develop strategies to close or address the gaps

As part of the gap analysis, states must compare current asset performance to desired performance levels, but they may also compare desired asset performance to target performance to calculate an expected gap.

Goals and Objectives

Vision and Mission

Connecticut strives to achieve a nationally competitive transportation system that is multi-modal, resilient, and long-lasting; addresses capacity issues; and helps the economy.

CTDOT Vision & Mission

CTDOT's vision is to lead, inspire, and motivate a progressive, responsive team, striving to exceed customer expectations.

CTDOT's mission is to provide a safe and efficient intermodal transportation network that improves the quality of life and promotes economic vitality for the State and the region.

Summary of TAM Objectives

CTDOT has adopted a set of TAM objectives that are aligned with the vision and mission of the agency. These objectives are helping to steer CTDOT as it develops, refines, and implements TAM policies, processes, and practices.

TAM Objectives

- Attain the best asset conditions achievable, given available resources
- Deliver an efficient and effective program that preserves our existing infrastructure
- Improve communication and transparency regarding decisions and outcomes
- Achieve and maintain compliance with FHWA asset management rules

Performance measures, projections, and targets are being developed to help achieve CTDOT TAM objectives. These are being linked so that CTDOT can operate more effectively and make progress towards federal requirements and state goals.

CTDOT Values

- Measureable results
- Customer service
- Quality of life
- Accountability & integrity
- Excellence

Asset Performance Measures

Connecticut has selected performance measures for this plan based on a combination of federal requirements and a desire to set performance goals for state-maintained traffic signals, signs, sign supports, and pavement markings. These measures are helping CTDOT actively manage the performance of each asset by understanding the impact of investments on the asset's state of repair. This allows for the establishment of funding priorities and targets that are achievable. A summary of the performance measures for bridges and pavements on the NHS is provided in Table 4-1.

Table 4-1. Summary of Federal Performance Measures for NHS Bridges and Pavements

Asset	Performance Measure	Measure Definition
Bridges	• **Percentage of NHS bridges classified as in good condition (weighted by deck area)** • **Percentage of NHS bridges classified as in poor condition (weighted by deck area)**	• Good and poor are defined by FHWA's rule on Performance Management
Pavements	• **Percentage of pavements on the Interstate System in good condition** • **Percentage of pavements on the Interstate System in poor condition** • **Percentage of pavements on the NHS (excluding the Interstate System) in good condition** • **Percentage of pavements on the NHS (excluding the Interstate System) in poor condition**	• Good and poor are defined by FHWA's rule on Performance Management

A summary of the performance measures for the six state-maintained assets in the TAMP is provided in Table 4-2. The table also shows the criterion for achieving a SOGR.

Table 4-2. Summary of State Performance Measures for CTDOT-Maintained Assets

Asset	Performance Measure	Measure Definition
Bridges	• **Percentage of bridges classified as in a SOGR (by number of bridges)**	• SOGR is defined by CTDOT as an NBI condition rating of 5 or higher
Pavements	• **Percentage of centerline miles in a SOGR**	• SOGR is defined by CTDOT as a PCI rating of 6 or higher
Traffic Signals	• **Percentage of traffic signals in a SOGR**	• SOGR is defined by CTDOT as an age of 25 years or less • Traffic signal condition rating is age-based with the following thresholds: 0-15 years is good, 16 – 25 years is fair, and over 25 years is poor
Signs – Limited Access	• **Percentage of signs in a SOGR**	• SOGR is defined by CTDOT as an age of 17 years or less • Sign condition rating is age-based with the following thresholds: 0-12 years is good, 13 – 17 years is fair, and over 17 years is poor
Signs – Non-Limited Access	• **Percentage of signs in a SOGR**	• SOGR is defined by CTDOT as an age of 17 years or less • Sign condition rating is age-based with the following thresholds: 0-12 years is good, 13 – 17 years is fair, and over 17 years is poor
Sign Supports	• **Percentage of sign supports in a SOGR**	• SOGR is defined by CTDOT as a condition rating of 5 or higher
Pavement Markings – Line Striping	• **Percent of pavement markings in a SOGR**	• For epoxy pavement markings, SOGR is defined by CTDOT as markings installed within three years • For water-based pavement markings, SOGR is defined by CTDOT as markings installed within one year
Pavement Markings – Symbols & Legends	• **Percent of pavement markings in a SOGR**	• For epoxy pavement markings, SOGR is defined by CTDOT as markings installed within three years • For water-based pavement markings, SOGR is defined by CTDOT as markings installed within one year

Asset Performance Targets

Asset performance and desired projections specify the conditions CTDOT seeks to achieve and sustain over a 10-year period to meet federal requirements, support state goals, and make progress in national goal areas. Projections presented in this section reflect both desired performance and expected performance at varying funding levels.

NHS Performance Targets

Federal regulation 23 CFR Part 490.107 requires that 2 and 4-year targets be set for bridges and pavements on the NHS. These targets are the expected performance of the assets based on the federally required measures given the funding availability and investment choices made by CTDOT.

The bridge and pavement performance projections for 2020 and 2022 for the expected funding level are the anticipated performance targets. CTDOT must establish these targets by May 20, 2018, coordinate with MPOs, and report the targets to FHWA by October 1, 2018. The 2 and 4-year targets are not required for the initial TAMP submittal in April 2018 but will need to be included in the final TAMP submitted in June 2019. However, Connecticut is including the 2 and 4-year results from the ten-year projections at current funding levels in this initial TAMP submittal as anticipated targets for bridge and pavement conditions. The anticipated 2 and 4-year performance targets for Connecticut bridges and pavements on the NHS are shown in Table 4-3.

FHWA Minimum Condition Level for Bridges

States must maintain bridges on the NHS so that the percentage of deck area of bridges classified as Structurally Deficient does not exceed 10 percent of the overall NHS deck area in a state.

Table 4-3. NHS Asset Performance Targets (anticipated)

Asset (unit of measure)	Current Condition		2-Year Targets (2020)		4-Year Targets (2022)	
	Good	Poor	Good	Poor	Good	Poor
NHS Bridge (deck area)	18.1%	15.0%	22.1%	7.9%	26.9%	5.7%
Interstate Pavement (lane miles)	66.2%	2.2%	65.5%	2.0%	64.4%	2.6%
Non-Interstate NHS Pavement (lane miles)	37.9%	8.6%	36.0%	6.8%	31.9%	7.6%

CTDOT Performance Targets

The anticipated 2 and 4-year performance targets for CTDOT-maintained assets are shown in Table 4-4. The table shows the percentage of the asset quantity expected to be in a SOGR in the target year.

Table 4-4. CTDOT-Maintained Asset Performance Targets (anticipated)

Asset (unit of measure)	2-Year Targets (2020) SOGR	4-Year Targets (2022) SOGR
Bridges (number of bridges)	96.1%	97.9%
Pavement (centerline miles)	62.9%	57.6%
Traffic Signals (number of signalized intersections)	64.0%	63.2%
Signs – Limited Access (number of sign panels)	42.4%	48.5%
Signs – Non-Limited Access (number of sign panels)	45.6%	49.2%
Sign Supports (number of sign supports)	n/a	n/a
Pavement Markings – Lines (linear feet)	32.8%	32.8%
Pavement Markings – Symbols (square feet)	75.9%	75.9%

10-Year Performance Goals

CTDOT has set long-term performance goals for both NHS assets and CTDOT-Maintained assets. In working towards these goals, CTDOT recognizes that the effort to achieve them may surpass 10 years and adjustments to these long-term goals will be needed over time as the asset management process matures and funding strategies change with future needs.

CTDOT's 10-year performance goals, based on national measures, for NHS assets are presented in Table 4-5. The table shows the desired percentage of assets in good and poor condition. The values shown in the table were determined based on review of a set of performance projections performed at varying funding levels. The resulting performance goals were established considering CTDOT's life cycle plans described in Chapter 5, and conditions achievable given a range of various funding levels. The values reflect federal requirements and state goals and, if achieved, will satisfy the minimum NHS condition levels defined by FHWA.

Table 4-5. 10-Year Performance Goals, Based on National Measures: NHS Assets

Asset (unit of measure)	Good	Poor
NHS Bridge (deck area)	>20%	<10.0%
Interstate Pavement (lane miles)	75.0%	<5.0%
Non-Interstate NHS Pavement (lane miles)	50.0%	<8.0%

FHWA Minimum Condition Level for Pavement

States must ensure no more than 5 percent of pavement lane miles on the Interstate System are in Poor condition.

CTDOT also has performance projections for state-maintained bridges, pavement, traffic signals, signs, sign supports, and pavement markings. CTDOT's 10-year performance goals for SOGR of state-maintained assets are presented in Table 4-6.

Table 4-6. 10-Year Performance Goals, Based on SOGR: State-Maintained Assets

Asset (unit of measure)	**SOGR**
Bridges (number of bridges)	**95.0%**
Pavement (centerline miles)	**80.0%**
Traffic Signals (number of signalized intersections)	**80.0%**
Signs – Limited Access (number of sign panels)	**80.0%**
Signs – Non-Limited Access (number of sign panels)	**70.0%**
Sign Supports (number of sign supports)	**90.0%**
Pavement Markings – Lines (linear feet)	**75.0%**
Pavement Markings – Symbols (square feet)	**75.0%**

In addition to these measures of condition, CTDOT tracks and publishes a number of other performance measures on the CTDOT Performance Measures website, through an online dashboard. The dashboard includes 21 performance measures organized into four CTDOT goal areas:

- Safe & Secure Travel
- Preserve & Maintain Network
- Mobility, Connectivity, Accessibility
- Efficiency & Reliability

The performance measures are updated at regular intervals. The data are presented both as an interactive dashboard and also as a printable report.

Measures are regularly reviewed by CTDOT's Performance Measures Standing Committee to determine their usefulness in helping CTDOT make strategic decisions for managing its infrastructure assets.

The performance measures mentioned in this TAMP are not yet included on the CTDOT Performance Measures website but are anticipated to be included in the future.

Asset Performance Projections

CTDOT manages its assets throughout their life cycle. Understanding each asset's life cycle and developing projections of future asset performance based on this understanding is a key piece of this practice. Chapter 5 Life Cycle Planning provides more information on CTDOT's life cycle planning and management practices.

Projected conditions for the six assets in the TAMP are included at varying funding levels for each asset. The following three funding levels were selected to be projected: No Funding, Current Funding, and Preferred Funding. In the projection Figures 4.1-4.9, red lines are used to indicate the percent of assets in poor condition while green lines are used to indicate the percent of assets in good condition according to federal performance measures; blue lines are used to indicate the percent of assets in a SOGR as defined by CTDOT performance measures. The complete performance projections are included in Appendix D.

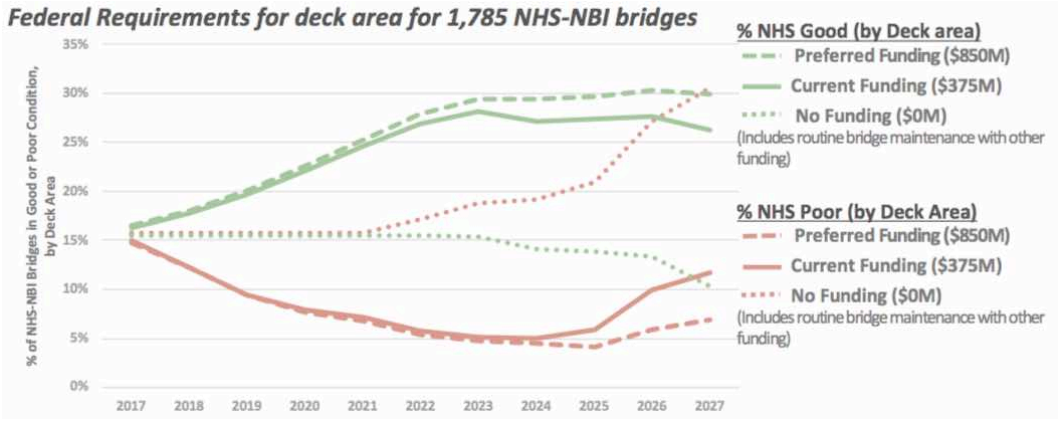
Funding uncertainty is a real concern for every state DOT. The funding levels used for these projections reflect the best available information as of July 2017. At the start of the TAMP development effort, the funding expectations were much greater that those that are now being used in this TAMP. In order to conduct the asset performance analyses, funding projections had to be finalized during the fall of 2017. It is possible that funding changes may occur in the final phases of this TAMP development and review. Any change in funding expectation will be reflected in the TAMP that is submitted in June 2019. CTDOT considers the TAMP to be a living document that will continue to be updated going forward at regular intervals.

Bridge Performance Projections

Projections of bridge performance were developed in dTIMS using a snapshot of condition data submitted on March 28, 2017 for the annual call for update of the NBI and NHS Element Level Collection 2017. The bridge projection analysis is run to optimize a bridge health index. The bridge health index is comprised of condition ratings weighted as follows: 15% deck, 15% superstructure, 15% substructure, 10% structural evaluation, 5% deck geometry, 5% underclearances, 5% waterway adequacy, 4% approach alignment, 2% structure open/posted/closed, 5% paint/coating, 5% bearings, 5% girders, 5% joints and 4% wearing surface. From the results, 10-year performance projections were developed for NHS bridges and state-maintained bridges.

Performance projections for NHS bridges are shown in Figure 4-1. These forecasts show the direct correlation between investment and performance over a 10-year period. The current funding level is only adequate to maintain

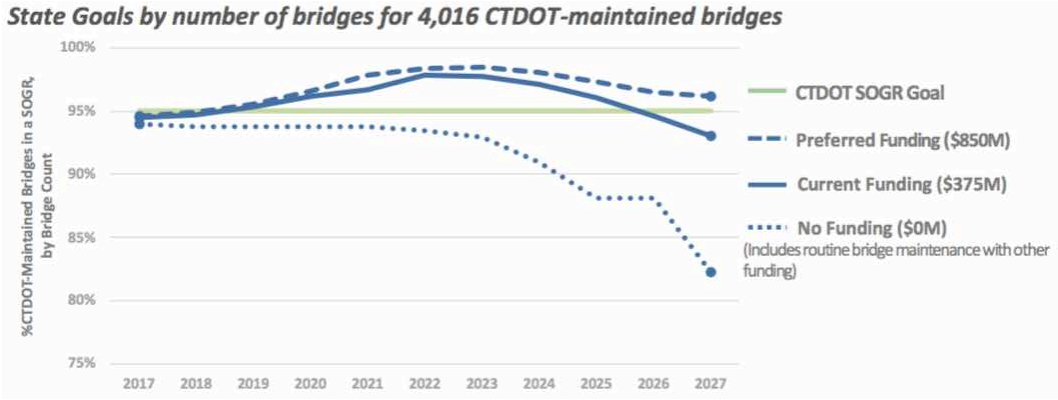
the federal minimum condition standard for 6 years before the condition declines below the minimum federal condition standard.



Based on funding as of 6/30/17

Figure 4-1. NHS Bridge Performance Projections

The performance projections for state-maintained bridges are shown in Figure 4-2. For bridge, the preferred funding is needed to reach and maintain SOGR targets over the 10-year period.



Based on funding as of 6/30/17

Figure 4-2. State-Maintained Bridge Performance Projections

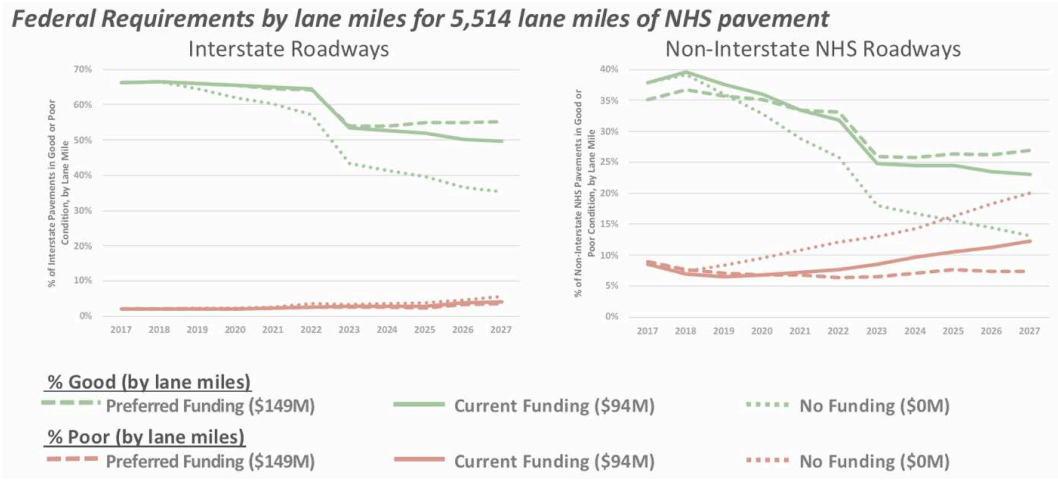
Pavement Performance Projections

Projections of pavement performance were developed in dTIMS using condition data submitted on June 15, 2017 for the HPMS. The analysis is run to optimize a PCI. The weighted index comprises 10% IRI, 25% cracking, 15% rutting, 30% disintegration, and 20% drainage. From the results, 10-year performance projections were developed for Interstate pavements, Non-Interstate NHS pavements and state-maintained pavements.

The performance projections for both Interstate pavements and Non-Interstate NHS pavements are shown in Figure 4-3. Although the current funding level is adequate to maintain the federal minimum condition standard

for Interstate pavements over the 10 years, the overall pavement conditions will decline throughout the entire 10-year period.

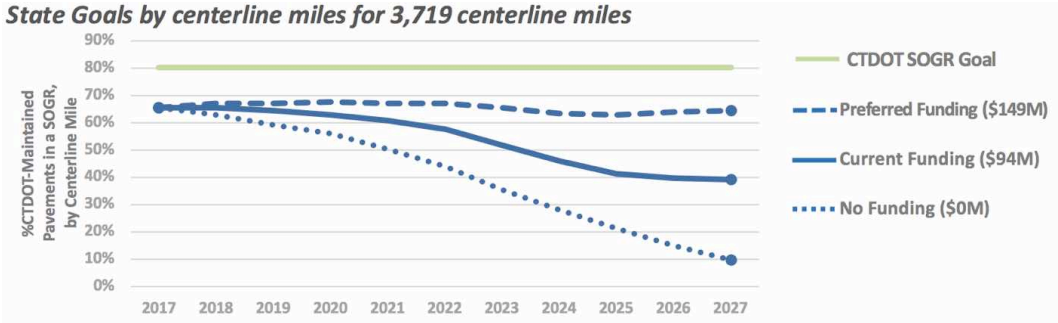
The sharp drop in good condition projected between 2022 and 2023 stems from two conditions; the first is the result of unusually large segments of pavement that date from the same paving years and which move into lower condition states in this time period; the second major source of this drop is a function of the way that condition states are defined for the national performance measures. There are only three condition states and the middle "fair" range is very broad compared to the "good" range, which is relatively stringent and difficult to maintain as measured in our pavement data.



Based on funding as of 6/30/17

Figure 4-3. NHS Pavement Performance Projections

The performance projections for state-maintained pavements are shown in Figure 4-4. Although the preferred funding allows us to maintain the existing condition, it is beyond the present capacity to deliver. The current funding leads to an overall decline of state-maintained pavement condition over the 10-year period.

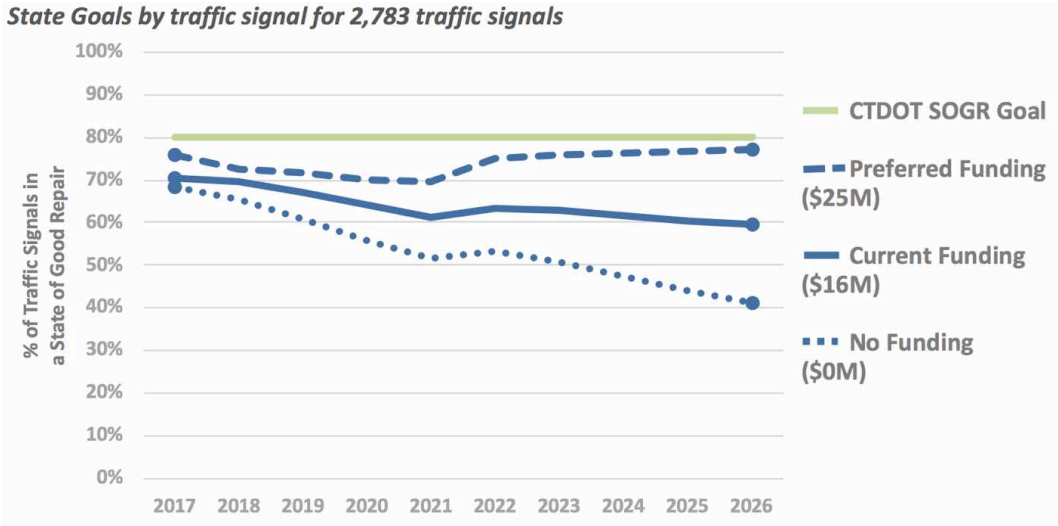


Based on funding as of 6/30/17

Figure 4-4. CTDOT-Maintained Pavement Performance Projections

Traffic Signals Performance Projections

Performance projections for traffic signals were developed based on the current process for managing this asset. Each year 100 traffic signals that have exceeded their service life would need to be replaced for this asset class to achieve its performance target in future years. Currently, CTDOT replaces approximately 60 signals each year under the annual traffic signal program that have exceeded their service life. Additional traffic signals are upgraded each year under other highway projects and encroachment permits by developers but some may not have reached their service life. The performance projections for traffic signals are shown in Figure 4-5.



Based on funding as of 6/30/17

Figure 4-5. Traffic Signals Performance Projections

Signs

Performance projections for signs were developed based on the current process for managing this asset. Each year 15,500 signs, that have exceeded their service life, would need to be replaced for this asset class to achieve its performance target in future years. Currently, CTDOT replaces approximately 5,000 signs each year that have exceeded their service life. Additional signs are replaced each year under other highway projects but these have not necessarily reached their service life.

Performance projections for Limited Access signs are shown in Figure 4-6. Performance projections for Non-Limited Access signs are shown in Figure 4-7. Adopting the preferred funding level would allow CTDOT to meet the desired performance target over the 10-year period of the TAMP.

Based on funding as of 6/30/17

Figure 4-6. Limited Access Signs Performance Projections

Funding value includes the cost of overhead sign supports and foundations that are not in poor condition but require replacement due to sign revisions.

Based on funding as of 6/30/17

Figure 4-7. Limited Access Signs Performance Projections

Sign Supports

CTDOT does not currently model future sign support performance. With 98% of sign supports in a SOGR, the modeling for this asset was not considered a priority with the time available to complete the TAMP. In the future, we expect that a condition-based deterioration methodology similar to bridges will be developed for sign supports.

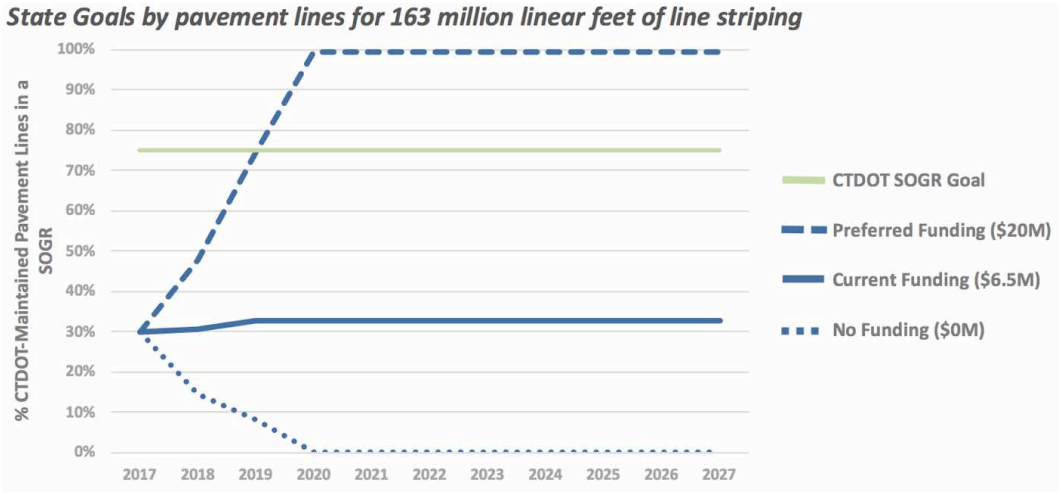
Pavement Markings

Performance projections for pavement markings were developed based on the current process for managing this asset. Pavement markings are organized into two categories determined by unit of measure: Line Striping (linear feet) and Symbols & Legends (square feet). In order to determine performance projections, the two categories are then further defined by two types: epoxy and water-based. The distinction of the two types is important to the projection

modeling since epoxy pavement markings have a three-year service life while water-based pavement markings have a one-year service life. In-laid pavement markings have been applied at limited locations on the state network thus far and are expected to have a service life of 6 years. At this time, due to their limited use, they have not been broken out as a separate category in the inventory so they are assumed to be epoxy for purposes of this TAMP.

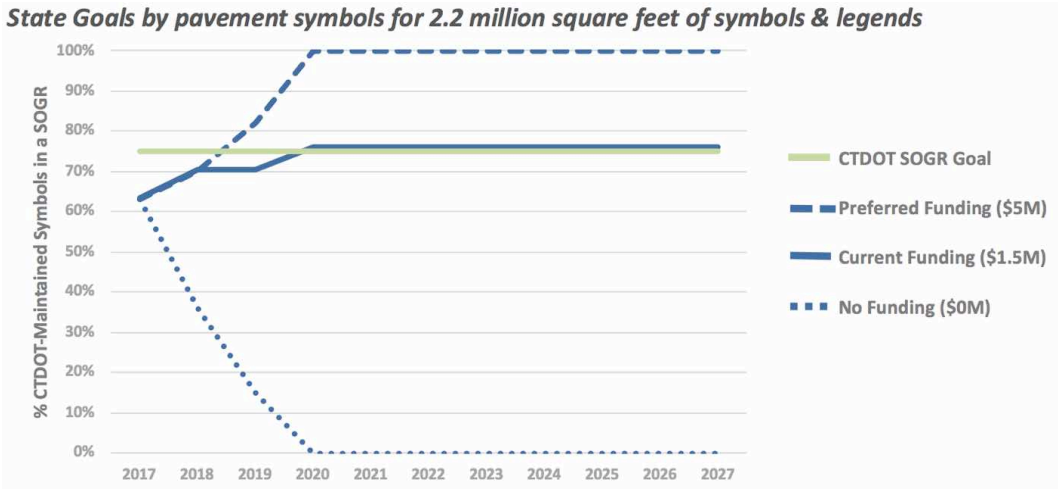
Each year nearly 54 million linear feet of line striping and 735,000 square feet of symbols and legends, that have exceeded their service life, would need to be replaced for this asset class to achieve its performance target in future years. Currently, CTDOT replaces approximately 13 million linear feet of line striping and 350,000 square feet of symbols and legends each year that have exceeded their service life. Additional epoxy pavement markings are replaced each year under other highway projects but these have not necessarily reached their service life.

Performance projections for line striping are shown in Figure 4-8 Performance projections for symbols and legends are shown in Figure 4-9.



Based on funding as of 6/30/17

Figure 4-8. Lines Performance Projections



Based on funding as of 6/30/17

Figure 4-9. Symbols Performance Projections

Asset Performance Gap Analysis

CTDOT has established a process for conducting a gap analysis by evaluating gaps between current and desired condition and developing strategies to close those gaps. FHWA defines a performance gap as "the gaps between the current asset condition and State DOT targets for asset condition, and the gaps in system performance effectiveness that are best addressed by improving the physical assets."

Connecticut's gap analysis includes two gap calculations: current gap and projected gap.

- **Current gap** is the gap between current performance and the 10-year desired SOGR.
- **Projected gap** is the gap between the current funding performance projection and the 10-year desired SOGR.

For this TAMP, 10-year projection refers to the projected performance in 2027. For traffic signals, the projection is for 2026.

