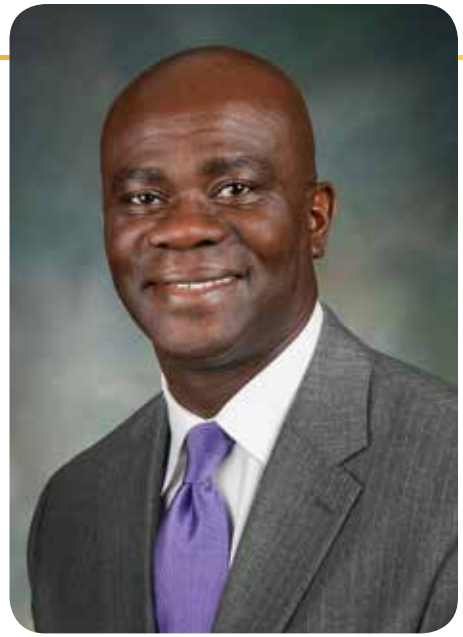
Transportation Asset Management Plan

August 2019

MDOT
Michigan Department of Transportation



Dear Reader:

It is my pleasure to provide you with this Transportation Asset Management Plan (TAMP) on behalf of the Michigan Department of Transportation (MDOT). MDOT is a long-standing supporter of the need for performance management in transportation systems, and the department greatly appreciates the strong effort being made at the federal level to implement the performance measures enacted by Congress.

This TAMP is a description of processes used in Michigan that result from two decades of asset management work. It is also an important step in a federal process where state departments of transportation and metropolitan planning organizations work together to understand and implement the new performance management requirements.

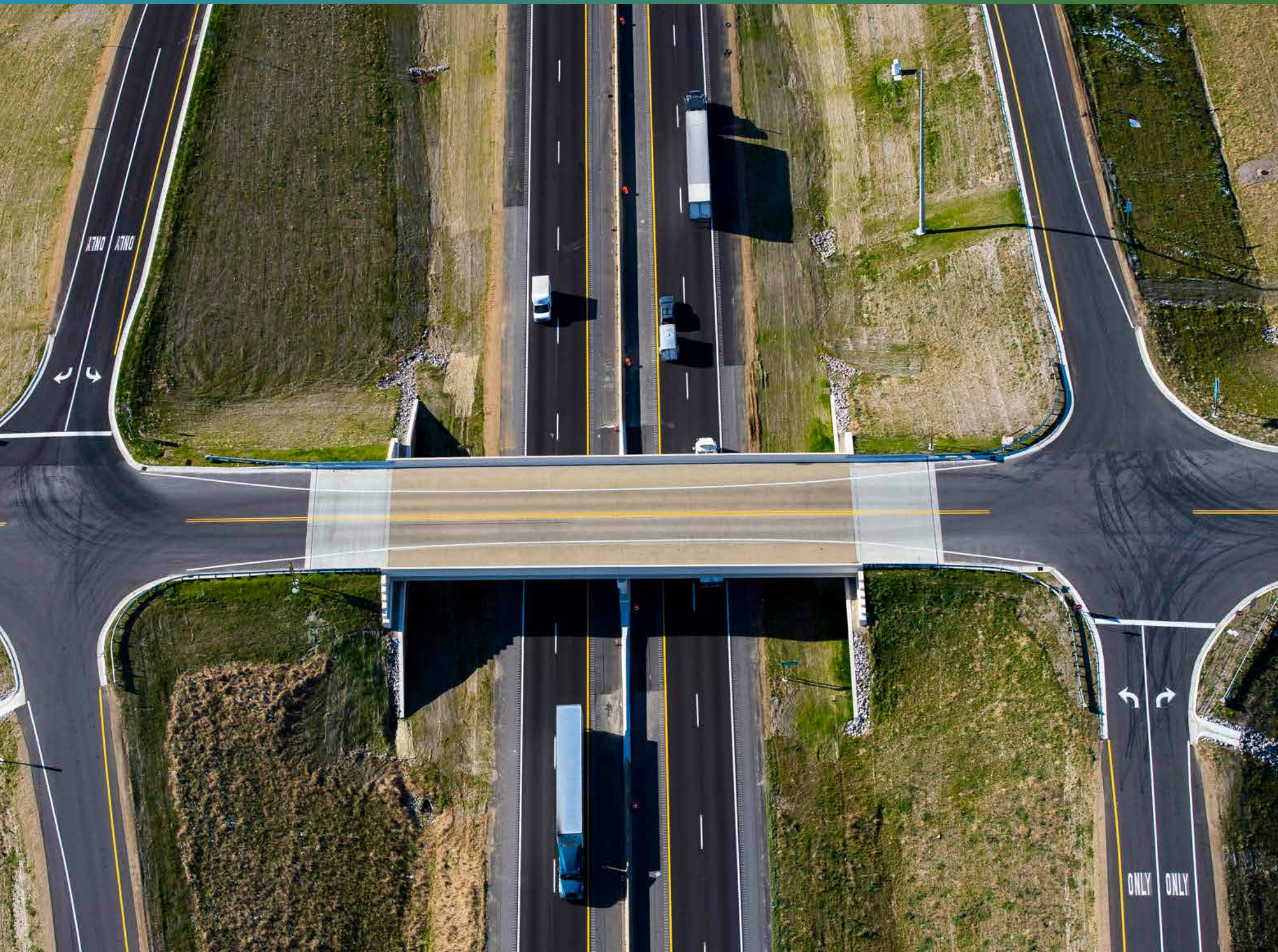
I would like to note that during preparation of this document, new transportation funding recommendations were proposed by Gov. Gretchen Whitmer during her Fiscal Year (FY) 2019 budget presentation and are under consideration by the Michigan Legislature as it develops the FY 2019-2020 budget for the state. The proposal would raise $2.5 billion annually to improve Michigan's transportation system; however, it will not be enacted in time for this document to reflect the changes it would bring. Therefore, it has not been reflected in the document.

If you have any questions, please contact either me or Todd White, director of the Bureau of Transportation Planning, at 517-335-2600 or WhiteT5@Michigan.gov.

Sincerely,

Paul C. Ajegba, P.E.

Director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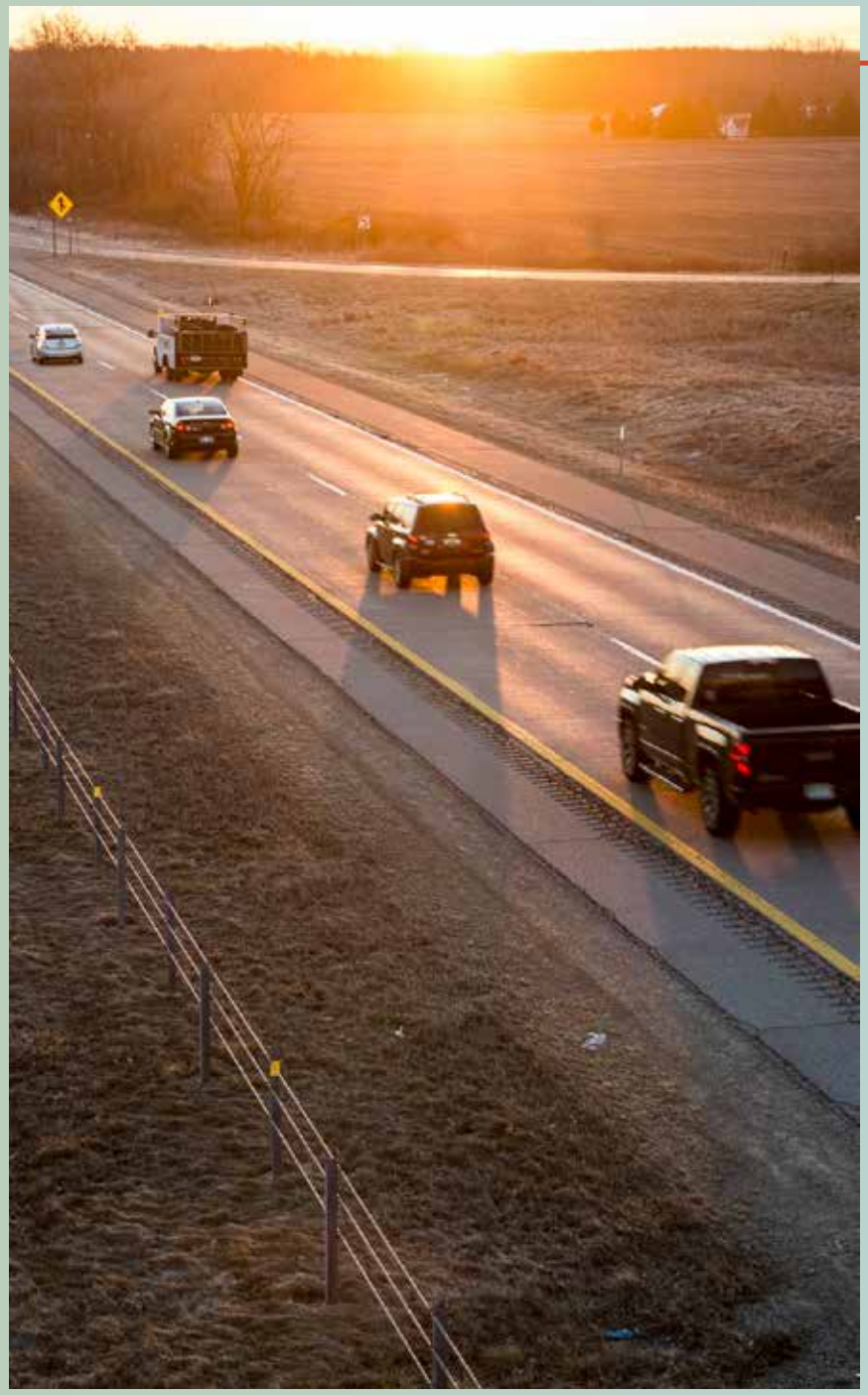
TAMP Acronyms

AASHTO	American Association of State Highway and Transportation Officials
Act 51	Michigan Public Act 51 of 1951
AD	Associated Distress
ATM	Active Traffic Management
BCFS	Bridge Condition Forecasting System
CAVs	Connected and Automated Vehicles
CFP	Call for Projects
CNG	Compressed Natural Gas
CPM	Capital Preventive Maintenance
CSM	Capital Scheduled Maintenance
CYE	Calendar Year Ending
DI	Distress Index
DTMB	Department of Technology, Management, and Budget
EDMC	Elemental Decomposition and Multi-Criteria
FAE	Federal-Aid-Eligible
FAST	Fixing America's Surface Transportation Act
FHWA	Federal Highway Administration
FY	Fiscal Year
GF	State General Fund
HMA	Hot Mix Asphalt
HPMS	Highway Performance Monitoring System
HTF	Federal Highway Trust Fund
IRI	International Roughness Index
ITS	Intelligent Transportation System
LCCA	Life Cycle Cost Analysis
MAP-21	Moving Ahead for Progress in the 21st Century Act
MDOT	Michigan Department of Transportation
MPO	Metropolitan Planning Organization
MSP	Michigan State Police
MTF	Michigan Transportation Fund
MTPA	Michigan Transportation Planning Association
NBI	National Bridge Inventory
NBIS	National Bridge Inspection Standards
NCHRP	National Cooperative Highway Research Program
NHS	National Highway System
P3	Public-Private Partnership
PASER	Pavement Surface and Evaluation Rating
PCFS	Pavement Condition Forecasting System
PCM	Pavement Condition Measure
PD	Primary Distress
RQFS	Road Quality Forecasting System
RSL	Remaining Service Life
RTF	Rural Task Force
SEMCOG	Southeast Michigan Council of Governments
SOGR	State of Good Repair
STC	State Transportation Commission
STF	State Trunkline Fund
STIP	Statewide Transportation Improvement Program
STPD	Statewide Transportation Planning Division
TAMC	Transportation Asset Management Council
TAMP	Transportation Asset Management Plan
TF2	Transportation Funding Task Force
TPM	Transportation Performance Measure



Introduction

In 2012, the Moving Ahead for Progress in the 21st Century Act (MAP-21) began a national effort to implement a performance-based approach to transportation investment decision-making. That effort was strengthened in 2015 by the Fixing America's Surface Transportation (FAST) Act. The performance goals enumerated in MAP-21 and affirmed by the FAST Act address safety, infrastructure condition, congestion, system reliability, economic vitality, and environmental sustainability.

The objective of the Transportation Asset Management Plan (TAMP) is to direct investment in existing transportation systems to effectively provide safety, mobility, access, and intermodal connectivity or support economic activity and the viability of older communities and ensure that the facilities and services continue to fulfill their intended functions within the constraints of state and federal law.

Implementing these new federal performance management requirements nationwide has been no small task. It has been a lengthy process, one that is still in progress. The Michigan Department of Transportation (MDOT) has set its performance targets, working cooperatively with its metropolitan planning organization (MPO) partners to develop targets according to federal due dates. However, data needs to be collected for new federal performance measures, such as pavement rutting, cracking and faulting. New tools are still needed to accurately measure and project pavement performance using the new measures as well as the International Roughness Index (IRI).

The new federal performance measures may, over time, prompt some changes to Michigan's decades-long approach to asset management and performance measurement. In 1997, the Michigan State Transportation Commission (STC) approved 10-year aspirational condition goals for Michigan's freeway (95 percent good/fair) and non-freeway (85 percent good/fair) state trunkline systems, based on pavement health. A year later, the STC approved similar goals for Michigan freeway and non-freeway bridges. These STC goals create the asset management objectives by which the department manages its pavements and bridges.

In the decade that followed, MDOT worked diligently to achieve those goals using its asset management process, as well as measurement and forecasting tools it had developed for pavement service life. In 2007, the agency successfully achieved its 10-year condition goal for pavements. Likewise, in 2008, the agency successfully achieved its 10-year condition

goal for non-freeway bridges. MDOT's asset management approach linked data, goals, investment strategies, programs, and projects in a systematic process to ensure achievement of desired results.

Expanding on MDOT's demonstrated success with asset management, the Michigan Legislature in 2002 created the Transportation Asset Management Council (TAMC). The TAMC's charge was to develop a statewide asset management strategy and the processes and tools needed to implement asset management practices for federal-aid-eligible (FAE) highways across state and local jurisdictions. Working from MDOT's example, the group developed tools that local agencies could use, as well as a methodology that all agencies could agree on for data collection and analysis. As a result, several hundred road agencies work together each year through their regional planning agencies and MPOs to gather performance data on almost 37,000 miles of FAE highway pavements and more than 11,000 highway bridges across the state. Of the 84 agencies with jurisdiction over the National Highway System (NHS), more than 60 percent use an asset management process to select projects and more than 50 percent use software or other tools to prioritize projects and have a separate investment plan for their higher-level system, which includes the NHS.

The development of this TAMP is just one step in a federal process that will take several years to fully implement. It is possible, even likely, that as data on the new federal performance measures (IRI, rutting, cracking, faulting) becomes available, it may differ from the data that Michigan has previously developed since the new data will relate to different aspects of road condition.

The focus of this TAMP, consistent with federal guidance, is on the Interstate Highway System and the NHS, and the national performance measures for pavements and bridges. Interstate and NHS pavements and bridges, while important from a national perspective, are just a subset of the total transportation infrastructure in Michigan.

Michigan's history of asset management and performance measurement helps set the context for the development of this TAMP. The focus of this plan is on those assets initially required by the federal government, Interstate and NHS pavements and bridges. The asset management planning process is led by the bureaus of Transportation Planning and Development, and engages all facets of the department to deliver the comprehensive and evolving Five-Year Transportation Program on an annual basis.

MDOT manages 82 percent of the NHS in Michigan. The remaining 18 percent of Michigan's NHS is operated, preserved and maintained by 84 local road agencies (66 cities and 18 counties or county road commissions). The entire network in Michigan is comprised of 122,036 route miles of pavement and 11,111 bridges. The TAMP focuses on the most critical portion of the network – the NHS, which encompasses 6,472 route miles and 2,963 bridges. The roadway and bridge system components addressed in the report are shown in green in Figures 1 and 2.

To view interactive NHS inventory maps of both pavement and bridges online, please visit MDOT's Featured Maps webpage at ***http://featuredmaps-mdot.opendata.arcgis.com/***. Once there, scroll down to the "MDOT NHS Inventory and Condition Analysis" map application and select "Explore."

During preparation of this document, new transportation funding recommendations were proposed by Gov. Gretchen Whitmer during her Fiscal Year 2019 budget presentation. The governor's budget message proposed a realignment of state finances that are used for transportation improvements and other aspects of state government. The governor set forth a clear and concise plan for government funding realignment that includes raising fuel taxes by 45 cents per gallon in three steps over a 12-month time frame. The proposal would raise $2.5 billion annually to improve Michigan's transportation system. While there is general agreement on the magnitude of the funding needed, the proposal will not be enacted in time for this document to reflect the changes it would bring. Therefore, calculation of the financial projections, future system condition forecasts, and performance gaps are based on current state and federal law.

This TAMP describes the asset management processes by which MDOT makes its program and project decisions. It also includes inventory and condition information, a description of investment strategies, and financial and performance gap analyses based on four investment strategies outlined in federal guidance:

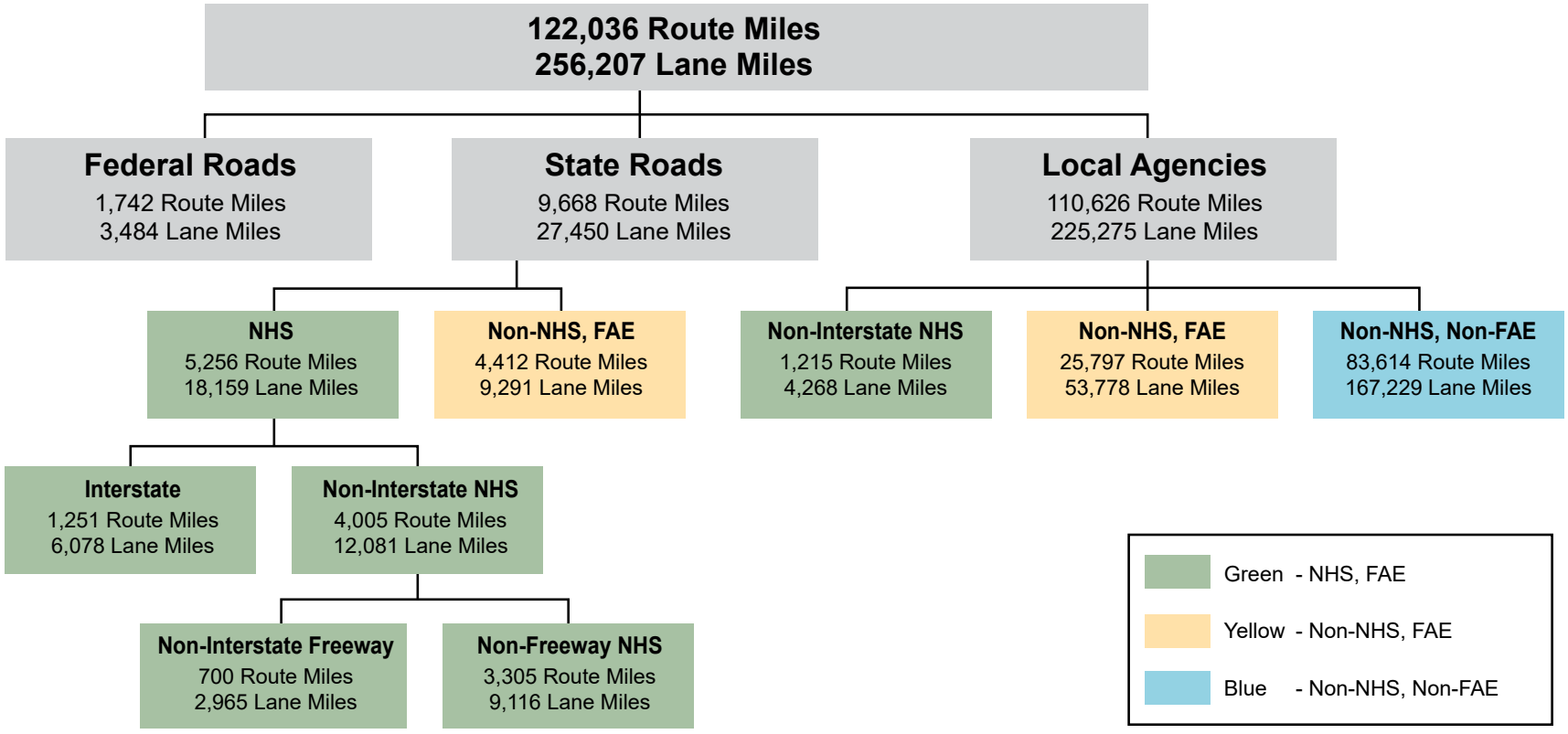
- **Achieve the national minimum condition level:** No more than 5 percent poor Interstate pavements; no more than 10 percent poor bridges.
- **Preserve the condition of the pavement and bridge assets:** Maintain current condition for Interstate and NHS pavements and bridges.

- **Achieve and sustain a desired State of Good Repair (SOGR):** SOGR aspirational goals for Interstate and NHS pavements and bridges based on MDOT's current goals for these systems.
- **Constrained Investment:** Investment of the funds reasonably expected to be available for Interstate and NHS pavement and bridges.

The chapters of the TAMP are based on the most recent available data and include:

- **Program Development Call for Projects (CFP) Process** – a description of MDOT's CFP process used to develop a list of pavement and bridge projects for the Statewide Transportation Improvement Program (STIP) that is intended to make progress toward performance goals, based on the investment strategies, life cycle planning, and potential risks.
- **Life Cycle Planning** – a description of the processes used to calculate life cycle impacts of the proposed investment strategies on pavements and bridges.
- **Risk Management Process** – a description of the process used to assess risks and develop a Risk Management Plan as required by regulations.

Figure 1: Michigan's Road Network[1]

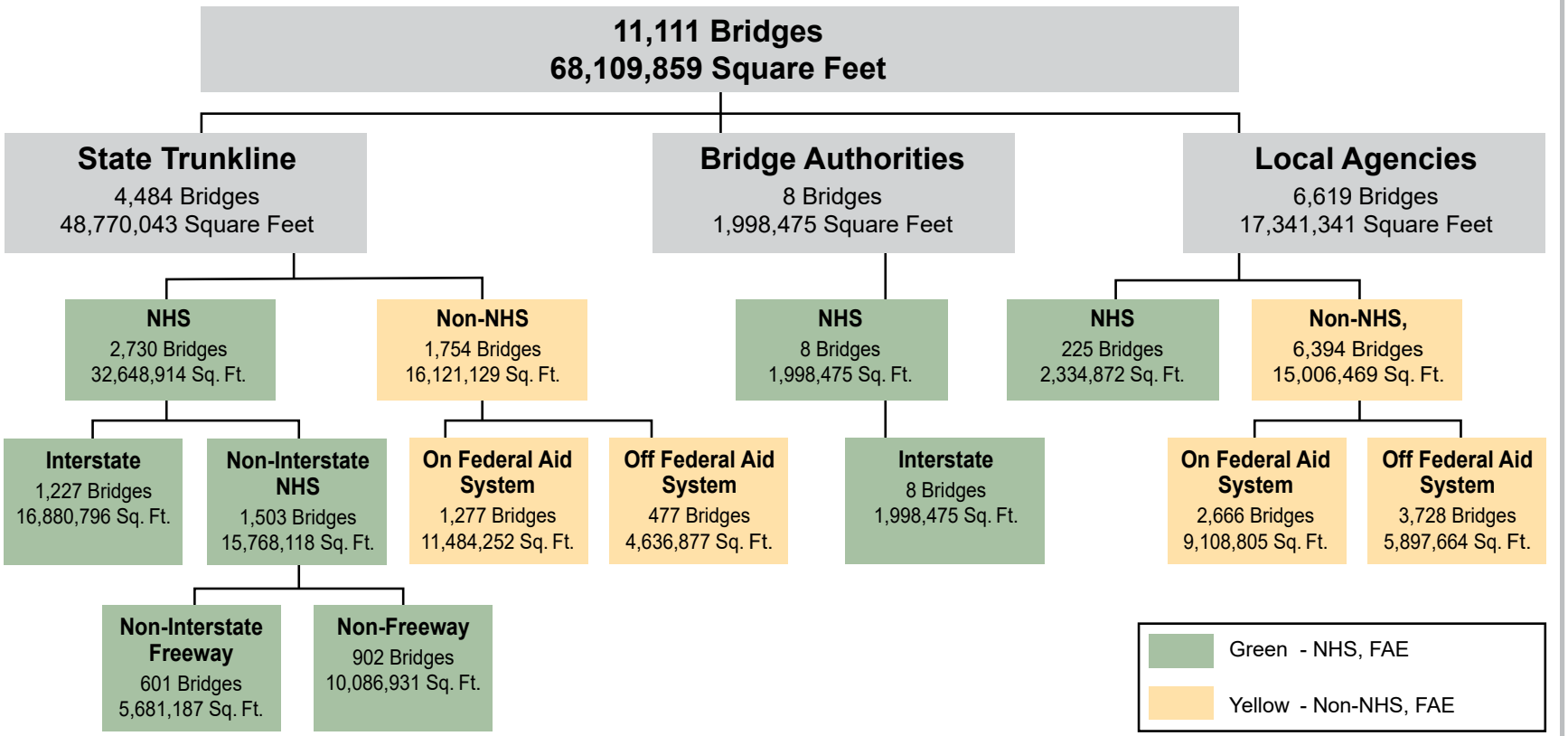


Source: MDOT Bureau of Transportation Planning

[1] Total includes roads not under MDOT or local jurisdiction, such as state park, federal, or Native American tribal roads.

- **Comparison of New Federal and Existing Michigan Performance Measures** – this chapter compares the new federal Pavement Condition Measure (PCM) to Michigan's existing performance measures.
- **Inventory and Condition Analysis** – a summary of the lane and route miles of pavement, as well as the deck area and number of bridges on the NHS and their current condition.
- **Financial Plan** – a description of state, federal and local revenues anticipated to be available for investment in the NHS over the next 10 years, including the process used to develop estimates.
- **Investment Strategies** – a description of investment strategies that are analyzed to determine the best investment strategy to help achieve progress toward the performance goal and a description of the process by which investment strategies guide the allocation of capital resources to achieve the goals established.
- **Performance Gap Analysis** – this chapter will explain what performance gaps are currently anticipated based on the identified set of goals, including the process used to address the following: 1) Targets for asset condition of NHS pavements and bridges; 2) Gaps, if any, in the performance of the NHS that affect NHS pavements and bridges; and 3) Alternative strategies to close or address the identified gaps.

Figure 2: Michigan's Bridge Network[2]



Source: Michigan Bridge Inventory

[2] *Deck area numbers shown reflect conversion from the metric values that were required in the March 15, 2018, National Bridge Inventory data submittal.*

Program Development Call for Projects (CFP) Process

MDOT takes an asset management approach to managing pavement and bridge (highway) investments. Asset management is a strategic approach to linking data, goals, investment strategies, programs, and projects into a systematic process to ensure achievement of a desired result. This strategic approach can be described in a circular model, as shown in Figure 4.

Steps in the asset management process are:

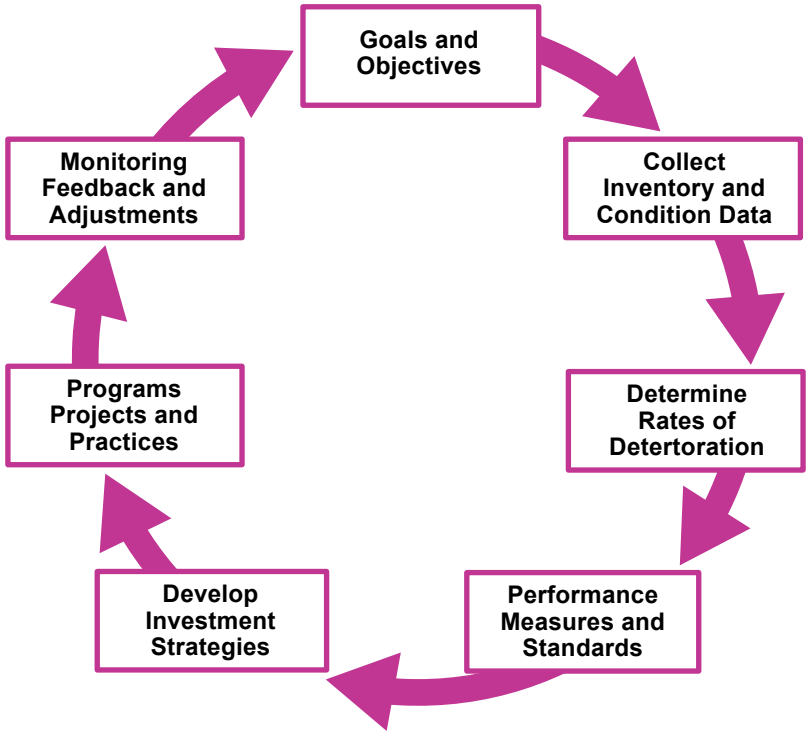
1. Goals and objectives are established.
2. System inventory and condition data are collected.
3. The condition data are analyzed, and rates of deterioration are computed.
4. Performance measures and standards are set or reaffirmed.
5. Life cycle network analysis is performed using forecasting tools.
6. Gaps in funding and performance and risk factors are evaluated.
7. Strategies are analyzed and selected.
8. The selected investment strategies are implemented through the development of programs, selection of projects, and use of practices that fit into the investment strategies.
9. The process and system are monitored and adjusted based on the outcome of the projects and programs that were implemented.

Figure 3: Pavement and Bridge Goals

Pavement Goals	Bridge Goals
• 95 percent freeway in fair or good condition. • 85 percent non-freeway in fair or good condition.	• 95 percent freeway bridges in fair or good condition. • 85 percent non-freeway bridges in fair or good condition.

MDOT's highway program development process is a yearlong, multi-stage process, as shown in Figure 5 on the following page. MDOT continues to emphasize and strengthen partnering efforts with transportation stakeholders and the general public throughout this process. MDOT also continues to implement processes developed at workshops and stakeholder meetings to incorporate context-sensitive solutions into transportation projects and seeks public input from a variety of sources on future Five-Year Transportation programs. MDOT is committed to improving its process of tracking public engagement at the regional level to enhance local communication and follow-up with transportation industry partners and the public.

Figure 4: Balancing Investments Asset Management Approach



Transportation Program Development Key Steps

Develop Revenue Estimates

The anticipated funding available and cost of future work constrain program development. State and federal revenue available for the capital program is forecasted based on historical trends, federal funding acts, and state legislation. Future funding that will be available for asset management is projected.

Develop Investment Strategies

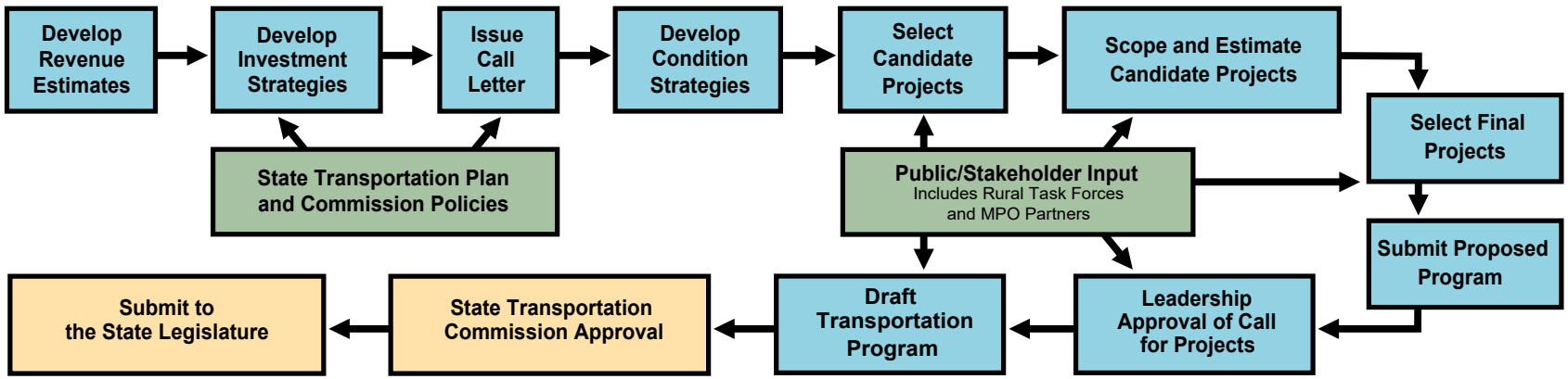
MDOT trunkline investment strategies have been driven by its vision and goals. Within the vision and goals are key components that help enhance the department's practices, allowing the department to be better, faster, cheaper, safer, and smarter. The STC establishes these policies, goals, and objectives that provide the basis for investment strategy decisions.

MDOT uses forecasting tools to evaluate the network-level impact of varying investment strategies on the whole life costs of assets. Risks that can affect the condition of the transportation assets in Michigan are evaluated as investment strategies are developed. Gap analysis is considered when various investment strategies are compared to determine the best strategy to meet the overall goals and objectives set by the STC.

Issue Call for Projects

MDOT issues an internal call for preservation projects annually for the Highway Program. A letter and instructions are issued to all seven MDOT region offices, which are responsible for proposing preservation projects. Key emphasis areas and strategic objectives are outlined, and detailed technical instructions are issued. Target funding levels for each region are calculated from a formula based on weightings relating to variables such as condition, usage, costs, and eligible assets. For pavement allocations, each region's relative share of eligible lane miles is weighted on several factors. The factors are weighted 50 percent on condition (including the federal performance measures), 25 percent on cost factors, and 25 percent on usage. Bridge funding is allocated based on deck area of eligible candidates.

Figure 5: Five-Year Transportation Program Development Process



Develop Condition Strategies

Regional improvement strategies for the road and bridge networks are developed by MDOT region staff using the Road Quality Forecasting System (RQFS) and Bridge Condition Forecasting System (BCFS) tools, as well as input from partners and stakeholders. These strategies guide project selection and ensure that a mix of fixes is incorporated into program development. There are a number of repairs or fixes that can be made to existing transportation assets that have different impacts on the trunkline network. Fixes are categorized into three groups: long-term, medium-term, and short-term. By applying a mix-of-fixes approach that includes a combination of long, medium, and short-term fixes, MDOT can systematically address system needs in the most cost-effective means possible. Examples of a mix of fixes include longer-lasting but higher-cost reconstructions and more moderately priced rehabilitation projects, as well as low-cost capital preventive maintenance (CPM) work and capital scheduled maintenance (CSM) on good and fair pavements and bridges. Early maintenance intervention with CPM and CSM extends the life of pavement and bridge assets by preserving the assets at high condition levels prior to incurring more costly repairs during later stages of asset deterioration. Once a recommended strategy is approved, candidate road and bridge projects are selected that are consistent with the strategy and funds available.

Candidate Project Selection and Submittal

Candidate projects are selected based on a need that meets the investment strategy and program criteria. Candidate projects are prioritized by analyzing risks, life cycle costs and other factors, such as the severity of the distress, the amount of traffic on the roadway, public input, maintenance costs, and the context of the roadway. For instance, a roadway that serves commercial or industrial businesses may be given preference over a similar roadway that does not. From the prioritized list of projects, a list of projects is selected to proceed with scoping and estimating. This list is determined by the funds available for construction.

Scope and Estimate Candidate Projects

The first step in preparing the scope of a project is to review the project and verify the proposed fix in the field. A group of technical staff is assembled and drives the proposed project from end to end. This van tour identifies work in addition to the pavement or bridge work; e.g., drainage work, sidewalk needs, safety work, access issues, etc. In addition, some project issues, such as environmental issues and utility conflicts, can be identified. Crash data are also compiled and analyzed to look for areas of concern during the van tour. Other items of work not originally considered may be added at this point in the process. For example, if a road project is proposed but no bridge work, the van tour may identify some preventive maintenance work that can

be performed on the bridges so that all the needs in the corridor can be addressed in a single project.

During this time, public input is solicited in several ways. Candidate projects are discussed with local road agencies, local governmental agencies, and MPOs and input is solicited from the general public either through the public agencies or through project-specific input sessions.

Once the need is verified on the van tour and additional issues are identified, a scoping document is prepared. The scoping document is a thorough analysis of all the aspects of the project and may look at several types of fixes so the most cost-effective fix can be selected. It also analyzes several methods of maintaining traffic during construction so that customer mobility can be maximized. Other items considered during scoping are upgrades to the operation of the roadway, complete streets/context-sensitive solutions, innovative construction methods, environmental concerns, and necessary permits, etc. Rough preliminary plans are drafted for the project during the scoping stage and these plans are used as the beginning point for the design stage of the project.

A detailed estimate is performed based on estimated contract pay items and the expected unit prices for these pay items. An inflation rate is applied to the estimate so that an accurate cost for the year of construction can be determined.

Final Project Selection

When the scoping documents are completed, and a project scope and estimate are finalized, project selection can be completed. Projects are selected to meet the approved strategies as closely as possible. During final project selection, consideration is given to providing balance of work across the regions so that mobility for users can be provided region-wide. Other items considered during final selection include risk, life cycle costs and other factors such as the severity of the distress, the amount of traffic, public input, maintenance costs, and the context of the roadway.

Proposed Program Submission

Candidate projects are submitted to the CFP subcommittees for review. Feedback is provided to the regions based on analysis of program consistency with approved strategies and submittal criteria, condition data, appropriate fix life project estimates, and if proposed project budgets are within established thresholds.

Call for Projects (CFP) Approval

The subcommittees then recommend approval of the projects to the CFP Approval Committee, which reviews the program and recommends approval to the MDOT chief administrative officer and chief operations officer.

The Approval Committee is not only responsible for recommending final approval of the program but is the centerpiece in the MDOT processes for ensuring statewide consistency and compliance. As such, the Approval Committee is responsible for the following actions throughout the CFP process:

- Approve program approach to Transportation System Management for consistency throughout the state;
- Approve region and statewide condition strategies;
- Recommend CFP Program (including project list) for final executive approval;
- Provide strategic direction;
- Approve funding;
- Resolve any projects or conflicts in the CFP submittals that do not comply with the guidelines in the CFP Letter;
- Approve changes to CFP process, tools, data, etc.; and
- Approve adding/deleting programs to the CFP.