Both current and projected gaps are shown in terms of the change in performance required to meet the desired SOGR. For measures of good conditions, a gap indicates the need to increase the percent of assets in good conditions by the specified amount. For measures of poor conditions, a gap indicates the need to reduce poor conditions by the specified amount.

NHS Assets

The gap analysis for NHS bridges and pavements is shown in Table 4-7. While there are minor current and projected gaps for bridge assets, there are bigger gaps for pavement assets, specifically projected gaps for Interstate and Non-Interstate roadways.

Table 4-7. Performance Gaps using Federal Performance Measures for NHS Assets

Asset	Good	Gap Exceed (Shortfall)	Poor	Gap Exceed (Shortfall)
NHS Bridge Performance Goal	**20%**		**10%**	
Current Performance	**18.1%**	(1.9%)	**15.0%**	(5.0%)
10-Year Projected Performance	**26.3%**	6.3%	**11.7%**	(1.7%)
Interstate Pavement Performance Goal	**75.0%**		**5.0%**	
Current Performance	**66.2%**	(8.8%)	**2.2%**	2.8%
10-Year Projected Performance	**49.8%**	(25.2%)	**4.0%**	1%
Non-Interstate NHS Pavement Performance Goal	**50.0%**		**8.0%**	
Current Performance	**37.9%**	(12.1%)	**8.5%**	(0.5%)
10-Year Projected Performance	**23.0%**	(27.0%)	**12.2%**	(4.2%)

CTDOT-Maintained Assets

The gap analysis for CTDOT-maintained assets is shown in Table 4-8. Sign supports currently exceed performance goals and pavement markings – symbols & legends are projected to exceed performance goals in ten years. All other state-maintained assets in the TAMP have current and projected performance gaps.

Table 4-8. Performance Gaps using CTDOT Performance Measures for CTDOT-Maintained Assets

Asset	SOGR	Gap Exceed (Shortfall)
Bridge Performance Goal	95.0%	
Current Performance	93.8%	(1.2%)
10-Year Projected Performance	93.0%	(2.0%)
Pavement Performance Goal	80.0%	
Current Performance	60.6%	(19.4%)
10-Year Projected Performance	39.0%	(41.0%)
Traffic Signals Performance Goal	80.0%	
Current Performance	71.6%	(8.4%)
10-Year Projected Performance	59.6%	(20.4%)
Signs – Limited Access Performance Goal	80.0%	
Current Performance	33.3%	(46.7%)
10-Year Projected Performance	54.5%	(25.5%)
Signs – Non-Limited Access Performance Goal	70.0%	
Current Performance	42.2%	(27.8%)
10-Year Projected Performance	58.3%	(11.7%)
Sign Supports Performance Goal	90.0%	
Current Performance	98.8%	8.8%
10-Year Projected Performance	n/a	n/a
Pavement Markings – Line Striping Performance Goal	75.0%	
Current Performance	29.8%	(45.2%)
10-Year Projected Performance	32.8%	(42.2%)
Pavement Markings – Symbols & Legends Performance Goal	75.0%	
Current Performance	63.6%	(11.4%)
10-Year Projected Performance	75.9%	0.9%

To close these performance gaps, CTDOT is focused on investing in assets to maintain a SOGR. CTDOT is adopting asset strategies that involve a series of treatments at optimal times to maintain assets in a SOGR to help improve asset condition over the life cycle of the asset while minimizing cost. CTDOT is also moving further towards a proactive, preservation-first approach. Using available funding, CTDOT will prioritize projects that can help close performance gaps using asset management principles and practices. For bridges and pavements, we have a prioritized focus on the NHS. For bridge projects there is an emphasis to maintain project schedules of all projects addressing poor bridges on the NHS in order to meet performance targets as projected. For performance that moves in the negative direction, additional funds or a reallocation of funds from other assets will be needed to make progress in closing the performance gaps. It is anticipated that in 2021, asset management will start driving the Financial Plan. The approaches for closing these gaps, achieving state targets, and making progress towards national goals are further detailed in subsequent chapters of the TAMP, including Chapter 5 Life Cycle Planning, Chapter 7 Financial Plan, and Chapter 8 Investment Strategies.

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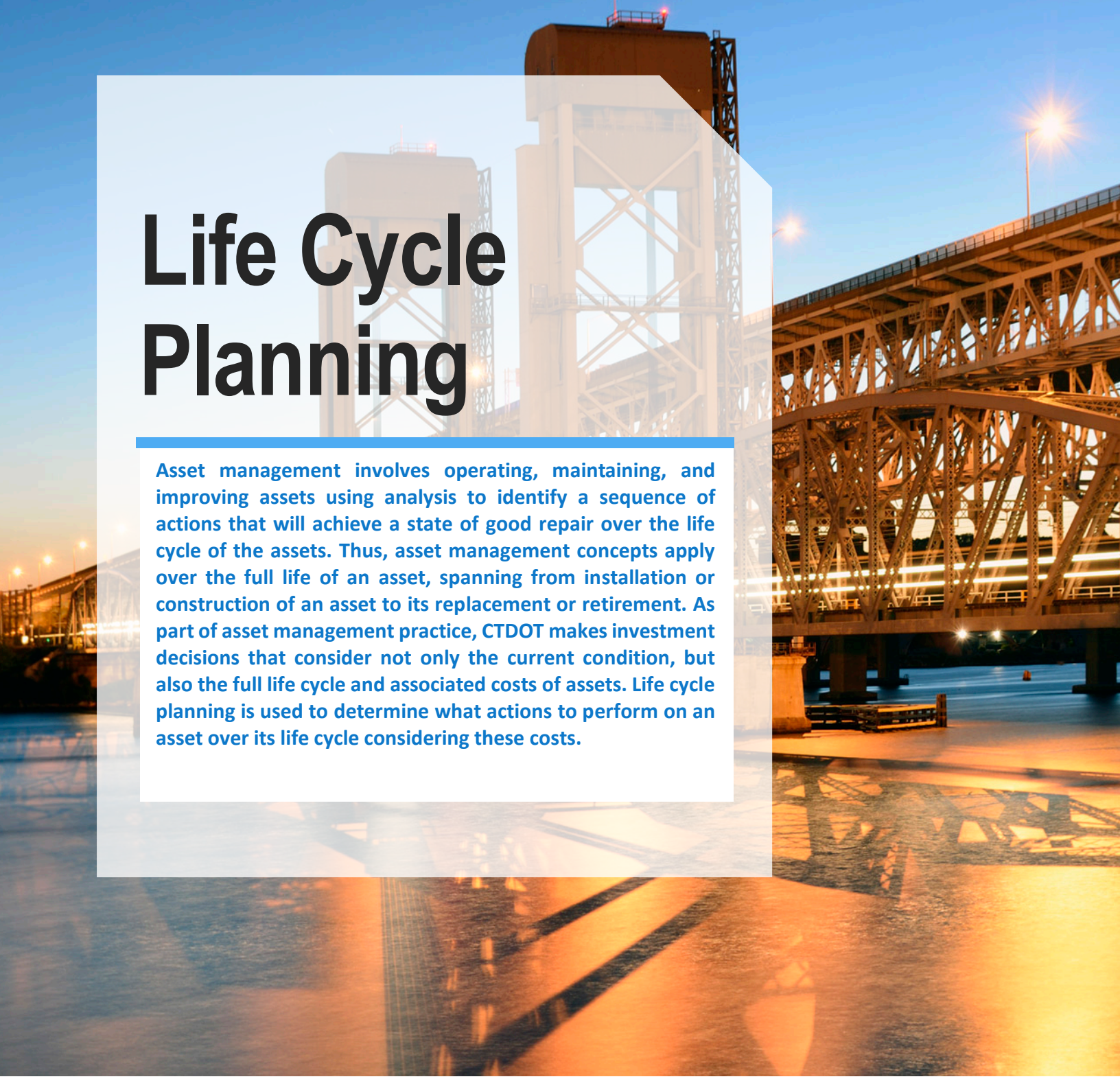

Life Cycle Planning

Asset management involves operating, maintaining, and improving assets using analysis to identify a sequence of actions that will achieve a state of good repair over the life cycle of the assets. Thus, asset management concepts apply over the full life of an asset, spanning from installation or construction of an asset to its replacement or retirement. As part of asset management practice, CTDOT makes investment decisions that consider not only the current condition, but also the full life cycle and associated costs of assets. Life cycle planning is used to determine what actions to perform on an asset over its life cycle considering these costs.

CHAPTER 5

Connecticut Department of Transportation
TRANSPORTATION ASSET MANAGEMENT PLAN

Overview

This chapter describes CTDOT's life cycle planning (LCP) for its bridges, pavements, traffic signals, signs, sign supports, and pavement markings. FHWA defines LCP 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 differs from life cycle cost analysis (LCCA) in that LCP is a network-level analysis to identify treatment strategies, while LCCA is a project-level analysis that compares design alternatives. LCP optimizes cost efficiency over the life of an asset and is a key element of asset management which helps extend asset life and improve performance.

The basic principle underlying both LCP and LCCA is fundamental to asset management: **Timely investments in an asset results in improved condition over a longer time period and lower long-term cost**. Application of preventive maintenance early in an asset's life when it is still in relatively good condition can delay the need for more costly rehabilitation, replacement, or reconstruction and result in an overall lower life cycle cost. This principle is illustrated by Figure 5-1. The figure shows asset condition and costs over time for two scenarios: an asset management approach of preventive maintenance and a reactive approach. The example shows potential savings of $160 million over 40 years with assets maintained in better overall condition.

LCP links the TAMP condition data and targets to the financial plan and investment strategies by using deterioration rates and treatment options to help identify optimal asset strategies. These LCP asset strategies are defined in FHWA's interim guidance on using LCP to support asset management as "a collection of treatments that represent the entire life of an asset class or sub-group."

LCP involves development of deterioration models based on condition history data, assumption of a life expectancy for each maintenance and rehabilitation treatment, and calculating full life cycle costs associated with alternative treatment strategies.

Life Cycle Cost

The cost of managing an asset class or asset sub-group for its whole life, from initial construction to the end of its service life.

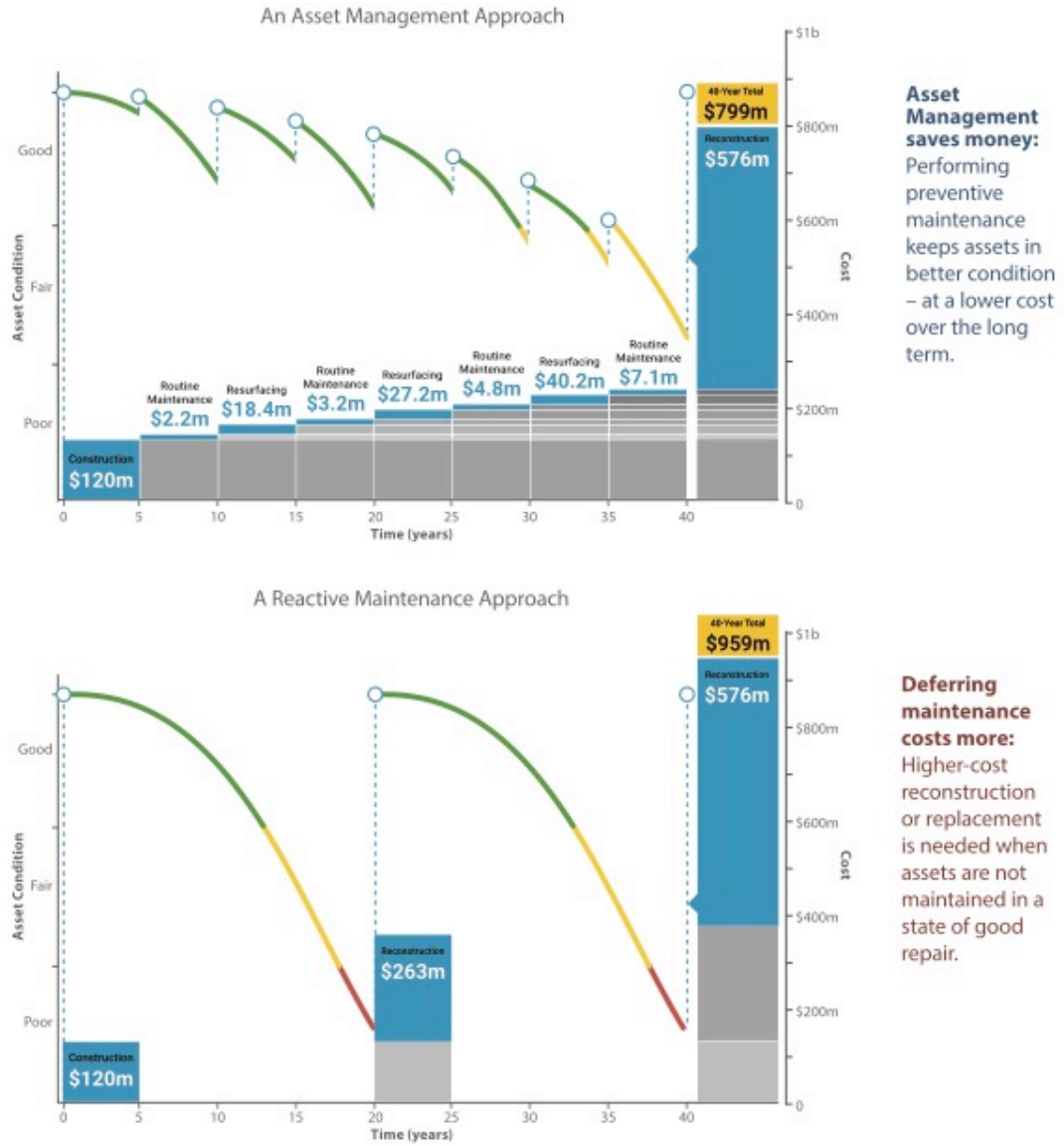

Figure 5-1. Sample Representation of Proactive Maintenance vs. Reactive Maintenance

Source: Rhode Island DOT, Investing in Rhode Island's Future: A 10-Year Plan to Strengthen Our State's Transportation Systems. 2014. Based on an analysis published by TXDOT. Texas DOT, Typical Life Cycle Costs of a Highway, 2014. http://ftp.dot.state.tx.us/pub/txdot-info/tpp/2040/Life Cycle-costs-of-a-highway.pdf

CTDOT conducts LCP for the six asset classes in the TAMP, using management systems and models to evaluate potential treatments and funding levels. LCP is a tool that can help CTDOT make progress towards asset performance targets. CTDOT's data collection, performance targets, modeling approach, asset treatments, and treatment strategies are key components of LCP. Current CTDOT LCP practices are summarized in this chapter.

Federal Legislative Context

FHWA requires that State DOTs establish a process for conducting LCP at the network level for NHS pavements and bridges.

Life Cycle Planning Process Requirements

The following elements must be included in a LCP process:

- Identification of deterioration models
- Potential work types, including treatment options and unit costs
- A strategy for minimizing life cycle costs and achieving performance targets
- Asset performance targets

In addition, LCP should include future changes in traffic demand and information on current and future environmental conditions including extreme weather events, climate change and seismic activity.

Life Cycle Planning for Bridges

Data Collection

Bridge data, including culverts, are collected through inspections performed to meet NBIS requirements, as well as more detailed element-level inspections. Data collection is discussed in detail in Chapter 3 Asset Data Management.

Modeling Approach

CTDOT uses dTIMS to detail its LCP strategy for bridges and to perform network-wide bridge analysis based on this strategy. CTDOT is also experimenting with AASHTOWare BrM software for deterioration modeling, but at this time, integrating inventory and condition data into the BrM system is still in development at CTDOT. CTDOT staff run deterioration models in dTIMS for the entire network, deduct the 60 designated major bridges from the dTIMS analysis, and then adds a separately prepared major bridge analysis to obtain a more accurate network-wide forecast. Engineers manually review bridge conditions and make recommendations for future projects on major bridges. Some major bridge projects can easily exceed the available budget in any given year, which will either cause the dTIMS analysis to stop or will result in no work ever being recommended on a particular major bridge because sufficient funds will never be available in any one year. Therefore, for the foreseeable future, treatments and associated costs

for work on major bridges will be entered into dTIMS manually, and the budgets available for other structures will be adjusted accordingly.

The dTIMS model predicts bridge conditions using inspection data with both component and element level rating systems. Condition is measured on a scale from 0 (worst/failed) to 9 (best) for components and a scale from 1 (best) to 4 (worst) for elements. As detailed in Chapter 2, overall bridge condition is established by determining the minimum value of the deck, superstructure, or substructure for span bridges and the culvert rating for culverts. If the rating is 4 or lower, the bridge is defined to be in poor condition. If the rating is 5 or 6, the bridge is defined to be in fair condition. If the rating is 7 or higher, the bridge is defined to be in good condition. The dTIMS system also calculates a Health Index (HI) on a scale from 0.00 to 100 based on a weighted average of component and element condition ratings. The maximum item ratings used for the HI calculation are shown in Table 5-1 with the data source of the rating identified: NBI field, National Bridge Element (NBE) field, CTDOT Bridge Inspection Form (CTDOT BRI-18) field.

Table 5-1. Bridge Health Index Components

Item	Maximum Points
Deck (NBI 58)	15
Superstructure (NBI 59)	15
Substructure (NBI 60)	15
Structural Evaluation (NBI 67)	10
Deck Geometry (NBI 68)	5
Underclearances (NBI 69)	5
Waterway Adequacy (NBI 71)	5
Approach Alignment (NBI 72)	4
Structure Open/Posted/Closed (NBI 41)	2
Paint (CTDOT BRI-18)	5
Bearings (NBE)	5
Girders (NBE)	5
Joints (NBE)	5
Wearing Surface (CTDOT BRI-18)	4
Total	100

Table 5-2 indicates the index value for the specified condition rating for the above components listed in Table 5-1.

Table 5-2. Bridge Health Index Weight Point Scale

Item	Item Rating	Weight Points
Deck (NBI 58), Superstructure (NBI 59), Substructure (NBI 60), Wearing Surface (BRI-18), Paint (BRI-18)	9	10
	8	10
	7	9
	6	7
	5	6
	4	4
	3	2
	2	1
	1	0
	0	0
Joints (NBE) Girders (NBE) Bearings (NBE)	1	5
	2	3
	3	1
	4	0
Structure Open/ Posted/Closed (NBI 41)	A (open) or G (new but not open)	2
	Other than A, G, or K	1
	K (closed)	0
Structural Evaluation (NBI 67), Deck Geometry (NBI 68), Underclearances (NBI 69), Waterway Adequacy (NBI 71), Approach Alignment (NBI 72)	9	10
	8	10
	7	7
	6	5
	5	4
	4	4
	3	2
	2	0
	1	0
	0	0

For items with weighted points, score is determined by taking the fraction of the total possible points that the item rating represents. For example, for a deck with a rating of 5, the Health Index deck component score would be (6/10) X 15 = 9.

dTIMS models deterioration using deterioration curves for each material, design type, and type of component or element, with sets of high, medium, and low curves for each modeled component or element, with a curve corresponding to each starting condition rating. The middle curve represents the performance of the typical example of a particular component; upper and lower curves are for components performing better or worse than expected for their age. The curves were generated based on historical condition inspection collected from 1992 through 2015, and then manually adjusted using engineering judgement to eliminate discrepancies created by data

collection anomalies. The curves were then run against historical data and further refined so that predictions based on historical data would replicate currently observed conditions. There are currently 2,122 deterioration curves for components, and 104 transition probability curves for elements.

A dTIMS run determines all feasible treatments for every bridge, including preservation, maintenance and replacement treatments; and calculates the costs and benefits for each possible treatment for each bridge. Multiple preservation and maintenance treatments may be recommended simultaneously. The treatment strategies are then optimized using an Incremental Benefit Curve (IBC) strategy. IBC is an optimization approach using a search strategies method within the network to maximize benefits while meeting a budget cost constraint. It is calculated using a compilation analysis variable holding the present value cost of all treatments and a compilation analysis variable holding the present value benefit (improvement in Health Index).

If replacement and rehabilitation actions are both feasible, the model chooses the treatment with the greater life cycle cost effectiveness over the analysis period (currently a 30 year analysis for bridges), with a minimum of 10 years between major treatments. The ultimate objective is to select an annual project mix which generates the greatest increase in the aggregate health index by the end of the analysis period given the available funding. As a result, it is possible that, given limited funds, dTIMS will select a less than optimum strategy for a particular structure in order to free up funds for a more beneficial project on another bridge.

Treatments

The treatments and costs used in the model are listed in Table 5-3.

Table 5-3. Bridge Model Treatments and Unit Costs (May 2017) using Estimator®

Treatment	Unit	Unit Cost	
		NHS	Non-NHS
Total Bridge Replacement Large	Deck Area (SF)	$370	$360
Total Bridge Replacement - Medium	Deck Area (SF)	$425	$415
Total Bridge Replacement -Small	Deck Area (SF)	$555	$545
Culvert Repair	Culvert Area Repaired (SF)	$130	$125
Culvert Replacement	Culvert Area (SF)	$245	$235
Deck Rehabilitation	Deck Area Repaired (SF)	$125	$125
Deck Replacement	Deck Area (SF)	$145	$145
Superstructure Repair	Deck Area (SF)	$140	$140
Superstructure Replacement	Deck Area (SF)		
Small (< 1,600 SF)		$361	$360
Medium (1,600 – 11,000 SF)		$305	$295
Large (> 11,000 SF)		$165	$155
Substructure Repair	Deck Area (SF)	$230	$230
Beam End Repair	Girder Quantity (LB/LF)	$5,000	$5,000
Bearing Replacement	Bearing Quantity (LB/LF)	$3,000	$3,000
Joint Replacement	Joint Length (LF)	$230	$230
Paint Rehabilitation	Area Repainted (SF)	$70	$70
Paint Replacement	Area Painted (SF)	$30	$30
Wearing Surface Replacement	Deck Area (SF)	$8	$8

Strategy

The specific set of treatments performed for each bridge modeled in dTIMS are determined based on the available budget and the life cycle cost-effectiveness of each treatment. Only bridges in good or fair condition are considered for preservation treatments. When a bridge has deteriorated to poor condition, the basic strategy is to either repair or replace the component driving the poor condition or replace the entire structure if that is more cost-effective.

Functional adequacy is also weighed when considering repair versus replacement.

In addition to using dTIMS to forecast condition, CTDOT maintains a list of bridges that are already structurally deficient and in need of repair. A Rehabilitation Study Report (RSR) is prepared for each bridge in need of rehabilitation. The RSR considers various rehabilitation options for the individual bridge, and an analysis is performed comparing the costs and benefits of major rehabilitation (e.g. deck replacement, select girder replacement, etc...), full superstructure replacement, and complete bridge replacement. The analysis starts with an assumption of a 75-year life cycle. The RSR presents various maintenance scenarios with the associated present value costs and future treatment schedule.

A challenge in developing an effective life cycle strategy for Connecticut's bridges is determining how best to maintain bridges reaching and exceeding the end of their design life. More than half of the bridges in Connecticut are over 50 years old. When these bridges were built they were designed to last 50 years. New bridges are now typically designed to last 75 years. Preventative maintenance (repairing beam ends, painting, or replacing bearings) and timely rehabilitation actions can extend the life of a structure. Without routine maintenance, costly bridge replacement becomes necessary for addressing needs of a deficient bridge.

Life Cycle Planning for Pavement

Data Collection

Pavement data are collected annually using specially equipped ARAN vans as discussed in detail in Chapter 3 Asset Data Management.

Modeling Approach

LCP strategies for pavement are developed using predictive models for how pavements will deteriorate if no treatments are performed, as well as following different treatment strategies. A treatment strategy is a sequence of treatments over the analysis period. CTDOT models pavement condition and deterioration using the dTIMS PMS. dTIMS is CTDOT's primary tool for storing, managing, analyzing and reporting pavement condition information.

CTDOT uses Deighton's dTIMS to detail its LCP strategy for pavements and to perform network-wide pavement analysis based on this strategy. As part of the analysis for this TAMP, CTDOT staff attempted for the first time to model the Maintenance Resurfacing Program in dTims to obtain a network-wide forecast that is more aligned with actual programming practices.

In order to achieve this, a new mill-and-resurface treatment was created to reflect the Maintenance Resurfacing Program treatment-application rules (worst-first) and expected performance. This allowed the comparison of the outcomes achieved with actual programming practice versus the outcomes possible with a strategy that optimizes life-cycle cost.

The dTIMS model predicts future pavement condition from current conditions using individual condition indices (transformations of distress measurements) which are understood by pavement managers to reflect pavement performance and consequently enable the application of treatments and prediction of performance.

Types of distresses included in each index are shown in Table 5-4. The lower of either the Structural Index or the Environmental Index is later used as the Cracking component in the PCI.

Table 5-4. Distresses Included in dTIMS Indices

Index	Included Distresses
Structural Index	Longitudinal and transverse cracking within wheel paths
Environmental Index	Longitudinal and transverse cracking outside of wheel paths
IRI	Longitudinal roughness based longitudinal profile
Rutting Index	Pavement distortion within wheel paths

Although the calculation of the individual condition indices is technically possible within dTIMS, CTDOT calculates the indices outside of dTIMS during the data-reduction processing of raw, 5-meter condition data into 0.10-mile segments used at the network level. Once loaded into dTIMS, they are used as the basis for the scenario analysis, which is represented at a high-level in Figure 5-2 and described in more detail below.

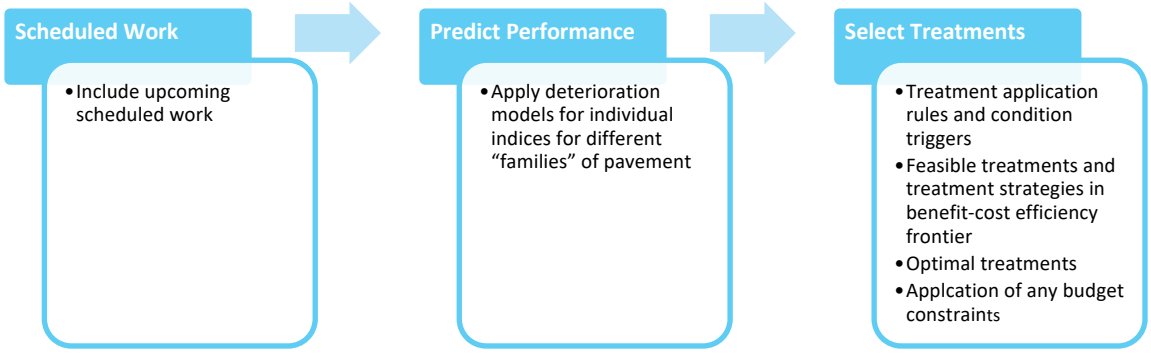

Figure 5-2. Overview of dTIMS Scenario Analysis

A combined condition index, called the PCI, is composed of these indices plus other legacy components such as drainage and disintegration. The PCI correlates to the individual "triggering" indices and is used in the optimization (the benefit-cost analysis). The PCI is on a 1.0 to 9.0 scale, from worst to best, reflects legacy agency practice, and is well understood within CTDOT. PCI calculation values are shown in Table 5-5.

Table 5-5. Pavement Condition Index

Component	Pavement Condition Index Weight (%)	Rating	Classification
Cracking	25	≥6	Good
		≥4 and <6	Fair
		<4	Poor
Rutting	15	≥6	Good
		≥4 and <6	Fair
		<4	Poor
Disintegration	30	≥6	Good
		≥4 and <6	Fair
		<4	Poor
Drainage	20	≥6	Good
		≥4 and <6	Fair
		<4	Poor
IRI	10	≥6	Good
		≥4 and <6	Fair
		<4	Poor
Total	100	≥6	Good
		≥4 and <6	Fair
		<4	Poor

To begin the scenario analysis, initial treatments are entered to include scheduled work for the initial year as well as projects that are in the project-development pipeline and expected to be accomplished. The dTIMS analysis then applies models for different pavement families to predict performance of those pavements and to select subsequent treatments. Feasible treatments are selected based on treatment triggers (conditions under which a treatment is feasible) that have been refined over time.