Five-Year Transportation Program and Statewide Transportation Improvement Program (STIP)

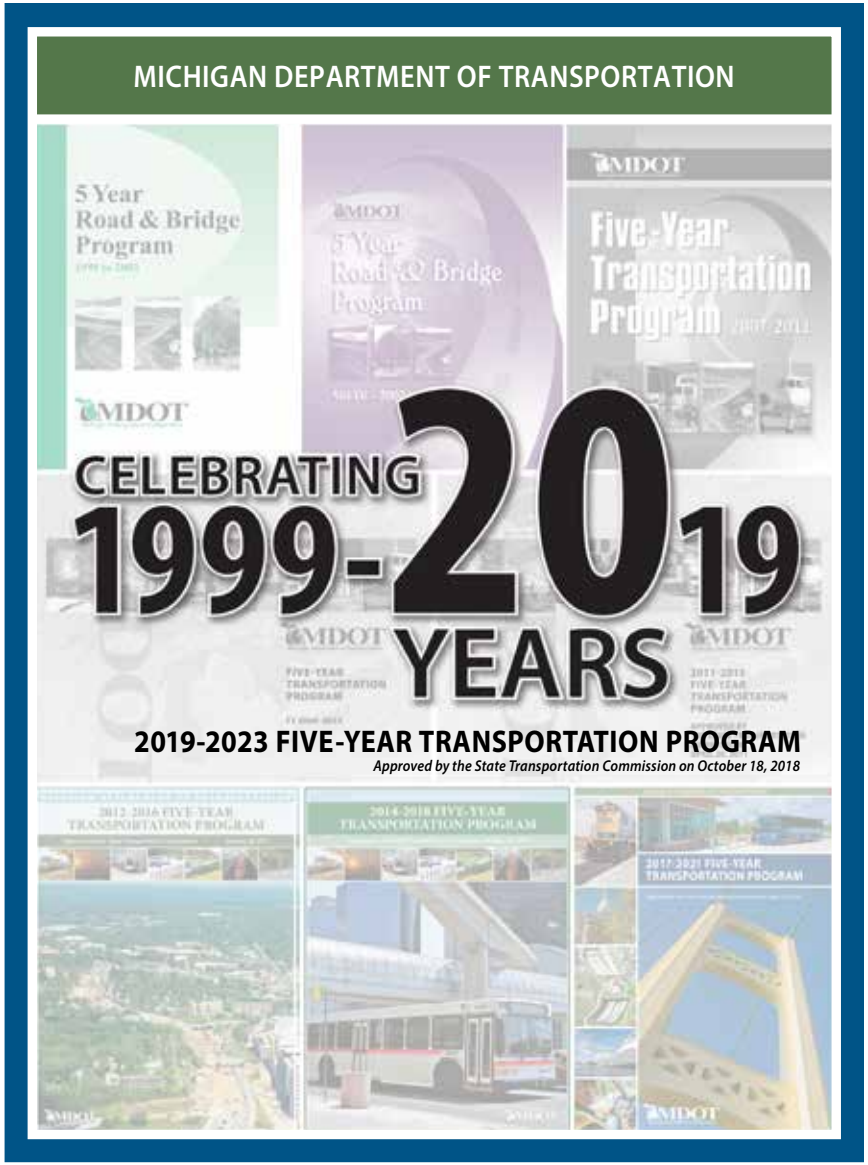
Assembly of the draft Five-Year Transportation Program begins after the CFP process is completed for the Highway Program. Each year, the Five-Year Transportation Program is finalized when it is approved by the STC. The document is also submitted to the Legislature. The Five-Year Transportation Program is an integral component of the department's input to the STIP. The Five-Year Transportation Program schedule has recently been synchronized with the STIP schedule to allow for seamless STIP updates by assuring that projects appear in both documents. Throughout the year, changes to scope, schedule, and budget are submitted to the STIP for inclusion in the bi-monthly TIP amendments by the Statewide Transportation Planning Division (STPD).

Public Involvement and Outreach

Outreach and coordination occur throughout the Five-Year Transportation Program process, beginning with candidate project selection and continuing through final project selection and review of the draft transportation program. Stakeholders include the public, rural task forces (RTFs), MPO partners, individual units of government, and the Legislature.

Adjustments Throughout the Process

Within a strategic, proactive asset management approach to system preservation, it is essential to monitor progress, obtain feedback, and, when necessary, make adjustments or refinements to improve the project selection process in future years. Within each annual cycle of the CFP process, MDOT makes observations about the data, analytical tools, assumptions made in the analysis, forecast condition, and the overall program development process, and makes the necessary modifications. Program and project changes are also made over the course of any given year in response to customer and stakeholder comments and changing system needs, reviews, and constraints. STPD provides a bi-weekly monitoring report to the department to keep projects aligned to investment categories. Additionally, there are quarterly monitoring meetings for more detailed analysis of progress in the investment categories.



Life Cycle Planning

MDOT uses two pavement condition modeling tools, the Road Quality Forecasting System (RQFS) and the Pavement Condition Forecasting System (PCFS), which evaluate pavement condition, deterioration and forecasting. While these life cycle tools do not use the new performance measures identified for the target setting required for the TAMP, they are used to develop and implement strategies to achieve and monitor progress toward internal targets within the department. Those internal targets help inform the decision-making process of developing targets for the TAMP.

MDOT directly manages 82 percent of Michigan's NHS located on state trunklines. There are asset management systems in place to track condition, deterioration, and investment. The remaining 18 percent of Michigan's NHS is located on the local system, which is managed by 84 jurisdictions (66 cities and 18 counties). Historically, there has been a cooperative data gathering effort through the Michigan TAMC to collect and share condition information on the entire federal-aid system, which fully encompasses the NHS, using the Pavement Surface and Evaluation Rating (PASER) process.

Road Quality Forecasting System (RQFS)

The RQFS is a network-level pavement condition model. It uses remaining service life (RSL) as the pavement performance measure to forecast future pavement condition of the trunkline system based on investment strategies. RSL is a forecasted estimate of time until a reconstruction or a major rehabilitation treatment is more cost-effective than preventive maintenance. For RQFS, RSL is divided into Categories I-VI, with I being the least amount of remaining pavement life and VI being the greatest amount of remaining pavement life. It is a tool that uses RSL estimations and fix lives based on the data collected from project-level deterioration curve analysis.

There are four inputs to RQFS: the pavement condition file, investment strategies, treatment costs, and inflation. The pavement condition file stores RSL information. The file is updated annually by MDOT staff. The strategies entered into RQFS identify specified percentages, or lane miles, of the pavement network to move from a lower RSL category to a higher RSL category. Strategies are finalized by MDOT experts familiar with pavement deterioration and knowledge of what is best for the system. A standard inflation cost is built into RQFS for accurate funding

forecasting needs. MDOT uses this tool in all phases of asset management, from initial investment strategy development to project selection and program monitoring and reporting.

Pavement Condition Forecasting System (PCFS)

The PCFS is a spreadsheet-based Markovian model used by the TAMC to estimate the surface condition of Michigan's paved roads. The model uses the latest four years of pavement condition ratings to calculate the probability that a segment of road will deteriorate over the course of the forecast period. In addition to pavement condition, inputs for the model include such variables as pavement management strategies, anticipated revenues available for road construction and maintenance, and the cost of road repairs. PCFS is the forecasting tool that is used to model network-level deterioration and forecast future condition for NHS pavements that are owned by county and/or local agencies in Michigan. The reason for a separate tool for the local NHS pavements is that RSL data are not available on non-trunkline (local) NHS pavements. The metric that is currently available for local NHS is PASER condition data.

Pavement Surface and Evaluation Rating (PASER) System

The PASER system was originally developed by the University of Wisconsin-Madison Transportation Information Center to be used as the state of Wisconsin's standard road rating system. PASER is a "windshield" road rating system that uses a 1 to 10 rating scale, with a value of 10 representing a new road and a value of 1 representing a failed road. Condition ratings are assigned by evaluating the type and amount of visual defects along a road segment while driving the segment. The PASER system interprets these observations into a condition rating.

The TAMC adopted and adapted the PASER system as the standard tool for gathering information on the condition of all FAE roads in Michigan. The information gathered by road-rating teams is reported on the TAMC interactive map and dashboards using the following categories:

Roads with PASER ratings of 8-10 are considered to be in "good" condition and require only routine maintenance. Routine maintenance is the day-to-day maintenance activities that are scheduled, such as street sweeping, drainage clearing, shoulder gravel grading, and sealing cracks to prevent standing water and water penetration.

Roads with PASER ratings of 5-7 are considered to be in "fair" condition and require some form of CPM. CPM is a planned set of cost-effective treatments to an existing roadway system and its appurtenances that preserves, impedes future deterioration, and maintains or improves the functional condition of the system without significantly increasing structural capacity. The purpose of CPM fixes is to protect the pavement structure, slow the rate of pavement deterioration and/or correct pavement surface deficiencies. Surface treatments are targeted at pavement surface defects primarily caused by the environment and by pavement material deficiencies.

Roads with PASER ratings of 1-4 are considered to be in "poor" condition and require structural improvements. This category includes work identified as rehabilitation and reconstruction that addresses the structural integrity of a road.

Bridge Management

MDOT performs network analyses using National Bridge Inventory (NBI) minimum condition ratings. Minimum condition ratings are found by taking the lowest condition of either the deck, superstructure, substructure, or culvert ratings. MDOT uses a web-based inspection and reporting system called MiBridge. MiBridge allows inspectors to enter both NBI and Element Level data. The system then provides inspection data that is readily accessible by the individuals managing the bridges. MiBridge also allows the inventory to be viewed quickly on a dashboard, providing condition information and sorting functions that directly connect to the condition-based goals. This allows the person performing the analysis to evaluate bridge performance at the network level while being able to drill down to the bridge level.

Bridge Condition Forecasting System (BCFS)

MDOT calculates the probability of deterioration of bridges, compares deterioration to investment in bridge projects, and predicts future network condition levels using an internally developed, spread-sheet-based Markovian model titled BCFS. BCFS uses the current minimum NBI conditions of the inventory as the starting point of the analysis. Anticipated budgets are entered to predict future work that will be performed on the network. BCFS also requires a preservation strategy to be entered that is used to dedicate a percentage of the budget to each primary work category. The primary work categories are preventive maintenance, rehabilitation and replacement. Project costs for each primary work category must be entered so that BCFS can calculate how many projects in each category can be performed. The anticipated benefits of each main work category are entered as an input and are used to determine the impacts of the proposed budgets. Finally, BCFS can account for programmed projects.

The cornerstone of BCFS is calculating and applying transition probabilities. Using the changing minimum NBI condition rating over time, BCFS calculates the likelihood that a structure will change from one minimum condition rating to another. A matrix is developed from the historic data and is applied to the entire network of bridges to project condition out each successive year included within the analysis. This projected network condition is a combination of deteriorating the calculated percentage of bridges in each condition rating and improving bridges based on future projects, budgets, preservation strategies, and the preservation path increasing or maintaining conditions.

For bridges, the minimum component condition rating is forecasted using BCFS at the network level. Deterioration is performed at the bridge level, or in units of "each." Average deck areas are then applied to the assumed number of bridges expected to deteriorate. As the required measure is in square feet of deck area, there will be an increased level of uncertainty as compared to reporting in units of each. MDOT is in the process of incorporating AASHTOWare Bridge Management software as an additional tool to improve deterioration models at the bridge level using a combination of component and element-level condition ratings. MDOT does not anticipate having the required calibrations done in time to incorporate this advanced method for the first performance period but will implement the process when complete.

Network-Level Deterioration Models

As stated previously, MDOT currently uses two network-level pavement models for deterioration and forecasting, and one model for bridges. RQFS is the tool that is used for the NHS pavements on MDOT's state trunkline system.

The collaboration of staffing expertise and data allows RQFS to produce network-level strategies and conclusions for program development. Reports that can be produced include pavement condition forecasts, RSL category information, percent of the network rehabilitated, program cost, and detailed investment strategy showing category to category shifts for reconstruction, rehabilitation, and CPM.

MDOT will continue to use NBI ratings to calculate good, fair, and poor, and will use the BCFS to forecast conditions. Bridge condition data are, generally, collected on a biennial basis, with a subset of the population inspected more frequently. In alignment with goals set by the STC, most reporting has been on percentage of bridges by count, while the national measure is based on percentage by deck area. The department is making the transition to deck area as part of the TAMP process. BCFS will be used to forecast future condition by deck area, and projects in the Five-Year Transportation Program will be compared to target dates to determine improvements. Based on this combination of deterioration and improvements, a fiscally constrained NHS bridge condition target will be established.

Work Types

MDOT uses a variety of work types to implement an asset management-based "mix of fixes" approach on both pavements and bridges, which are applied throughout the life cycle of each asset. The goal is to implement the correct fix at the correct time of the life cycle at the least cost to maximize the life of the asset. The Statewide Transportation Planning Division maintains a list of these work types. Requests for new or modification of existing work type codes are reviewed by MDOT's Work Type Code Approval Committee to ensure alignment with MDOT business practices.

MDOT tracks and evaluates pavement condition on a project-by-project basis and uses that project-level data to develop network-level assumptions of what sort of life-adding benefits individual fix types can provide. These network-level assumptions are updated as needed. As part of this process, MDOT plans to provide up-to-date cost per lane mile information, and additional life assumptions, for the major work types with the next submittal. Asset management work types include initial construction (new construction), maintenance (routine maintenance), preservation (CSM of bridges, CPM of roads), rehabilitation (repair road or bridge), and reconstruction (full replacement of road surface, base, and sub-base, and bridge replacement).

Unit Costs

Figure 6a: Unit Cost Table

	Bridges: $ / Bridges	Pavements: $ / Lane Miles
Reconstruction	$6,400,000	$2,300,000
Rehabilitation	$960,000	$590,000
Preservation	$460,000	$90,000

Work Type Matrices Regional Variations

RQFS is designed to develop pavement condition forecasts at both the state and MDOT region levels with individual cost matrices for each geographic area and network type. While the model is not designed specifically to create separate costs based on pavement type, there are ways to see the difference in costs between concrete and hot mix asphalt (HMA) for certain fixes. For example, the statewide average cost per lane mile for an interstate reconstruction project is $1.9 million for HMA and $3.1 million for concrete based on 2017 cost data and the University region interstate reconstruction average was $2.0 million for HMA and 2.4 million for concrete.

Strategy Development and Evaluation

The various investment strategies are developed, analyzed and compared to determine how they would impact the overall goals and objectives set by the STC.

The life cycle planning tools use the network-level deterioration models available to forecast future asset conditions, based on investment strategies designed to strive to meet the condition targets of each investment scenario. The models can produce projected system condition using investment level as a control. Conversely, the models can produce projected investment requirements utilizing desired system condition levels as a control. Using these models enables MDOT to develop investment strategies that achieve the desired outcome, using the most cost-efficient distribution of investments between work types.

System Stratification

In 2016, MDOT further stratified the pavement network from two tiers (Freeway and Non-Freeway) to the following four network tiers to provide a mechanism for focusing investment on the high-volume, economically significant roads (see Figure 6, shown in green):

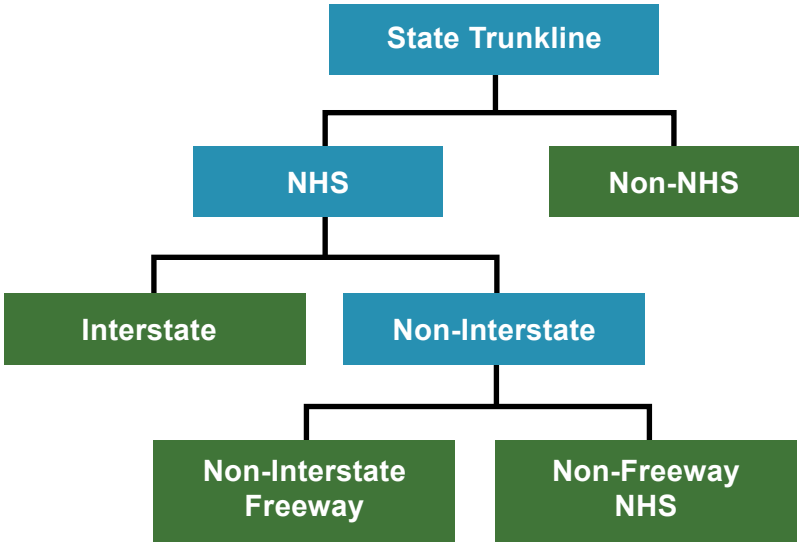
- Interstate
- Non-Interstate Freeway
- Non-Freeway NHS
- Non-NHS

This analysis will be done on a tiered basis with individual analyses for Interstate and Non-Interstate NHS pavements, although the tools have the capability to stratify the networks even further into more discrete tiers. In addition, the tools have the capability to create regional strategies that will influence the overall statewide strategies. All tiers are managed by the department's asset management process, but only the NHS-related tiers are documented in the TAMP.

Forecasting Pavement Conditions

MDOT is exploring the use of various forecasting models based on best practices from across the country in order to better forecast future pavement conditions. It is also looking into developing its own forecasting model. The intent is to incorporate new or modified deterioration and forecasting models based on new federal measures and metrics mandated by the Federal Highway Administration (FHWA). MDOT does not anticipate having a tool, or the data needed to run such a model, fully implemented for the first performance period. As such, MDOT is interested in partnering, if possible, with other states or organizations (e.g., the American Association of State Highway and Transportation Officials (AASHTO)) to come up with a robust tool that can forecast future condition in a way that will allow for an investment plan and gap analysis based on the new federal measures and metrics.

Figure 6b: System Stratification Diagram



Risk Management Process

Introduction

This chapter examines how, for this TAMP, MDOT evaluated and applied risk management. Specifically, the chapter describes the processes MDOT followed in identifying risks to NHS pavements and bridges - referred to as the "transportation system" - as well as NHS performance, and the steps MDOT is taking to manage these risks.

As described in further detail within the chapter, MDOT considers both hazards and threats in its risk management process, such as natural hazards (e.g., extreme storm events) and man-made threats (e.g., cyber-attacks). The scale of the risk can vary from broad impacts across the system to narrowly focused impacts on a specific facility or transportation asset. In addition, risks may be associated with organizational or other constraints outside of MDOT's control, such as limited funding. To help characterize the risk that MDOT faces, risk categories were defined and evaluated. MDOT identified hazards and threats in each of these categories and has proposed actions/strategies for dealing with each.

Continuous improvement of agency skills and processes is central to MDOT's approach to risk management. Future TAMPs will therefore include updates to the processes, identified hazards and threats, and mitigation strategies that MDOT has incorporated into its decision-making frameworks.

In addition, MDOT will strive to institutionalize mitigating top-priority risks as part of its ongoing investment and operations decision-making processes.

Risk Assessment and Management Process

MDOT's risk assessment and management process for the TAMP followed four analysis steps:

- Step 1: Define risk and risk management;
- Step 2: Identify threats and mitigation strategies;
- Step 3: Use a risk matrix to evaluate overall risk to MDOT's mission; and
- Step 4: Evaluate if there are MDOT assets repeatedly damaged by emergency events.