In the scenario analysis, dTIMS examines what treatments each pavement segment is eligible to receive for each year (including future years), and develops multiple strategies for each road segment representing a series of treatments over the scenario time horizon. These strategies are driven by the performance curves and the values that conditions are reset to following treatments. Each strategy uses a discount rate and inflation rate to calculate

an incremental benefit/cost value that represents maximum benefit-to-cost ratio. The scenario analysis then compares across strategies to select an optimal set of treatments based on benefit/cost. Costs are pavement-related costs and benefits are the difference in condition between the strategy and a baseline do-nothing strategy, weighted by a function, the square root of the AADT, recognizing that benefits accrue to a larger number of users.

Treatments

CTDOT's pavement treatments and unit costs are listed in Table 5-6. Each treatment has conditions under which it is feasible to be applied, a treatment trigger, and an impact on pavement condition which resets values for each of the individual condition indices.

Table 5-6. Pavement Treatment Costs using Estimator®

Treatment	Unit	Unit Cost
Ultra Thin Treatment	SY	$8.97
Mill and Fill /Maintenance Resurfacing (2 in.)	SY	$25.61
Mill and Fill (2 inches)	SY	$25.61
Mill and Fill (3 inches)	SY	$34.75
Rubblization	SY	$156.15
Structural Rehabilitation + Joint Repair	SY	$51.78
Structural Rehabilitation	SY	$49.99
Reclamation	SY	$66.73
Reconstruction (light, flexible)	SY	$102.83
Reconstruction (medium, flexible)	SY	$132.15
Reconstruction (heavy, flexible)	SY	$165.98
Reconstruction (light, composite)	SY	$108.57
Reconstruction (medium, composite)	SY	$138.28
Reconstruction (heavy, composite)	SY	$172.89
Diamond Grinding	SY	$14.67
Diamond Grinding + Joint Repair	SY	$20.65
Concrete Pavement Repairs and Structural Overlay	SY	$46.60
Rubberized Chip Seal	SY	$6.39
Thin Overlay	SY	$19.20
Microsurfacing	SY	$7.05

Strategy

The LCP strategy modeled in dTIMS is analyzed by first running an "unconstrained program" in terms of treatment scopes. The benefit-cost optimization leads to the observation that pavement preservation strategies are prioritized at all funding levels; rehabilitation and reconstruction are also selected but increasingly so at higher funding levels, in particular to decrease the "backlog" of pavement segments that are beyond the condition levels at which preservation is feasible.

Approximately 35% of CTDOTs pavement lane miles were constructed prior to 1950 and another 44% were constructed between 1950 and 1980. A majority of these pavements were built with a 20-year design life. Through rehabilitation and resurfacing programs, CTDOT has been working to extend the useful life of these pavements, particularly through increased use of preservation treatments. In 2010, CTDOT began a transition to a more balanced program of pavement maintenance, preservation, overlays, and rehabilitation. The intent is to move away from a "worst first" strategy which emphasizes treating pavements in poor condition. A preservation program strives to extend the life of pavements in good condition.

Recommended treatments are evaluated by CTDOT staff when determining what work to perform on a pavement section. Currently approximately 50% of the projects recommended by dTIMS are programmed for delivery. There are many reasons why some variation from the recommendations is inevitable – actual project costs vary based on funding source and delivery mechanism, actual pavement deterioration varies based on site-specific characteristics, and selection of paving locations includes multiple considerations beyond pure benefit/cost. Additionally, project limits may be altered to coordinate with another infrastructure need, to capture economies of scale in project delivery (adjacent segments in similar conditions) and other factors.

CTDOT mandates use of Superpave mix design on all pavement construction projects, with polymer-modified asphalts on all resurfacing for Interstates and Expressways (Functional Class 1 or 2). CTDOT leverages the work of the Pavement Advisory Team and the HMA Steering Committee to provide lessons learned into effective pavement design, construction and preservation techniques.

Life Cycle Planning for Traffic Signals

Data Collection

Traffic signals data are managed by the Division of Traffic Engineering in a SQL database with a Microsoft Access front end for data entry and viewing. Data collection is discussed in detail in Chapter 3 Asset Data Management.

Modeling Approach

CTDOT models traffic signals using an age-based approach. The model assumes that traffic signals should be replaced after 25 years, the age at which they are no longer considered in a SOGR.

Treatments

Typical treatments and costs are shown in Table 5-7. Replacement of the all signal equipment at an intersection and LED replacements at fixed intervals are the only treatments used for lifecycle planning for traffic signals.

Table 5-7. Traffic Signal Model Treatments and Unit Costs using Estimator®

Treatment	Unit	Unit Cost
Replace Traffic Signal	Each	$200,000
Replace Overhead Flashing Beacon	Each	$50,000

Strategy

CTDOT's life cycle strategies for traffic signals are summarized in Table 5-8. The current life cycle strategy for traffic signals in Connecticut is to replace traffic signals after 25 years. Traffic signals are also upgraded during intersection improvement projects, through encroachment permits by developers, and in response to customer complaints. CTDOT currently replaces approximately 60 signalized intersections per year under the annual traffic signal program.

Table 5-8. CTDOT's Life Cycle Strategies for Traffic Signals

Asset Management Method	Description
Age-Based Replacement	Traffic Signals replacement based on expected life
Service Replacement	Traffic signal replacement based on response to customer complaints, sensor detection malfunction, etc.
Other Projects	Traffic Signal upgrade, replacement, installation, or removal due to modifications to the roadway, regardless of age

CTDOT's intent in the future is to manage the lifecycle of traffic signal assets at a component level rather than as an entire signalized intersection. For example, the new approach would assume LED replacements at 8 and 16 years and span pole or mast arm replacements at 50 years. CTDOT has only begun implementing this approach for the LED component.

Life Cycle Planning for Signs

Data Collection

CTDOT has a sign inventory that was captured using images from the 2013 Photolog. Data collection is discussed in detail in Chapter 3 Asset Data Management.

Modeling Approach

CTDOT models signs using an age-based approach. The model assumes that signs are replaced after 17 years, the age at which they are no longer considered in a SOGR.

Treatments

Typical treatments and costs for signs are shown in Table 5-9. Replacement is currently the only treatment for signs.

Table 5-9. Sign Model Treatment and Unit Costs using Estimator®

Treatment	Unit	Unit Cost
Replace Sheet Aluminum Sign	SF	$35
Replace Extruded Aluminum Sign		
• Sign Sheeting	SF	$25
• Sign Support Steel	CWT	$305
• Foundation (typically 2 per sign) for signs mounted on the side of the road.	EA	$3,500

Note: CWT = Hundredweight (US weight equivalent to 100 pounds)

Strategy

CTDOT's life cycle strategies for signs are summarized in Table 5-10. The current life cycle strategy for signs in Connecticut is to replace assets after 17 years. Signs may also be scheduled for replacement following visual inspections, corridor replacement of all signs by type or location, corridor replacement of signs in a project area such as Maintenance Resurfacing projects, or for statewide safety initiatives such as school zone warning signs and ramp wrong way signs.

Table 5-10. CTDOT's Life Cycle Strategies for Signs

Management Method	Description
Age-Based Replacement	Signs are replaced based on manufacturer expected life
Nighttime Visual Inspections	Signs are replaced based on visual observation of each sign
Corridor Replacement	Signs are replaced by type or location regardless of age or condition
Safety Initiatives	Signs are removed, replaced or installed by type regardless of age or condition based on safety needs
Other Projects	Sign upgrade, replacement, installation, or removal due to modifications to the roadway, regardless of age

Life Cycle Planning for Sign Supports

Data Collection

Sign support data are collected during inspections, typically on a 4-year basis. Data collection is discussed in detail in Chapter 3 Asset Data Management.

Modeling Approach

CTDOT has not yet modeled sign supports to project condition.

Treatments

Typical treatments and costs are shown in Table 5-11. Replacement is currently the only treatment for sign supports.

Table 5-11. Sign Support Model Treatments and Unit Costs using Estimator®

Treatment	Unit	Unit Cost
Replace Cantilever	Each	$100,000
Replace Full Span	Each	$250,000
Replace Bridge Mount	Each	$50,000

Strategy

CTDOT's life cycle strategies for sign supports are summarized in Table 5-12. The current life cycle strategy for sign supports in Connecticut is to replace assets when they fall into poor condition (overall rating less than 5) or are overstressed (Combined Stress Ratio greater than 1.03). CTDOT staff review the inspection list and program assets for replacement based on condition. However, many sign supports are replaced during projects initiated for other assets (signs) or highway improvements.

For signing projects, the recent code changes and sign size increases have made older sign supports become obsolete. This has required many non-condition based replacements over the past several years. Other strategies are now being implemented to reduce these types of replacements. Whenever possible, sign supports are being removed and replaced with signs mounted along the side of the road. Also, more recently, Traffic Engineering has begun reducing the sign legend spacing to maintain current sign sizes in order to retain existing sign supports in good condition.

Table 5-12. CTDOT's Life Cycle Strategies for Sign Supports

Management Method	Description
Condition-Based Replacement	Sign support replacement or repair based on poor or overstressed condition
Signing Replacement Projects	Sign support replacements driven by installation of larger sign panels on the support to meet MUTCD requirements.
Corridor Replacement	Sign supports are replaced by location regardless of condition
Other Projects	Sign upgrade, replacement, installation, or removal due to modifications to the roadway, regardless of condition

Life Cycle Planning for Pavement Markings

Data Collection

Pavement markings data are based on assumptions for inventory and age. Data collection is discussed in Chapter 3 Asset Data Management.

Modeling Approach

CTDOT models pavement markings using an age-based approach. The model assumes that water-based pavement markings are replaced after 1 year and epoxy pavement markings are replaced after 3 years.

Treatments

Typical treatments and costs for pavement markings are shown in Table 5-13. Replacement is currently the only treatment for pavement markings. At this time CTDOT is not able to easily obtain a unit cost for water-based treatments. Although paint costs can be obtained, the labor, equipment and maintenance and protection of traffic costs are complex to calculate across the network.

Table 5-13. Epoxy Pavement Marking Model Treatments and Unit Costs using Estimator®

Treatment	Unit	Unit Cost
Line Striping Replacement (epoxy only)	Linear Feet	$0.50
Symbols and Legends Replacement (epoxy only)	Square Feet	$3.50

Strategy

CTDOT's life cycle strategies for pavement markings are summarized in Table 5-14. The current life cycle strategy for pavement markings in Connecticut is to replace water-based pavement markings annually and epoxy pavement markings on a 3-year cycle. Location and priority are often based on visual inspection, public requests, and needs designated by construction projects. Since Maintenance is unable to apply epoxy markings due to application constraints, Maintenance's only available in-house treatment is water-based markings. Therefore, the Maintenance Resurfacing Program applies water-based markings at the time of paving followed with epoxy markings applied at a later date under contract.

Table 5-14. CTDOT's Life Cycle Strategies for Pavement Markings

Management Method	Description
Condition-Based Replacement	Reduced retroreflectivity or level of service triggers location-specific treatments.
Age-Based Replacement	Replace pavement marking based on asset age

CTDOT is moving towards a pavement marking program that would replace all pavement markings with epoxy every 3 years as a goal but starting at every 4 years initially. CTDOT is continuously researching products to find marking material that can provide a longer service life for the conditions in Connecticut.

Summary

The LCP process helps CTDOT consider the costs of maintaining an asset throughout its life and the optimal strategies for preserving asset condition while minimizing costs. Connecticut's LCP approach for bridge and pavement assets is relatively advanced, analyzing component condition ratings using management systems and developing management strategies based on modeled treatments. LCP for traffic signals, signs, sign supports, and pavement markings is a less mature process. Connecticut uses age-based replacement for these assets and is starting to invest in and improve modeling capabilities. The results of the LCP process are used to define the TAMP financial plan and investment strategies.

Risk Management

Managing transportation assets also entails managing risk. Risk is the positive or negative effects of uncertainty or variability upon Connecticut's transportation objectives. CTDOT must balance a wide variety of risks on an ongoing basis and take prudent mitigation actions given funding constraints. Risks range from daily operational concerns to potentially catastrophic risk of asset failures.

CHAPTER 6

Connecticut Department of Transportation
TRANSPORTATION ASSET MANAGEMENT PLAN

Overview

This chapter discusses the CTDOT's risk management approach, identifies risks to the CT transportation systems, and discusses CTDOT's initial TAM risk assessment, evaluation, prioritization, and potential treatments. The objective for the TAM risks is to achieve the SOGR as defined for each asset.

Considering risk is important in developing a TAMP for the simple reason that mitigating risks can require transportation agencies to spend significant resources responding to and/or mitigating risk. Reacting to the uncertainty presented by risks is more expensive than proactive management. Employing risk management strengthens asset management programs by explicitly recognizing that any objective faces uncertainty and identifying strategies to reduce that uncertainty and its effects. Being proactive rather than reactive in managing risk will help CTDOT to better utilize capital funding toward maximizing the condition of all transportation assets.

Federal Legislative Context

As defined by FHWA, "Risk is the positive or negative effects of uncertainty or variability upon agency objectives." –Ref FHWA-HIF-12-035

The Federal Rules and Regulations Part 515 Section 515.7 (c) mandates that, "A State DOT shall establish a process for developing a risk management plan." Specific requirements for the process are listed below.

Risk Management Process Requirements

- Identification of risks that can affect the condition of NHS pavements and bridges and the performance of the NHS, including risks associated with current and future environmental conditions
- Assessment of the identified risks in terms of the likelihood of their occurrence and their impact and consequence if they do occur
- Evaluation and prioritization of the identified risks
- Mitigation plan for addressing the top priority risks (required in June 2019)
- Approach for monitoring the top priority risks (required in June 2019)
- Summary, for NHS bridges and pavement, of the evaluations of facilities repeatedly damaged by emergency events (required in June 2019)

Transportation Risk

Every transportation system faces a range of general types of risks as well as risks specific to the individual system and state. Some of the broad transportation risks that are currently of particular focus to CTDOT are listed below.

Common Transportation Agency Risks also faced by CTDOT

- Insufficient State and Federal funding
- Insufficient staffing
- Construction inflation costs
- Inability to meet targets and adhere to the financial plan due to delayed and overbudget project delivery
- Extreme weather or climate events
- Lack of asset management support throughout the Agency
- Changing agency priorities due to political pressures
- Availability and quality of data, information, and reliable models to allow the accurate projection of future conditions

Of particular focus at CTDOT in 2017-2018 are risks associated with resources to achieve the goals of both Asset Management and the Agency overall goals. Currently, CTDOT is monitoring risks to its budget and seeking increased revenue through the legislature to replenish the Special Transportation Fund (STF) so that investment can be made in our infrastructure.

Staffing is becoming a significant risk to CTDOT to design and deliver work due to an inability to retain newer staff and refill vacant positions. Experienced staff is a crucial resource that is being reduced through attrition. Approximately twenty percent of the employees are eligible to retire. The number of employees leaving state service is expected to notably increase when terms of the State employee contracts for the retirement Cost of Living Adjustment (COLA) change in 2022.

Sufficient asset inventory and condition data are fundamental to the effective practices of asset management. As such, there are inherent and numerous program risks regarding adequate collection, accuracy and completeness of asset data.

CTDOT's Risk Management Approach

Traditionally, transportation risks have been addressed during the execution of projects or as part of the development of asset programs. For example, addressing risks to bridges has been a vital focus for CTDOT. The tragic Mianus River bridge collapse in 1982 on I-95 in Greenwich, Connecticut, drew national attention to the need to carefully inspect and maintain highway bridges. CTDOT's Bridge Safety and Evaluation Unit in the Division of Bridges is charged with ensuring the safety of the traveling public by identifying bridge deficiencies through the inspection process and ensuring that these deficiencies are quickly addressed.

CTDOT is actively engaged in improving its approach to risk management. Specific initiatives have been undertaken at the project, program and enterprise levels. The goal is to identify and plan ahead for potential project risks instead of reacting to issues that could have been avoided. Training was held for targeted groups and functions within CTDOT to expand the understanding of key components of implementing risk management.

Program Level

TAM, addressed at the program level, has been the most significant risk management initiative to-date. CTDOT initiated development of a risk management plan for asset management as an improved business process and to address the federal rules and regulations. This federal mandate requires specific information, including the identification of risks, assessment, evaluation prioritization, and mitigation.

Project Level

At the project level, the goal is to improve project execution by better managing project risks through identifying and planning for potential risks to the public, the project schedule or to the project budget. A proactive approach is accomplished by identifying project risks and creating a risk register, which is then used to evaluate projects for potential risks to the project design, scope, schedule or budget. NHI Training was conducted in Connecticut in 2016 with a specific focus on training Project Engineers on the Risk Management process. Risk registries are included in all FHWA Projects of Division Interest, which are typically projects that are larger in size or apply innovative methods. In July 2017, a Construction Directive for Project Modifications and Contingency Management was issued to address the financial risks of a project.

Enterprise Level

At the enterprise level, there has been considerable action at the executive level to identify risks and implement a risk management strategy across CTDOT. Following the productive launch at the asset management program level, an executive

seminar was conducted on October 26, 2016 to provide introductory exposure to risk management to executives and managers. The program included presentations by FHWA Connecticut Division to share their working knowledge with risk management at the agency, program and project levels. This was a valuable experience to gain a better understanding of how priorities are set. Following the seminar, initiatives were undertaken to advance risk management at the executive level, including development of an agency level risk registry with input from the executive office and bureaus. The next step is to develop guidance and structure to successfully roll out an Agency Risk Management Plan.

CTDOT TAM Risk

CTDOT introduced risk management to asset stewards and working groups for bridges, pavements and signals through training, workshops and meetings. These meetings focused on development of registers for specific asset classes. In addition, asset stewards for future TAMP assets, specifically geotechnical and hydraulic assets, were included in the training and workshop development processes so that they could better integrate risk management into their own asset management activities. An introductory, two-hour webinar was conducted for the group to introduce participants to the concepts and terminology prior to the workshop. The March 2016 full-day workshop guided participants through the initial identification and ranking of key asset risks, and to learn the risk management development process. Follow-up meetings were held to continue the risk management process for bridges, pavements and signals. Additional meetings were held to introduce and initiate the process for sign supports and pavement markings, as well as risks to the TAMP.

The steps to develop the information required by FHWA as part of the Risk Management Plan for the TAMP are shown schematically in Figure 6-1. The process also includes the tracking and mitigation of risks. The arrows in the schematic demonstrate the cyclical and continuous cycle that is followed as part of effectively managing the risks.

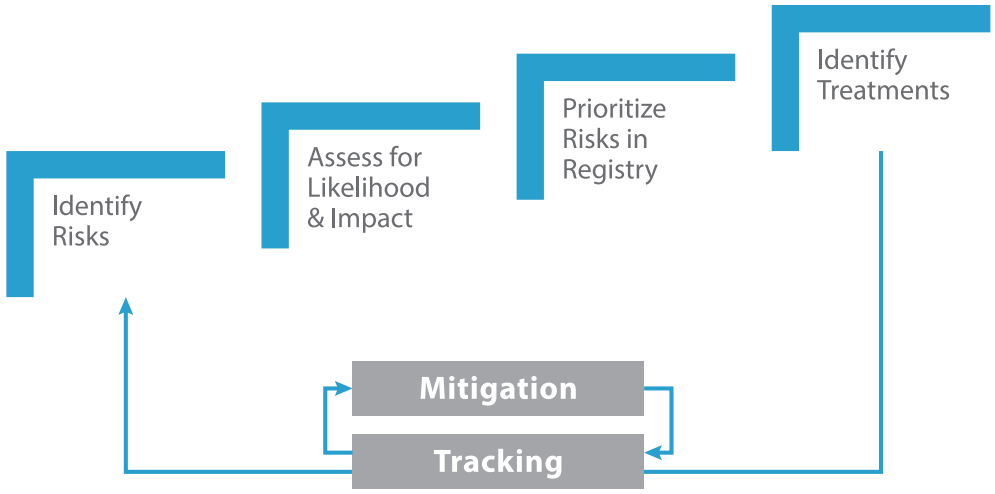

Figure 6-1. Steps to Achieving CTDOT's TAM Risk Process

Identification and Assessment

As part of its asset management initiative, CTDOT began identifying and assessing asset risks to achieving the objective, which in the case of the assets, is the risk to obtaining a SOGR target. (Note: SOGR targets are defined for each asset in Chapter 4 Objectives and Performance). This identification and assessment process was initiated at the risk management workshop held on March 23, 2016. As part of the workshop, a preliminary risk register was developed based on the experiences and knowledge of asset stewards and asset working groups. The risk register is a simple table format or matrix that is used as a risk management tool to summarize an organization's risks, analyze the likelihood and impact, and record possible risk-response strategies.

Each risk is defined by a risk statement that consists of two elements: a description of the risk event and a summary of its potential impact. For example:

Risk Event (*if*)

- CTDOT does not have a certified TAMP in accordance with MAP-21/FAST Act

Potential Impact (*then*)

- Federal funding on projects will be reduced to 65% federal participation

In performing the assessment, CTDOT staff used the risk matrix shown in Figure 6-2 to classify the likelihood and impact of each identified risk. The matrix includes five categories for likelihood and five categories for impact. The rating of a risk is classified as "Low, Medium, High, or Very High" based on the combination of likelihood and impact.

The CTDOT risk registry includes risk registers identified for the TAM program and the six asset classes included in the TAMP.

In developing the risk management process, the initial focus was on threats. Throughout the process, asset stewards were asked to consider and assess opportunities using the same approach.

Risk Matrix with Impact and Likelihood Definitions			Likelihood				
			Rare	Unlikely	Likely	Very Likely	Almost Certain
			Less than once every 10 years	Once in more than 3 but less than 10 years	Once between 1-3 years	Once a year	Several times a year
Impact	Catastrophic	Potential for multiple deaths & injuries, substantial public & private cost.	Medium	Medium	High	Very High	Very High
	Major	Potential for multiple injuries, substantial public or private cost and/or foils agency objectives.	Low	Medium	Medium	High	Very High
	Moderate	Potential for injury, property damage, increased agency cost and/or impedes agency objectives.	Low	Medium	Medium	Medium	High
	Minor	Potential for moderate agency cost and impact to agency objectives.	Low	Low	Low	Medium	Medium
	Insignificant	Potential impact low and manageable with normal agency practices.	Low	Low	Low	Low	Medium

Figure 6-2. Risk Matrix with Impact and Likelihood Definitions

Risk Prioritization and Mitigation Strategies

High and Very High priority risks are listed in the risk register in Table 6-1. The risks are organized according to asset class. CTDOT asset working groups helped develop potential risk mitigation actions, which are listed under the Risk Response column. A total of 109 risks were identified as part of the initial TAMP and are listed in the TAM risk registry in Appendix E. The 38 high and very high priority risks are listed in Table 6-1.

Table 6-1. High and Very High Priority Risks and Responses

Asset	Risk Statement	Risk Rating	Potential Strategies
Bridge	If the rate of bridge deterioration increases faster than predicted as bridges age, then the percent of Structurally Deficient (SD) bridges (by deck area) will increase.	Very High	• Make necessary adjustments to the deterioration modeling and recommended treatments in the dTIMS software • Seek and justify additional funding if necessary

Asset	Risk Statement	Risk Rating	Potential Strategies
Bridge	If we do not address corrosion due to the use of deicing salts on our bridges, then the rate of deterioration may increase.	Very High	• Protect the existing concrete from salt with coatings and the use of low permeability concrete on new bridge and superstructure replacements • Continue to rinse bridges
Bridge	If we do not have load ratings on all bridges, then we may not be able to evaluate safe loads for deteriorated bridges discovered during inspections.	High	• Leverage qualified resources to perform load ratings
Bridge	If we have a lack of bridge maintenance staff and don't continue to maintain our bridges, bridges will continue to deteriorate leading to more serious bridge conditions requiring replacements earlier than necessary.	High	• Share resources by having the Office of Construction (construction inspectors) and the Office of Maintenance Operations / Transportation Maintenance (maintenance district staff) coordinate on bridge maintenance needs thru Bridge Repair Unit (BRU) contracts, administered by the Office of Construction • Hire more bridge maintenance staff to initiate a bridge painting program in the future • Address repairs with Capital Program Funding using Variable Quantity Contracts and bid the work
Bridge	If we don't document institutional knowledge and existing processes, then we will spend more on design time, be less efficient at preparing quality plans, and it will result in longer project schedules.	High	• Document institutional knowledge, provide training, etc. to address attrition within CTDOT
Bridge	If we do not increase the load capacity of bridges, then we will be limiting future freight movements.	High	• Make the load carrying capacity of all bridges a high priority

Asset	Risk Statement	Risk Rating	Potential Strategies
Pavement	If we don't deliver the recommended projects, then pavement conditions will deteriorate and we will lose public credibility.	High	• Define a multi-year program with estimated timelines, and schedules • Provide management support and commitment • Establish reliable contract vehicles to deliver the paving program
Pavement	If we don't select the right projects, then lifecycle costs to achieve or maintain SOGR will increase.	High	• Use flexible, responsive contract vehicles • Continually improve the PMS to optimize project selection • Increase staffing and update the work program to justify the staffing increase • Tolerate some of this risk in the short-term as new technology is implemented
Pavement	If staffing levels are inadequate or if staff are not properly trained, then program delivery will suffer.	High	• Leverage qualified outside resources • Develop a multi-year work program identifying resources needed to achieve objectives • Develop and implement a succession plan
Pavement	If we do not consider the complexity of implementing changes in technology, contracting, etc., opportunities that will enable us to achieve SOGR will be missed.	High	• Incorporate change/new technology into the business process • Develop and deploy effective implementation plans • Match resources to objectives
Traffic Signal	If traffic signal assets deteriorate to a poor condition, then the safety to the public, the efficiency of travel, and the quality of life will be affected.	Very High	• Ensure adequate resources are dedicated to these assets and their related activities • Develop and implement a TAMP

Asset	Risk Statement	Risk Rating	Potential Strategies
Traffic Signal	If we lack traffic signal asset inventories with adequate information on condition, then we can't optimize investments and set priorities.	Very High	• Develop an inventory of traffic signal assets; use new technology to inventory assets and document their age/condition; and coordinate with the Offices of Maintenance and Construction to update/maintain the inventory • Improve tracking of part service records to retire components that repeatedly break down and/or do not achieve the expected service life
Traffic Signal	If there is a lack of adequate maintenance staff who are technically skilled in signal repair, then the performance of traffic-control devices will degrade and public safety will be affected.	High	• Ensure appropriate and sufficient staff and provide technical training to staff. • Investigate leveraging outside resources fort some work if needed/possible.
Sign	If regulatory signs deteriorate to poor condition, then the safety of the public, the efficiency of travel, and the quality of life will suffer.	Very High	• Look into the use of different sheeting types and laminate products to be added onto high significance signs (ex. Stop signs) in order to increase life expectancy of reflectivity and reduce graffiti - effort to be put into reviewing current specifications to have Contractors and Maintenance utilize the same products
Sign	If warning signs deteriorate to poor condition, then the safety of the public, the efficiency of travel, and the quality of life will suffer.	Very High	• Look into the use of different sheeting types and laminate products to be added onto high significance signs (ex. Pedestrian Crossing signs) in order to increase life expectancy of reflectivity and reduce graffiti - effort to be put into reviewing current specifications to have Contractors and Maintenance utilize the same products

Asset	Risk Statement	Risk Rating	Potential Strategies
Sign	If design staff levels are inadequate, then we will not be able to maintain a SOGR for signs.	Very High	• Reprioritize staffing, add staffing or leverage outsource resources
Sign	If staff is not trained to an adequate level, then we will not operate as efficiently as we should. There will be potential duplication of efforts, wasted resources, impacts to public safety and negative public perception.	High	• Develop and implement a training plan
Sign	If guide signs deteriorate to poor condition, then the safety of the public, the efficiency of travel, and the quality of life will suffer.	High	• Look into the use of different sheeting types and laminate products to be added onto high significance signs (ex. Exit Gore signs) in order to increase life expectancy of reflectivity and reduce graffiti - effort to be put into reviewing current specifications to have Contractors and Maintenance utilize the same products
Sign	If the sign inventory is not complete and current, then we cannot optimize investments and set priorities.	High	• Develop and implement a comprehensive plan to address the needs of Maintenance and Design. Consider gathering new inventory data once the plan is in place.
Sign	If there is a lack of adequate maintenance staff to fabricate, install and repair signs, then the performance of signs will degrade and public safety will be affected.	High	• Add staffing and upgrade fabrication equipment
Sign	If posted signs do not match roadway conditions, then drivers may not be prepared for the roadway conditions.	High	• Program projects to address identified deficiencies
Sign	If posted signs do not match approved OSTA and MUTCD requirements, then FHWA funding may be in jeopardy, there is potential for litigation based on incorrect signage, and an increased potential for crashes.	High	• Complete Traffic Investigation Reports (TIR) in a timely manner and compare authoritative databases upon completion