Step 1: Define risk and risk management

In lieu of reimagining what the concepts of "risk" and "risk management" mean, MDOT used FHWA's stated definitions of these terms to guide its risk assessment and management analysis. FHWA defines risk as "the positive or negative effects of uncertainty or variability upon agency objectives." (23 CFR § 515.5) Likewise, FHWA defines risk management as "the process and framework for managing potential risks, including identifying, analyzing, evaluating, and addressing the risks to assets and system performance." (23 CFR § 515.5)

Step 2: Identify threats and mitigation strategies

In 2012, the Michigan State Police (MSP) produced the **Michigan Hazard Analysis** report, which identified the various hazards that pose threats to the state of Michigan (not specifically defined for transportation). The report groups these hazards into three categories: 1) natural hazards; 2) technological hazards; and 3) human-related hazards. Each category includes between four to 14 hazards that can cause regional and/or local impacts. MDOT reviewed these hazards and identified those that could pose a direct threat to MDOT's mission. Based upon discussions with MDOT officials and stakeholders, three additional hazards were included as hazardous to MDOT's mission: landslides, freeze-thaw impacts, and cyberattacks.

Given the wide spectrum of hazards that can occur in the state of Michigan, MDOT initially decided to narrow its risk management focus to just agency and program threats most hazardous to the transportation system (i.e., those threats that primarily affect MDOT operations and project development). These threats are briefly defined and displayed in Figures 7a and 7b. In addition, MDOT developed mitigation strategies to address each of the agency and program threats identified, which is also detailed in the following section.

Agency Threats

Characteristics of changing financial/funding, economic, and demographic trends and procedural requirements that can affect the way MDOT does business (e.g., declining transportation funding) and/or impact MDOT's ability to achieve its goals and objectives affecting the agency's mission, vision, and values. These agency risks, and their corresponding numerical consequence rating (which is discussed in more detail later in the chapter), are detailed in Figure 7a.

Figure 7a: Agency Threats Most Hazardous to MDOT

Agency Threats: Impacting what MDOT needs to develop a program

Threat Categories	Threats	Consequence Rating *(1 – Minimal to 5 – Severe)*
Labor	Staffing Shortage	5
	Inability to Attract Needed Talent	5
Technology	Ability to Procure and Manage Changing and New Transportation System Technologies	3
	Ability to Procure State-of-the-Practice Technology Support for Day-to-Day Staff Support	3
Financial	Federal and State Funding Levels	3
	Federal and State Funding Structure Change	3
	Changes in Federal Regulations and MDOT's Ability to Comply	2
	Trust Funding Levels/Trust Fund Cliff	1

Labor Strategy: MDOT has undertaken several measures intended to retain institutional knowledge, such as process documentation. Also, to retain talent, MDOT is undergoing a multi-year plan to reinvigorate MDOT culture through the Workforce and Succession Planning System, a program referred to as "The House." MDOT recently hired an organizational development officer who will be consolidating and strengthening the department's capabilities around recruitment, training, employee development and organizational performance. This effort is targeted toward improving MDOT's recruitment and retention efforts. Additionally, there is a group tasked with determining what future job type or classifications will be needed to support MDOT in a rapidly changing environment.

Technology Strategy: MDOT is employing several tactics to advance its IT goals and reduce risks in IT. MDOT recently hired an enterprise information management officer who is reviewing the department's IT structure to ensure MDOT is well positioned to manage changing technologies and procure new transportation system technologies. The newly created position is meant to provide direction and strategy in IT and position the department well to take advantage of "big data" from intelligent transportation systems (ITS) and connected and automated vehicles (CAVs). In addition, MDOT has a Data Governance Council as well as data stewardship communities of interest in place to maintain the integrity of its transportation data. In a world with ever-increasing risk of cyberattacks, MDOT, in partnership with the Department of Technology, Management, and Budget (DTMB), has a team of resources dedicated to enhancing the security of its IT assets.

Financial Strategy: MDOT partners with AASHTO and other state DOTs to educate federal lawmakers about transportation funding needs. MDOT also partners with Michigan's Governor's Office, TAMC, and local road agencies to educate state lawmakers about state transportation funding needs. MDOT works with its federal and state partners to ensure MDOT staff have the most accurate information needed to make decisions. MDOT also has implemented many innovations and efficiencies to ensure funds are used in the best possible way. MDOT also invests heavily in asset management to prolong the life of bridges and pavement.

Program Threats

These are threats that may affect a group of MDOT projects, an MDOT program, or the ability to meet performance targets, such as systematic threats (market fluctuations) and site-specific threats (natural hazards). Programmatic threats to MDOT and their corresponding numerical consequence ratings are detailed in Figure 7b.

Figure 7b: Program Threats Most Hazardous to MDOT

Program Threats: Impacting what MDOT needs to deliver a program

Threat Categories	Threats	Consequence Rating *(1 – Minimal to 5 – Severe)*
System Maintenance	Spikes in Maintenance Costs	3
	Needed Support for Winter Operations in Response to Severe Winter Season	3
Project-Costs	Material Costs Spike	3
	Labor Cost Spike	2
	Recurring Congestion	2
Climate Change	Long-term Climate Change and Threats to System Operations and Infrastructure	2
System Disruption	Economic Downturn	2
	Failure to Address Critical Functions	2
	Demographics	2
Project-Level Disruptions	Increasing Extreme Weather Conditions at the Project Level	2
	Labor Disputes	1

Climate Change Strategy: MDOT conducted a high-level vulnerability assessment of MDOT assets to identify strategies that can be adopted to mitigate climate change-related risks. MDOT is also collecting culvert data, an asset that often leads to roadway damage or closures during extreme precipitation events, to gain better understanding of these assets. The TAMC also partnered with local agencies to undertake a pilot project collecting culvert location and condition data on roads under local control, such as local NHS segments. MDOT is supporting the Southeast Michigan Council of Governments' (SEMCOG) vulnerability study in southeast Michigan as well.

System Maintenance Strategy: Spikes in maintenance costs are managed by MDOT's Statewide Maintenance alignment team. The team reviews costs to date and critical and priority needed maintenance. The team then determines budget distribution depending on need and safety. MDOT can ask the state Legislature for additional funding when severe winter weather depletes the budget.

System Disruption Strategy: MDOT continues to use the CFP and other planning processes to ensure the selected projects are suitable to meet condition goals based on the projections and trends, including economic and demographic forecasts. MDOT also continues to work with the FHWA Division Office to develop risk assessments for critical functions and stewardship agreements.

Project Costs Strategy: MDOT monitors costs on a monthly basis and uses recent costs as part of the average prices that are part of the engineers' estimate. Average unit prices are impacted when prices increase. MDOT also invests in technology such as ITS and active traffic management (ATM) lanes to address, as economically as possible, recurring congestion.

Project-Level Disruptions: MDOT conducted a high-level vulnerability assessment of MDOT asset facilities to identify strategies that can be adopted to mitigate climate change-related risks.

Step 3: Use a risk matrix to evaluate overall risk to MDOT's mission

After this initial assessment, MDOT used a risk matrix approach to identify which programmatic and agency threats were most significant (i.e., which threats posed the greatest overall risk to MDOT's mission). The risk matrix sets the likelihood of a threat or hazard occurring against the impact (or consequence) if the threat or hazard does occur. The combination of likelihood and impact yields the overall risk to MDOT's mission. Overall risk includes the potential for failure, including not only catastrophic failure of a transportation asset, such as a bridge, but also failure to achieve desired condition levels, preserve asset value, or ensure desired levels of service.

Likelihood Definition

MDOT defines both qualitatively and quantitatively the likelihood that a threat or hazard will occur. The agency qualitatively ranks likelihood from an "almost never" chance of occurring to an "almost certain" chance of occurring, and quantitatively ranks likelihood from 1 (minimal) to 5 (almost certain).

Numerical Likelihood Rating System Descriptions

5	**Almost Certain:** Hazard or threat occurs frequently, often more than once annually
4	**Likely:** Hazard or threat is likely to occur at least once annually
3	**Possible:** Hazard or threat could occur at least once annually
2	**Unlikely:** Hazard or threat is unlikely to occur annually
1	**Almost Never:** Hazard or threat rarely, if ever, occurs

Impact/Consequence Definition

MDOT defines impact (or consequence) as the degree of transportation system disruption if a hazard occurs. MDOT's numerical consequence rating system ranges from 1 through 5 and represents the impact of risks from "minimal" to "severe," respectively. The following list provides a more detailed description of MDOT's numerical consequence rating system.

Numerical Consequence Rating System Impact Descriptions

5	**Severe:**
	Loss of life;
	Severe compromise of the strategic objectives and goals of MDOT; and
	Impact cannot be managed without additional funding from government.
4	**Major:**
	Significant health and safety incident involving multiple members of the public;
	Significant compromise of the strategic objectives and goals of MDOT; and
	Impact cannot be managed without re-prioritization of MDOT programs.
3	**Moderate:**
	Health and safety incident involving multiple members of the public;
	Compromise of the strategic objectives and goals of MDOT; and
	Impact can be managed with some re-planning and modest extra financial or human resources.
2	**Minor:**
	Minor health and safety incident involving a member of the public;
	Minor impact on service delivery; and
	Impact can be managed within current resources with some re-planning.
1	**Minimal:**
	No loss or significant threat to health or life;
	Limited effect on the outcomes and/or objectives of MDOT; and
	Impact can be managed within current resources.

Overall Risk Definition

Overall risk is defined as the combination of the likelihood of occurrence and the magnitude of consequence. Overall risk is displayed as a risk matrix in Figure 8, where the likelihood and impact of both agency and program risks are combined and overlaid on top of a color scheme that visually conveys overall risk from green (virtually no overall risk) to red (very high overall risk). As indicated by this color scheme, the overall risks that MDOT is the most concerned about are those that are both likely to occur and likely to have severe consequences when occurring (i.e., those with high overall risk and indicated by red). This does not mean, however, that those risks found in the green or yellow areas (i.e., those with low to moderate overall risk) will be or should be ignored. For example, there are some risks that occur regularly and require MDOT's attention that the agency is well-prepared to accommodate. The fact that these risks occur regularly, and that MDOT needs to respond each time, also suggests that varying levels of mitigation might be required to reduce the frequency and impacts of these risks.

Figure 8: Overall Risk

The Likelihood and Impact of Potential Agency and Program Risks

Evaluating Overall Risk to MDOT's Mission

The numerical likelihood and consequence ratings were multiplied to obtain an overall risk score for each hazard and these scores were applied to Michigan regions to assess their overall risk, as shown in Figure 9. The regional hazards with the highest overall risk scores are extreme heat, extreme cold, and wildfires. The regional hazards with the lowest overall risk scores have either a low likelihood of occurring, or a minimal to minor impact if they do occur (or both), in the Michigan regions listed in Figure 9.

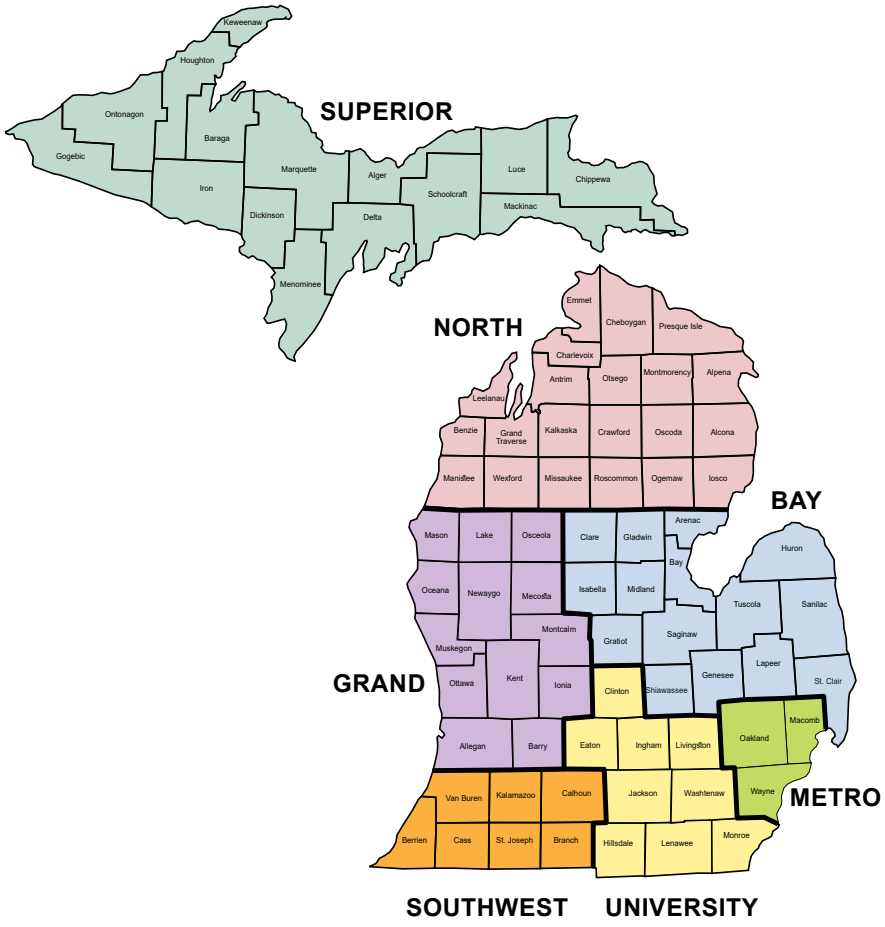


Figure 9: Overall Risk for Michigan Regions				
Virtually None	Minimal	Moderate	High	Very High
Superior Region				
Ice/Sleet Storms	Snowstorms	Dam Failures	Extreme Cold	Extreme Heat
Drought	Flooding			Wildfires
Cyber Attacks				
Public Health Emergencies				
Terrorism				
North Region				
Ice/Sleet Storms	Snowstorms	Dam Failures	Extreme Cold	Extreme Heat
Drought	Flooding			Wildfires
Cyber Attacks				
Public Health Emergencies				
Terrorism				
Southwest, Grand, University, and Bay Regions				
Drought	Snowstorms	Ice/Sleet Storms	Extreme Cold	Extreme Heat
Wildfires	Flooding	Dam Failures		
Cyber Attacks				
Public Health Emergencies				
Terrorism				
Metro Region				
Drought	Snowstorms	Ice/Sleet Storms	Extreme Cold	Extreme Heat
Wildfires	Flooding	Dam Failures		
Cyber Attacks				
Public Health Emergencies				
Terrorism				

Figure 10 presents the analysis completed for Figure 9 in more detail. Specifically, it evaluates the overall risk of both natural and human-related hazards to MDOT's mission. The colored dots in Figure 10 represent visually the likelihood, impact, and overall risk of potential hazards. Like the risk matrix in Figure 9, the green dots under the likelihood section represent hazards that almost never occur or are unlikely to occur, the yellow dots represent hazards that could possibly occur, and the red dots represent hazards that are either likely or almost certain to occur. Similarly, the green dots under the consequence section represent hazards that would have a minimal or minor impact, the yellow dots represent hazards that would have a moderate impact, and the red dots represent hazards that would have a major or severe impact. The dots under the overall risk section represent the overall risk scores for each of the Michigan regions, as well as statewide. As such, the green dots represent hazards that have either a low likelihood of occurring or a minimal to minor impact if they do occur (or both), the yellow dots represent hazards that have either a possible chance of occurring or moderate impact if they do occur (or both), and the red dots represent hazards that have either a likely or almost certain chance of occurring and a major or severe impact if they do occur (or both).

Step 4: Repeatedly Damaged Assets

The review of the past 20 years, as required by 23 CFR Part 667.5, has found no instance of the same roadway section or bridge having been repaired more than once using FHWA Emergency Relief Program funding. MDOT has reviewed its records and will continue to monitor, record, and issue reports regarding the use of FHWA Emergency Relief Program funding, as required by the TAMP regulations.

Figure 10: Overall Risk of Natural and Human-Related Hazards to MDOT's Mission

Hazards	Likelihood Score*					Consequence Ratings					Overall Risk to MDOT's Mission				
	Superior Region	North Region	Southwest, Grand, University, and Bay Regions	Metro Region	Statewide	Reputation	Health and Safety	Service Delivery	Financial (Costs of "Do Nothing")	Composite Rating	Superior Region	North Region	Southwest, Grand, University, and Bay Regions	Metro Region	Statewide
Natural Hazards															
Ice/Sleet Storms	🟢	🟢	🔴	🔴	🟡	🟢	🟡	🟢	🟢	🟢	🟢	🟢	🟡	🟡	🟢
Snowstorms	🟢	🟢	🟢	🟢	🟢	🟡	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Extreme Heat	🔴	🔴	🔴	🔴	🔴	🟢	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴
Extreme Cold	🔴	🔴	🔴	🔴	🔴	🟢	🔴	🟢	🟢	🟢	🔴	🔴	🔴	🔴	🔴
Flooding	🟢	🟢	🟢	🟢	🟢	🟡	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Dam Failure	🟢	🟢	🟢	🟢	🟢	🔴	🔴	🔴	🟡	🔴	🟡	🟡	🟡	🟡	🟡
Drought	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Wildfires	🔴	🔴	🟢	🟢	🟡	🟡	🔴	🟡	🔴	🟡	🔴	🔴	🟢	🟢	🟡
Human-Related Hazards															
Cyber Attacks	🟢	🟢	🟢	🟢	🟢	🟡	🟡	🔴	🔴	🟡	🟢	🟢	🟢	🟢	🟢
Public Health Emergencies	🟢	🟢	🟢	🟢	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Terrorism	🟢	🟢	🟢	🟢	🟢	🟡	🔴	🔴	🔴	🔴	🟢	🟢	🟢	🟢	🟢

**As provided by the MSP Hazard Analysis Report (except cyber attacks, which MDOT aligned with terrorism's frequency score for each region).*

Comparison of New Federal and Existing Michigan Performance Measures

A New Requirement - Federal Pavement Condition Measure

The new federal pavement performance measure included in this TAMP was created by MAP-21 in 2012 and strengthened by the FAST Act in 2015.

The new federal PCM is based on several very specific inputs spelled out in federal guidance. It is a composite measure in that it determines pavement surface condition through an index of four pavement metrics. These metrics rate the pavement in specific categories that determine the overall PCM value of either good, fair, or poor. These metrics are:

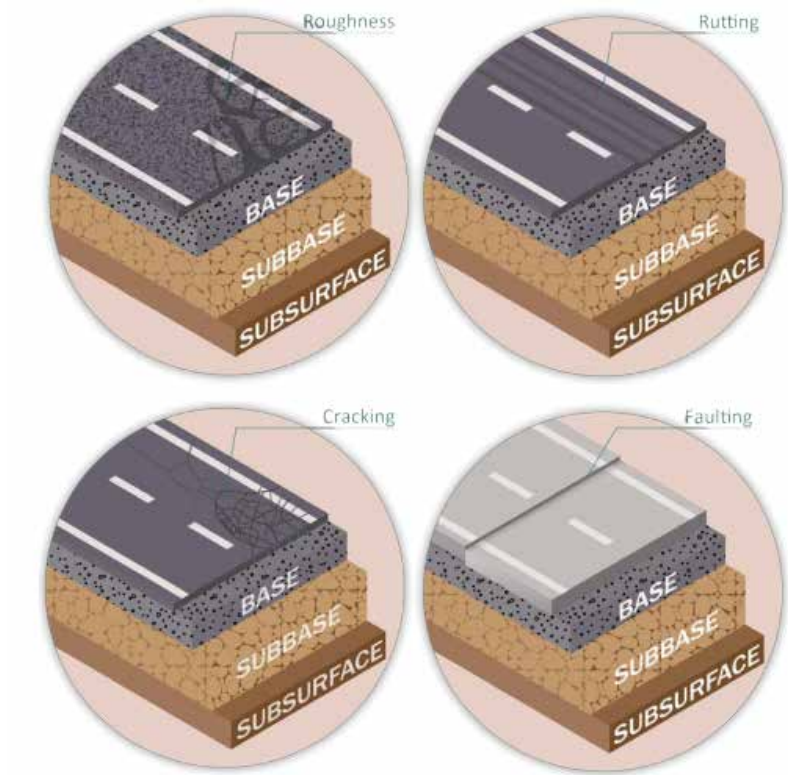
- **IRI** – A reference statistic of pavement surface roughness that simulates a typical vehicle's suspension response to moving over the road at 50 mph.
- **Cracking** – A measurement of the severity of longitudinal surface cracks in asphalt pavements or transverse surface cracks in concrete pavements.
- **Rutting** – A measurement of the average depth of both wheel paths. Applies only to asphalt pavements.
- **Faulting** – A measurement of the severity of separation between sections of concrete pavement.

The new federal measure applies to all states, regardless of previous asset management efforts, and will provide a standardized national snapshot of pavement surface condition across all states. A national measure is valuable at the federal level for strategic planning. While the new federal PCM provides a starting place to measure the surface condition of the federal highway system, there are other pavement management metrics that provide a more robust assessment of the long-term health of pavement.

MDOT's Performance Measure

MDOT has been using asset management and its RSL performance measure to manage pavement condition for more than 20 years. RSL is a measure of current pavement condition and refers to the number of years a pavement has remaining before major repairs or reconstruction is needed. As such, it is a leading indicator of pavement surface condition that represents not only current condition but what can be expected for the pavement's future. An RSL rating considers the structural integrity of the pavement, along with a significant amount of contextual data regarding the pavement's history. Because of this contextual data, RSL is a dynamic, detailed, and tactical measure that more completely evaluates the long-term health of pavement. Having a clear understanding of the pavement's health allows MDOT to make informed investment decisions that are targeted at extending the useful life of the asset.

Figure 11: Pavement Condition Metrics



Source: State of California TAMP

MDOT uses its asset management "mix of fixes" approach to invest in state highways and bridges, making strategic investments at the right time to extend their life. The projects selected using this asset management approach have been shared with the public each year for the past 20 years in the MDOT Five-Year Transportation Program.

Distress Index and RSL Methodology

On a two-year frequency, MDOT has detailed surface distress type/severity surveys performed across the trunkline network. The survey data are organized into individual Primary Distress (PD) and Associated Distress (AD) combinations dependent on the observations made in the survey. MDOT devised a distress point system several decades ago that transforms the detailed survey information into a quantified index representing relative surface condition. Varying distress point values are applied to each individual PD/AD survey "call," the points for all survey calls made within a subject pavement section's length are then summed, and a normalizing multiplication factor is applied to the sum to account for variation in pavement section length. The resultant index is called the Distress Index (DI).

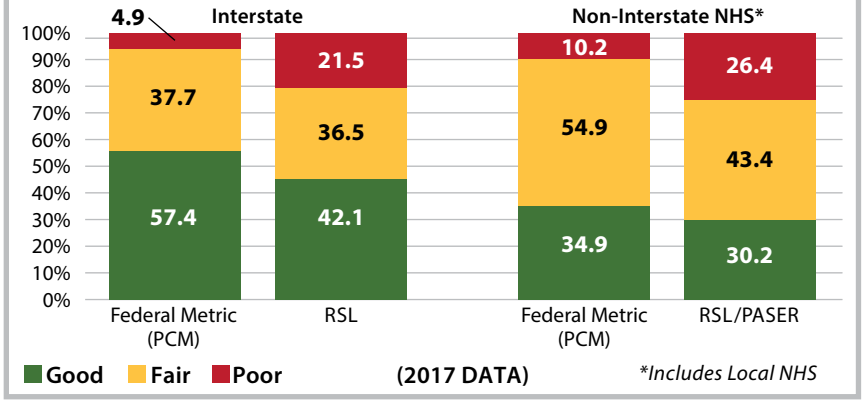
MDOT uses DI in several interrelated ways. It is used to assess and monitor surface condition for prospective project selection (including distinction between Rehabilitation and Reconstruction v. CPM-type work legitimacy and first-level CPM alternatives selection). In turn, DI is used as part of the CFP's screening procedures to verify appropriateness of proposed projects. Relatedly, DI time series change analysis is performed per construction fix type to: a) develop fix-life estimates that are utilized as guidelines for project programming within the CFP process, and b) support the Life Cycle Cost Analysis (LCCA) process for pavement-type selection on pending projects with large preliminary pavement cost estimates. Furthermore, the developed fix-life estimate values, once applied to individually programmed projects per the CFP guidelines, are utilized by the RSL estimation process, which is the foundational "pavement health" assumptive input to the RQFS software utilized by Statewide Planning for network monitoring and planning efforts.

Within its 2018-2022 Five-Year Transportation Program document, MDOT defines RSL as the estimated remaining time (in years) until a pavement's most cost-effective treatment requires either reconstruction or major repair. The RSL estimate is, therefore, an "economic longevity" measurement. On an annual basis, the RSL estimation process begins with automation that uses inputs of project history (i.e., work type, location, and timing) and best-fit modeling of historically collected DI data. The outputted "Proposed RSL" values are then provided to MDOT Region staff for review and adjustment as needed. Region reviews are guided by a broader range of factors including current structural health in terms of whether or not continued preventive maintenance treatment would be more cost-effective than major restoration, rehabilitation, or even reconstruction; pavement structure (including base, subbase, and subgrade) material and dimensional quality; drainage system performance; construction and maintenance history; traffic loading trend and quantity; surface condition - cracking pattern/severity, ride quality, and rutting or faulting. Finally, the reviewed/adjusted values are made available to the RQFS software as an updated base-year dataset.

How the State and Federal Measures Compare

Figure 12 shows how the performance of the same pavements may vary when assessed by different measures.

Figure 12: Performance Measure Comparison



Source: MDOT Bureau of Transportation Planning

The new federal measure indicates that the percent of poor Interstate pavements is just under 5 percent based on PCM's surface condition metrics, while the overall health of the pavement assessed with Michigan's RSL performance measure increases the poor rating to more than 21 percent. Likewise, the federal PCM also indicates a larger percentage of good Interstate pavements than Michigan's RSL performance measure. These differences along the rating spectrum are explained by the differences between the rating systems and the expanded focus on pavement health (RSL) versus ride quality (PCM).

The graph for non-Interstate pavements presents similar statistics (i.e., the federal PCM presents a different view of pavement than Michigan's RSL performance measure). Michigan's RSL performance measure presents a significantly higher percentage of poor non-Interstate pavements than the federal PCM. The federal PCM also presents a higher percentage of good non-Interstate pavements than Michigan's RSL performance measure.

Projecting Future Pavement Condition and Investment

MDOT has used the RQFS for the past two decades to forecast future pavement condition. As a network-level model that uses the RSL performance measure, RQFS allows MDOT to make strategic investment decisions with these informed pavement impact statistics.

At present, MDOT does not have enough information to use the federal PCM to reliably forecast the impact of future investment. For this reason, the agency cannot base its financial strategies on the federal PCM at the present time. This issue was explored in depth with the FHWA Michigan Division while the TAMP was developed. FHWA confirmed the assertion made by MDOT that PCM would perform similarly to RSL and that investment strategies regarding the condition of the pavement network could be based on this assumption. For this TAMP cycle, projections of future pavement condition will continue to rely on MDOT's RSL performance measure, with the understanding that it is an analogous pavement performance measure that will drive future similar changes in the PCM.

MDOT supports the federal effort to gain a better understanding of pavement condition nationwide but, at least for now, MDOT will continue to rely on its RSL performance measure to best determine how to invest in its infrastructure in a way that achieves the greatest benefit for system health overall. The agency will continue to gather data using the new PCM metrics and report progress toward the PCM targets as detailed in the Performance Gap Analysis Chapter.

Inventory and Condition Analysis

Michigan's NHS is a vital network of roads that supports the mobility of its citizens, as well as the vitality of the state economy. While MDOT manages most of the state's NHS, approximately one-fifth of the network is maintained by local transportation agencies at the county or municipal level.

Inventory

Figure 13 summarizes the NHS pavement infrastructure maintained in the state of Michigan. This figure indicates the number of lane miles of Interstate and Non-Interstate NHS pavement in Michigan. In addition, the ownership of those pavements is also identified.

Figure 13:
State of Michigan 2017 NHS Pavement Inventory

Route Type	Lane Miles	Route Miles
Interstate (State-Owned)	6,078	1,251
Non-Interstate NHS	16,349	5,220
State-Owned	12,081	4,005
Locally Owned	4,268	1,215

Source: MDOT Bureau of Transportation Planning

Figure 14 summarizes the deck area of NBI structures carrying the NHS in the state of Michigan. This figure shows the breakdown between the Interstate and Non-Interstate NHS networks.

Deck area numbers are based on English unit data from the March 15, 2018, National Bridge Inventory.

These pavement and bridge inventories are interactive inventories that track NHS inventory by jurisdiction, including cities and villages, counties, regional planning areas, and MPOs. They will be on the department's public data portal for public viewing. *https://mdot.maps.arcgis.com/apps/MapSeries/index.html?appid=be36cb6ba7884298b4341aa93d6e6096*

Figure 14: State of Michigan 2018 NHS Bridge Inventory

Route Type	Deck Area (sq. ft.)	Number of Bridges
Interstate	18,877,756	1,235
Non-Interstate NHS	18,102,675	1,728
State-Owned	15,768,177	1,503
Locally Owned	2,334,498	225

Source: MDOT Bureau of Transportation Planning

Pavement Condition

MDOT's business process uses RSL as the primary performance measure for evaluating current and forecasting future pavement condition. However, RSL data are not collected by local agencies. For the NHS roads that are locally owned, pavement condition is evaluated using the PASER performance measure, consistent with the data collection practices of the TAMC. While PASER data collection efforts began in 2004, the data in Figures 18 and 19 is reported beginning in 2008 to present consistent, blended condition information on the Non-Interstate NHS. Michigan will continue to use these measures to track pavement health alongside the federal measures for pavement condition. The different ratings for good, fair, and poor condition pavements for both RSL and PASER are in Figure 15.

Figure 15: Michigan NHS 2017 Pavement Health Rating

RSL/PASER Pavement Health Rating		
Condition	RSL	PASER
Good	8+ Years	8-10
Fair	3-7 Years	5-7
Poor	0-2 Years	1-4

Source: MDOT Bureau of Transportation Planning

This differentiation in performance measure is displayed in Figure 16. MDOT manages the entire Interstate system, and pavement health data are shown exclusively using RSL data. Since the Non-Interstate NHS is owned by several agencies, including MDOT, both RSL and PASER information is displayed according to pavement ownership. A combined Non-Interstate NHS pavement health is also shown using a blend of the RSL and PASER data.

Figure 16: Michigan NHS 2017 Pavement Health Rating

State of Michigan 2017 NHS Current Pavement Health Rating

Route Type	Good		Fair		Poor	
	Percent of Network	Lane Miles	Percent of Network	Lane Miles	Percent of Network	Lane Miles
Interstate (RSL)	42%	2,557	37%	2,217	21%	1,304
Non-Interstate NHS (RSL/PASER)	30%	4,937	44%	7,096	26%	4,316
State-Owned (RSL)	35%	4,169	44%	5,380	21%	2,532
Locally Owned (PASER)	18%	768	40%	1,716	42%	1,784
All NHS (RSL/PASER)	33%	7,494	42%	9,313	25%	5,620

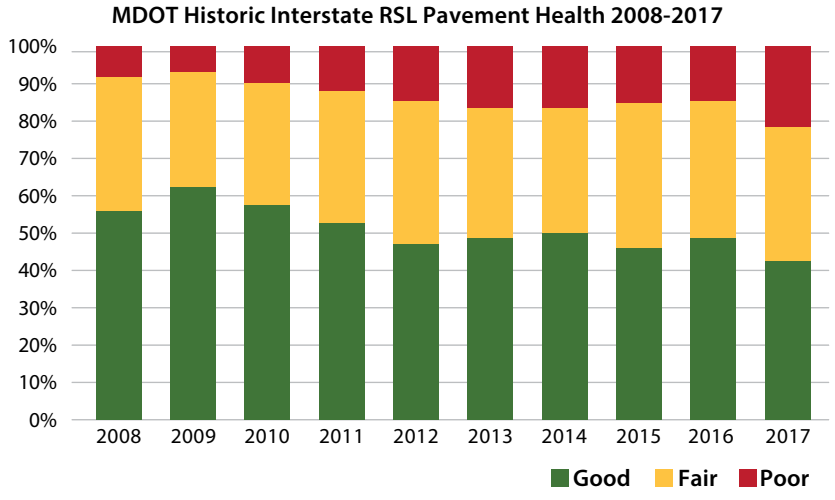
Source: MDOT Bureau of Transportation Planning

For the Interstate system, pavement health based on RSL has gradually trended downward, with poor pavement increasing and good pavements decreasing. In addition, large amounts of fair pavements have the potential to fall into poor health in future years.

The Non-Interstate NHS network's overall pavement health remained relatively stable from 2008 through 2010 based on RSL and PASER. However, since 2011 there has been a steady decline in good pavements that have transitioned to fair and then poor health. Like the Interstate system, the high percentage of pavement in fair condition creates a future risk for increased amounts of Non-Interstate segments falling into poor health.

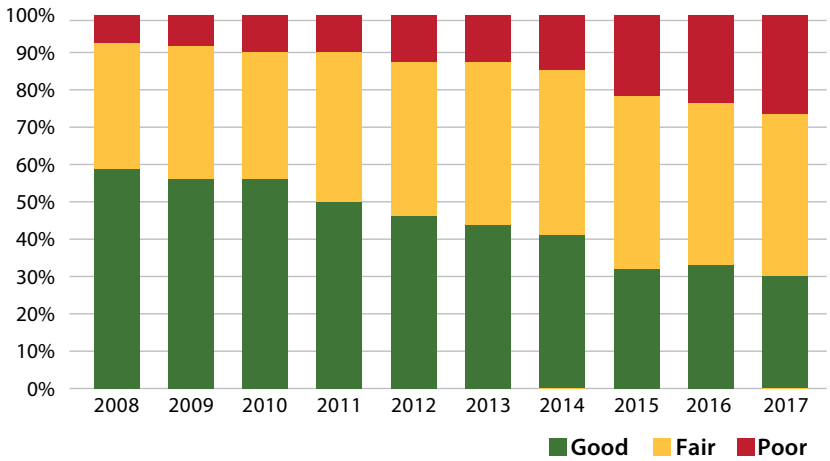
Figures 17 and 18 show both the Interstate and Non-Interstate NHS networks' historic pavement health by percent of the system in good or fair health. For both the Interstate and Non-Interstate NHS networks, pavement health has declined in the past decade. Figure 19 shows the Interstate and Non-Interstate NHS conditions side by side.

Figure 17: Interstate RSL Pavement Health



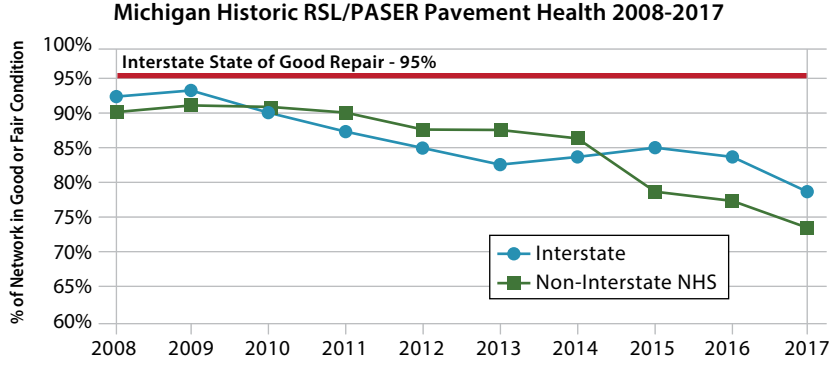
Source: MDOT Bureau of Transportation Planning

Figure 18: Non-Interstate RSL Pavement Health



Source: MDOT Bureau of Transportation Planning

Figure 19: Historic Pavement Condition



Source: MDOT Bureau of Transportation Planning

In addition to Michigan's historic pavement health measures, MDOT is also tracking the new federal PCM for the Interstate, as well as IRI for the Non-Interstate NHS based on FHWA transition requirements. The PCM is a composite rating of three metrics (IRI, Cracking, and Faulting/Rutting). The rating system for good, fair, and poor pavement for each measure is seen in Figure 20.

Figure 20: Michigan NHS 2017 Pavement Condition Ratings

PCM/IRI Pavement Condition Ratings		
Condition	PCM	IRI
Good	3 Metrics Rated "Good"	<95
Fair	All Other Combinations	95-170
Poor	2+ Metrics Rated "Poor"	>170

Figure 21 shows the current pavement condition of the NHS by PCM or IRI. It should be noted that there is a significant difference in the percentage of good, fair and poor using these measures as compared to the historical pavement health measures shown previously. The reason for this is that PCM and IRI evaluate current surface condition, while the pavement health measures evaluate current pavement health and estimate how long the pavement may stay in that condition.

Figure 21: Michigan NHS 2017 Pavement Conditions

State of Michigan 2017 NHS PCM and IRI Ratings						
Route Type	Good		Fair		Poor	
	Percent of Network	Lane Miles	Percent of Network	Lane Miles	Percent of Network	Lane Miles
Interstate[1] (PCM)	57.4%	3,301	37.7%	2,170	4.9%[3]	279
Non-Interstate NHS[2] (IRI)	49.2%	7,959	31.9%	5,160	18.9%	3,057

Source: 2017 HPMS submittal data

[1] Extent excludes 140 lane miles of bridges and 188 lane miles of missing PCM condition data.

[2] Extent excludes 148 lane miles of bridges and 24 lane miles of missing IRI condition data.

[3] 4.85 percent before rounding.

Bridge Condition

Jurisdiction of bridges is split between MDOT and local agencies, similar to NHS pavements. Unlike pavements, this split has no impact on reporting bridge condition. Regardless of ownership, all NHS bridges are evaluated using the NBI scale. Condition ratings are based on a 0-9 scale and assigned for the deck, superstructure and substructure of each bridge or as an overall rating for bridge-length culverts. Figure 22 identifies these components of the structure. These ratings are recorded in the NBI database. Condition ratings are an important tool for transportation asset management as they are used to identify preventive maintenance needs and to determine rehabilitation and replacement projects that require funding, as shown in Figure 23.