Asset	Risk Statement	Risk Rating	Potential Strategies
Sign Support	If we don't have an accurate or complete inventory and the inventory is not properly updated, then we cannot properly manage this asset and it becomes a safety hazard.	High	• Use the existing process to complete the inventory and continually update it
Sign Support	If there is a lack of staff to conduct routine maintenance, then this impacts structure life, safety, and increases the risk of failure.	High	• Prioritize / address resource needs
Pavement Markings	If there is insufficient staffing due to sign priorities, VIP paving, complaints, and available staff skill sets, then less work will get done and safety will be impacted.	Very High	• Address staffing issues
Pavement Markings	If funding is lower than expected or insufficient, then less work will be completed and safety will be impacted.	Very High	• Take steps to ensure necessary funding
Pavement Markings	If weather conditions are not favorable for paint application (cold/rain), then less work will get done and safety will be impacted.	High	• Adopt strategies to account for variability in weather
Pavement Markings	If equipment is not functioning properly and up-to-date for application needs (example painting of rumble strips, etc.), then work cannot be achieved and safety will be impacted.	High	• Develop plan to address critical equipment redundancy needs
Pavement Markings	If there is insufficient MPT (Maintenance and Protection of Traffic) staff and equipment, then work cannot be achieved and safety will be impacted.	High	• Improve coordination between Signs & Markings and MPT crew schedules
TAM	If there is insufficient funding to support the design, construction and maintenance of assets, then the targets set in our TAMP cannot be achieved.	Very High	• Identify and implement mechanisms to optimize and prioritize the use of funding towards maximum benefit in achieving SOGR

Asset	Risk Statement	Risk Rating	Potential Strategies
TAM	If there is insufficient staffing to support the design, construction and maintenance of assets then the targets set in our TAMP cannot be achieved.	Very High	• Quantify impacts to asset performance due to staffing shortages • Prioritize work and allocate staff based on most critical needs • Seek alternative means to achieve work
TAM	If a significant percentage of the of the assets are beyond the expected life (age), then the practical ability to achieve SOGR will be impeded.	High	• Monitor relationship(s) between age and expected lifecycle/performance • Evaluate tradeoff to lifecycle for replacement vs rehabilitation on SOGR
TAM	If there is insufficient ability to collect, store, retrieve, analyze, interpret and report data, then key asset management functions, such as current and projected performance prediction, cannot be properly achieved.	High	• Develop and implement an effective strategy to provide information technology support for asset management functions • Include a continuous improvement plan to strategically address the mounting needs
TAM	If there is not public stakeholder understanding of preservation practices over 'worst first' practices, then there will be confusion regarding project selection, diminished credibility and lack of public support.	High	• Develop a communication plan that includes information for public stakeholders
TAM	If work is not programmed based on TAM methodologies, then there will be inefficient use of funding, reduction in the ability to achieve SOGR, reduced credibility to the program and potential FHWA financial penalties in bridge and pavement programs.	High	• Utilize information from TAM methods to program work • Track and quantify work programmed based on TAM methodologies to analyze the effectiveness to achieving SOGR

Asset	Risk Statement	Risk Rating	Potential Strategies
TAM	If multiple processes to handle each asset are not streamlined into a unified asset management approach, then the effectiveness of programming according to TAM methods will be reduced.	High	• Understand and accept the benefits of the asset management approach • Have mechanisms in place to facilitate unified management across functional areas (e.g. Asset Working Groups) • Accept that a percentage of work will not be done according to TAM methods • Executive support for unified approach
TAM	If there are not processes in-place to systematically manage and maintain additional assets, specifically those not yet included in the TAMP, that were customarily replaced through highway design contracts, then these additional assets will deteriorate and the SOGR will be impeded.	High	• Identify and prioritize additional assets • Develop plans to address SOGR of these additional assets • Include in future TAMP's
TAM	If there is not sufficient alignment with the STIP CTDOT Statewide Transportation Improvement Program (STIP), then CTDOT will not pass the consistency determination assessment and penalties will be imposed.	High	• Refine a strategy to track asset management specific work • Prepare information for the consistency determination assessment

A categorized summary of the total number and assessment of the risks identified as part of the initial TAMP is provided in Figure 6-3. This provides an initial synopsis for tracking and consideration.

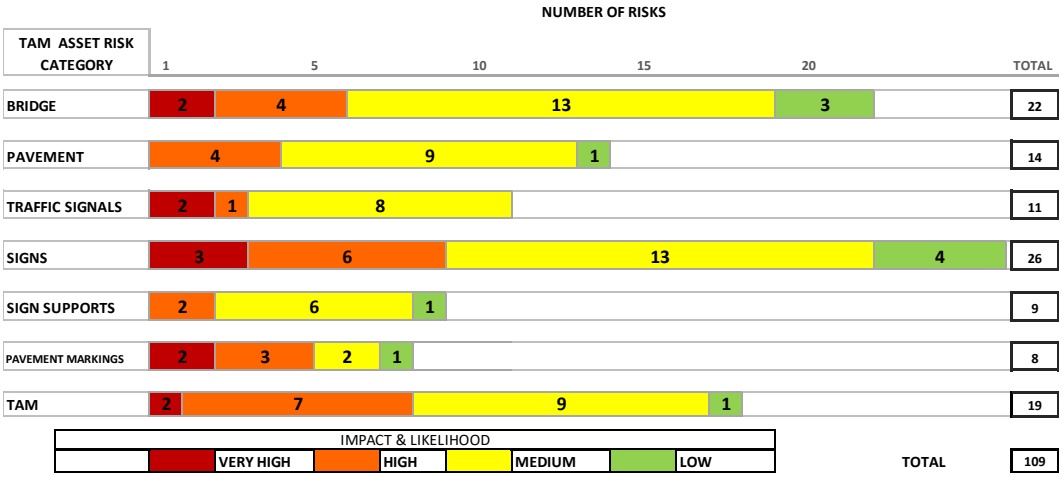

Figure 6-3. Summary of Risks by Category

From the initial summary of risks, four common topics were identified; funding, staffing, coordination and data. These common topics were also apparent at the enterprise risk level. A distribution of risk topics is presented in Figure 6-4.

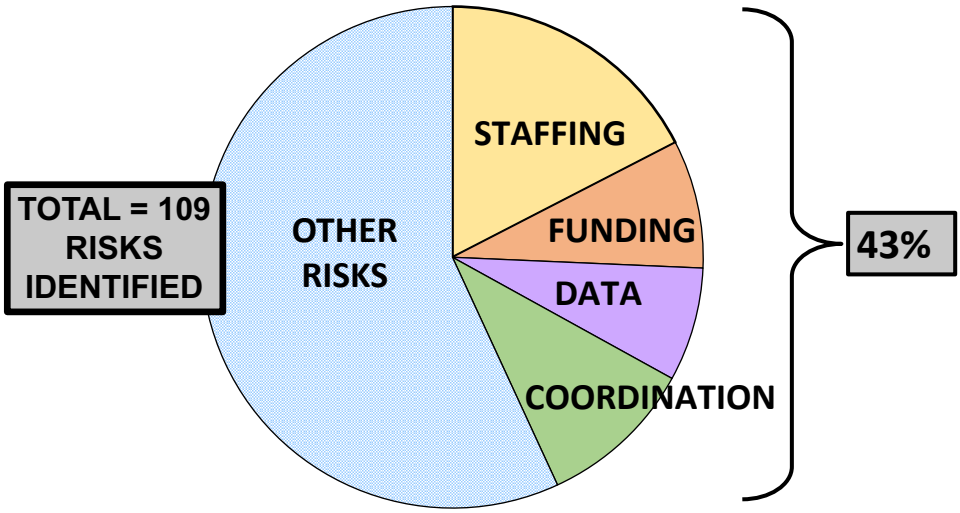

Figure 6-4. Distribution of Risk Topics

The TAM risk management reassessment cycle is anticipated to be in alignment with the TAM update cycle every four years. As experience is gained, it is envisioned that more advanced analyses can be employed to include quantitative analyses of the risks and information gained to determine if there is a better update cycle for the process. Initial steps are being taken to identify ongoing mitigations as well as needs.

Summary of Transportation Assets Repeatedly Damaged by Emergency Events

The second part (Part 667) of the rule issued by FHWA requires state DOTs to perform periodic evaluation of facilities repeatedly requiring repair and reconstruction due to emergency events. According to FHWA, state DOTs "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." Evaluation is defined as "an analysis that includes identification and consideration of any alternative that will mitigate, or partially or fully resolve, the root cause of the recurring damage, the costs of achieving the solution, and the likely duration of the solution." Reasonable alternatives are defined as "options that could partially or fully achieve the following:

1. Reduce the need for Federal funds to be expended on emergency repair and reconstruction activities;
2. Better protect public safety and health and the human and natural environment; and
3. Meet transportation needs as described in the relevant and applicable Federal, State, local, and tribal plans and programs."

While the requirement for evaluations is its own rule, the TAMP requires that the risk management process include a summary of the evaluations for NHS bridges and pavements.

CTDOT interprets this summary to include any assets that have been damaged multiple times and subject to multiple emergency declarations for federal funding. Inquiries were conducted with asset owners, working groups, maintenance and operations as well as financial services staff. In addition, an inquiry was made to FHWA-CT office to see if their reporting and records could provide information to address this evaluation. So far, only one bridge asset was identified that necessitated repairs after both Hurricane Irene and Storm Sandy. In the past, analyses were conducted and submitted to FHWA that showed the cost of repairs was minor in comparison to the replacement cost and therefore did not justify reconstruction. All additional facilities identified did not have more than one record of emergency declarations.

Efforts have been taken to address resiliency of these assets. These include listings of areas of known flooding, listing of NHS extreme weather locations, a Post Sandy FHWA funded Tri-State (sub-regional) Assessment, and a pilot project Connecticut Department of Transportation Climate Change and Extreme Weather Vulnerability Pilot Project (Dec 2014): https://www.fhwa.dot.gov/environment/sustainability/resilience/pilots/2013-2015_pilots/connecticut/final_report/index.cfm

Processes are being sought and developed to enhance CTDOT's ability to track transportation assets repeatedly damaged by emergency events.

Financial Plan

The financial plan connects the transportation asset management objectives and targets to investment strategies, revenues, and project delivery programs. The financial plan summarizes current and anticipated future funding sources, outlining the financial constraints under which CTDOT operates. These constraints drive the decision-making process. The financial plan also estimates the cost of expected future work to implement the investment strategies and achieve progress towards targets set for federal requirements and state goals.

CHAPTER 7

Connecticut Department of Transportation
TRANSPORTATION ASSET MANAGEMENT PLAN

Overview

This chapter describes funding sources and uses for TAM in Connecticut for the NHS and for the State Highway System, comprised of all state-maintained roads, and provides a valuation of assets included in the TAMP. Transportation funding in Connecticut comes primarily from federal and state gas tax revenues. The federal gas tax is the main revenue stream for federal highway programs. Connecticut's state gas tax revenue is directed to a transportation-related state account, the Special Transportation Fund (STF), which is used to fund a wide variety of transportation programs. This includes asset management activities through Fix-it-First and Let's Go CT. The following financial plan shows CTDOT's planned and estimated available funds for TAM and anticipated expenditures by asset class over the 10-year period of the TAMP.

Federal Legislative Context

FHWA requires each state DOT to include a financial plan that spans at least 10 years and identifies funding and costs over that time in their TAMP. FHWA defines financial plan as "a long-term plan spanning 10 years or longer, presenting a State DOT's estimates of projected available financial resources and predicted expenditures in major asset categories that can be used to achieve State DOT targets for asset condition during the plan period, and highlighting how resources are expected to be allocated based on asset strategies, needs, shortfalls, and agency policies." The plan should provide a summary of financial resources and needs for pursuing asset management objectives and achieving performance targets.

FHWA also requires that states establish a process for developing a financial plan as part of the TAMP. The process must produce the items listed below.

FHWA Financial Plan Process Requirements

- Estimated cost of expected future work to implement the investment strategies of the TAMP, by fiscal year and work type
- Estimated funding levels to address the costs of future work types, by fiscal year
- Identification of anticipated funding sources
- Asset valuation estimate for NHS bridge and pavement assets and the needed annual investment to maintain asset value

CTDOT's Financial Plan Approach

Since the Capital Program was already set for the next three years (2018-2020), prior to asset projections, CTDOT used the current Capital Program to develop the investment strategies incorporated in the first TAMP financial plan. The current Capital Program used an allocation strategy to address perceived needs among the various asset classes and, by extension, was used to populate the asset management funding uses and sources. TAM enables CTDOT to become more data-driven. For the years beyond 2020, CTDOT will increasingly use strategies that target specific levels of funding towards meeting the target SOGR goal for each asset.

For each project in our Capital Program, CTDOT uses scope codes to categorize the entire project into a classification by work type and/or asset (i.e. system preservation, preventative maintenance, operational improvements, capacity improvements, major bridge replacement, etc.). Although operational improvement and capacity improvement designated projects may preserve or replace an asset, these scope codes are not included in the TAMP financial plan since they often replace assets that are still considered in a SOGR, but their replacement is eminent due to a need to relocate or upgrade the asset to meet the needs of the new or modified transportation system. Also, the project cost is not representative of the asset management performance benefit gained, if any. There are also other programs in the Capital Program for assets not yet included in the TAMP (i.e. illumination, railroad grade crossings, guiderail, etc.); therefore these assets are also not included in this financial plan. As the asset management process matures, the financial plan process will change with asset management needs having more impact in driving the Capital Program.

The Benefit of Asset Management

Better Data
+
Better Tools
=
Better Outcomes

Asset Management Funding Uses

This section shows Connecticut's projected asset management expenditures over the 10 year period of the TAMP, organized by asset. These expenditures draw on the various federal and state funding sources described previously.

CTDOT-Maintained TAMP Assets

A summary of estimated asset management funding sources for the six CTDOT maintained assets in the TAMP is shown in Table 7-4. These estimates were developed based on current funding, anticipated future funding, and experience.

Table 7-4. Summary of Estimated Asset Management Funding for the TAMP's Six Assets. (as of July 2017)

	Value by Fiscal Year ($M) in 2017 dollars										
Description	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
Bridge	$356	$402	$550	$335	$375	$375	$375	$375	$375	$375	$375
Pavement	$110	$94	$94	$94	$94	$94	$94	$94	$94	$94	$94
Traffic Signals	$22	$21	$29	$19	$16	$16	$16	$16	$16	$16	$16
Signs	$22	$40	$30	$30	$30	$30	$30	$30	$30	$30	$30
Sign Supports	$5	$4	$4	$4	$4	$4	$4	$4	$4	$4	$4
Pavement Markings	$10	$8	$8	$8	$8	$8	$8	$8	$8	$8	$8
Total	$525	$569	$715	$490	$527	$527	$527	$527	$527	$527	$527

NHS Assets

Spending on NHS assets in Connecticut is not currently tracked as a separate item. Funding estimates for NHS bridge and pavements were calculated using assumptions based on work history and programmed work.

For bridges, CTDOT extracted the expected funding on NHS bridges from the programmed work through 2020. For years beyond 2020, the TAMP assumes the recommended actions in dTIMS and uses those funding values as the estimated expenditures.

For pavement, a series of assumptions based on historical spending were made in order to estimate spending on the NHS. The TAMP assumes that 58% of the Maintenance Resurfacing pavement projects will take place on the NHS during the 10-year period of the TAMP. The basis for this assumption is that of the Maintenance Resurfacing pavement projects that took place from 2011 to 2015, on average 58% were on the NHS.

The TAMP assumes that 85% of pavement preservation projects will take place on the NHS during the 10-year period of the TAMP. The basis for this assumption is as follows: During the period of 2009 to 2015 about 95.6% of pavement preservation projects took place on the NHS. However, future preservation program expenditures on the NHS are expected to be lower because non-NHS preservation treatments are proposed to increase in the near term. For preservation projects already programmed for 2018, about 22.4% of the preservation work will take place on non-NHS pavements. Adjusting for these factors, an average of about 85% is assumed.

Applying 58% to CTDOT's expected $69M in Maintenance Resurfacing funding and 85% to $25M in preservation funding yields a result of $61M annual spending on NHS pavements over the 10-year period of the TAMP. A summary of estimated NHS asset management funding uses is shown in Table 7-5.

Table 7-5. Summary of Estimated NHS Asset Management Funding Uses

	Value by Fiscal Year ($M) in 2017 dollars										
Description	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
NHS Bridge	$313	$402	$489	$295	$189	$236	$222	$253	$158	$282	$299
NHS Pavement	$75	$61	$61	$61	$61	$61	$61	$61	$61	$61	$61
Total	$388	$463	$550	$356	$250	$297	$283	$314	$219	$343	$360

Asset Management Funding Sources

This section shows CTDOT's projected funding for asset management purposes over the 10-year period of the TAMP, organized by source. Table 7-1 provides a high level summary of funding sources for asset management. Years 2017-2020 are based on expected funding. Years 2021-2027 are estimated to be an average of the first few years of funding (2017-2019) applied to each of the years.

Table 7-1. Summary of Funding Sources for the TAMP's Six Assets. (as of July 2017)

	Value by State Fiscal Year ($M) in 2017 dollars										
	Actual	Planned			Estimated						
Description	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Federal	$248	$182	$306	$223	$243	$243	$243	$243	$243	$243	$243
State	$269	$375	$383	$265	$274	$274	$274	$274	$274	$274	$274
Other	$8	$12	$26	$2	$10	$10	$10	$10	$10	$10	$10
Total	$525	$569	$715	$490	$527	$527	$527	$527	$527	$527	$527

Federal Funds

Federal funding for transportation is provided through the Highway Trust Fund (HTF), which is funded by the federal gas tax supplemented with additional revenues from the State Highway Account and other funds. For a detailed

explanation of federal funding support, refer to *Funding Federal-Aid Highways*[1], a 2017 publication of FHWA.

Typically, Congress authorizes federal transportation funding in advance of states' capital planning process. Once authorized, funds are apportioned or allocated to states through federal programs. Apportioned funds must then be obligated, or committed, to specific projects, and actually expended, before the HTF reimburses money to the state.

The expected federal funding for asset management in Connecticut by source is summarized in Table 7-2. Connecticut receives federal funding for asset management primarily through two programs: the National Highway Performance Program (NHPP) and the Surface Transportation Block Grant (STBG). The NHPP represents the single largest category of federal revenues for Connecticut and the majority of funding for the state's highway and bridge assets. The NHPP was created to provide support for the NHS and to ensure that federal-aid highway investments help support progress towards NHS performance targets.

The Surface Transportation Program (STP) was renamed the Surface Transportation Block Grant (STBG) program by the FAST Act. This program provides flexible funding for state and local transportation improvements and preservation. Portions of the STBG fall within the statewide discretion of CTDOT and therefore are considered eligible for asset management spending. In addition to the NHPP and the STBG, CTDOT uses other federal sources such as Congestion Mitigation and Air Quality (CMAQ) that are directed to asset management activities and are represented in Table 7-2 as Other. In addition to the federal funding sources shown in Table 7-2, CTDOT also typically receives redistribution of additional obligational authority after fully obligating its federal program.

National Highway Performance Program (NHPP)

The NHPP provides funding to support the condition and performance of the NHS and to support progress towards federal requirements and state goals.

Table 7-2. Summary of Federal Funding Sources for the TAMP's Six Assets. (as of July 2017)

	Value by Fiscal Year ($M) in 2017 dollars.										
	Actual	Planned			Estimated						
Description	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
NHPP	$58	$31	$56	$96	$48	$48	$48	$48	$48	$48	$48
STBG	$67	$35	$117	$48	$72	$72	$72	$72	$72	$72	$72
Other	$123	$116	$133	$79	$123	$123	$123	$123	$123	$123	$123
Total	$248	$182	$306	$223	$243	$243	$243	$243	$243	$243	$243

1 FHWA, "Funding Federal-Aid Highways", January 2017,

https://www.fhwa.dot.gov/policy/olsp/fundingfederalaid/FFAH_2017.pdf

State Funds

State funding for transportation is provided through the Special Transportation Fund (STF), which is primarily funded with state gas taxes, sales and use tax, driver license fees, and motor vehicle registration fees. Connecticut sells bonds to finance transportation projects and pays the debt service using revenue from the STF.

The expected state funding for asset management by funding program is summarized in Table 7-3. At a high level, there are three programs: State Funds, Fix-It-First and Let's Go CT.

State Funds are traditionally used to match federal funds and pay for CTDOT's maintenance program and other non-federally eligible programs. CTDOT moved to a constrained state funding program in 2008 and readjusted the allocation of state funding to now include SOGR work specific to asset classes. CTDOT has been successful in demonstrating the need for state match to the federal program that supports preservation, but in recent years new programs have provided additional funding for SOGR work.

Fix-it-First is a 100% state program comprising two sub-programs: one for bridge repairs and one for road repairs, with priority given to assets in poor condition. Fix-it-First, established effective in July 2007, has increased TAM funding available for preserving Connecticut's transportation infrastructure.

Let's Go CT is Governor Malloy's transportation vision accompanied by a five year ramp-up in funding for fiscal years 2016 through 2020. This program funds projects addressing maintenance and preservation needs as well as system expansion. Portions of Let's Go CT focus on achieving and maintaining a SOGR and therefore are considered funding for asset management.

Table 7-3. Summary of State Funding Sources for the TAMP's Six Assets. (as of July 2017)

	Value by Fiscal Year ($M) in 2017 dollars										
	Actual	Planned			Estimated						
Description	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
State Funds	$130	$109	$155	$123	$136	$136	$136	$136	$136	$136	$136
Fix It First	$101	$129	$177	$142	$138	$138	$138	$138	$138	$138	$138
Let's Go CT	$38	$137	$51	$0	$0	$0	$0	$0	$0	$0	$0
Total	$269	$375	$383	$265	$274	$274	$274	$274	$274	$274	$274

Asset Valuation

FHWA requires state DOTs to include an estimate of asset value for NHS pavements and bridges. The financial plan process must also calculate the investment needed to maintain asset value. FHWA has acknowledged that there are many ways to estimate asset value and are leaving it to State DOT's to select their methodology. FHWA has suggested that GASB 34 can be utilized for the asset valuation. At CTDOT, GASB 34 calculates the value of its road and bridge infrastructure to be approximately 8.3 billion dollars. This total value does not appear to be a good representation of the value of our infrastructure when considering that the cost for reconstructing one major interstate interchange is estimated to be nearly 4 billion dollars.

For purposes of this TAMP, CTDOT chose to take a replacement value approach using a unit construction cost multiplied by the number of assets. At this time, non-asset related construction costs assume a 1.0 factor; however, it is expected that this factor will be developed for each asset in future TAMPs to account for costs related to design, rights of way, project administration, utilities, maintenance and protection of traffic, etc.

The asset values for all NHS bridges and pavements included in the TAMP is summarized in Table 7-6. The valuation is calculated using the asset inventory unit multiplied by the unit replacement cost and the non-asset related project cost factor that results in the replacement value. The replacement value is equal to the asset valuation for the asset.

Given how asset value is estimated, asset values do not change as a function of asset condition. Thus, no investment is required to maintain asset value. However, the investment needed to maintain SOGR and reach performance targets is modeled by CTDOT and discussed in Chapter 5.

Table 7-6. NHS Asset Valuation Estimate

Asset	Inventory (unit)	Unit Replacement Cost	Non-Asset Related Project Cost Factor (Under Review)	Replacement Value
NHS Bridge	26,270,638 Square Feet	$420	1.0	$11,035,000,000
NHS Pavement	51,579,000 Square Yards	$85	1.0	$4,384,215,000

The asset values for all CTDOT-maintained assets included in the TAMP is summarized in Table 7-7.

Table 7-7. CTDOT-Maintained Asset Valuation Estimate

Asset	Inventory (unit)	Unit Replacement Cost	Non-Asset Related Project Cost Factor (Under Review)	Replacement Value
Bridge (Includes NHS)	37,734,498 SF	$420	1.0	$15,850,000,000
Pavement (Includes NHS)	99,000,000 SY	$85	1.0	$8,415,000,000
Signals				$521,800,000
Traffic Signals	2,551 Each	$200,000	1.0	$510,200,000
Overhead Flashing Beacons	232 Each	$50,000	1.0	$11,600,000
Signs				$162,000,000
Sheet Aluminum	1,582,857 SF	$35	1.0	$55,400,000
Extruded Aluminum	50,000 Each	Total of Component Unit Costs	1.0	$105,800,000
Sign Supports				$232,700,000
Cantilever	609 Each	$100,000	1.0	$60,900,000
Full Span	605 Each	$250,000	1.0	$151,250,000
Bridge Mount	411 Each	$50,000	1.0	$20,550,000
Pavement Markings				$89,200,000
Lines	163,000,000 Linear Feet	$0.50 (epoxy)	1.0	$81,500,000
Symbols	2,200,000 Square Feet	$3.50 (epoxy)	1.0	$7,700,000
TOTAL VALUATION				$25,270,700,000

The TAMP financial plan paints a picture of available funding for asset management, expected expenditure on asset management, and the value of the assets included in the TAMP. Connecticut currently receives funding for asset management activities in nearly equal proportions from state and federal sources. CTDOT has programmed work for the six assets in the TAMP and has a plan to fund asset management activities over the 10-year period of the TAMP. Those funds will be applied according to the investment strategies presented in Chapter 8.

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Investment Strategies

Asset management investment strategies communicate CTDOT's investment approach to achieve asset performance targets and make progress towards federal requirements and state goals given available funding levels. These investment strategies reflect CTDOT's TAM priorities.

CHAPTER 8

Connecticut Department of Transportation
TRANSPORTATION ASSET MANAGEMENT PLAN

Overview

Connecticut's mission for transportation is to provide a safe and efficient intermodal transportation network that improves the quality of life and promotes economic vitality for the State and the region. Asset management is a process that CTDOT is embracing to help fulfill this mission. The TAMP is documenting asset management practices and serves as a tool to aid investment decision-making.

The investment strategies represent an approach to applying the resources described in the Chapter 7 Financial Plan, using the treatment strategies described in Chapter 5 Life Cycle Planning, managing the risks presented in Chapter 6 Risk Management, and closing the performance gaps detailed in Chapter 4 Objectives and Performance. The strategies in this TAMP represent CTDOT's asset management investment philosophy, showing investment priorities.

Federal Legislative Context

FHWA requires that states include investment strategies as part of their TAMP. FHWA defines investment strategies as "a set of strategies that results from evaluating various levels of funding to achieve State DOT targets for asset condition and system performance effectiveness at a minimum practicable cost while managing risks." The TAMP must discuss how the investment strategies make progress towards achieving a desired SOGR over the life cycle of the assets in the plan, improving or preserving asset condition, achieving 2- and 4-year state DOT targets for NHS asset condition and performance, and achieving national performance goals. "Desired SOGR" means the desired asset condition over the 10-year period of the TAMP, also referred to as 10-year desired SOGR in this plan.

FHWA also requires that states establish a process for developing investment strategies as part of the TAMP. Specific requirements for the process are listed below.

Investment Strategies Process Requirements

The process must describe how investment strategies are influenced, at a minimum, by:

- Performance gap analysis (Chapter 4)
- Life cycle planning (Chapter 5)
- Risk management analysis (Chapter 6)
- Anticipated available funding and estimated cost of future work (Chapter 7)

Overall Strategy

The asset management processes support and contribute to the investment strategies that guide resource allocation. Investment strategies are what make the technical details meaningful at a transportation network level and help communicate Connecticut's message of maintaining a SOGR and making progress towards federal requirements and state goals. CTDOT follows a series of investment strategies that guide resource allocation, including an investment philosophy of maintaining a SOGR, a focus on safety, and developing Complete Streets.

The investment strategies are driven by performance targets and projections, life cycle planning, risk management analysis, and anticipated funding and cost of future work described in other chapters of the TAMP. The performance gap analysis, enabled by life cycle planning, helps define the investment needs of the system. Life cycle plans use the estimated cost of future work to establish network level strategies for managing assets. Available funding is a constraint for performance modeling, allowing Connecticut to more accurately predict future scenarios. Risk management adds to the analysis, adjusting potential outcomes based on positive and negative risks. These asset management processes are required in the TAMP and contribute to the investment strategies.

CTDOT's primary investment strategy for TAM is to invest in assets to maintain a SOGR. This strategy focuses on using a statewide approach to preserve and maintain CTDOT's transportation assets in such a manner that sustains the asset condition in a SOGR and extends the asset life until replacement is warranted. CTDOT is moving towards a proactive, preservation-first strategy. As CTDOT continues to transition towards this strategy, the financial demand to address reactive, worst-first needs is expected to decrease; however, it is

recognized that there will still be situations when a worst-first response is appropriate.

CTDOT anticipates two challenges to a SOGR asset management investment strategy. The first is that in order to most effectively maintain SOGR for assets in the TAMP, CTDOT must implement cross-asset optimization. As CTDOT strives to meet minimum federal requirements and make progress towards state goals, cross-asset optimization will be vital to ensure that all asset categories receive due attention. This involves balancing and prioritizing spending across all assets, including bus and rail Public Transportation assets. The second challenge is that CTDOT must ensure that there is adequate, skilled staff to maintain all of CTDOT's assets.

Asset-Specific Strategies

CTDOT aims to run a balanced transportation network with investments occurring where needed for preservation and safe operation of assets. The investment strategies for the assets included in the TAMP are managed at a statewide approach.

Bridge

CTDOT has been contending with the combination of aging infrastructure and resource constraints. Recent improvements in network-level bridge condition can be attributed to the following bridge-specific investment strategies.

Bridge-Specific Investment Strategies

- Focus on maintenance activities that directly improve asset performance
- Focus on planning and programming future work on major bridges
- Focus on programming NHS bridges in poor condition

In 2010, CTDOT began to focus on maintenance activities and SOGR operations to reduce a growing backlog of bridge maintenance needs identified during the biennial inspection program. In 2014, CTDOT took a forward-looking approach to the 60 major bridges and setup individual rehabilitation or replacement schedules for each of the major bridges for the next 10 years with the intent to update these schedules as needed. Additionally, for all state-maintained bridges, CTDOT's Bridge Management Group is programming work and coordinating through quarterly meetings with design and maintenance staff to determine if a capital project is needed or if deficiencies can be addressed through the Office of Maintenance Operations. In 2015, following the

proposed federal bridge performance measures CTDOT began to focus on designating and prioritizing bridge projects addressing NHS bridges in poor condition in the Capital Program to safeguard their schedules from delays.

Pavement

CTDOT has several pavement-specific investment strategies listed below.

Pavement-Specific Investment Strategies

- Continue efforts towards a single pavement management system for modeling and programming treatments
- Increase systematic preservation of good condition pavements
- Incorporate additional preservation treatment options
- Increase rehabilitation and reconstruction of pavement sections

Management and investment in pavement assets is increasingly being guided by the CTDOT PMS in addition to existing methods and engineering judgment. Maintenance is now using the condition data provided by Pavement Management to aid in selection of their resurfacing projects. For the first time, CTDOT has been able to model the maintenance resurfacing treatment in dTims allowing future analyses to better select treatments that will most likely increase systematic preservation. The pavement preservation program can expand further as additional preservation treatment options are incorporated. An increase of rehabilitation and reconstruction of pavement sections will gradually eliminate the backlog of this type of work, leading to the subsequent preservation of these pavements in the future.

Traffic Signals

CTDOT's traffic signal-specific investment strategies are listed below.

Traffic Signal-Specific Investment Strategies

- Continue planning traffic signal replacement projects based on projected age
- Continue efforts to develop traffic signal component based life cycle planning.

Signs

CTDOT's sign-specific investment strategies are listed below.

Sign-Specific Investment Strategies

- Continue planning sign replacement projects based on projected age
- Continue efforts towards replacing signs deemed poor based on nighttime visual inspections.

Sign Supports

CTDOT's sign support-specific investment strategies are listed below.

Sign Support-Specific Investment Strategies

- Continue programming sign support projects based on poor or overstressed conditions
- Following efforts to model the condition of sign supports, begin to plan projects based on projected condition.
- Continue efforts to reduce the number of sign supports whenever possible by removing and replacing with signs mounted along the side of the road.
- Increase efforts to maintain sign panel sizes by reducing the legend spacing on sign supports in good condition.
- Overdesign sign supports with a larger factor of safety to allow for replacement of larger sign panels as Manual on Uniform Traffic Control Devices (MUTCD) requirements change

Pavement Markings

CTDOT's pavement marking-specific investment strategies are listed below.

Pavement Marking-Specific Investment Strategies

- Continue efforts towards developing a pavement markings replacement program to obtain a State of Good Repair across the network

Process Improvements

TAM is a series of processes intended to help preserve asset condition over the life of the asset at minimal cost. Practicing TAM means continuous improvement. Process improvements need to be documented and reevaluated on an ongoing basis to be effective in advancing TAM. CTDOT is striving to improve processes in the areas of asset data management, asset performance, modeling capabilities, risk management, and funding allocation for asset management purposes.

CHAPTER 9

Overview

This chapter supplements the discussion of current asset management practices in Connecticut with identifying key process improvements that will serve as a guide to enable us to continue maturing our TAM practices. The TAMP is a living document that will evolve to reflect changing TAM practices and processes at CTDOT.

Federal Legislative Context

FHWA recommends that state DOTs conduct periodic self-assessments of asset management capabilities. As written in the TAMP Final Rule, "based on the results of the self- assessment, the State DOT should conduct a gap analysis to determine which areas of its asset management process require improvement."

TAM Process Improvements

Throughout the TAMP development, process improvements were identified by all involved. Participants generated ideas for TAM process improvements during workshops held by CTDOT for bridges, pavements, additional assets, objectives and performance measures, risk, and finance. The improvements suggested in this chapter include key ideas generated during the TAMP development process as well as the workshops. These ideas represent CTDOT's next steps in its implementation of TAM.

Asset Management Group

Champion – TAM Implementation Lead

- Prioritize additional assets to incorporate into future TAMPs.
- Establish a Standard Operating Procedure for all asset modeling with specified scenario funding levels, time periods based on asset life cycle and consistent inputs for inflation and discount rates with defined scheduling.
- Establish a Standard Operating Procedure for the calculation of asset valuation. Also improve the process by developing and incorporating a depreciation methodology based on condition and age into the asset valuation for each asset.
- Correlate project selection process with network performance by asset.
- Explore and implement methodologies using cross asset allocation to improve project selection and prioritization.

- Formalize and improve the risk management process.
- Explore opportunities for alignment of TAMP with other CTDOT plans as applicable.
- Consider other national goal areas, in particular freight, in regards to the TAMP investment strategies.
- Update memorandum on Asset Management Systems (Commissioner Redeker, February 26, 2013) and develop and issue CTDOT Policy Statement on Asset Management.
- Formalize TAM Steering Committee into a CTDOT Standing Committee.

All Assets

Champion –Asset Stewards

- Develop Risk Mitigation and Tracking Plans.
- Coordinate implementation of Data Quality Standards.
- Verify field performance of treatment life expectancies to incorporate into models in order to improve forecasting of asset deterioration.

Bridges

Champion – Bridges Asset Steward

- Review and program feasible treatments recommended by the bridge analysis model to prioritize work and improve network performance.
- Implement proactive preservation programs for painting, joint replacement, and rinsing of bridges.
- Develop and implement a process to address deteriorated elements in addition to the Capital Project process.

Pavements

Champion – Pavements Asset Steward

- Develop a comprehensive 3-year program identifying Preservation and Maintenance Resurfacing projects by year, to be updated annually.
- Develop a 10-year Reconstruction and Rehabilitation program identifying projects by year, to be updated annually.
- Implement Pavement Action Plan recommendations pertinent to asset management including:
    - Refine pavement analysis methodology
    - Improve tracking of paving work
    - Sync pavement sections with LRS

- Pursue ability to run analysis model for longer periods in order to reach a 50 year pavement design life.

Traffic Signals

Champion – Traffic Signals Asset Steward

- Improve capability of Traffic Signals Database to include an additional level of detail for signal component installation years as required for tracking and managing life cycle replacement of signal components for asset management purposes.

Signs

Champion – Signs Asset Steward

- Consistently capture date and sign attributes at Construction and Maintenance installations.
- Update initial 2013 sign data to reflect current inventory.
- Implement CAD to GIS solution upon successful completion of pilot.

Sign Supports

Champion – Sign Supports Asset Steward

- Develop performance forecasting capabilities.
- Maintain inspection cycle.
- Update sign support inventory with backlog of sign support installations and removals.
- Complete process in the CPD to allow for tagging of sign supports as an asset in projects.

Pavement Markings

Champion – Pavement Markings Asset Steward

- Develop a consistent network investment program.
- Improve methods to track and maintain pavement markings for better lifecycle management.
- Seek alternative contracting methods including performance based.

Engineering

- Integrate asset management in capital planning.
- Look for ways to automate asset updates associated with capital projects.

Construction

- Relate work items to asset identification in SiteManager where appropriate to update inventory and condition and capture needed costs for asset life cycle management.

Maintenance

- Relate work items to asset identification in a MMS where appropriate to update inventory and condition and capture needed costs for asset life cycle management.
- Implement Asset Management positions responsible for maintaining the asset inventories at each district for all work accomplished through Maintenance.

Finance

- Coordinate financial management with capital planning with asset management priorities.

Planning

- Support locating assets on the Linear Reference System.
- Coordination of performance measures with MPOs.

Technology Services

- Provide necessary resources (hardware, software, communications, technical) to support a data-driven asset management approach to our transportation system.
- Provide server capabilities to run deterioration modeling and life cycle analyses.

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Appendix A. Asset Management System Memorandum from Commissioner dated February 26, 2013

STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION

subject: **Asset Management System**

memorandum

date: February 26, 2013

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to: Mr. Thomas Harley
Mr. Michael Lonergan
Mr. Thomas Maziarz
Mr. Eugene Colonese
Mr. Michael Sanders
Mr. Robert Card

from: James Redeker
Commissioner

I am committing this agency to develop and implement an Asset Management System involving all modes of our transportation network.

Certain foundational elements of an Asset Management System such as performance metrics and condition data collection have been in use and under development for a number of years. However with the passage of federal funding legislation (Map21) in 2012, Asset Management programs have been mandated to remain eligible for federal transportation monies.

Attached is an initial outline of our Transportation Asset Management System (TAMS) Development Project establishing Deputy Commissioner Anna M. Barry as Agency Sponsor. It also identifies a Management Steering Committee, and a Development Project lead. Jennifer Trio has been assigned this task full time.

Every bureau in the agency will have roles to play in this significant and critically important undertaking. Moving forward, we will face deadlines for implementation established by our federal partners and you will need to ensure that appropriate resources are deployed to meet those challenges. Deputy Commissioner Barry will schedule the agency kick-off meeting as soon as possible. However, other Project activities may precede it.

Attachment

cc: Comr. Redeker – Dep. Comr. Barry
Cheryl Malerba - John Krewalk
Pamela Sucato
Judd Everhart – Kevin Nursick
Randal Davis
Denise Rodosevich

Connecticut Department of Transportation
Transportation Asset Management System Development Project (TAMS)
Initial Implementation Approach
February 26, 2013

As a multi-modal transportation agency the Connecticut Department of Transportation (Department) has unique challenges in the implementation of federal requirements for asset management and performance indicators. This memorandum defines the initial approach the Department will take to structure an agency-wide program.

Federal Highway Administration Asset Management

MAP-21 requires each State to develop a risk-based asset management plan for the National Highway System (NHS) to improve or preserve the condition of the assets and the performance of the system.

States are required to have developed and implemented an NHS asset management plan the second fiscal year after USDOT issues regulations for asset management plan development. The CTDOT secretary is required to issue a regulation within 18 months of the enactment of MAP 21, or no later than April 1, 2014. The latest date for plan implementation would be October 1, 2015.

The Highway Plan must include at least the following:

- Summary list, including condition, of the State's NHS pavements and bridges.
- Asset management objectives and measures.
- Performance gap identification.
- Lifecycle cost and risk management analysis.
- Financial plan.
- Investment strategies.

If a State has not developed and implemented an asset management plan consistent with the requirements by the beginning of the 2nd fiscal year after the establishment of the process, the Federal share for National Highway Performance Program projects in that fiscal year is reduced to 65%.

Federal Transit Administration Asset Management

MAP-21 also establishes new requirements for transit asset management by FTA's grantees. These include new reporting requirements to promote accountability. The goal of improved transit asset management is to implement a strategic approach for assessing needs and

prioritizing investments for bringing the nation's public transit systems into a state of good repair.

Through regulation, FTA will establish a National Transit Asset Management System by October 1st, 2013. The regulation will:

- Define "state of good repair;"
- Set objective standards for measuring the condition of capital assets, including equipment, rolling stock, infrastructure and facilities; and
- Establish performance measures and targets for state of good repair.

Transit asset management plans must include capital asset inventories and condition assessments and investment prioritization. Agencies will be required to report on condition system and changes in it, performance measure targets and progress reports.

Milestone	**Date**
Through regulation, FTA will establish a National Transit Asset Management System	Tuesday, October 01, 2013
Agency must establish performance targets in relation to the definition of state of good repair established by FTA.	Wednesday, January 01, 2014
USDOT is required to issue a regulation for FHWA within 18 months of the enactment of MAP 21	Tuesday, April 01, 2014
The latest date for Highway Plan Implementation would be October 1, 2015	Thursday, October 01, 2015

Connecticut DOT Approach

The purpose of this memorandum is to present and explain the approach that the Senior Management Team recommends for the initial development phase of the Department is TAMS. The team developed the general framework during a working session at the November FHWA training program on asset management. Attached is the Draft Organization Chart for the initial development process. (Note: position and committee titles are proposed and may be changed.)

Governing Principles

1. The Development Team structure should promote management and staff support for the development process.
2. The structure should be adjusted as needed to optimize management and staff support for the implementation and operational phases.

3. Senior Management must oversee and provide appropriate support for each phase of the program, and ensure broad agency policy interests are accommodated.
4. The structure should promote maximum efficiencies where they make sense and allow for individualized solutions where needed.
5. Each bureau must own its part of the program, especially where maintenance and/or operations functions may reside elsewhere.

General Structure

1. The TAMS Program may address the following areas, as law requires or need arises:

    a. Bridges
    b. Equipment
    c. Facilities
    d. Pavement
    e. Rail
    f. Safety
    g. Technology
    h. Traffic
    i. Transit

2. The Deputy Commissioner will be the Agency Sponsor.
.
3. The bureau chiefs and other executive team members will provide guidance, oversight and resources to the TAMS Management Steering Committee.

4. The TAMS Management Steering Committee will act as the liaison to the Bureaus and key divisions to ensure that each area's interests are represented properly and to ensure each area is supporting the project appropriately. The Steering Committee will oversee and support the efforts of the TAMS Implementation Lead.

5. The TAMS Management Steering Committee will consist of:

    a. Representatives from Engineering & Construction

        i. Division Chief, Design Services (Chair)
        ii. Division Chief, Bridges and Structures
        iii. Division Chief, Highways
        iv. Division Chief, Traffic

    b. Director of Technology Services

    c. Finance & Administration

i. Capital Programs
ii. Assistant Director, Strategic Planning and Projects
iii. Facilities

d. Highway Maintenance & Operations

i. Maintenance Director Highway Operations

e. Public Transportation

i. Rail Administrator
ii. Transit Administrator

f. Policy & Planning

i. Assistant Director Strategic Planning and Projects

6. A TAMS Implementation Lead will be assigned full-time to the development of the TAMS. With the support of the Steering Committee, the coordinator will develop the initial assessments and internal and external scopes of services required for initial implementation steps.

7. The Transportation Assistant Planning Director and Transportation Division Chief will act as program mentors to the Implementation Lead, to provide necessary management and technical support and to ensure proper linkage to the Performance Metrics and Standards. The TAMS Lead will interact with the Program Sponsor. However, direction will be provided by the Transportation Division Chief (Chair).

8. The Policy & Planning Transportation Assistant Planning Director will ensure that the Performance Metrics and Standards requirements are properly integrated with the Asset Management Systems.

9. The structure and representation will be adjusted as the needs of the system evolve.

10. Next steps:

a. Present to executive team at staff meeting

b. Confirm Steering Committee members and back-up designees

c. Initial meeting of executive team with Steering Committee

    i. Project scope and mission
    ii. Communications protocol

d. Implementation Lead and Steering Committee develop:

    i. Inventory of existing systems
    ii. Vision of future State
    iii. Initial implementation plan
    iv. Gap analysis
    v. Financial requirements and resources

Note: the memo references a draft organization chart for TAM development. The original draft organization chart is now obsolete; the current organization chart is included as Figure 1-1.

Appendix B. Asset Fact Sheets

Connecticut Transportation Asset Management Plan

Bridge

Data Confidence High

Description

- CTDOT inspects 5,306 roadway bridges, 1,785 of which are National Bridge Inventory (NBI) structures on the National Highway System (NHS).
- 4,016 of these bridges are state maintained; the remaining 1,290 are maintained locally or under another jurisdiction
- CTDOT defines a bridge as a crossing of at least six feet in length, including culverts. The Federal Highway Administration (FHWA) defines an NBI bridge as a structure measuring more than 20 feet in length.
- CTDOT has a distinct Major Bridge Program for large or expensive-to-replace bridges. 60 structures are currently categorized as Major Bridges.

State of Good Repair (SOGR)

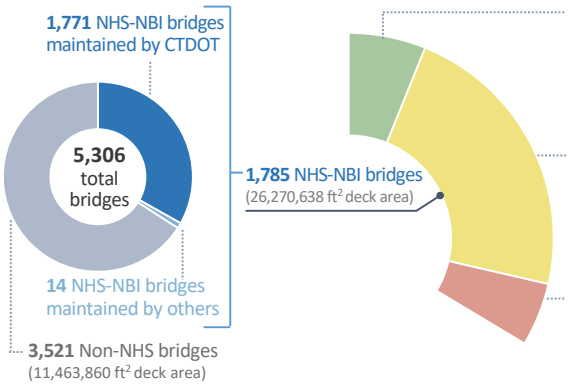
A bridge for which the condition rating for each of the three major components for a span bridge (Substructure, Deck, and Superstructure) or the structural condition of a culvert is rated at least a 5 on a 0-9 condition scale is classified as being in a SOGR.

Bridge Age

The average NHS-NBI bridge in Connecticut is 53 years old, which is 11 years older than the national average of 42 years. The state has a high percentage of Structurally Deficient (SD) bridges (by deck area) compared to the national average.

NHS-NBI Inventory and Condition

Federal Requirements



Good **4,761,084 ft²**
18.1% of deck area on NHS-NBI bridges is in good condition (422 bridges).
[NBI condition ratings of 7,8, or 9]

Fair **17,584,485 ft²**
66.9% of deck area on NHS-NBI bridges is in fair condition (1,261 bridges).
[NBI condition ratings of 5 or 6]

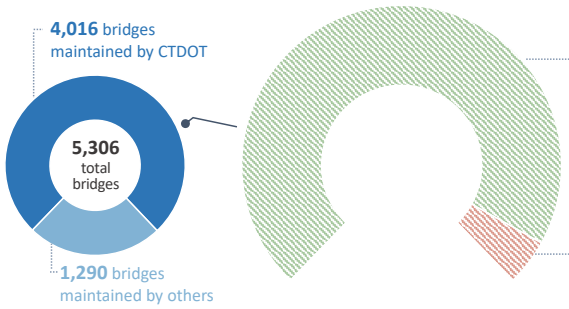
Poor **3,925,069 ft²**
15.0% of deck area on NHS-NBI bridges is in poor condition (102 bridges).
[NBI condition ratings of 0, 1, 2, 3, or 4]
As of 1/1/18, Poor=SD

Good-Fair-Poor defined by MAP-21/FAST Act

Based on CTDOT 3/31/17 NBI Submittal

CTDOT-Maintained Inventory and Condition

State Goals



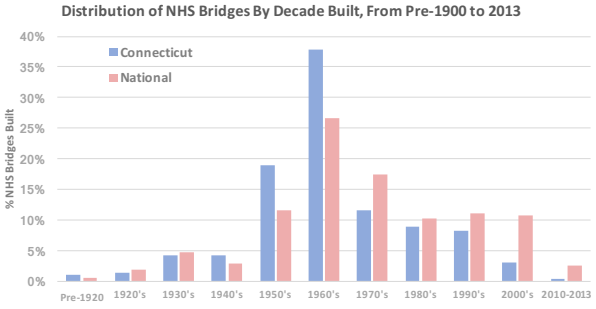
State of Good Repair **3,768 bridges**
93.8% of CTDOT-maintained state bridges are in good or fair condition
[NBI condition ratings of 5 or higher]

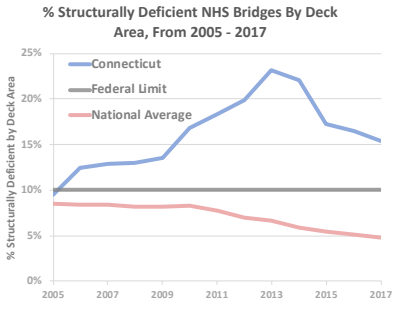
Poor **248 bridges**
6.2% of CTDOT-maintained state bridges are in poor condition
[NBI condition ratings of 4 or lower]

SOGR defined by CTDOT

Based on CTDOT 3/31/17 Snapshot

History





Based on National Data available from FHWA

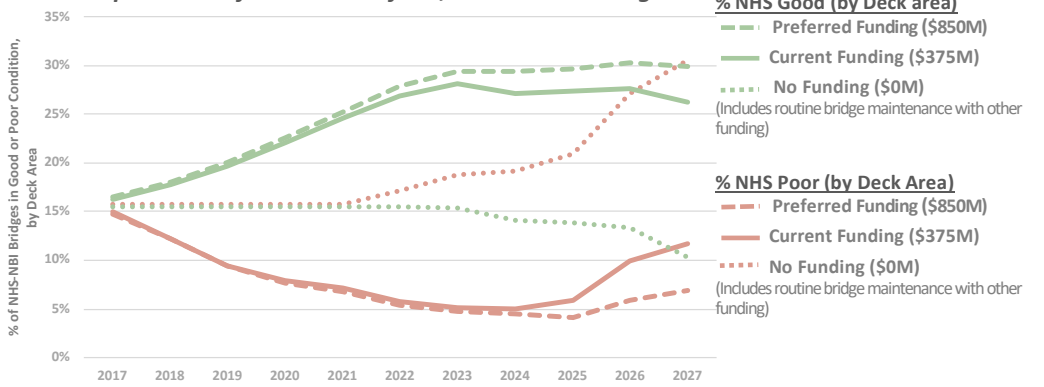
Connecticut Transportation Asset Management Plan

Bridge



NHS-NBI Bridge Performance Projections

Federal Requirements for deck area for 1,785 NHS-NBI bridges



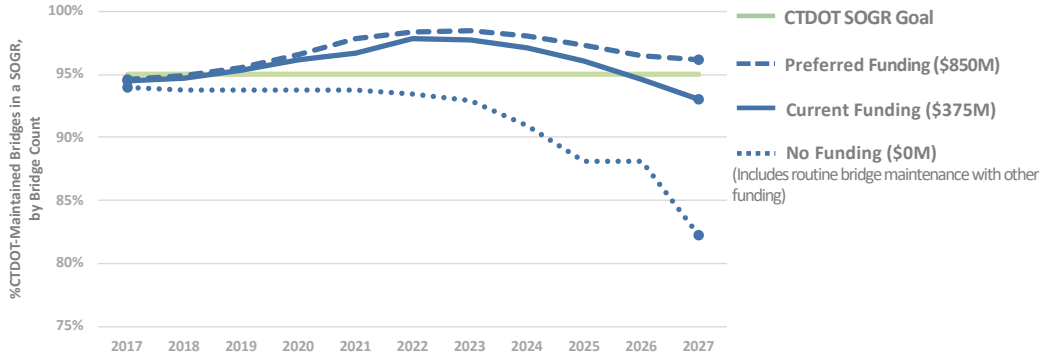
Based on funding as of 6/30/17

Performance Projections at Current Funding Level ($375M Budget)

Year	2017	2018	2019	2020	2021	Goal
NHS Good (by deck area)	16.3%	17.7%	19.7%	22.1%	24.5%	>20%
NHS Poor (by deck area)	14.9%	12.3%	9.4%	7.9%	7.1%	<10%

CTDOT-Maintained Bridge Performance Projections

State Goals by number of bridges for 4,016 CTDOT-maintained bridges



Based on funding as of 6/30/17

Performance Projections at Current Funding Level ($375M Budget)

Year	2017	2018	2019	2020	2021	Goal
SOGR	94.5%	94.7%	95.3%	96.1%	96.7%	95%

Performance Projections

The chart on the left depicts bridge condition for various funding scenarios. These were developed through an analysis program using CTDOT bridge condition data, as of May 2017.

Asset Valuation

$15,850,000,000

Asset value is estimated using the replacement value. For bridges, replacement value is the product of deck area and unit construction cost. For 5,306 bridges: 37,734,498 sqft * $420/sqft = $15.9 billion.

Measures and Targets

CTDOT has set the following bridge condition goals:

Federal Requirements:

- 10% or less Structurally Deficient by deck area on NHS-NBI bridges (Federal minimum is less than 10% Structurally Deficient)
- 20% or more Good by deck area on NHS-NBI bridges

State Goal:

- 95% or more of State-Maintained bridges in a SOGR (State target)

Connecticut Transportation Asset Management Plan

Pavement

Data Confidence High

Description

- There are 3,719 centerline miles of state maintained routes and roads in Connecticut, 1,391 of which are on the National Highway System (NHS) including 346 Interstate miles.
- There are another 17,812 miles of town maintained roads, 51 of which are on the NHS.
- 70.5% of CTDOT maintained roadways are flexible (asphalt) pavements, 29.0% are composite pavements (asphalt over concrete), and under 0.5% are rigid (concrete) pavements.

State of Good Repair (SOGR)

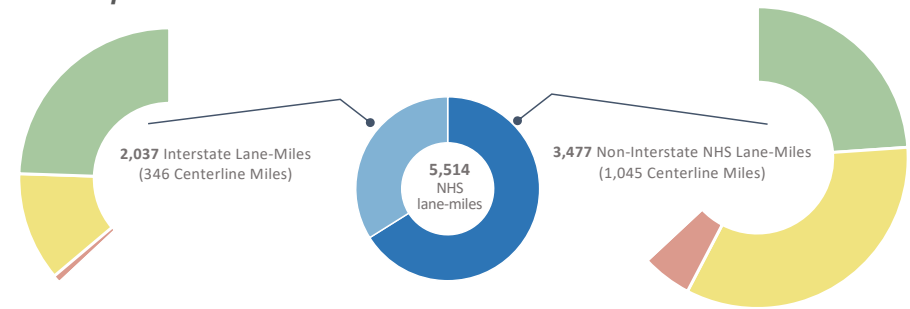
A pavement section for which the Pavement Condition Index (PCI) is 6 or greater is classified as being in a State of Good Repair (SOGR). The PCI is based on cracking, rutting, drainage disintegration, and ride. FHWA uses a different condition measure for NHS pavements.

Pavement Age

The average Connecticut NHS pavement structure was constructed 47 years ago, and the average surface age is 7.4 years old.