Figure 22: Anatomy of a Bridge or Culvert

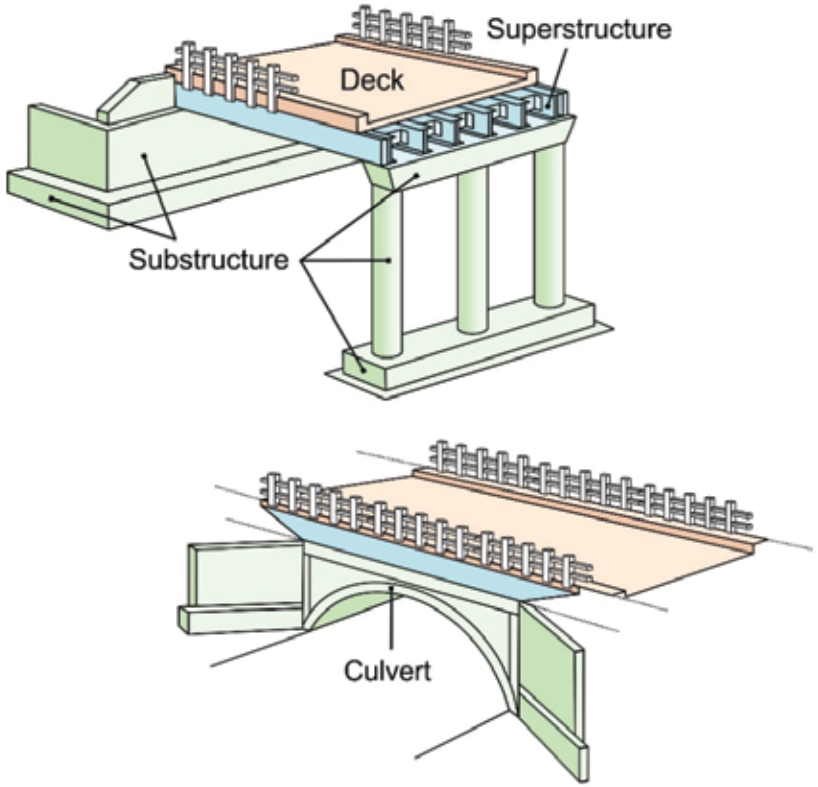


Figure 23: Bridge Condition Ratings

NBI Condition Ratings			
7-9	Good Condition		Routine maintenance candidate.
5-6	Fair Condition		Preventive maintenance and minor rehabilitation candidate.
4	Poor Condition	Poor	Major rehabilitation or replacement candidate.
2-3		Serious or Critical	Emergency repair or high-priority major rehabilitation or replacement candidate. Unless closely monitored, it may be necessary to close until corrective action can be taken.
0-1		Imminent Failure or Failed	Major rehabilitation or replacement candidate. ***Bridge is closed to traffic.***

Source: Michigan Bridge Inventory

In the past decade, investments in Interstate bridges have decreased the amount of poor deck area on bridges in that network. However, considerable bridge deck area remains in fair condition (i.e., there are still a number of bridges in fair condition). These bridges require a significant investment in preservation activities to slow or defer their transition to poor condition.

The same trend can also be seen for Non-Interstate NHS bridges. Poor bridge deck area has decreased but the large number of fair deck area remains a potential concern for the future.

Figure 24 displays NHS bridge condition by deck area. Figures 25 through 27 shows the percent of NHS deck area in good or fair condition based on historic NBI data. Both Interstate and Non-Interstate NHS bridge conditions have improved over the past two decades; however, in recent years they have leveled out.

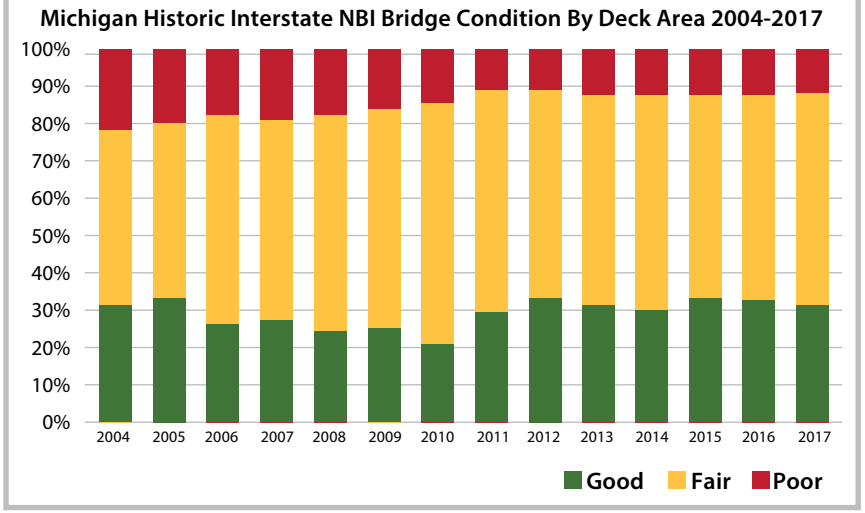
Figure 24: NHS Bridge Condition

State of Michigan 2017 NHS Bridge Condition by Deck Area

Route Type/ Owner	Good		Fair		Poor	
	Deck Area	Percent	Deck Area	Percent	Deck Area	Percent
Interstate	5,932,453	31%	10,699,637	57%	2,247,181	12%
Trunkline	5,640,976	34%	8,992,639	53%	2,247,181	13%
Bridge Authorities	291,477	15%	1,706,998	85%	-	0%
Non-Interstate NHS	6,097,672	34%	10,594,948	58%	1,410,370	8%
Trunkline	5,361,528	34%	9,432,469	60%	974,121	6%
Local Agencies	736,144	31%	1,162,479	50%	436,249	19%
Total NHS	**12,030,125**	**33%**	**21,294,585**	**57%**	**3,657,551**	**10%**

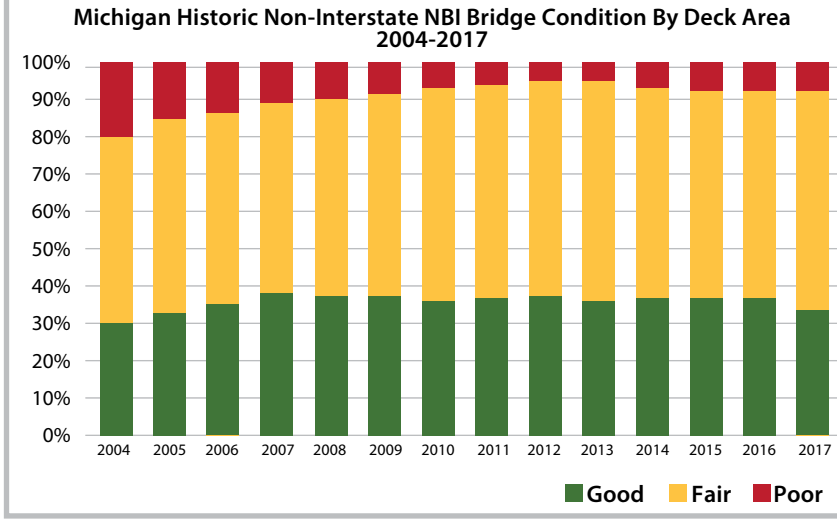
Source: Michigan Bridge Inventory
Deck area numbers shown reflect conversion from the metric values that were required in the March 15, 2018, National Bridge Inventory data submittal.

Figure 25: Historic Interstate NBI Bridge Conditions



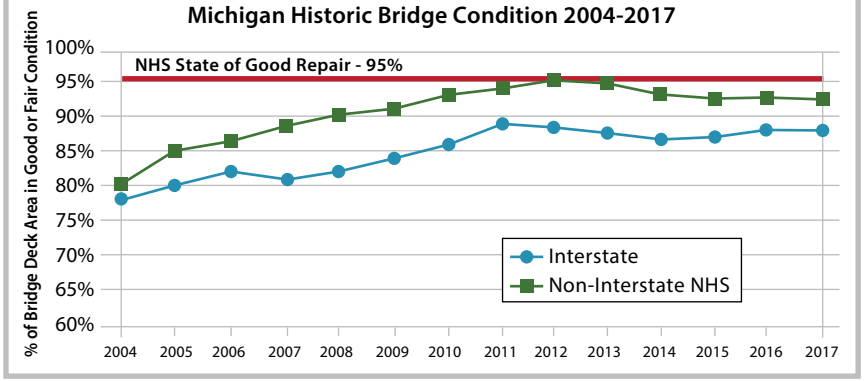
Source: Michigan Bridge Inventory

Figure 26: Non-Interstate NHS NBI Bridge Conditions



Source: Michigan Bridge Inventory

Figure 27: NBI Bridge Condition



Source: Michigan Bridge Inventory

Financial Plan

This Financial Plan chapter describes the sources of funding available for Interstate and NHS pavement and bridge investment, how future revenues available for capital improvements are estimated as part of the financial plan development process, how the value of capital assets is determined, and how the cost of work to sustain those assets is calculated. It also provides 10-year projections of revenue available for capital investment in Interstate and NHS pavements and bridges based on the best available data.

Identifying Funding Sources and Estimating Funding Levels

Funding for the NHS is comprised of federal aid, state revenue and local revenue. The STPD develops funding estimates.

Funding Sources

Federal Transportation Funding

Federal-aid revenue is based on FAST Act funding available for Michigan. Revenue estimates for the FAST Act are provided by FHWA on their website, and by apportionment and obligation authority notices that are provided by the FHWA Michigan Division.

On Dec. 4, 2015, the FAST Act was signed into law. This legislation replaced MAP-21, which expired on Sept. 30, 2014. The FAST Act authorizes the investment of $305 billion in federal funding in the nation's surface transportation system for five years, through fiscal year (FY) 2020. The legislation breaks the cycle of short-term funding authorizations that characterized the federal program in the recent past. In covering nearly five full fiscal years, it represents the longest surface transportation authorization bill enacted since 1998.

The FAST Act builds on the reforms included in MAP-21, which was put in place in 2012. MAP-21 increased the emphasis on freight by encouraging agencies to have greater interaction with freight stakeholders and engage in specific freight planning efforts. The FAST Act continues this focus on freight by creating two new programs to better target investments to projects that promote efficient movement of freight. MAP-21 also transformed federal highway and transit programs through the establishment of a performance-based approach

to decision-making. The FAST Act supports this initiative by funding efforts to collect and manage data for performance analysis, and to improve the capacity of transportation agencies to better link investments with outcomes.

Reliance on non-transportation revenue to support investments in surface transportation is continued in the FAST Act. It transfers $70 billion from the federal General Fund into the federal Highway Trust Fund (HTF) to ensure that all the investments in highways and transit during its five-year duration are fully paid for. Federal revenue beyond 2020 is estimated to grow at the rate assumed throughout the FAST Act.

Federal aid accounts for about 64 percent of MDOT's Highway Capital Program, on average. In Michigan, PA 51 of 1951 (Act 51) prescribes the amount of federal aid to be invested in the MDOT system and the local system. Act 51 states MDOT's share of federal aid is 75 percent of the federal apportionment and the local share is 25 percent, to be used on FAE roads.

State Transportation Funding

State revenue estimates are based on MDOT's share of the Michigan Transportation Fund (MTF), as estimated by consensus with the Michigan Department of Treasury, Economic and Revenue Forecasting Division. Future state revenues are forecasted using a long-range forecasting model managed by MDOT's STPD. In 2017, collections began for new state transportation revenues from legislation passed in November 2015. The state forecast assumes an annual "dedicated income tax revenue" transfer at the FY 2021 level to continue. Estimated annual amounts are in year of expenditure dollars.

The state has experienced challenges in providing adequate transportation funding. For many years, Michigan had difficulty finding state and local funds to match federal aid. State General Fund (GF) dollars were used in 2014-2016 to assure that MDOT did not lose available federal aid.

In 2015, a funding package that provides more state transportation revenue was signed into law. The nine-bill package included registration fee increases, motor fuel tax increases, and appropriations from income tax revenue. The 2015 funding package generates new revenue incrementally beginning in FY 2017 through FY 2021. Transportation funding estimates in this document are based on current state law and would be subject to revision should the law change to modify and/or enhance future revenue.

The 2015 revenue package is expected to generate $1.2 billion for transportation when it takes full effect in FY 2021: $600 million from gas taxes and registration fees, and $600 million from income tax revenues. Almost 94 percent of the new revenue will be distributed through the Act 51 formula for road agencies: 39.1 percent for state highways, 39.1 percent for Michigan's 83 county road agencies, and 21.8 percent for 533 villages and cities.

The gasoline tax increased from 19 to 26.3 cents per gallon on Jan. 1, 2017, and the diesel fuel tax increased from 15 to 26.3 cents per gallon. The motor fuel tax was applied to compressed natural gas (CNG) as well. Beginning in 2022, fuel tax rates will be tied to inflation to help remedy the decline in purchasing power of the fuel tax.

Registration fees for most cars and trucks increased 20 percent on Jan. 1, 2017. New electric car fees of $100 per year, and $30 per year for plug-in hybrid cars, equalize road-user fees for vehicles that use little or no taxed fuel.

The user fee increases are estimated to generate an additional $600 million per year for the MTF. Starting in FY 2019, $150 million in income tax revenues will be appropriated for roads, increasing to $325 million in FY 2020, and then $600 million in FY 2021. The forecasted revenue from FY 2022 to 2028 assumes that $600 million will be transferred from income tax revenues every year to the MTF. These revenues will be distributed to road agencies only, under the current Act 51 formula.

Before transportation revenue is available for trunkline road and bridge projects, non-capital uses must be deducted from the fund. These non-capital uses include debt service, administration, grants to other departments, routine maintenance, buildings and facilities, I-75 Milestone and Availability Payments, and Public-Private Partnership (P3) Freeway Lighting Project payments. The estimated revenue available for the NHS portion of the trunkline Capital Program is based on MDOT's historic capital investment on the NHS. Of this revenue, only a portion will be available for asset management of pavements and bridges on the NHS. STPD and the Bureau of Bridges and Structures generate the cost to implement investment strategies for pavements and bridges, respectively. Department leadership approves investment levels, which can be annually adjusted to maintain asset value.

Local Transportation Revenue Sources

Revenues at the local level for roads are generally held by local governing bodies. MDOT does not have jurisdiction over local roads and, therefore, does not maintain data regarding the revenues associated with these roads. Funding for roads on the local level is generally a mix of federal, state, and local general funds and/or local property taxes. Most of the funding for local roads and bridges, under the jurisdiction of a county road commission or the jurisdiction of a city or village, comes from state revenue, which is determined by the Act 51 formula distribution. Federal funding is passed through from the state level for roads that are eligible for funding. The Financial Plan in the TAMP estimates state and federal funding for non-trunkline road and bridges on the NHS. No local general funds or local property taxes are estimated.

These revenue estimates are based on FAST Act estimates of federal funding to local jurisdictions for use on FAE local roads. The state revenue estimate is based on the share of the MTF for counties, cities, and villages, including the state revenue package that was enacted in November 2015. Revenue for non-trunkline roads and bridges on the NHS was estimated based on the NHS road lane miles and number of bridges as a proportion of the total FAE road lane miles and number of bridges on the local system.

Funding Trends

Federal Transportation Revenues

In the 10 years before passage of the FAST Act, federal funding for Michigan's highways fluctuated. Apportioned program funding to Michigan first exceeded $1 billion in 2004. In 2016, apportioned program funding to Michigan still barely exceeded $1 billion. The FAST Act's implementation broke this trend in funding, and is providing modest increases through FY 2020. These increases are assumed to continue through FY 2028, as the plan assumes a 2 percent growth rate through this period.

State Transportation Revenues

Act 51 established the MTF as the means of collecting and distributing state transportation revenues. For many years, the main sources of MTF funding were motor fuel taxes and vehicle registration fees. As previously discussed, state transportation funding in the coming years is shifting from two sources to three. In 2019, funds from Michigan income tax revenues were transferred into the MTF to augment the funding available for transportation within the state.

State Fuel Tax Trends

Between 2005 and 2014, Michigan's fuel tax revenues were flat or declining. In 2012, collected fuel tax revenues declined to their lowest point since 1997. In 2013 and 2014, gallons sold remained flat, but fuel tax revenues increased slightly in 2015 and 2016. In 2017, fuel tax revenues rose as a result of the new state transportation revenue package. These revenues increased slightly in 2018.

State Vehicle Registration Tax Trends

Most of the vehicle registration tax in the state is based on "ad valorum" vehicles. These vehicles include the model year 1983 and newer. Their tax is calculated on the "base price" of the vehicle; therefore, as long as the price of vehicles are increasing steadily, and Michigan drivers are purchasing new cars, the registration taxes will reflect growth. Vehicle registration revenues have been increasing in Michigan annually. The last time they reflected declines was in 2008 and 2009 due to the state and national economic downturn.

Estimating Funding Levels

Trunkline Capital Program

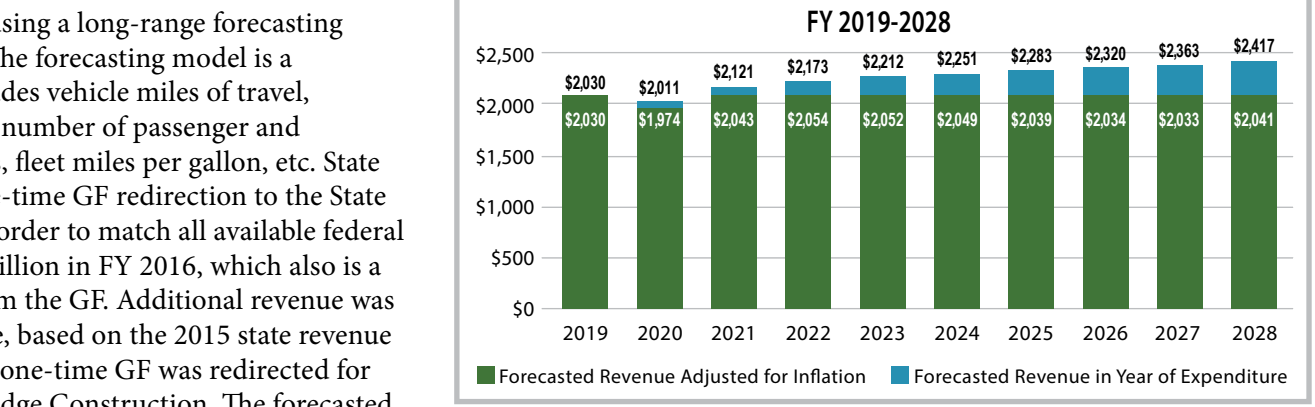
The FY 2019-2028 federal aid revenues are based on FAST Act estimates of federal funding available for Michigan. Federal funding beyond FY 2020 is estimated to grow about 2 percent annually, which is the rate assumed throughout the FAST Act. The intent of Act 51 regarding federal highway aid is to distribute approximately 25 percent of federal aid to local jurisdictions for use on FAE local roads, with the remainder to be used by MDOT.

State revenue estimates are based on MDOT's share of the MTF, as estimated by consensus with the Michigan Department of Treasury, Economic and Revenue Forecasting Division.

Future state revenues are forecasted using a long-range forecasting model managed by MDOT's STPD. The forecasting model is a multi-factor driven process that includes vehicle miles of travel, historical revenue trends, fuel prices, number of passenger and commercial vehicles, registration fees, fleet miles per gallon, etc. State revenue included $113 million in one-time GF redirection to the State Trunkline Fund (STF) in FY 2016 in order to match all available federal aid. In addition, it included $101.8 million in FY 2016, which also is a portion of a one-time redirection from the GF. Additional revenue was added to the overall revenue available, based on the 2015 state revenue package. In FY 2019, $117 million in one-time GF was redirected for Trunkline Preservation/Road and Bridge Construction. The forecasted revenue from FY 2022 to 2028 assumes that $600 million will be transferred from income tax revenue every year to the MTF, with these revenues distributed to road agencies under the current Act 51 formula.