NHS Roadways Inventory and Condition

Federal Requirements



Good-Fair-Poor defined by MAP-21/FAST Act

Interstate Pavements

Good	Fair	Poor
1,349 Lane-Miles	**644 Lane-Miles**	**44 Lane-Miles**
66.2% are in Good condition	31.6% are in Fair condition	2.2% are in Poor condition

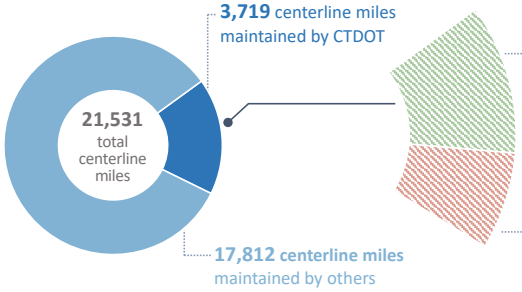
Non-Interstate NHS Pavements

Good	Fair	Poor
1,318 Lane-Miles	**1,861 Lane-Miles**	**297 Lane-Miles**
37.9% are in Good condition	53.5% are in Fair condition	8.6% are in Poor condition

Based on CTDOT 6/15/17 HPMS Submittal

CTDOT-Maintained Roadways Inventory and Condition

State Goals



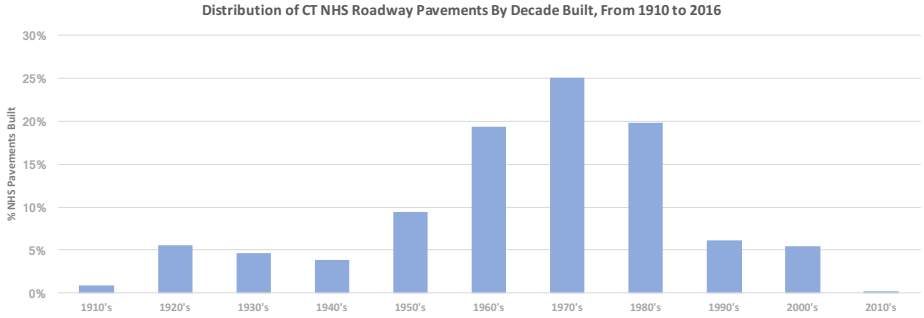
State of Good Repair **2,254 centerline miles**
60.6% of CTDOT-maintained centerline miles has a PCI of 6 or greater

PCI Poor **1,465 centerline miles**
39.4% of CTDOT-maintained centerline miles have a poor condition PCI rating lower than 6

SOGR defined by CTDOT

Based on CTDOT 6/15/17 Snapshot

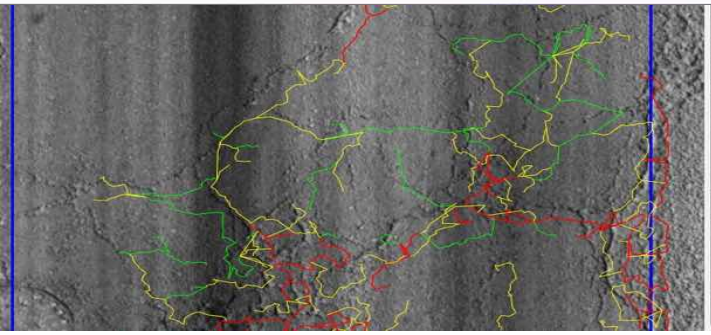
History

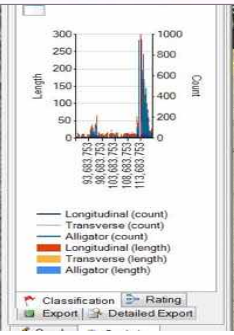


Based on National Data available from FHWA

Connecticut Transportation Asset Management Plan

Pavement

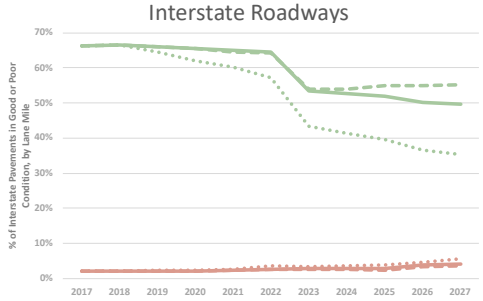




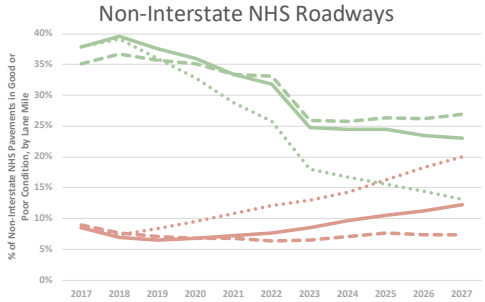
NHS Pavement Performance Projections

Federal Requirements by lane miles for 5,514 lane miles of NHS pavement

Interstate Roadways



Non-Interstate NHS Roadways



% Good (by lane miles)
Preferred Funding ($149M)
Current Funding ($94M)
No Funding ($0M)

% Poor (by lane miles)
Preferred Funding ($149M)
Current Funding ($94M)
No Funding ($0M)

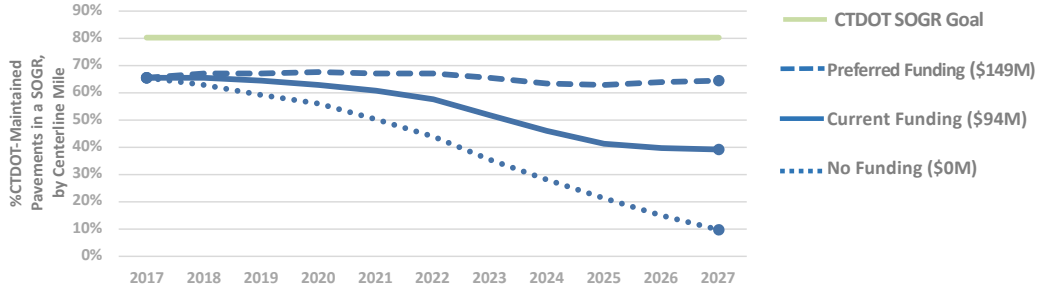
Based on funding as of 6/30/17

Performance Projections at Current Funding Level ($94M Budget)

Year	2017	2018	2019	2020	2021	Goal
Interstate Good	66.2%	66.5%	66.0%	65.5%	65.0%	75%
Interstate Poor	2.2%	2.2%	2.1%	2.0%	2.3%	<5%
Non-Int NHS Good	37.9%	39.6%	37.6%	36.0%	33.4%	50%
Non-Int NHS Poor	8.6%	6.9%	6.6%	6.8%	7.2%	<8%

CTDOT-Maintained Pavement Performance Projections

State Goals by centerline miles for 3,719 centerline miles



Based on funding as of 6/30/17

Performance Projections at Current Funding Level ($94M Budget)

Year	2017	2018	2019	2020	2021	Goal
SOGR	65.3%	65.4%	64.4%	62.9%	60.9%	80%

Performance Projections

The charts on the left depicts pavement condition for various funding scenarios. These were developed through an analysis program using CTDOT pavement deterioration curves as of August 2017.

Asset Valuation

$8,400,000,000

Asset value is estimated using the replacement value. For pavements, replacement value is the product of pavement area (SY) and unit construction cost. For 4,136 centerline miles of pavement: 99 million SY
* $85/SY = $8.4 Billion

Measures and Targets

CTDOT has set the following pavement condition goals:

Federal Requirements:

- Interstate: 75% good condition and less than 5% poor condition (Federal minimum is less than 5% poor)
- Non-Interstate: 50% good condition and less than 8% poor condition

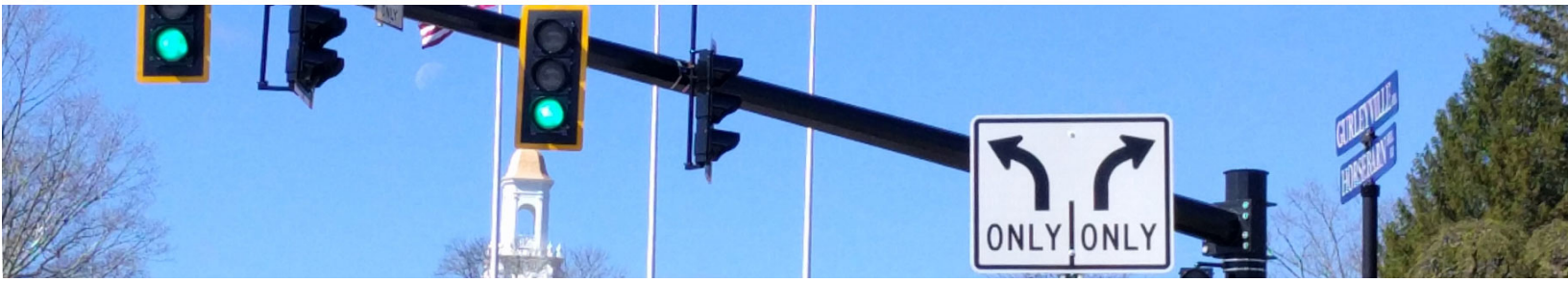
State Goal:

- 80% or more of State-maintained pavements in a SOGR (State)

Connecticut Transportation Asset Management Plan

Traffic Signals

Data Confidence
Medium



Description

- CTDOT is currently responsible for maintaining 2,783 State owned traffic signals:
  - 2,551 Traditional Traffic signals
  - 232 Overhead flashing beacons
- Of the 2,551 traditional traffic signals, 945 are part of 107 computerized traffic signal systems
- CTDOT defines a traffic signal unit as all traffic control equipment at a given intersection or location
- There are an additional 285 independent signs with flashers that are managed as part of the sign asset

State of Good Repair (SOGR)

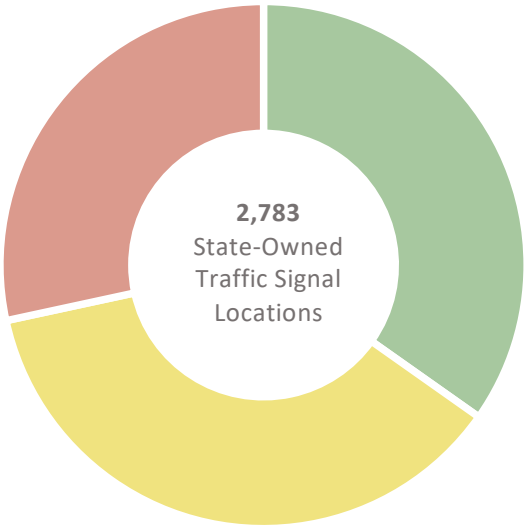
The State of Good Repair for traffic signals is determined to be 25 years of life. This is based on expectations of controller and signal head life with interim component replacements that are required at varying intervals.

Traffic Signal Age

- 28% of traffic signals are older than 25 years
- 8% of traffic signals are older than 50 years

Traffic Signal Inventory and Condition

State Goals



Good

968 Locations

34.8% are in Good condition (0-15 years old)

Fair

1,025 Locations

36.8% are in Fair condition (16-25 years old)

Poor

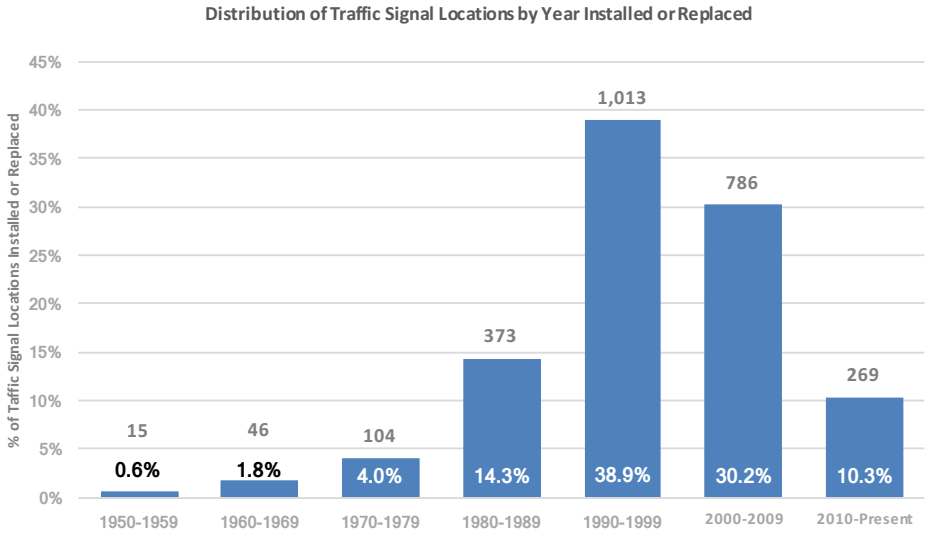
790 Locations

28.4% are in Poor condition (26+ years old)

Good-Fair-Poor and SOGR defined by CTDOT

Based on CTDOT 3/27/17 Snapshot

History



177 traffic signal locations have unknown installation years.

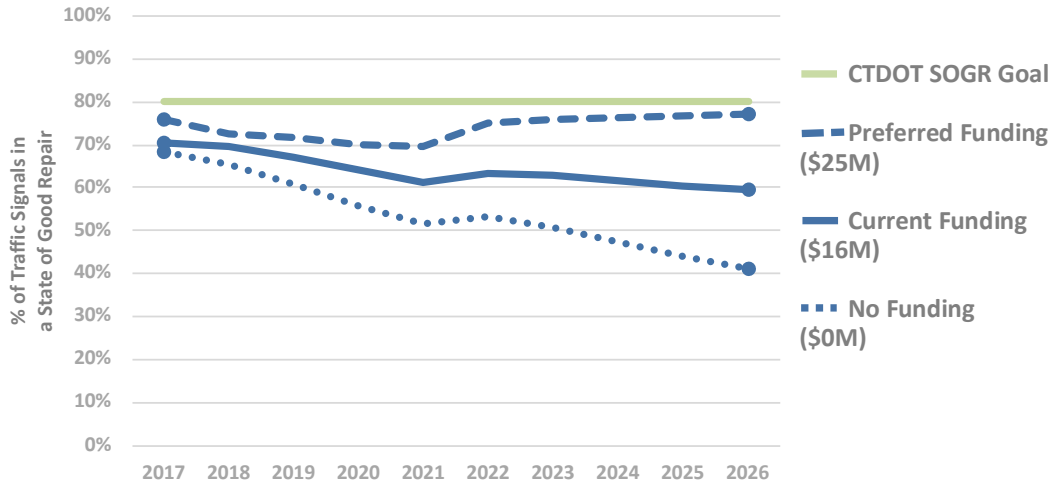
Based on CTDOT 2017 Snapshot

Connecticut Transportation Asset Management Plan

Traffic Signals

Traffic Signals Performance Projections

State Goals by traffic signal for 2,783 traffic signals



Based on funding as of 6/30/17

Projected Performance at Current Funding Level ($16M Budget)

Year	2017	2018	2019	2020	2021	Goal
SOGR	70.4%	69.6%	67.0%	64.0%	61.4%	80%

Performance Projections

In order to maintain a State of Good Repair, nearly 100 traffic signals need replacement each year. Currently, approximately 60 traffic signals are replaced each year.

Asset Valuation

$522,000,000

Asset value is estimated using the replacement value. For traffic signals, replacement value is the product of traffic signal and unit construction cost.
For 2551 traffic signals : 2551 * $200,000 = $510,200,000
For 232 Overhead flashing beacons: 232 * $50,000 = $11,600,000

Measures and Targets

There are no Federal requirements at this time. CTDOT has set the following traffic signal condition goal:

State Goal:

- 80% or more of state owned traffic signals in a SOGR

Connecticut Transportation Asset Management Plan

Signs

Data Confidence Low

Description

- CTDOT is responsible for maintaining approximately 263,000 signs (regulatory, warning, and guide) that are located on State owned and maintained roadways
- CTDOT defines a sign as a panel attached to a post(s) or sign structure and a sign assembly as the combination of sign panel(s) and their post(s), support, or sign structure at a single location.
- Overhead sign supports and foundations are managed as a separate asset

State of Good Repair (SOGR)

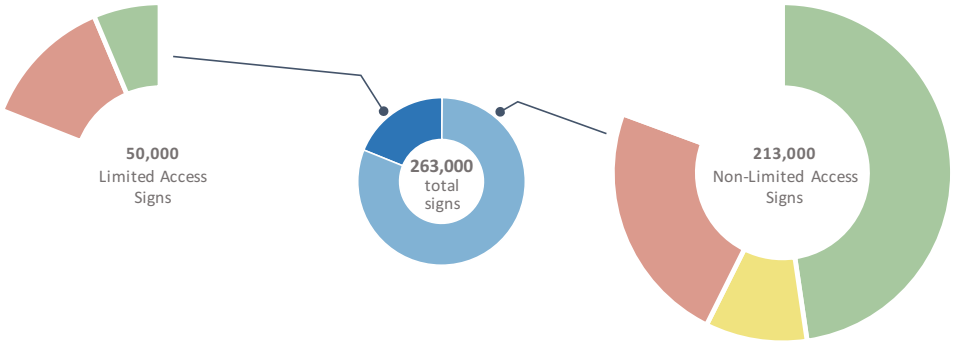
A sign installed within 17 years is classified as being in a State of Good Repair. This is based on expectations of retroreflectivity life. Retroreflectivity is a measure of the amount of light reflected by a surface back to the source of the light.

Sign Age

- Nearly 60% of all signs have exceeded their expected sign life or effective service life
- 21% of signs on limited access roadways are older than 25 years

Sign Inventory and Condition

State Goals



Good-Fair-Poor and SOGR defined by CTDOT

Limited Access Signs

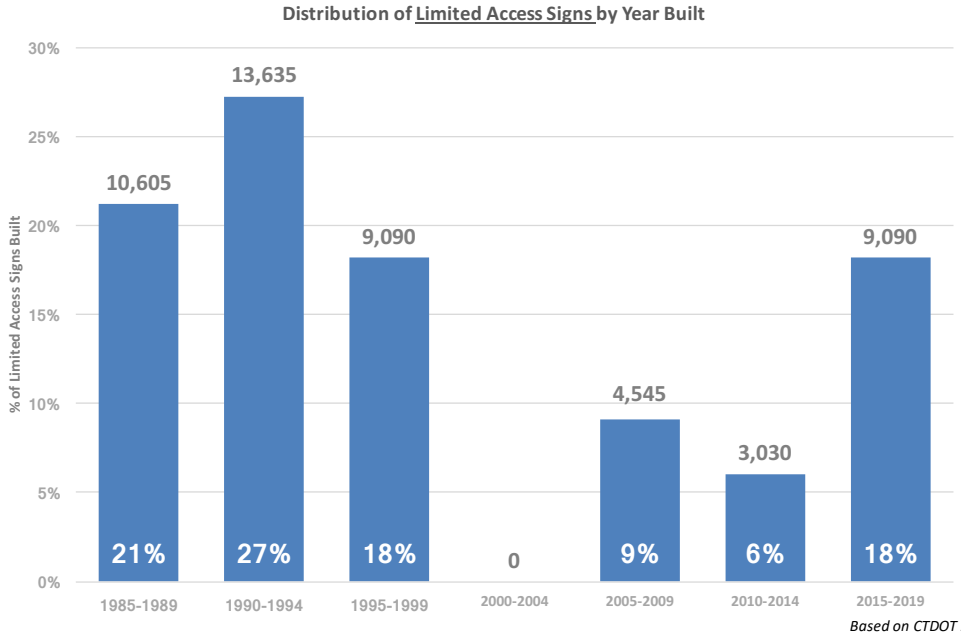
Good	Fair	Poor
16,667 Signs	**0 Signs**	**33,333 Signs**
33.3% are in Good condition (0-12 years old)	0% are in Fair condition (13-17 years old)	66.7% are in Poor condition (18+ years old)

Non-Limited Access Signs

Good	Fair	Poor
65,000 Signs	**25,000 Signs**	**123,000 Signs**
30.5% are in Good condition (0-12 years old)	11.7% are in Fair condition (13-17 years old)	57.8% are in Poor condition (18+ years old)

Based on CTDOT 2013 inventory

History



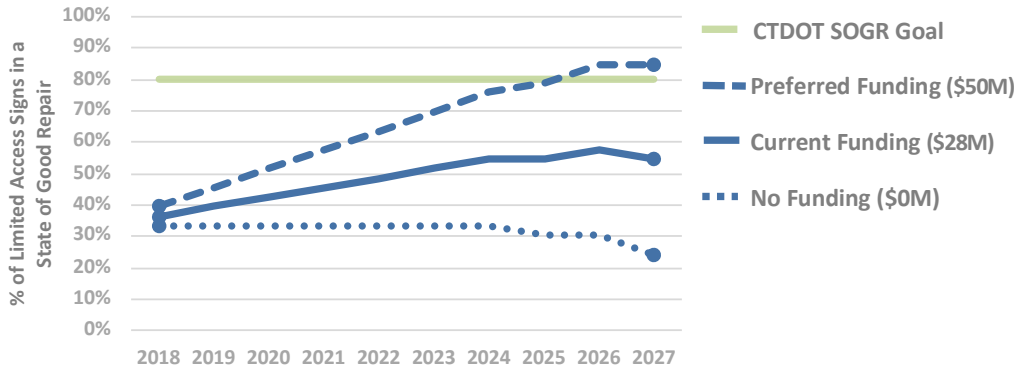
Based on CTDOT 2017 Snapshot

Connecticut Transportation Asset Management Plan

Signs

Limited Access Signs Performance Projections

State Goals by limited access roadway sign for 50,000 signs



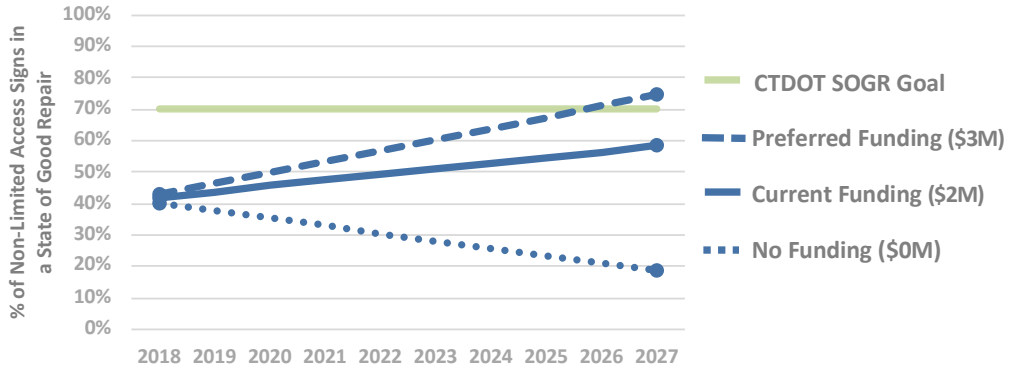
Based on funding as of 6/30/17

Projected Performance at Current Funding Level ($28M Budget)

Year	2018	2019	2020	2021	2022	Goal
SOGR	36.4%	39.4%	42.4%	45.5%	48.5%	80%

Non-Limited Access Signs Performance Projections

State Goals by non-limited access roadway sign for 213,000 signs



Based on funding as of 6/30/17

Projected Performance at Current Funding Level ($2M Budget)

Year	2018	2019	2020	2021	2022	Goal
SOGR	42.0%	43.8%	45.6%	47.4%	49.2%	70%

Performance Projections

In order to maintain a State of Good Repair, nearly 15,500 signs need replacement each year. Currently, approximately 5,000 signs are replaced each year.

Asset Valuation

$162,000,000

Asset value is estimated using the replacement value. For signs, replacement value is the product of square footage and unit construction cost.
Sheet Aluminum: $55,400,000
Extruded Aluminum: $105,800,000

Note: This value does not include the cost of overhead sign supports and foundations.

Measures and Targets

There are no Federal requirements at this time. CTDOT has set the following sign condition goals:

State Goals:

- 80% or more of signs on limited access roadways in a SOGR
- 70% or more of signs on non-limited access roadways in a SOGR

Connecticut Transportation Asset Management Plan

Sign Supports

Data Confidence Medium

Description

- CTDOT is responsible for maintaining about 1,625 overhead sign supports on state maintained roadways
- Sign supports are made up of three categories:
  - 609 Cantilevers
  - 605 Full-Span
  - 411 Bridge Mounted
- CTDOT defines a sign support as the structure (horizontal member(s), post(s) and foundation) carrying sign panels or variable message boards at a single location
- Sign panels attached to the sign support are managed as a separate asset

State of Good Repair (SOGR)

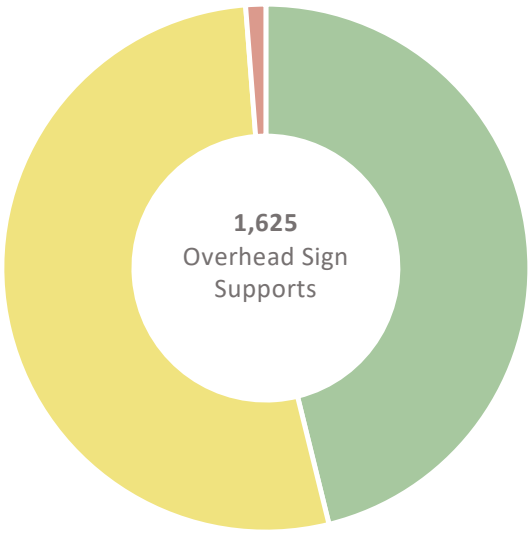
Sign supports with an overall rating of at least a 5 on a 0-9 condition scale are classified as being in a State of Good Repair.

Support Age

- Overhead sign supports have an estimated 34-year life expectancy
- Approximately 70% of the sign supports do not have a recorded age in the inventory
- Of the 470 sign supports with a known age, 77 sign supports are beyond 34 years

Sign Support Inventory and Condition

State Goals



Good

750 Sign Supports

46.2% are in Good condition

Fair

855 Sign Supports

52.6% are in Fair condition

Poor

20 Sign Supports

1.2% are in Poor condition

Good-Fair-Poor and SOGR defined by CTDOT

Based on CTDOT May, 2017 Snapshot

History

This graph may be provided at a later date after determinations can be made on the age of the sign support inventory.

Sign Supports

Sign Support Performance Projections

This graph may be provided at a later date

Performance Projections

Projections for sign supports have not yet been completed, but approximately 15 sign supports are replaced each year due to poor condition.

Asset Valuation

$233,000,000

Asset value is estimated using the replacement value. For sign supprts, replacement value is based on the average unit construction cost by type:
Cantilever $100,000 * 609 = $60,900,000
Full Span $250,000 * 605 = $151,250,000
Bridge Mount $50,000 * 411 = $20,550,000

Note: This value does not include the cost of the sign panels.

Measures and Targets

There are no Federal requirements at this time. CTDOT has set the following sign support condition goal:

State Goal:

- 90% or more of sign supports in a SOGR

Connecticut Transportation Asset Management Plan

Pavement Markings

Data Confidence
Very Low

Description

- CTDOT is responsible for maintaining pavement markings on approximately 4,140 centerline miles of on State maintained roadways
- Pavement Markings include:
  - Line Striping
  - Symbols & Legends (arrows, crosswalks, etc.)
- CTDOT pavement marking applications are either water-based by State forces and Epoxy by Contractor

State of Good Repair (SOGR)

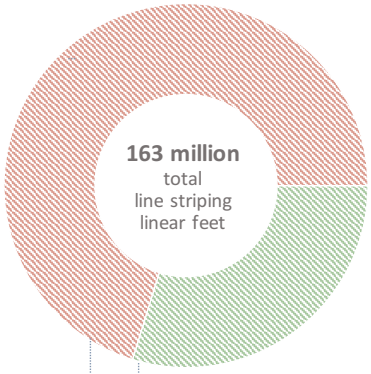
Epoxy pavement markings installed within 3 years are classified in a State of Good Repair whereas water-based pavement markings installed within 1 year are classified in a State of Good Repair. This is based on expectations of retroreflectivity life and wear. Retroreflectivity is a measure of the amount of light reflected by a surface back to the source of the light.

Marking Age

- Nearly 70% of all line striping and 37% of all symbol and legend pavement markings have exceeded their expected service life.

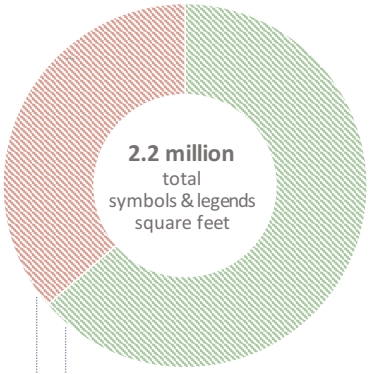
Pavement Markings Inventory and Condition: Line Striping and Symbols & Legends

State Goals



State of Good Repair **48.5 million linear feet**
29.8% of line striping is in a state of good repair

Poor **114.5 million linear feet**
70.2% of line striping is in poor condition



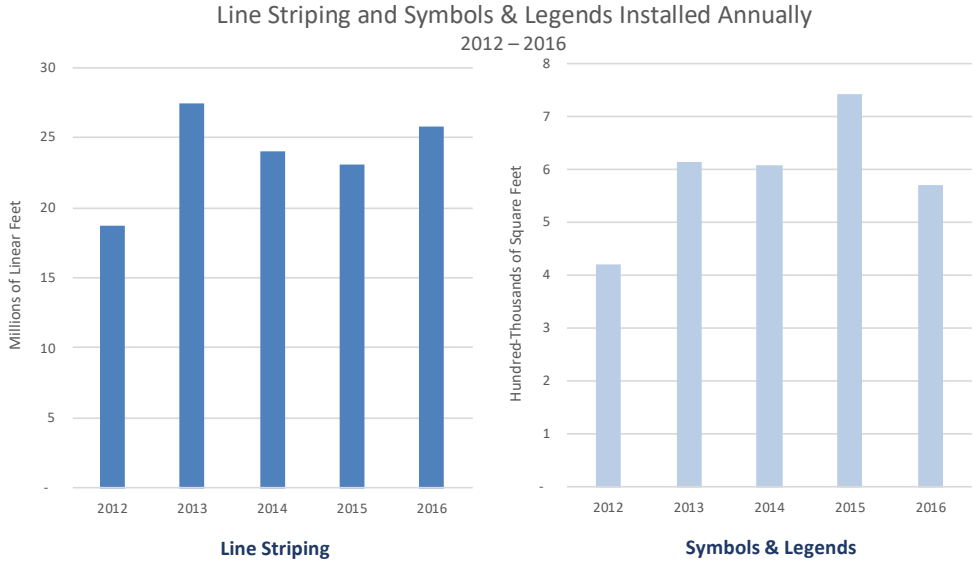
State of Good Repair **1.4 million square feet**
63.6% of symbols & legends are in a state of good repair

Poor **0.8 million square feet**
36.4% of symbols & legends are in poor condition

SOGR defined by CTDOT

Based on CTDOT 2017 Snapshot

History



Based on CTDOT 2017 Snapshot

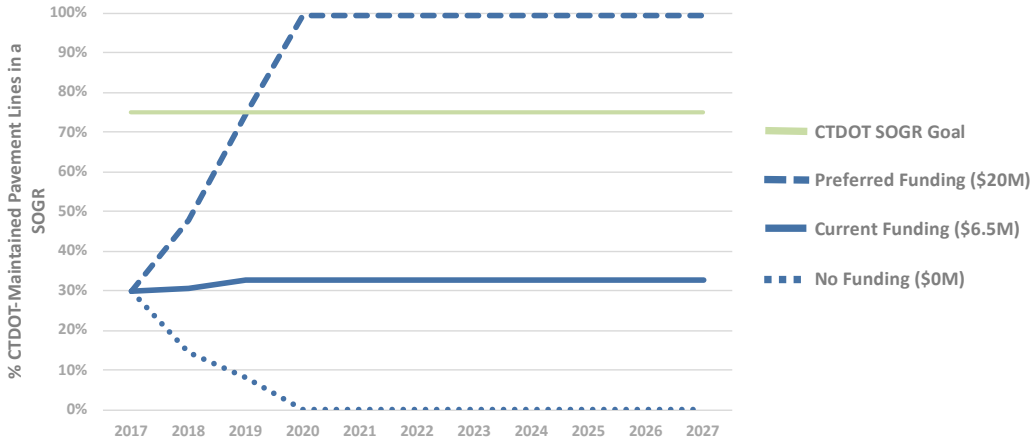
Connecticut Transportation Asset Management Plan

Pavement Markings



Pavement Markings Performance Projections

State Goals by pavement lines for 163 million linear feet of line striping

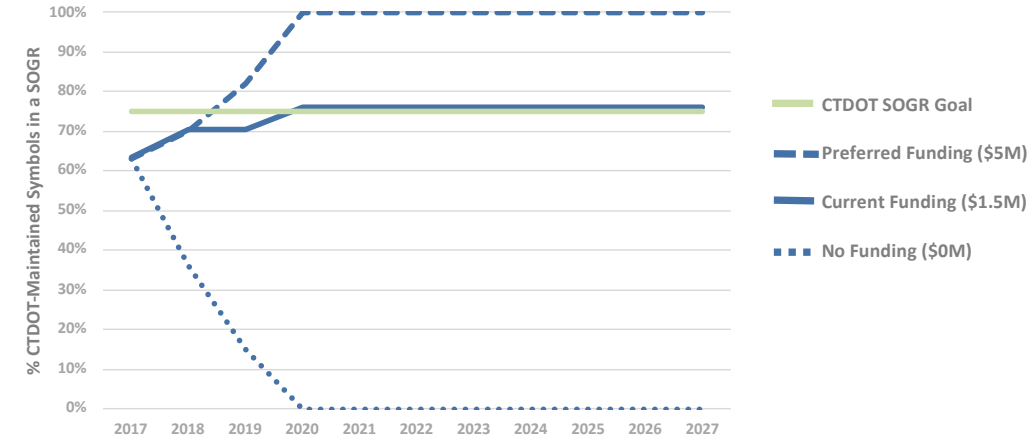


Based on funding as of 6/30/17

Performance Projections at Current Funding Level ($6.5M Budget)

Year	2017	2018	2019	2020	2021	Goal
SOGR	29.7%	30.7%	32.5%	32.8%	32.8%	75%

State Goals by pavement symbols for 2.2 million square feet of symbols & legends



Based on funding as of 6/30/17

Performance Projections at Current Funding Level ($1.5M Budget)

Year	2017	2018	2019	2020	2021	Goal
SOGR	63.4%	70.2%	70.2%	75.9%	75.9%	75%

Performance Projections

In order to maintain a State of Good Repair, nearly 54 million linear feet of line striping and 735,000 square feet of symbols & legends epoxy pavement markings need to be remarked each year. Currently, approximately 13 million linear feet and 350,000 square feet are remarked each year.

Asset Valuation

$90,000,000

Asset value is estimated using the replacement value method. For pavement markings, replacement value is the product of square footage and unit construction cost considering epoxy only.
Line striping: 163 million LF * $0.50/LF = $81,500,000
Symbols: 2.2 million SF * $3.50/SF = $7,700,000

Measures and Targets

There are no Federal requirements at this time. CTDOT has set the following pavement marking condition goals:

State Goals:

- 75% or more of line striping pavement markings in a SOGR
- 75% or more of symbols & legends pavement markings in a SOGR

Appendix C. CTDOT Asset Data Readiness Assessment Blank Sample

Readiness Form Sections

Using the Data Readiness Assessment Form

This form was developed to assist CTDOT Asset Stewards plan, document and share information about how asset data will be collected, updated, stored, and accessed. It is intended to be used both for assets that have established data programs as well as for assets that are in the beginning stages of the data planning process:

- For assets that do not yet have an established inventory or condition assessment process, the form provides a checklist of items that should be considered before moving forward with data collection. For example, is there a plan in place for how the data will be updated? Have potential data users been identified and involved in planning what attributes should be gathered?
- For established assets, the form helps the asset steward to document the current data program and consider future improvements. For example, can the asset data updating process be made more efficient by tapping into information included in CAD files? Should additional data access points be considered?

The process for completing and updating this form is as follows:

1. The asset steward meets with Asset Management and AEC representatives to walk through the form. This initial meeting provides a good opportunity to share information about current practices and potential future improvements. This will typically require a 1-2 hour session, and will result in an initial draft of the form plus a list of follow up questions that require further investigation or discussion.
2. The asset steward or their designee follows up as needed to complete the draft form.
3. The asset steward convenes a meeting of the asset work group to review the initial version, provide a common understanding of current practice and future needs, and discuss any concerns or ideas for improvement.
4. The asset steward updates the form as needed following the work group meeting, and transmits a copy to Asset Management.
5. The form is posted on the Asset Management web site.
6. Updated forms for each asset are included in CTDOTs Transportation Asset Management Plan (TAMP), which is updated every four years.

Note that this form is intended to supplement rather than replace metadata creation for CTDOT GIS data layers and other data sets.

Administrative Information	
Asset Name	Click or tap here to enter text.
Asset Steward Name and Position	Click or tap here to enter text.
Person Completing this Form (if different)	Click or tap here to enter text.
Date of Update	

Asset Definition and Identification	
Asset Definition	Click or tap here to enter text.
Unit of Measure (list all – e.g. “each” and “linear feet”)	Click or tap here to enter text.
Has Components? • If “Yes”, list components	Choose an item. Click or tap here to enter text.
Unique Asset ID *(Name of Data Element)*	Click or tap here to enter text.

Asset Data Requirements	
Data Users and Uses	
Primary CTDOT users of the data (current or anticipated) – list business unit names	Click or tap here to enter text.
Will some or all of the asset data be shared externally?	Choose an item.
If yes, who are the anticipated external data recipients or users	Click or tap here to enter text.
Is the data necessary to meet a Federal or State Requirement? *(describe as necessary)*	Choose an item. Click or tap here to enter text.
What business decisions will be made based on the data?	Click or tap here to enter text.
Data Needs	
Type(s) of data that **currently** exist for this asset *(check all that apply)*	☐ **Inventory (quantity/extent, type, etc.)** ☐ **Individual Asset Location** ☐ **Asset Condition** ☐ **Asset Condition History** ☐ **Work History** ☐ **Other** **Additional Notes:** Click or tap here to enter text.

Asset Data Requirements	
Type(s) of data that are being considered for **future** collection for this asset *(check all that apply)*	☐ **Individual Asset Location** ☐ **Inventory (quantity/extent, type, etc.)** ☐ **Asset Condition** ☐ **Asset Condition History** ☐ **Work History** ☐ **Other** **Additional Notes:** Click or tap here to enter text.
If/when additional asset data are collected, what will CTDOT be able to do that it cannot do now?	Click or tap here to enter text.
Geographic Scope of Asset Data • If "Other", describe	Choose an item. **Additional Notes:** Click or tap here to enter text.
Data Dictionary	
Has a Data Dictionary Been Defined? • If Yes, include link or document reference	Choose an item. Click or tap here to enter text.
Electronic Data Dictionary Submitted to Asset Management (Y/N)? • Include inventory ***and*** condition data elements as needed *(describe as necessary)*	Choose an item. Click or tap here to enter text.
Was the Data Dictionary Reviewed? *(check types of review criteria used)*	☐ **Check for Coverage of Important Attributes of Interest to Multiple Stakeholders?** ☐ **Check for Future Maintainability/Sustainability of Information?** ☐ **Check for Consistency with Location Referencing Standards?** ☐ **Check for Duplication with other Data Sets?** ☐ **Check for Integration Needs with Existing Data Sets?**

Asset Data Requirements	
• Have potentially sensitive data elements been identified? *(describe as necessary)*	Choose an item. Click or tap here to enter text.

Data Ownership and Stewardship	
Individual authorized to approve changes to data structure *(e.g. new attributes, changes to attribute coding)*	☐ **Asset Steward** ☐ **Others:** Click or tap here to enter text.
Individual authorized to grant access to data	☐ **Asset Steward** ☐ **Others:** Click or tap here to enter text.
Technical contact for questions about data meaning, derivation or quality	☐ **Asset Steward** ☐ **Others:** Click or tap here to enter text.

Asset Data Collection, Storage and Updating	
Data Collection	
Business Units responsible for asset inventory/condition data collection planning, oversight, QA, and data acceptance (list all units involved)	Click or tap here to enter text.
Data Collection Method (current or proposed)	Click or tap here to enter text.
Is a data QA/QC Plan in place? • If "Yes", provide reference to plan	Choose an item. Click or tap here to enter text.
Asset Location Identification and Management	
GIS Feature Type(s) for this Asset *(describe as necessary)*	☐ **Point:** Click or tap here to enter text. ☐ **Linear (Continuous):** Click or tap here to enter text. ☐ **Polygon (Area):** Click or tap here to enter text. **Additional Notes:** Click or tap here to enter text.

Asset Data Collection, Storage and Updating	
Type of Location Referencing and Workflow for Assignment *(describe as necessary)* ***Note:*** ***X/Y*** *- location definition independent of LRS* ***Linear Referencing*** *– relies on LRS definition (e.g. Route + Milepoint) for location*	To Be Determined **How is the asset location determined, when, and by whom?** Click or tap here to enter text.
Business Unit(s) with responsibility for asset location data updating	☐ **Asset Steward** ☐ **Others:** Click or tap here to enter text.
Method for synchronizing asset location with the official LRS to reflect periodic road changes.	Click or tap here to enter text.
Data Storage	
Authoritative system for current asset attribute data	Click or tap here to enter text.
Business Unit(s) responsible for loading data into the authoritative system	Click or tap here to enter text.
Data Updating	
Is data for this asset updated via periodic inventory/inspections that refresh data for the entire inventory?	☐ **Yes – periodic refresh is currently used** ☐ **Yes – this is the intended future method for data updating** ☐ **NA/Not in place or planned** **If in place or planned, what is the refresh cycle (# years)?** Click or tap here to enter text.

Asset Data Collection, Storage and Updating	
Is there a plan or interest in updating asset data based on capital project plans?	☐ **Yes – currently in place** ☐ **Yes – currently under investigation** ☐ **Would like to explore for future implementation** ☐ **NA/Not in place or planned** **What attributes can be updated based on capital project information?** Click or tap here to enter text.
Is there a plan or interest in updating asset data based on maintenance service memos?	☐ **Yes – currently in place** ☐ **Yes – currently under investigation** ☐ **Would like to explore for future implementation** ☐ **NA/Not in place or planned** **What attributes can be updated based on maintenance service memos?** Click or tap here to enter text.
Is there a plan or interest in updating asset data based on encroachment permits?	☐ **Yes – currently in place** ☐ **Yes – currently under investigation** ☐ **Would like to explore for future implementation** ☐ **NA/Not in place or planned** **What attributes can be updated based on encroachment permits?** Click or tap here to enter text.
What asset data elements can be derived from project plans or other project data sources but are difficult to observe in the field for this asset? (e.g. quantities, material types, buried features, administrative classifications)?	**Describe:** Click or tap here to enter text.
Contract Requirements for Data Provision	
Are there any applicable contract requirements for data provision for this asset? *(please describe)*	Choose an item. Click or tap here to enter text.
• If Yes or Under Development, are data elements and format standards in place? *(please describe)*	Choose an item. Click or tap here to enter text.

Asset Data Collection, Storage and Updating

Technology Solutions

Is a mobile application for field data collection currently available for this asset? *(please describe)*	Choose an item. Click or tap here to enter text.
• If Yes, please describe platform and provide reference to further information on attributes collected.	**Current Mobile Application Description:** Click or tap here to enter text.
• If No, would a mobile application for field data collection be of potential value? *(please describe how it might be used)*	Choose an item. **Potential Uses:** Click or tap here to enter text.
Please describe any other technology solutions or improvements which would benefit data collection and maintenance for this asset	Click or tap here to enter text.

Derivative Data Set Creation and Management

Provide information for spatial data layers, enterprise data (TED), and other specialized derivative data sets created from the authoritative source of asset inventory and condition data. These derivative data sets may contain subsets of data elements from the source, or transformations of data elements to facilitate particular uses.

Derivative Data Set #1

Type of Derivative Data Set *(Provide data set name and description)*	NA Click or tap here to enter text.
Data Update Methodology	Choose an item. **Describe:** Click or tap here to enter text.
Data Refresh Cycle (e.g. continuous – as data changes; nightly; annual; no set cycle)	**Cycle:** Click or tap here to enter text.
Business Unit responsible for performing or managing the data update	Click or tap here to enter text.

Derivative Data Set Creation and Management	
Is a Data Dictionary available for this data set? • If Yes, include link or document reference	Choose an item. Click or tap here to enter text.
Derivative Data Set #2	
Type of Derivative Data Set *(Provide data set name and description)*	NA Click or tap here to enter text.
Data Update Methodology	Choose an item. **Describe:** Click or tap here to enter text.
Data Refresh Cycle (e.g. continuous – as data changes; nightly; annual; no set cycle)	**Cycle:** Click or tap here to enter text.
Business Unit responsible for performing or managing the data update	Click or tap here to enter text.
Is a Data Dictionary available for this data set? • If Yes, include link or document reference	Choose an item. Click or tap here to enter text.
Derivative Data Set #3	
Type of Derivative Data Set *(Provide data set name and description)*	NA Click or tap here to enter text.
Data Update Methodology	Choose an item. **Describe:** Click or tap here to enter text.
Data Refresh Cycle (e.g. continuous – as data changes; nightly; annual; no set cycle)	**Cycle:** Click or tap here to enter text.
Business Unit responsible for performing or managing the data update	Click or tap here to enter text.
Is a Data Dictionary available for this data set? • If Yes, include link or document reference	Choose an item. Click or tap here to enter text.

Derivative Data Set Creation and Management	
Derivative Data Set #4	
Type of Derivative Data Set *(Provide data set name and description)*	NA Click or tap here to enter text.
Data Update Methodology	Choose an item. **Describe:** Click or tap here to enter text.
Data Refresh Cycle (e.g. continuous – as data changes; nightly; annual; no set cycle)	**Cycle:** Click or tap here to enter text.
Business Unit responsible for performing or managing the data update	Click or tap here to enter text.
Is a Data Dictionary available for this data set? • If Yes, include link or document reference	Choose an item. Click or tap here to enter text.

Asset Work History Tracking	
Do you currently track work that impacts the inventory or condition of this asset?	Choose an item.
If yes, what sources do you use? *(describe as appropriate)*	☐ **Capital Project Plans:** Click or tap here to enter text. ☐ **Maintenance Service Memos:** Click or tap here to enter text. ☐ **Encroachment Permits:** Click or tap here to enter text. ☐ **Other (Describe):** Click or tap here to enter text.

Asset Work History Tracking	
What data do you currently track? *(describe as appropriate)*	☐ **Asset ID or Route Location(s) treated:** Click or tap here to enter text. ☐ **Type of work activity:** Click or tap here to enter text. ☐ **Date of last replacement/repair:** Click or tap here to enter text. ☐ **Specific components of assets treated:** Click or tap here to enter text. ☐ **Quantity of assets treated:** Click or tap here to enter text. ☐ **Cost of work on specific assets:** Click or tap here to enter text. ☐ **Other:** Click or tap here to enter text.
What data would you like to track? *(describe as appropriate)*	☐ **Asset ID or Location(s) treated:** Click or tap here to enter text. ☐ **Type of work activity:** Click or tap here to enter text. ☐ **Specific components of assets treated:** Click or tap here to enter text. ☐ **Date of last replacement/repair:** Click or tap here to enter text. ☐ **Quantity of assets treated:** Click or tap here to enter text. ☐ **Cost of work on specific assets:** Click or tap here to enter text. ☐ **Other:** Click or tap here to enter text.
Authoritative system available for tracking **asset specific** work history? *(describe as necessary)*	**System:** Click or tap here to enter text. Click or tap here to enter text.

Data Access Points	
How will the asset inventory and condition data be made accessible to potential users within CTDOT?	**Asset Stewards/Managers:** Click or tap here to enter text. **General Data Users:** Click or tap here to enter text.
How will the asset inventory and condition data be made accessible to potential users external to CTDOT?	Click or tap here to enter text.

Additional Notes
Please provide any additional information which may be useful to the management of the asset:
Click or tap here to enter text.

Glossary

Asset Condition History. Changes in condition over time for the asset - for development of deterioration curves or service life estimates.

Authoritative System. The single source system of record for a particular type of data. This is the data repository where the data is maintained.

Contract Requirements. Contract language that requires provision of asset inventory and/or work accomplishment data elements in a specified format following completion of a project.

Data Access Points. Where users go to obtain data – this may be a desktop application, a web portal, or a data service/API.

Data Dictionary. Data element names, descriptions, types, sizes. May include domain information such as sample values or lists of values.

Derivative Data Set. A data set that is derived from one or more authoritative data sources - e.g. a GIS layer showing basic bridge characteristics - with data pulled from the bridge management system.

Electronic Data Dictionary. Electronic means in a digital, tabular format (e.g. spreadsheet or database table.)

Sensitive Data. Private data such as personally identifying information or other data that should have restricted access for security reasons.

Synchronizing Asset Location. For example, a highway realignment to straighten a curve would shorten a route. A sign that had been located at milepoint 3.0 might now be located at milepoint 2.9. Synchronization would correct milepoint locations in historical data.

***Tip**: use Alt+← to return to the original hyperlink location.*

Appendix D. Performance Projections

Bridge

Table D-1. % NHS Good, by Deck Area

Funding	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Preferred ($850M)	16.5%	18.1%	20.1%	22.5%	25.2%	27.9%	29.4%	29.5%	29.6%	30.3%	30.0%
$500M	16.7%	18.7%	20.7%	23.4%	25.9%	28.7%	29.2%	28.6%	29.2%	30.2%	29.1%
Current ($375M)	16.3%	17.7%	19.7%	22.1%	24.5%	26.9%	28.1%	27.1%	27.3%	27.6%	26.3%
$280M	16.7%	18.7%	20.7%	23.4%	25.8%	27.9%	28.0%	27.1%	27.3%	27.6%	26.3%
No Funding ($0M)	15.4%	15.4%	15.4%	15.4%	15.4%	15.4%	15.4%	14.1%	13.8%	13.4%	10.4%

Table D-2. % NHS Poor, by Deck Area

Funding	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Preferred ($850M)	14.8%	12.3%	9.4%	7.7%	6.8%	5.3%	4.7%	4.5%	4.2%	5.9%	7.0%
$500M	14.5%	11.1%	8.6%	7.3%	6.3%	4.9%	4.8%	4.6%	4.2%	7.2%	8.5%
Current ($375M)	14.9%	12.3%	9.4%	7.9%	7.1%	5.7%	5.1%	4.9%	5.8%	10.0%	11.7%
$280M	14.5%	11.1%	8.6%	7.3%	6.4%	5.3%	5.2%	5.0%	5.2%	9.9%	13.0%
No Funding ($0M)	15.7%	15.7%	15.7%	15.7%	15.7%	17.1%	18.8%	19.2%	20.9%	27.1%	30.5%

Table D-3. % CTDOT-Maintained SOGR, by Number of Bridges

Funding	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Preferred ($850M)	94.6%	94.9%	95.6%	96.6%	97.9%	98.4%	98.5%	98.0%	97.4%	96.5%	96.2%
$500M	94.7%	95.2%	96.1%	97.3%	97.9%	98.2%	98.2%	98.0%	97.5%	96.5%	95.2%
Current ($375M)	94.5%	94.7%	95.3%	96.1%	96.7%	97.9%	97.7%	97.1%	96.0%	94.6%	93.0%
$280M	94.7%	95.2%	96.1%	97.3%	98.1%	98.0%	97.7%	96.9%	95.4%	93.7%	91.3%
No Funding ($0M)	94.0%	93.8%	93.8%	93.8%	93.8%	93.5%	92.9%	90.9%	88.1%	88.1%	82.2%

Pavement

Table D-4. % Interstate Good, by lane miles

Funding	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Preferred ($149M)	66.2%	66.5%	66.0%	65.4%	64.5%	64.3%	53.9%	54.0%	54.9%	54.9%	55.3%
Current ($94M)	66.2%	66.5%	66.0%	65.5%	65.0%	64.4%	53.5%	52.8%	52.0%	50.2%	49.8%
No Funding ($0M)	66.2%	66.5%	64.4%	62.1%	60.1%	57.2%	43.4%	41.3%	39.7%	36.7%	35.2%

Table D-5. % Interstate Poor, by lane miles

Funding	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Preferred ($149M)	2.2%	2.2%	2.0%	2.0%	2.3%	2.5%	2.5%	2.6%	2.4%	3.4%	3.6%
Current ($94M)	2.2%	2.2%	2.1%	2.0%	2.3%	2.6%	2.8%	2.9%	2.9%	3.8%	4.0%
No Funding ($0M)	2.2%	2.2%	2.3%	2.4%	2.7%	3.5%	3.4%	3.6%	3.7%	4.7%	5.6%

Table D-6. % Non-Interstate NHS Good, by lane miles

Funding	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Preferred ($149M)	35.1%	36.7%	35.7%	35.2%	33.4%	33.2%	26.0%	25.8%	26.4%	26.2%	27.0%
Current ($94M)	37.9%	39.6%	37.6%	36.0%	33.4%	31.9%	24.8%	24.4%	24.5%	23.4%	23.0%
No Funding ($0M)	37.9%	39.2%	35.9%	32.9%	28.8%	25.7%	18.0%	16.7%	15.5%	14.5%	13.1%

Table D-7. % Non-Interstate NHS Poor, by lane miles

Funding	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Preferred ($149M)	9.0%	7.7%	7.1%	6.8%	6.8%	6.3%	6.5%	7.1%	7.7%	7.3%	7.4%
Current ($94M)	8.6%	6.9%	6.6%	6.8%	7.2%	7.6%	8.5%	9.7%	10.6%	11.3%	12.2%
No Funding ($0M)	8.6%	7.3%	8.3%	9.6%	10.9%	12.1%	13.0%	14.3%	16.3%	18.3%	20.1%

Table D-8. % CTDOT-maintained SOGR, by centerline miles

Funding	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Preferred ($149M)	65.3%	67.1%	67.2%	67.3%	67.0%	66.8%	65.2%	63.2%	62.7%	63.9%	64.4%
Current ($94M)	65.3%	65.4%	64.4%	62.9%	60.9%	57.6%	51.7%	46.0%	41.1%	39.5%	39.0%
No Funding ($0M)	65.3%	62.9%	59.3%	55.9%	50.4%	43.8%	35.6%	27.9%	21.1%	14.6%	9.7%

Traffic Signal

Table D-9. % SOGR, by traffic signal

Funding	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Preferred ($25M)	75.9%	72.7%	71.5%	70.2%	69.5%	74.9%	76.0%	76.3%	76.6%	77.0%
Current ($16M)	70.4%	69.6%	67.0%	64.0%	61.4%	63.2%	62.9%	61.7%	60.6%	59.6%
No Funding ($0M)	68.3%	65.5%	60.7%	55.8%	51.5%	53.4%	50.8%	47.5%	44.2%	41.1%

Sign

Table D-10. % Limited Access Roadway Signs SOGR

Funding	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Preferred ($50M)	39.4%	45.5%	51.5%	57.6%	63.6%	69.7%	75.8%	78.8%	84.8%	84.8%
Current ($28M)	36.4%	39.4%	42.4%	45.5%	48.5%	51.5%	54.5%	54.5%	57.6%	54.5%
No Funding ($0M)	33.3%	33.3%	33.3%	33.3%	33.3%	33.3%	30.3%	30.3%	24.2%	33.3%

Table D-11. % Non-Limited Access Roadway Signs SOGR

Funding	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Preferred ($3M)	42.8%	46.4%	49.9%	53.4%	56.9%	60.4%	64.0%	67.5%	71.0%	74.5%
Current ($2M)	42.0%	43.8%	45.6%	47.4%	49.2%	51.0%	52.8%	54.6%	56.4%	58.3%
No Funding ($0M)	39.9%	37.6%	35.2%	32.9%	30.5%	28.2%	25.8%	23.5%	21.1%	18.8%

Pavement Marking

Table D-12. % Line Striping SOGR, by linear foot

Funding	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Preferred ($20M)	29.7%	47.7%	74.3%	99.4%	99.4%	99.4%	99.4%	99.4%	99.4%	99.4%	99.4%
Current ($6.5M)	29.7%	30.7%	32.5%	32.8%	32.8%	32.8%	32.8%	32.8%	32.8%	32.8%	32.8%
No Funding ($0M)	29.7%	14.6%	8.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table D-13. % Symbols SOGR, by square foot

Funding	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Preferred ($5M)	63.0%	70.0%	82.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Current ($1.5M)	63.4%	70.2%	70.2%	75.9%	75.9%	75.9%	75.9%	75.9%	75.9%	75.9%	75.9%
No Funding ($0M)	63.0%	36.0%	15.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Appendix E. TAM Risk Registry

Table E-1. List of Risks Identified

Asset	Risk Statement	Risk Rating	Potential Strategies
Bridge	If the rate of bridge deterioration increases faster than predicted as bridges age, then the percent of Structurally Deficient (SD) bridges (by deck area) will increase.	Very High	• Make necessary adjustments to the deterioration modeling and recommended treatments in the dTIMS software • Seek and justify additional funding if necessary
Bridge	If we do not address corrosion due to the use of deicing salts on our bridges, then the rate of deterioration may increase.	Very High	• Protect the existing concrete from salt with coatings and the use of low permeability concrete on new bridge and superstructure replacements • Continue to rinse bridges
Bridge	If we do not have load ratings on all bridges, then we may not be able to evaluate safe loads for deteriorated bridges discovered during inspections.	High	• Leverage qualified outside resources to perform load ratings
Bridge	If we have a lack of bridge maintenance staff and don't continue to maintain our bridges, then bridges will continue to deteriorate leading to more serious bridge conditions requiring replacements earlier than necessary.	High	• Share resources by having the Office of Construction (construction inspectors) and the Office of Maintenance Operations / Transportation Maintenance (maintenance district staff) coordinate on bridge maintenance needs thru Bridge Repair Unit (BRU) contracts, administered by the Office of Construction • Hire more bridge maintenance staff to initiate a bridge painting program in the future • Address repairs with Capital Program Funding using Variable Quantity Contracts and bid the work
Bridge	If we don't document institutional knowledge and existing processes, then we will spend more on design time, be less efficient at preparing quality plans, and it will result in longer project schedules.	High	• Document institutional knowledge, provide training, etc. to address attrition within CTDOT
Bridge	If we do not increase the load capacity of bridges, then we will be limiting future freight movements.	High	• Make the load carrying capacity of all bridges a high priority
Bridge	If we don't achieve Structurally Deficient (by deck area) below 10% by the end of 2019, then FHWA will continue to levy the bridge penalty and there may not be enough eligible NHS-NBI bridge projects available to use the bridge penalty funding, therefore we will lose federal money	Medium	• Develop priorities for Design and Construction to repair and then inspect the NHS-NBI bridge projects with structural deficient components
Bridge	If funding decreases or % Structurally Deficient (by deck area) increases (with current funding), then we may need to fix the deficiency using maintenance forces or post bridges for lighter loads	Medium	• Prioritize work to fix individual problems as they come up through federally eligible BRU contracting.
Bridge	If we have a lack of design engineering staff, then we can't deliver project designs on time and possibly not maximize our federal funds	Medium	• Convince the legislature to increase staff. • Leverage qualified outside resources to help with the bridge design program.
Bridge	If we have a lack of engineering consultant management staff, then we can't oversee consultants adequately	Medium	• Use in-house design staff to oversee consultants. • Convince the legislature to increase staff and/or leverage qualified outside resources.