Revenue adjusted for inflation assumes a 1.9 percent inflation rate, which is the average annual compounded increase of the Consumer Price Index - All Urban Consumers, Detroit, for the period covering 1997-2017 (U.S. Bureau of Labor Statistics). This rate was used to convert year of expenditure dollars to constant (2019) dollars. Figure 28 shows the total state and federal forecasted revenues for the trunkline before uses, by FY, in both year of expenditure and base year (2019) dollars.

Figure 28: Forecasted Total Revenues for the Trunkline Before Capital and Non-Capital Uses
(in millions)



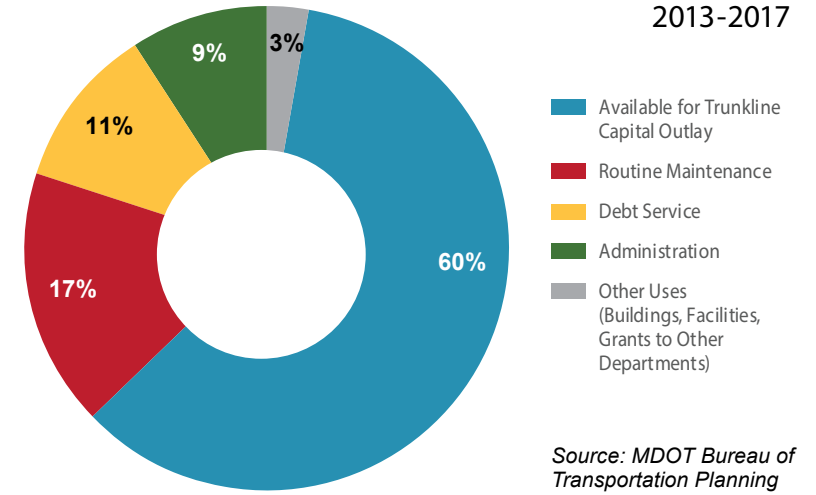
Revenue is before capital and non-capital uses. Numbers may not calculate exactly due to rounding.

Source: MDOT Bureau of Transportation Planning

Before transportation revenue is available for trunkline road and bridge projects, non-capital uses must be deducted. These non-capital uses include routine maintenance, debt service, administration, and other uses such as building and facilities, and grants to other departments. Figure 29 shows the average historic trunkline allocations from FY 2013 to 2017.

Figure 30 summarizes state and federal revenue forecasted to be available for the capital highway program through FY 2028, after deducting dedicated revenues for non-capital uses. However, not all of these funds will be available for asset management of pavements and bridges. MDOT has several other responsibilities, such as safety initiatives, for which it is required to use funding. The revenue available for the NHS portion of the trunkline capital program is estimated at almost 85 percent, which is the percent of currently planned highway capital road and bridge program investments that are on the NHS. The Investment Strategies chapter includes a discussion of the estimated revenue for asset management of trunkline pavements and bridges on the NHS.

Figure 29: Average Historic Trunkline Allocations



Source: MDOT Bureau of Transportation Planning

Figure 30: MDOT Highway Revenue Forecast in Year of Expenditure Dollars *(in millions)*

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Federal Highway Revenue	$826	$843	$864	$878	$896	$914	$932	$951	$970	$992
State Highway Revenue	$1,204	$1,168	$1,258	$1,295	$1,316	$1,337	$1,351	$1,370	$1,393	$1,425
Total Revenues for Trunkline Before Uses	$2,030	$2,011	$2,121	$2,173	$2,212	$2,251	$2,283	$2,320	$2,363	$2,417
(Less) Non-Capital Uses*	$435	$462	$397	$401	$423	$438	$445	$454	$461	$335
(Less) Routine Maintenance	$349	$351	$353	$354	$361	$367	$374	$381	$388	$395
Revenue Avaliable for Highway Capital Program	$1,246	$1,198	$1,372	$1,417	$1,429	$1,446	$1,464	$1,485	$1,513	$1,687
Revenue Available for NHS Portion of Highway Capital Program**	**$1,059**	**$1,018**	**$1,166**	**$1,204**	**$1,214**	**$1,229**	**$1,244**	**$1,262**	**$1,286**	**$1,434**

** Administration, Trunkline and Federal Debt Service, Buildings and Facilities, Grants to Other Departments, I-75 Public Private Partnership (P3) Milestone and Availability Payments, and P3 Freeway Lighting Project Payments.*

***Includes other programs beside the road and bridge programs. Numbers may not calculate exactly due to rounding.*

Source: MDOT Bureau of Transportation Planning

Non-Trunkline Roads and Bridges on the NHS

FY 2019-2028 revenue estimates are based on FAST Act estimates of federal funding to local jurisdictions for use on FAE local roads. The state revenue estimate was based on the share of the MTF for counties, cities, and villages, including the state revenue package that was enacted in November 2015. Revenue for non-trunkline roads and bridges on the NHS are shown in Figure 31. Estimates were based on road lane miles and number of bridges.

Figure 31: FY 2019-2028 Forecasted Transportation Revenue for Local Roads and Bridges on the NHS in Year of Expenditure Dollars *(in millions)*

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Federal Revenue	$16	$16	$18	$18	$19	$19	$19	$20	$20	$20
State Revenue	$55	$60	$67	$67	$68	$70	$71	$72	$73	$75
Total Revenues	**$72**	**$77**	**$85**	**$86**	**$87**	**$89**	**$90**	**$91**	**$93**	**$95**

Numbers may not calculate exactly due to rounding.

Source: MDOT Bureau of Transportation Planning

Estimating Costs of Expected Future Work to Implement Investment Strategies

MDOT conducts investment planning, which guides capital resource allocation to achieve established goals. Program categories or "templates" are developed to allocate revenues according to the department's investment strategy. These program categories are defined by FY, by work type to be performed, or deficiency to be addressed. Asset management work types include initial construction (new construction), maintenance (routine maintenance), preservation (CSM of bridges, CPM of roads), rehabilitation (repair road or bridge), and reconstruction (full replacement of road surface, base, and sub-base, and bridge replacement).

Program emphasis areas are determined by MDOT leadership and help guide the allocation of funding among the templates. Goals and performance standards are established for many of the program categories, with funding allocated in a manner to achieve these goals and standards. These include strategic direction such as increased investment in higher-level system tiers (Interstate and Non-Interstate NHS) and maximizing investment impacts through a balance of mix of fixes to achieve pavement and bridge condition goals. The template provides both a tool to constrain the overall statewide program to available revenues, and a mechanism to monitor the use of funds. The investment template is also guided by the STC's policies, legislative mandates, statewide need, geographic equity, and economic considerations. Investment strategies are summed by work type, by FY, and are shown in the Investment Strategies chapter.

Estimating the Value of Michigan's NHS Pavement and Bridge Assets, and Annual Investment Needed to Maintain These Assets

Infrastructure assets are long-lived capital assets that normally are stationary in nature and typically can be preserved for a significantly greater number of years than most capital assets. Asset values are estimated for the current time; they are not the historic (original construction) costs.

NHS Pavement Valuation

To estimate the value of NHS pavement, an average cost per lane mile for reconstruction was developed based on actual road construction costs from the Bureau of Development. The average cost per lane mile was then multiplied by the number of NHS lane miles. This estimates the amount it would cost today to reconstruct Michigan's NHS roads. In 2017, the cost to reconstruct all of Michigan's NHS pavements was estimated at $35.6 billion based on 17,814 trunkline NHS road lane miles at $1.9 million per trunkline NHS lane mile and 4,242 federal-aid paved non-trunkline NHS road lane miles at $0.6 million per non-trunkline NHS lane mile. NHS lane miles over bridges are excluded from the road valuation calculation.

NHS Bridges Valuation

MDOT owns about 88 percent of the NHS bridge deck area in Michigan. The asset valuation method for bridges on the NHS was based upon the Elemental Decomposition and Multi-Criteria (EDMC) Method (Dojutrek et al., 2012), which uses different deterioration rates for various bridge components. This accounts for the condition, service life, and preservation investments in the valuation. The estimated value of NHS bridges in 2017 was $15.6 billion. This estimate is for NBI bridges only, including local agency NHS bridges and those owned by bridge authorities.

Investments Needed to Maintain the Asset Value of NHS Pavements and Bridges

The annual investments needed to maintain Michigan's NHS pavement condition are estimated using RQFS and PCFS. Annual investments needed to maintain MDOT's NHS bridge condition are estimated using the BCFS. These software programs use current pavement condition, projected deterioration, estimated project fix life, current cost data, and a mix-of-fix strategy to estimate the funding that would be needed to maintain the NHS pavement and bridge conditions. The annual investments needed to maintain NHS roads and bridges are shown in the Investment Strategies chapter.

Identifying Risks and Assumptions

Forecasted revenues and construction costs are based on the best available information at the time they are prepared. Because foresight and information are not perfect, uncertainties and risks are inherent in any forecast. Some risks stem from uncertainties about fiscal and monetary policy, inflation, commodity prices, labor markets, abnormal weather, international economic growth and/or geopolitical tensions, and business and consumer sentiment. These risks can affect many items, from revenues and construction costs to project delivery and timing, system performance, and target achievement.

Financial Plan assumptions are based on existing legislation, historic growth rates, and estimates and guidance from federal and state agencies. Short-term federal and state revenues are developed using estimates prepared by FHWA and the Michigan Department of Treasury, respectively. Long-term federal revenue growth is based on short-term estimated growth. Long-term state revenue growth is forecasted using a long-range forecasting model managed by MDOT's STPD. Future income tax revenue transfers to state revenue are assumed based on existing legislation. The forecasted revenue from FY 2022 to 2028 assumes that $600 million will be transferred from income tax revenues every year to the MTF, with these revenues distributed to road agencies under the current Act 51 formula. Finally, base-year construction costs are developed from road construction information accumulated in RQFS and PCFS, while future construction costs are inflated based on FHWA guidance.

Investment Strategies

By implementing an asset management approach, MDOT develops an understanding of the current gaps in system performance, how pavement and bridge assets should be managed throughout their whole life, how to mitigate the risks that pose a threat to pavement and bridge assets, and how funding distribution and various trade-off options influence the overall system condition and performance. This asset management approach helps MDOT find the right balance among various investment strategies so that progress toward targets is made, risks minimized, and assets managed for their whole life.

Investment Strategy Process

Department goals for state trunkline pavement and bridge condition are established by the STC and influence the manner in which MDOT invests in and maintains state-owned transportation infrastructure. To do this, MDOT conducts investment planning. Investment strategies guide the allocation of capital resources to achieve the goals established. Investments are focused where they will most benefit the public, consistent with the direction established.

Investment strategies are developed using anticipated available funding, life cycle planning, financial and performance gap analysis, and the results of risk analysis. Annually, MDOT uses updated information on available funding, and the estimated cost of future work by work type, to perform life cycle analysis for pavement and bridge assets. This analysis is produced for strategies that would:

- Achieve and sustain a desired SOGR;
- Improve or preserve the condition of the pavement and bridge assets;
- Achieve the constrained Michigan targets for asset condition; and
- Achieve the national minimum condition level.

For each strategy, gaps in funding are identified. The risks associated with each strategy are also evaluated. The various strategies are analyzed and compared to determine how they would impact the overall goals and objectives set by the STC.

The desired mix of fixes, investment levels, and funding targets are developed for the selected investment strategy and provided in the Highway CFP program instructions. They form the basis for project selection and prioritization. The selected investment strategy is communicated to the public by way of the annual Five-Year Transportation Program.

The Program Development Call for Projects Process chapter details the steps of the Transportation Program Development activities leading to investment strategies. Investment strategies are influenced by several factors.

Influence of the Financial Plan

The anticipated funding available and cost of future work constrains the development of investment strategies. State and federal revenue available for the NHS portion of Michigan's pavement and bridge assets is forecasted based on historical trends, federal funding acts, and state legislation. Future funding that will be available for asset management over a minimum time frame of 10 years is projected. The expected cost of future work to implement the investment strategies is determined. The Financial Plan is considered when various investment strategies are compared to determine the best strategy to meet the overall goals. The available funds are allocated to program areas based on selected investment strategies.

Influence of Performance Gap Analysis

Monitoring and reporting performance gap is an important part of demonstrating whether the organization is delivering the desired levels of service. It provides information on the progress toward the organization's strategic goals, accountability to customers, and identifies areas in need of improvement.

Performance gap analysis includes the following:

- Develop condition targets for assets;
- Assess the current condition of assets;
- Identify the performance and funding gap of assets; and
- Understand the relationship between varying funding levels and future asset conditions.

This gap analysis is considered when various investment strategies are compared to determine the best strategy to meet the overall goals and objectives set by the STC.

Influence of Life Cycle Analysis

Michigan incorporates life cycle considerations when modeling future asset conditions. MDOT uses forecasting tools to evaluate and forecast the network-level impact of varying investment strategies on the whole life costs of roads and bridges. The life cycle analysis tools used are detailed in the Life Cycle Planning chapter.

Influence of Risk Management

Risks that can affect the condition of roads and bridges in Michigan are evaluated as investment strategies are developed. MDOT also considers risk as part of the program development process.

Risk management encompasses the following:

- Identifying agency-level risks that could impact implementation of asset management programs;
- Identifying program-level risks that could impact implementation of specific programs;
- Evaluating the agency and program-level risks in terms of their likelihood of occurrence, the consequences if they occur, and using the results to prioritize the risks; and
- Identifying strategies for mitigating the highest priority risks.

Results of the risk management analysis are considered when various investment strategies are compared to determine the best strategy to meet the overall goals and objectives set by the STC.

Local Road Agencies Investment Strategies

The state of Michigan has a substantial number of local governments. Included in the state's system of local governments are counties, townships, cities, and villages. The 83 counties, 275 cities, and 258 villages have ownership and control over the local road system. Sixty-six cities and 18 counties manage some NHS segments. These segments comprise 18 percent of the NHS.

The TAMC was formed to promote the use of asset management practices among Michigan's road and bridge-owning agencies; to develop a coordinated, unified effort by the various agencies within the state; and to advise the STC on a statewide asset management strategy. There is a new state requirement that local agencies with 100 or more route miles will be required to prepare and manage their respective transportation systems through an approved asset management plan.

The TAMC's primary responsibility is to oversee the biennial collection of physical inventory and condition data on all FAE roads and bridges in Michigan, including NHS routes. The TAMC also provides training and other events to help local agencies understand the importance of asset management as they plan their capital programs.

Each local agency develops its own transportation investment strategy and budgets accordingly. MDOT incorporates local revenue available from state and federal sources only (excluding other local funds), along with work expected to be performed on the locally owned NHS pavement and bridges, into the Financial Plan. MDOT's STPD coordinates with local agencies and MPOs on STIP and TIP amendments and performance target-setting and monitors the local investment on non-state-owned NHS pavements and bridges.

Investment Strategy Analysis

As part of MDOT's asset management program, four investment strategies were developed and considered. After MDOT determined the estimated available funding and NHS funding needs for the TAMP time frame, the department worked through various investment strategies to select a strategy that would best meet the state's asset management objectives. The financial plan, life cycle planning, gap analysis and risk mitigation strategies were considered when each investment strategy was reviewed. Anticipated funding available from the financial plan, including the local share of federal funding where appropriate, is used when various investment strategies are compared to determine the most realistic strategy to meet the overall goals and objectives set by the STC. More than 50 percent of the local NHS agencies prioritize projects and have a separate investment plan for their higher-level system, which includes the NHS.

Life cycle planning was completed for the various investment strategies. MDOT currently uses two network-level pavement models and one model for bridges, which are detailed in the Life Cycle Planning chapter. The life cycle planning identifies the amount of work needed by category for each investment strategy.

Financial gap analysis is considered when various investment strategies are compared to determine the most realistic strategy to meet overall goals and objectives. Where funding gaps existed, cross-asset analysis was considered.

Agency-level and program-level risks that could impact implementation of the analysis were considered. Obtaining the anticipated state income tax revenue is a major risk to all the pavement and bridge preservation investment strategies. Without this funding, the funding gap between available revenue and investment needed would be greater.

To develop an investment strategy to reach each goal, MDOT used life cycle analysis that represented the most efficient and effective approach to achieving the asset management objective. A mix of fixes was developed that would produce the desired asset condition.

The life cycle analysis constrained the amount of preservation work by year to balance mobility impacts. The desired level of work for this investment objective was compared to the available funding as identified in the 10-year financial plan forecast.

The four investment strategies that were evaluated are detailed on the following pages.

Achieve the National Minimum Condition Level for Pavement

The national minimum condition level for Interstate pavement requires that no more than 5 percent of the Interstate system be in poor condition based on the federal PCM. At this time, MDOT has achieved the national minimum condition level based on the federal PCM measure. Michigan's 2017 Highway Performance Monitoring System (HPMS) reports 4.85 percent poor pavement on the Interstate system based on the PCM.

In addition to reporting system condition based on the federal PCM, MDOT also uses its own pavement performance measure, RSL, for evaluation of the national minimum condition level, as it better reflects the pavement's overall health. The investment needed to achieve no more than 5 percent poor based on RSL (rather than PCM) for the Interstate in Michigan exceeds the pavement funding available. Using the RSL performance measure, the total estimated shortfall in investment over the 10-year period is almost $1.8 billion. Even if all NHS trunkline pavement funding is redirected to the Interstate, there are still not enough funds to do the work needed to reach the national minimum condition level. Additionally, if all pavement funds are redirected to the Interstate, there would be no funds for capital investment on the Non-Interstate NHS routes. This would result in a drastic decline of condition of the Non-Interstate pavement and have undesirable impacts on the motoring public. Redirecting bridge funding would also result in an unacceptable decline in statewide bridge condition.

Figure 32: National Minimum Condition Level Pavement Investment Strategy - Based on RSL Performance Measure *(in millions)*

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	10-Year Total
Revenue for NHS											
Revenue Available for NHS Trunkline Capital Program	$1,059	$1,018	$1,166	$1,204	$1,214	$1,229	$1,244	$1,262	$1,286	$1,434	$12,117
Maintenance (Pavement and Bridge)	$349	$351	$353	$354	$361	$367	$374	$381	$388	$395	$3,674
Expected Cost of Future Work - Constrained Target											
Trunkline Pavement (No Local)	$473	$598	$679	$685	$693	$682	$682	$682	$682	$682	$6,537
Pavement - National Minimum Condition Level - Expected Work Needed											
Reconstruction	$198	$463	$463	$463	$481	$501	$521	$542	$563	$586	$4,780
Rehabilitation	$153	$324	$453	$446	$456	$261	$272	$283	$294	$306	$3,248
Preservation	$29	$44	$26	$26	$27	$28	$29	$30	$31	$33	$303
Initial construction	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total	$380	$831	$942	$935	$965	$790	$822	$854	$889	$924	$8,331
National Minimum Condition Level Pavement Revenue Gap	**$92**	**($233)**	**($263)**	**($250)**	**($272)**	**($108)**	**($140)**	**($172)**	**($207)**	**($242)**	**($1,794)**

Gap for National Minimum Condition Level compares expected work needed to constrained pavement - trunkline amounts only.
Source: MDOT Bureau of Transportation Planning

Pavement State of Good Repair (SOGR)

Michigan's goal for pavement SOGR is 95 percent good/fair on the Interstate and 85 percent good/fair on Non-Interstate NHS pavement based on the RSL performance measure (rather than the federal PCM). The investment needed to meet the SOGR exceeds the available pavement funding. The total estimated shortfall in investment over the 10-year period is more than $10.4 billion. Redirecting funding from the bridge preservation and other programs would result in an intolerable decline in the condition of those assets and would not be enough to bring the pavement condition up to a state of good repair.