Asset	Risk Statement	Risk Rating	Potential Strategies
Bridge	If we do not coordinate with future highway design planning, then we may not pick the most cost-effective solution to rehabilitate or replace our bridges	Medium	• Continue to facilitate communication between the Division of Bridge's Bridge Management Group and the Division of Highway Design's Project Development Unit.
Bridge	If we don't provide correct scopes and cost estimates at the initiation of the PPI (Proposed Project Information), then it will impact schedules, cause delays, lead to cost increases which may impact the capital plan	Medium	• Understand the uncertainties of the scope and cost estimates at PPI initiation and adjust when more definitive information is available. • Update the scope and cost estimates after RSR approvals and subsequent design phases (60%, 90%, etc).
Bridge	If we don't have reliable deterioration modeling, then we won't program appropriate treatments efficiently or cost effectively	Medium	• Take advantage of dTims' ability to modify and adjust the deterioration modeling with updated historical information.
Bridge	If we do not predict and prepare accurate schedules at design approval, then it can lead to schedule delays and impacts to the financial program	Medium	• Take advantage of using and maintaining project scheduling programs (Microsoft Project) to generate, mitigate, and track project schedules.
Bridge	If we face inadequate funding, then it will limit the capital programing bridge conditions will suffer, impacting the travelling public	Medium	• Prioritize our bridge projects using performance-based decisions. • Develop lower cost project delivery to repair/replace more bridges with the same funding such as design build and Variable Quantity contracting.
Bridge	If we have a lack of staff or equipment for bridge safety inspection (State and Consultants), then we do not discover bridge deficiencies in a timely manner and will not meet the FHWA NBIS Oversight Program	Medium	• Retain staff and maintain equipment. • Hire and train to address the needs.
Bridge	If the load on the bridge exceeds the load rating of the bridge, then the health of the bridge is affected	Medium	• Identify locations that this is frequently occurring. • Coordinate with freight enforcement and regulations to develop a plan to understand and address impacts of loadings to the bridges. • Obtain better information of loadings via the use of technology. • Increase the load carrying capacity of new bridges.
Bridge	If we don't have predictable and timely environmental permitting ("conditional permits") for design-build bridge projects, then we cannot do: a) design/build projects where permit requirements are unknown at bidding (about 15% to 30% design); b) we will have schedule delays where permits are the critical path; c) we will eliminate possible design-build project candidates which would save Connecticut money and time	Medium	• Develop performance based permitting to focus upon best practices and limits. • Schedule regular progress meeting (Team of 8 and EDC-4) with permit agencies • Develop new, improved processes
Bridge	If maintenance forces are reduced and we experience a bridge hit, then repairs would need to be accomplished under the Capital Program or done under an Emergency Declaration, costing Connecticut more money to repair	Medium	• Maintain or increase bridge maintenance staff.
Bridge	If we don't embrace new materials and technologies, then we won't have reduced-maintenance bridges	Low	• Other states knowledge and experiences, CTDOT research, and attendance of vendor seminars/webinars.
Bridge	If we have inadequate or late public involvement and controversy arises, then it can lead to schedule	Low	• Early public outreach.

Asset	Risk Statement	Risk Rating	Potential Strategies
	delays, and we may have to re-scope projects, and experience increased costs		
Bridge	If our inspection staff lacks the appropriate training, then we do not discover bridge deficiencies	Low	• Treat this risk by keeping training a high priority for bridge inspectors.
Pavement	If we don't deliver the recommended projects, then pavement conditions will deteriorate and we will lose public credibility	High	• Define a multi-year program with estimated timelines, and schedules • Provide management support and commitment • Establish reliable contract vehicles to deliver the paving program
Pavement	If we don't select the right projects, then lifecycle costs will increase to achieve or maintain SOGR	High	• Use flexible, responsive contract vehicles • Continually improve the PMS to optimize project selection • Increase staffing and update the work program to justify the staffing increase • Tolerate some of this risk in the short-term as new technology is implemented
Pavement	If staffing levels are inadequate or if staff are not properly trained, then program delivery will suffer	High	• Leverage qualified outside resources • Develop a multi-year work program identifying resources needed to achieve objectives • Develop and implement a succession plan
Pavement	If we do not consider the complexity of implementing changes in technology, contracting etc., then opportunities that will enable us to achieve SOGR will be missed.	High	• Incorporate change/new technology into the business process • Develop and deploy effective implementation plans • Match resources to objectives
Pavement	If we don't get adequate funding, then pavement conditions will deteriorate and future funding needs to achieve or maintain SOGR will increase	Medium	• Provide adequate funding • Initiate program to specifically address paving needs including the 'Backlog' of pavements
Pavement	If construction costs increase, then we cannot deliver the recommended program	Medium	• Express paving program needs in terms of lane-miles instead of current costs • Flexible funding
Pavement	If the materials are of poor quality, then performance will be shortened, and costs will increase	Medium	• Continue to review specifications and controls to address changes in materials
Pavement	If the construction is of poor quality, then performance will be shortened, costs will increase, and public perception will be impacted negatively	Medium	• Continue implementation of statistically based specifications that support more consistent and higher quality of construction
Pavement	If pavement data are incomplete or of poor quality for the program level, then we can't identify correct treatments and costs	Medium	• Implement the QMP (Quality Management Plan) • Develop a QMP for all other data inputs
Pavement	If we do not embrace pavement preservation, then costs will increase, and conditions will decrease.	Medium	• Educate and promote pavement preservation practices inside and outside of the agency • Conduct public outreach to understand preservation project selection • Collaborate with CTLTAP for local agency education
Pavement	If construction industry can't handle the capacity, then pavement conditions will deteriorate, maintenance and construction will decline in quality, costs will increase, and some treatments won't be available	Medium	• Establish a multi-year plan so that the industry can plan for the program requirements.
Pavement	If don't routinely address longitudinal paving joints, cracks and potholes, then we will shorten the life of	Medium	• Institute Crack Fill/Seal Program • Investigate preventative maintenance techniques

Asset	Risk Statement	Risk Rating	Potential Strategies
	the asphalt paving surfaces, particularly at high value roadways and create a safety issue		• Allocate appropriate resources
Pavement	If we don't consider the age of the network, we could have unexpected performance and changed field conditions in projects	Medium	• Understand the impacts of the aging network • Use of nondestructive and forensic techniques to minimize uncertainty
Pavement	If the pavement analysis model is inaccurate, then funding could be inadequate, needed projects won't be identified and constructed, and we can't identify correct treatments and cost	Low	• Review and continuously update analysis inputs: specifically, deterioration models, treatment triggers and costs • Allocate appropriate resources to achieve
Traffic Signal	If traffic signal assets deteriorate to a poor condition, then the safety to the public, the efficiency of travel, and the quality of life will be affected	Very High	• Ensure adequate resources are dedicated to these assets and their related activities • Develop and implement an Asset Management Plan
Traffic Signal	If we lack asset inventories with adequate information on condition, then we can't optimize investments and set priorities	Very High	• Develop an inventory of traffic signal assets; use new technology to inventory assets and document their age/condition; and coordinate with the Offices of Maintenance and Construction to update/maintain the inventory • Improve tracking of part service records to retire components that repeatedly break down and/or do not achieve the expected service life.
Traffic Signal	If there is a lack of adequate maintenance staff who are technically skilled in signal repair, then the performance of traffic-control devices will degrade and public safety will be affected	High	• Ensure appropriate and sufficient staff and provide technical training to staff. • Investigate leveraging outside resources for some work if needed/possible.
Traffic Signal	If design staffing is inadequate, then we will not be able to maintain a state of good repair of our traffic signal devices	Medium	• Treat this risk by ensuring adequate staff for SOGR projects. • Identify possible tasks for on-call consultants for SOGR projects. • Develop and implement asset management system to increase efficiency of SOGR projects.
Traffic Signal	If there is not adequate technology, design tools and training, then we cannot meet project deadlines, there will be duplication of work, we will not be able to maintain a state of good repair, and the efficiency of travel and quality of life will be impacted.	Medium	• Treat by supporting efforts to update technology, design tools, and training.
Traffic Signal	If we do not coordinate between work units (Bridge Safety, Bridge Design, Office of Maintenance (including District offices, Highway Operations, and the Signal Lab,) Office of Information Systems (OIS) and Engineering Applications), then we will not operate as efficiently as we could	Medium	• Develop a coordination strategy based on the alignment of work schedules and strategic communications. • Ensure appropriate offices are included in the Traffic Signal Asset Management working group. • Ensure appropriate offices are involved with design reviews.
Traffic Signal	If pedestrian detector systems are not functioning properly, then the signal will not run efficiently, safety, congestion, and quality of life will be impacted.	Medium	• Treat this risk by identifying a method to systematically check and track if pedestrian signals are functioning properly
Traffic Signal	If politics drives our traffic decisions, then we may install unwarranted traffic signals which could cause issues, or a location could be programmed for an equipment upgrade when there may be a location with a greater need.	Medium	• Treat this risk by coordination with the municipalities and providing education of the disadvantage of unwarranted traffic signals • Implement a data driven selection process for locations for equipment upgrades

Asset	Risk Statement	Risk Rating	Potential Strategies
Traffic Signal	If future regulations (MUTCD, AASHTO, NESC, PURA, etc.) and requirements are revised or developed, then we could face higher costs and efforts to remain compliant	Medium	• Treat this risk by being engaged and involved in development of future regulations, so that we have the longest time possible to anticipate future needs and so that the requirements align with CT's needs • Opportunity: Accurate inventory and condition information will enable us to more efficiently address deployment of future requirements
Traffic Signal	If we experience reductions in funding, then the performance of our traffic signal assets will suffer	Medium	• Treat by seeking needed funding using data and support information to clearly define the need and consequences of no action • Treat by employing a traffic signal asset system to optimize the use of resources over the life cycle of the assets
Traffic Signal	If we do not coordinate between work units within the Division of Traffic Engineering (Operations, Safety, Project Design,) then we will not operate as efficiently as we could	Medium	• Treat by developing and employing a prescribed plan to communicate and coordinate work being conducted between units in the Division of Traffic Engineering. • Ensure each office has a representative in the Asset Management Working Group
Sign	If regulatory signs deteriorate to poor condition, then the safety of the public, the efficiency of travel, and the quality of life will suffer.	Very High	• Look into the use of different sheeting types and laminate products to be added onto high significance signs (ex. Stop signs) in order to increase life expectancy of reflectivity and reduce graffiti - effort to be put into reviewing current specifications to have Contractors and Maintenance utilize the same products
Sign	If warning signs deteriorate to poor condition, then the safety of the public, the efficiency of travel, and the quality of life will suffer.	Very High	• Look into the use of different sheeting types and laminate products to be added onto high significance signs (ex. Pedestrian Crossing signs) in order to increase life expectancy of reflectivity and reduce graffiti - effort to be put into reviewing current specifications to have Contractors and Maintenance utilize the same products
Sign	If design staff levels are inadequate, then we will not be able to maintain a state of good repair for signs.	Very High	• Leverage qualified outside resources, reprioritize staffing, or add staffing
Sign	If staff is not trained to an adequate level, then we will not operate as efficiently as we should. There will be potential duplication of efforts, wasted resources, impacts to public safety and negative public perception.	High	• Come up with a training plan for implementation
Sign	If guide signs deteriorate to poor condition, then the safety to the public, the efficiency of travel, and the quality of life will suffer.	High	• Look into the use of different sheeting types and laminate products to be added onto high significance signs (ex. Exit Gore signs) in order to increase life expectancy of reflectivity and reduce graffiti - effort to be put into reviewing current specifications to have Contractors and Maintenance utilize the same products
Sign	If the sign inventory is not complete and current, then we cannot optimize investments and set priorities.	High	• Comprehensive plan to address the needs of Maintenance and Design. • Potentially reinventory.
Sign	If there is a lack of adequate maintenance staff to fabricate, install & repair signs, then the	High	• Add staffing and upgrade fabrication equipment

Asset	Risk Statement	Risk Rating	Potential Strategies
	performance of sign devices will degrade and public safety will be affected.		
Sign	If posted signs do not match roadway conditions, then drivers may not be prepared for the roadway conditions	High	• Program projects to address identified deficiencies
Sign	If posted signs do not match approved OSTA signage requirements and MUTCD requirements, then FHWA funding may be in jeopardy, potential for litigation based on incorrect signage, and potential for crashes	High	• Complete TIR's in a timely manner and compare authoritative databases upon completion
Sign	If there is not adequate coordination with the Division of Bridge, then we cannot meet project deadlines and we will not be able to maintain a state of good repair and the efficiency of travel will be impacted.	Medium	• Improve coordination. • See if Bridge Design can create a plan to utilize On-Call staff more efficiently.
Sign	If sign posts are not installed properly, then sign visibility and sign post breakaway safety features may be minimized	Medium	• As signs are replaced, replace the post with a proper breakaway post. • Maintain quality control on the specifications
Sign	If there is a lack of support staff (clerical, planning, OEP, Environmental Compliance), then we cannot meet project deadlines and we will not be able to maintain a state of good repair and overall efficiency.	Medium	• Add staffing and streamline required procedures
Sign	If signing decisions are determined by public acts set forth by the legislature, then we will install signs that cause confusion, clutter, violate federal standards, and detract resources.	Medium	• Purpose of a sign - To provide regulations, warnings, and guidance information for road users. Signs should be used only where justified by engineering judgment or studies
Sign	If the Department's sign catalog, associated database, and sign details are not current and accurate, then Department staff and consultants can't request proper signage; the Sign Shop will receive orders for obsolete signs; and signage being installed will not meet current MUTCD requirements	Medium	• Update all sign details, the sign catalog, and the associated database
Sign	If there is not adequate coordination within the Division of Traffic, then we will not operate as efficiently as we should. There will be wasted resources, duplication of efforts, and negative public perception.	Medium	• Improve coordination, potential for Lean or reorganization to eliminate gaps
Sign	If there is not adequate technology, design tools and training, then we cannot meet project deadlines, there will be duplication of work, we will not be able to maintain a state of good repair and the efficiency of travel and quality of life will be impacted.	Medium	• Make purchases • Develop plan to stay current and effective.
Sign	If funding is inadequate, then the performance of the signs will suffer.	Medium	
Sign	If future regulations and requirements are instituted, then we could face higher costs, greater efforts to remain compliant, greater demands on limited resources, and negative initial public perception.	Medium	
Sign	If new technologies are not implemented at the sign shop or for sheeting materials, then retroreflective properties of the signing will degrade requiring more frequent replacement	Medium	• Continue coordination with sheeting manufacturers and make purchases as necessary
Sign	If a new sign catalog, associated database, and sign details are created, then the format of the	Medium	• The Division of Traffic Engineering has received approval from the FHWA to

Asset	Risk Statement	Risk Rating	Potential Strategies
	information can be revised to a more user-friendly form		create a new sign catalog, associated database, and sign details as part of the sign inventory management system to be used for QA/QC within the inventory system. This should be completed no later than 6/30/18.
Sign	If new design technologies are implemented, then the associated design man hours can be reduced	Medium	• Research and implement design technologies associated with geospatial CAD initiatives and CAD to GIS/authoritative database capabilities
Sign	If new sign sheeting technologies are implemented, then sign replacement needs may be reduced	Medium	• Research and implement new sign sheeting technologies
Sign	If there is not adequate coordination with the Division of Highways (Guiderail), then we cannot meet project deadlines, design features may not be included, and public safety may be affected.	Low	• Improve coordination. • See if Highway Design can create a plan to utilize On-Call staff more efficiently.
Sign	If there is not adequate coordination with the Office of Maintenance, then we will not operate as efficiently as we should. There will be potential duplication of efforts, wasted resources, impacts to public safety and negative public perception.	Low	• Continue coordination as necessary and create opportunities to improve technology for the signing crews
Sign	If there are inadequate sign shop supplies and equipment, then Maintenance staff will not be able to replace and repair signs.	Low	• Make purchases and try to maintain current technologies
Sign	If new technologies are not implemented for designers, then quality and quantity of signing projects will not be able to be improved	Low	• Continue to implement and utilize new technology as it becomes available
Sign Support	If we don't have an accurate or complete inventory and the inventory is not properly updated, then we cannot properly manage this asset and it becomes a safety hazard	High	• Take advantage of the process developed and implemented to complete the inventory and to continually update the inventory.
Sign Support	If there is a lack of staff to conduct routine maintenance, then this impacts structure life, safety and potential failure	High	• Prioritize/address resource needs.
Sign Support	If standards change (for signs or sign supports), then we need to address sign support design	Medium	• Develop a plan to address and deploy changes for existing signs. • Use safety factors for the design of new signs.
Sign Support	If sign supports are not inspected regularly, then there is the potential for failure	Medium	• Return to inspecting regularly and adjusting the inspection cycle to every 6 years for sign supports in a State of Good Repair.
Sign Support	If there is insufficient funding for inspection, then there is the potential for failure	Medium	• Increasing the funding to cover the inspection cost.
Sign Support	If there is insufficient funding for sign support replacements, then there is the potential for failure and will create a backlog of asset needs	Medium	• Seek funding as needed. • Give these projects a higher priority in the obligation plan, during the project prioritizations.
Sign Support	If we have a lack of Bridge Safety & Evaluation staff for inspection, Traffic staff for design, and State Bridge Design for design, then it impedes the management of the sign support asset	Medium	• Retain more staff. • Look into reorganizing existing staffing to streamline the design/inspection process.
Sign Support	If there is a lower priority given to sign supports than bridges, because of the availability of resources and staff, then these sign supports do not get addressed adequately and could have safety impacts	Medium	• Review and communicate priorities for all types of sign supports.
Sign Support	If there is a lack of coordination between the Office of Traffic and Bridge Safety & Evaluation, then we	Low	• Assign central point of contact for each functional area: .

Asset	Risk Statement	Risk Rating	Potential Strategies
	will not have a complete inventory which can lead to possible duplication of effort and impedes project delivery		• Coordinate and prioritize the work with State Bridge Design. • Take advantage of the attendance of Bridge Safety & Evaluation in the weekly traffic status meetings.
Pavement Marking	If there is insufficient staffing due to sign priorities, VIP paving, complaints, and available staff skill sets, then less work will get done and safety will be impacted.	Very High	• Address staffing issues
Pavement Marking	If funding decreases or is uncertain, then less work will get done and safety will be impacted	Very High	• Take steps to ensure necessary funding
Pavement Marking	If weather conditions are not favorable for paint application (cold/rain), then less work will get done and safety will be impacted	High	• Adopt strategies to account for variability in weather
Pavement Marking	If equipment is not functioning properly and up-to-date for application needs (example painting of rumble strips, etc.), then work cannot be achieved and safety will be impacted	High	• Develop plan to address critical equipment redundancy needs
Pavement Marking	If there is insufficient MPT (Maintenance and Protection of Traffic) staff and equipment, then work cannot be achieved and safety will be impacted.	High	• Improve coordination between Signs & Markings and MPT crew schedules
Pavement Marking	If the quality of paint is poor but meets specifications, then 1) the longevity of is reduced 2) in some cases impacts ability to apply, clogs equipment, decreases productivity	Medium	• Review the specifications and what materials meet the specifications under the contract. Consider reducing length of contract to reduce the impact of poor quality paints that meet the specifications but do not perform well. • Address National performance standards through cooperation with NTPEP testing.
Pavement Marking	If the public drives over wet paint, then claims will increase	Medium	• Seek operational improvements that allow for additional painting without the concern of impacting the travelling public. Extra effort already being done by using additional cones and no longer painting both white and yellow lines. • Seek out improving drying times and operational options - continue to cooperate with AASHTO testing at NTPEP.
Pavement Marking	If standards (MUTCD) change, then more work is required	Low	• Anticipate changes to MUTCD and develop strategy to effectively transition to new standards
TAM	If there is insufficient funding to support the design, construction and maintenance of assets, then the targets set in our TAMP cannot be achieved	Very High	• Identify and implement mechanisms to optimize and prioritize the use of funding towards maximum benefit in achieving SOGR
TAM	If there is insufficient staffing to support the design, construction and maintenance of assets, then the targets set in our TAMP cannot be achieved	Very High	• Quantify impacts to asset performance due to staffing shortages • Prioritize work and allocate staff based on most critical needs • Seek alternative means to achieve work
TAM	If a significant percentage of the of the assets are beyond the expected life (age), then the practical ability to achieve SOGR will be impeded	High	• 1) Monitor relationship(s) between age and expected lifecycle/performance • Evaluate tradeoff to lifecycle for replacement vs rehabilitation on SOGR
TAM	If there is insufficient ability to collect, store, retrieve, analyze, interpret and report data, then key asset management functions, such as current	High	• Develop and implement an effective strategy to provide information technology support for asset management functions

Asset	Risk Statement	Risk Rating	Potential Strategies
	and projected performance prediction, cannot be properly achieved		• Include a continuous improvement plan to strategically address the mounting needs
TAM	If there is not public stakeholder understanding of preservation practices over 'worst first' practices, then there will be confusion regarding project selection, diminished credibility and lack of public support	High	• Develop a communication plan that includes information for public stakeholders
TAM	If work is not programmed based on TAM methodologies, then there will be inefficient use of funding, reduction in the ability to achieve SOGR, reduced credibility to the program and potential FHWA financial penalties in bridge and pavement programs	High	• Utilize information from TAM methods to program work • Track and quantify work programmed based on TAM methodologies to analyze the effectiveness to achieving SOGR
TAM	If multiple processes to handle each asset are not streamlined into a unified asset management approach, then the effectiveness of programming according to TAM methods will be reduced.	High	• Understand and accept the benefits of the asset management approach • Have mechanisms in place to facilitate unified management across functional areas (e.g. Asset Working Groups) • Accept that a percentage of work will not be done according to TAM methods • Executive support for unified approach
TAM	If there are not processes in-place to systematically manage and maintain additional assets, specifically those not yet included in the TAMP, that were customarily replaced through highway design contracts, then these additional assets will deteriorate and the SOGR will be impeded	High	• Identify and prioritize additional assets • Develop plans to address SOGR of these additional assets • Include in future TAMPs
TAM	If there is not sufficient alignment with the STIP CTDOT Statewide Transportation Improvement Program (STIP), then CTDOT will not pass the consistency determination assessment and penalties will be imposed.	High	• Refine a strategy to track asset management specific work • Prepare information for the consistency determination assessment
TAM	If there is not adequate understanding, acceptance and support at the executive and management levels, then the objectives of the TAMP will not be achieved	Medium	• Efforts should be conducted to sustain engagement, including: 1) reaching out to new executives and managers; 2) continue communication to steering committee
TAM	If there is not adequate understanding, acceptance and support at the working level, then the objectives of the TAMP will not be achieved	Medium	• Support of asset working groups • Disseminate information and set clear expectations • Provide training
TAM	If key knowledgeable staff involved in the TAM lifecycle are not retained, then progress towards implementation of TAM will be stagnated	Medium	• Train multiple staff to be less dependent upon the expert knowledge of one/few people • Provide career opportunities and favorable working conditions to retain experienced staff • Document procedures to address turn-over
TAM	If there are not adequate (electronic, user-friendly, accurate, and timely) asset management collection and storage systems, then we do not have the foundational data needed for effective TAM practices	Medium	• Improved mechanisms to adopt and contract technological advancements • Provide training to users • Own data in non-proprietary formats to allow for integration with newer data management systems
TAM	If there are not processes in-place to systematically manage and maintain additional assets that are included in the TAMP other than bridge and pavement, that were customarily replaced through	Medium	• Continue to manage these assets • Develop plans to address SOGR of these additional assets

Asset	Risk Statement	Risk Rating	Potential Strategies
	highway design contracts, then these additional assets will deteriorate and the SOGR will be impeded		
TAM	If we do not have a FHWA certified TAMP in accordance with the deadlines set forth by legislation, then the Department is penalized with a reduction in Federal participation from 80/90% to 65%, resulting in an additional $100 Million in State funds needed to maximize Federal dollars.	Medium	• Continue efforts to support and meet applicable TAM requirements including those for the FHWA Annual Consistency Determination.
TAM	If there is not coordination with other plans (such as CTDOT Statewide Transportation Improvement Program (STIP), CT Strategic Highway Safety Plan, CTDOT Freight Plan, CTDOT Long Range Plan, etc.), then: 1) the benefits of the TAM will not be fully realized; 2) there is potential for wasting resources as well as overlap/redundancy; 3) the credibility of the Department and program will be impacted.	Medium	• Strategically improve coordination as the plans are developed and evolve along with the ability to quantify and project performance.
TAM	If there is not the ability to easily adapt organizationally or technologically, then CTDOT will not be able to integrate new processes and improvements that will enable the cost effective and timely management of assets.	Medium	• Explore agile contracting and delivery that allows the organization to adapt technology in a timely manner • Seek improved methods of implementing improved processes.
TAM	If we do not make the minimum condition requirements for pavement and bridge, then we lose flexibility to move funding between asset needs and restricts our financial planning.	Medium	• Concentrated effort to address minimum condition requirements.
TAM	If best practices for security and back-up of asset data are not employed, then the data needed to employ TAM will not be readily available, extensive work and cost will be required to rebuild asset data, if at all possible.	Low	• Design and employ data management best practices including security and back-ups