Figure 33: State of Good Repair (SOGR) NHS Investment Strategy - Based on RSL Performance Measure *(in millions)*

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	10-Year Total
Revenue for NHS											
Revenue Available for NHS Trunkline Capital Program	$1,059	$1,018	$1,166	$1,204	$1,214	$1,229	$1,244	$1,262	$1,286	$1,434	$12,117
Maintenance (Pavement and Bridge)	$349	$351	$353	$354	$361	$367	$374	$381	$388	$395	$3,674
Expected Cost of Future Work - Constrained Target											
NHS Pavement (Trunkline and Local)	$544	$677	$758	$770	$778	$770	$770	$773	$773	$776	$7,389
Pavement - State od Good Repair - Expected Work Needed											
Reconstruction	$239	$888	$888	$891	$925	$963	$1,000	$1,042	$1,081	$1,126	$9,042
Rehabilitation	$271	$747	$1,035	$940	$1,044	$810	$841	$691	$629	$591	$7,597
Preservation	$113	$137	$94	$95	$99	$183	$107	$111	$115	$120	$1,175
Initial construction	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total	$622	$1,773	$2,017	$1,926	$2,067	$1,956	$1,947	$1,844	$1,825	$1,837	$17,815
State of Good Repair - NHS Pavement Revenue Gap	**($78)**	**($1,096)**	**($1,259)**	**($1,155)**	**($1,290)**	**($1,186)**	**($1,177)**	**($1,072)**	**($1,052)**	**($1,061)**	**($10,426)**

Source: MDOT Bureau of Transportation Planning

Preserve Current Condition

Michigan's current condition on Interstate routes is 78.5 percent good/fair and 73.6 percent good/fair on the Non-Interstate NHS pavement based on Michigan's long-term health performance measure, RSL (rather than the federal PCM). The investment needed to preserve current pavement conditions exceeds the available pavement funding. The total estimated shortfall in investment over the 10-year period is more than $8.4 billion. Redirecting funding from the bridge preservation and other program would result in an unacceptable decline in the condition of those assets and MDOT would not be able to maintain the current pavement condition.

Figure 34: Preserve Current Condition NHS Pavement Investment Strategy - Based on RSL Performance Measure
(in millions)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	10-Year Total
Revenue for NHS											
Revenue Available for NHS Trunkline Capital Program	$1,059	$1,018	$1,166	$1,204	$1,214	$1,229	$1,244	$1,262	$1,286	$1,434	$12,117
Maintenance (Pavement and Bridge)	$349	$351	$353	$354	$361	$367	$374	$381	$388	$395	$3,674
Expected Cost of Future Work - Constrained Target											
NHS Pavement (Trunkline and Local)	$544	$677	$758	$770	$778	$770	$770	$773	$773	$776	$7,389
Pavement - Preserve Condition- Expected Work Needed											
Reconstruction	$227	$876	$876	$876	$910	$945	$982	$1,020	$1,060	$1,101	$8,872
Rehabilitation	$274	$655	$771	$706	$975	$704	$452	$469	$486	$433	$5,924
Preservation	$109	$133	$90	$90	$93	$97	$100	$103	$107	$111	$1,034
Initial construction	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total	$610	$1,664	$1,737	$1,673	$1,978	$1,745	$1,534	$1,592	$1,653	$1,645	$15,830
Preserve Condition - NHS Pavement Revenue Gap	**($66)**	**($988)**	**($979)**	**($902)**	**($1,200)**	**($976)**	**($764)**	**($819)**	**($880)**	**($868)**	**($8,441)**

Source: MDOT Bureau of Transportation Planning

Constrained Investment for Pavement

Michigan's constrained investment strategy for pavement is based on available funding. Michigan's highway capital program places significant emphasis on the preservation of pavement. MDOT's CFP process includes strategic direction that emphasizes the Interstate and NHS networks over Non-NHS routes. To develop an investment strategy for available funding, MDOT used a life cycle analysis that represented the most efficient and effective approach. A mix of fixes was developed that would produce the best possible outcome with the funding available.

This investment strategy represents the funding available for pavement preservation of the NHS. There is no financial gap with this investment strategy.

The constrained investment strategy described in the Performance Gap Analysis chapter allows Michigan to achieve the two-year (midpoint) and four-year (full performance) targets for the Transportation Performance Management (TPM) pavement condition.

Figure 35: Constrained NHS Pavement Investment Strategy - Based on RSL Performance Measure *(in millions)*

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	10-Year Total
Revenue for NHS											
Revenue Available for NHS Trunkline Capital Program	$1,059	$1,018	$1,166	$1,204	$1,214	$1,229	$1,244	$1,262	$1,286	$1,434	$12,117
Maintenance (Pavement and Bridge)	$349	$351	$353	$354	$361	$367	$374	$381	$388	$395	$3,674
Expected Cost of Future Work - Constrained Target											
NHS Pavement (Trunkline and Local)	$544	$677	$758	$770	$778	$770	$770	$773	$773	$776	$7,389
Pavement - Constrained Investment - Expected Work Needed											
Reconstruction	$207	$267	$516	$410	$351	$448	$398	$400	$400	$412	$3,809
Rehabilitation	$238	$248	$185	$280	$342	$251	$296	$297	$297	$289	$2,724
Preservation	$99	$162	$57	$80	$85	$70	$75	$76	$76	$76	$857
Initial construction	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total	$544	$677	$758	$770	$778	$770	$770	$773	$773	$776	$7,389
Constrained Investment - NHS Pavement Revenue Gap	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**

Source: MDOT Bureau of Transportation Planning

Bridge Investment Strategies

The national minimum conditional level for bridges is no more than 10 percent structurally deficient (or poor) by deck area on the NHS. While current bridge conditions are very near this penalty threshold, one project under construction on large deck area bridges represents more than 4 percent of the NHS deck area statewide. With the completion of this project and using constrained investments, the national minimum condition level for NHS bridges is expected to be achieved and maintained throughout the 10-year forecast period. In other words, achieving the national minimum conditional level for bridges, a constrained investment, and preserving the conditions of the bridge assets by deck area are all achieved under the same investment strategy.

Figure 36: National Minimum Condition Level / Constrained Investment / Preserve Asset NHS Bridge Investment Strategy *(in millions)*

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	10-Year Total
Revenue for NHS											
Revenue Available for NHS Trunkline Capital Program	$1,059	$1,018	$1,166	$1,204	$1,214	$1,229	$1,244	$1,262	$1,286	$1,434	$12,117
Maintenance (Pavement and Bridge)	$349	$351	$353	$354	$361	$367	$374	$381	$388	$395	$3,674
Expected Cost of Future Work - Constrained Target											
Trunkline Bridge	$142	$169	$120	$93	$103	$99	$112	$112	$112	$112	$1,174
Bridge Authorities and Local Agencies	$27	$32	$23	$27	$40	$56	$74	$24	$26	$25	$354
Total	$169	$201	$143	$120	$143	$155	$186	$136	$138	$137	$1,528
Bridge - Constrained - Expected Work Needed											
Reconstruction	$72	$86	$61	$47	$53	$50	$52	$52	$52	$52	$576
Rehabilitation	$38	$45	$32	$25	$28	$27	$34	$34	$34	$34	$329
Preservation	$32	$38	$27	$21	$23	$22	$27	$27	$27	$27	$269
Bridge Authorities and Local Agencies	$27	$32	$23	$27	$40	$56	$74	$24	$26	$25	$354
Total	$169	$201	$143	$120	$143	$155	$186	$136	$138	$137	$1,528
NHS Bridge Revenue Gap - National Minimum Condition Level	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**

Source: MDOT Bureau of Bridges and Structures

Bridge State of Good Repair (SOGR)

Michigan's goal for bridge SOGR is 95 percent good/fair by deck area on the NHS. The total estimated shortfall in investment over the 10-year period is $323 million. Redirecting funding from the bridges not on the NHS would result in an unacceptable decline in the condition of those assets. This strategy was used to identify the revenue gap between current conditions and the SOGR.

Figure 37: State of Good Repair (SOGR) NHS Bridge Investment Strategy *(in millions)*

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	10-Year Total
Revenue for NHS											
Revenue Available for NHS Trunkline Capital Program	$1,059	$1,018	$1,166	$1,204	$1,214	$1,229	$1,244	$1,262	$1,286	$1,434	$12,117
Maintenance (Pavement and Bridge)	$349	$351	$353	$354	$361	$367	$374	$381	$388	$395	$3,674
Expected Cost of Future Work - Constrained Target											
Trunkline Bridge	$142	$169	$120	$93	$103	$99	$112	$112	$112	$112	$1,174
Bridge Authorities and Local Agencies	$27	$32	$23	$27	$40	$56	$74	$24	$26	$25	$354
Total	$169	$201	$143	$120	$143	$155	$186	$136	$138	$137	$1,528
Bridge - Constrained - Expected Work Needed											
Reconstruction	$89	$103	$78	$64	$69	$67	$66	$66	$66	$66	$735
Rehabilitation	$47	$54	$41	$34	$36	$35	$43	$43	$43	$43	$420
Preservation	$39	$45	$34	$28	$30	$29	$35	$35	$35	$35	$343
Bridge Authorities and Local Agencies	$27	$32	$23	$27	$40	$56	$74	$24	$26	$25	$354
Total	$201	$233	$175	$152	$175	$187	$218	$168	$170	$169	$1,851
NHS Bridge Revenue Gap - State of Good Repair	**$32**	**$32**	**$32**	**$32**	**$32**	**$32**	**$32**	**$32**	**$32**	**$32**	**$323**

Source: MDOT Bureau of Bridges and Structures

Selected Investment Strategy

The selected pavement and bridge investment strategy is constrained investment, meaning it is constrained to available funding, minimizes risk, has no financial gap and manages assets for their whole life. It is the best achievable strategy consistent with the overall goals and objectives established by the STC.

This investment strategy drives project selection for both the Five-Year Transportation Program and the STIP. The investment strategy is implemented within the department through the annual integrated Highway CFP process, which provides the mechanism for project selection. The desired mix of fixes, investment levels, and the funding targets are developed for the selected investment strategy and provided in the CFP program instructions. The selected investment strategy is communicated to the public by way of the annual Five-Year Transportation Program.

Performance Gap Analysis

Establishment of Targets for Asset Condition of NHS Pavements and Bridges

A methodology has been adopted by MDOT for vetting and approving pavement and bridge targets. Pavement and bridge TPM teams have been created that include multi-disciplinary representation throughout the department as well as representation from the Michigan Transportation Planning Association (MTPA). These teams are tasked with developing target recommendations, which are then presented to the full MTPA, as well as MDOT leadership, for approval.

Pavement Target-Setting Process

As required by law, MDOT has established targets for the national pavement condition measures, identified as Percent Good and Percent Poor, on the Interstate and Non-Interstate NHS. Targets are required for two and four-year intervals for each measure, with eight targets in total (for the Interstate measures, there will be no two-year targets in the First Performance Period, per 23 CFR Part 490; therefore, there will only be six targets in this period). The rule establishes four metrics to be used to determine condition, depending on the surface type of the pavement: IRI, Cracking Percent, Rutting, and Faulting.

Data used to determine pavement condition are collected by a private contractor who supplies MDOT with data on an annual basis. These data are submitted to MDOT's Data Inventory and Integration Division, where it is segmented into tenth-of-a-mile units. These data are used to determine overall pavement condition for each year and will establish the baseline condition on which targets will be founded.

Using the condition data from prior years, MDOT conducted historical trend analyses to forecast future condition, which were used to establish targets. The analysis included data on available metrics from the last decade, which was used to develop trend lines to help project future condition. Other factors considered were the largest percent changes in condition from year to year to assess variability. Reasons for year-to-year changes were determined to the best extent possible. The department subcategorized the good, fair, and poor metric ranges to consider trends within those categories and determined the likelihood of further category shifts within the two and four-year periods.

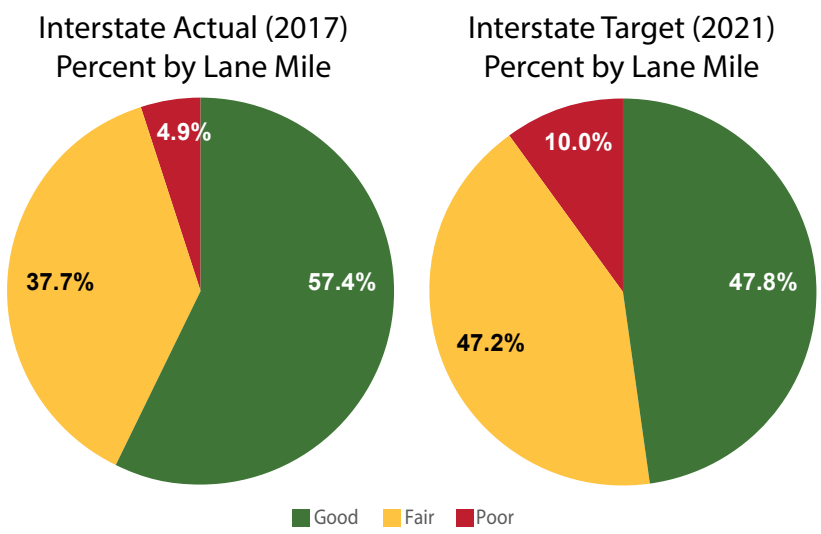
In the First Performance Period, defined as the four-year period between Jan. 1, 2018, and Dec. 31, 2021, the Non-Interstate NHS is subject to the Non-Interstate NHS Transition Period, in which the IRI is the only metric required to be used to determine overall pavement condition. This change was reflected in MDOT's target development process for this period.

Pavement Condition Targets

The MDOT TPM pavement team developed the federally required targets for Interstate PCM and Non-Interstate NHS IRI, which were submitted to FHWA on Oct. 1, 2018.

Figure 38 illustrates the targets MDOT set for the federal PCM on the Interstate for 2021, and their value relative to MDOT's actual 2017 federal PCM condition.

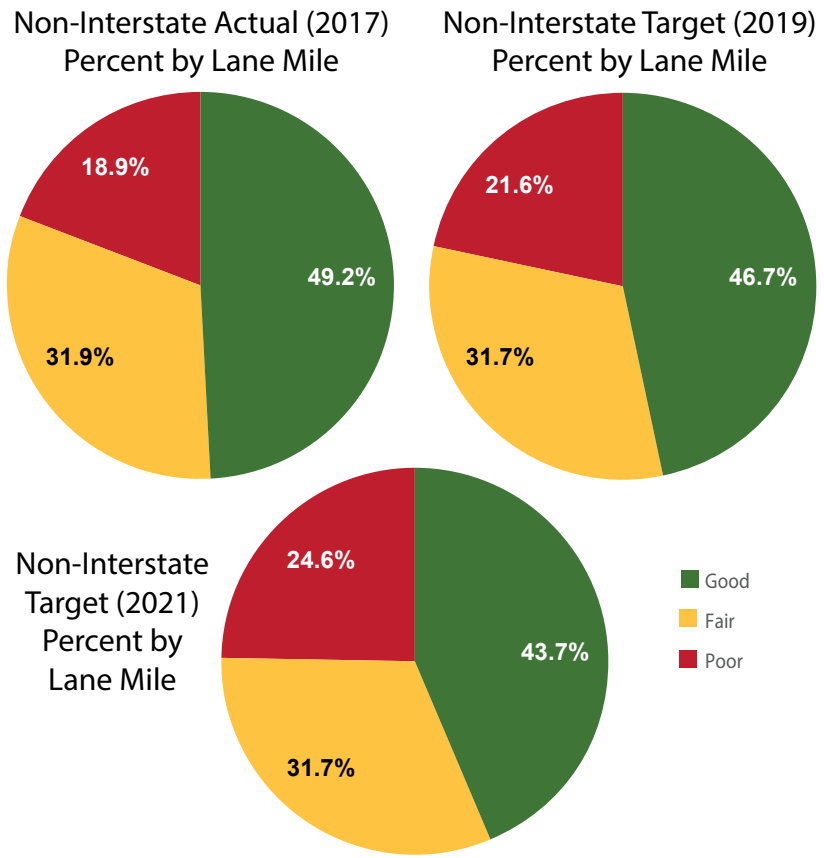
Figure 38: Interstate PCM Ratings



Source: MDOT Bureau of Transportation Planning

Figure 39 illustrates the targets MDOT set for the IRI measure on the Non-Interstate NHS for 2019 and 2021, and their value relative to MDOT's actual 2017 IRI condition.

Figure 39: Non-Interstate NHS Pavement IRI Rating



Source: MDOT Bureau of Transportation Planning

For clarity and comparison, Figure 40 summarizes the good and poor lane miles rating data from Figures 38 and 39 and displays this information in table form.

Figure 40: Percent Interstate and Non-Interstate NHS Lane Miles in Good and Poor Condition

Measure	Actual 2017 Condition	Two-Year Target(s) CYE Dec. 31, 2019	Four-Year Target(s) CYE Dec. 31, 2021
Percent Interstate Lane Miles in Good Condition	57.4%	-	47.8%
Percent Interstate Lane Miles in Poor Condition	4.9%	-	10.0%
Percent Non-Interstate NHS Lane Miles in Good Condition	49.2%	46.7%	43.7%
Percent Non-Interstate NHS Lane Miles in Poor Condition	18.9%	21.6%	24.6%

Source: MDOT Bureau of Transportation Planning

Figure 41: Conservative Pavement Targets

Conservative Pavement Targets
The conservative nature of the approved pavement targets is based on several factors:

1)	Forecasts indicate that trunkline pavement condition based on RSL is declining.
2)	Sample size for the cracking metric will move from 30 to 100 percent of roads sampled.
3)	Issues surrounding the data, such as the use of new vendors and the introduction of more advanced data collection may make data collection inconsistent.
4)	A buildup in the Interstate IRI category at the edge of good gives the potential for a significant number of segments to fall into fair.
5)	The use of a composite score means that all three metrics must be good to be counted as good. If only one metric was to fall, the whole segment is no longer considered good.
6)	At the current time, the sample size available for previous years is relatively small for the use of trend analysis.

Other major potential risks include climate changes and funding levels.

Bridge Target-Setting Process

In addition to pavement targets, MDOT, as required by law, established targets for bridge condition measures, identified as percent good and percent poor, by deck area on the NHS. Targets are required for two and four-year intervals for each measure, with four targets in total. The minimum general condition rating from the NBI is used to determine good, fair, and poor categories.

Bridge condition data are collected throughout the year by inspectors as delegated by the bridge owner. Data collection and quality control follows the requirements of the National Bridge Inspection Standards (NBIS). Bridges are generally inspected on a biennial basis. Inspection data are submitted through MDOT's MiBridge inspection and reporting system. By March 15 of each year, the data is submitted to FHWA as required by the NBIS.

The MDOT bridge performance team, in coordination with Michigan's MPOs, evaluated current conditions, performed analysis, and considered internal and external factors of potential influence to establish the bridge performance baseline and two- and four-year Interstate and Non-Interstate NHS bridge targets.

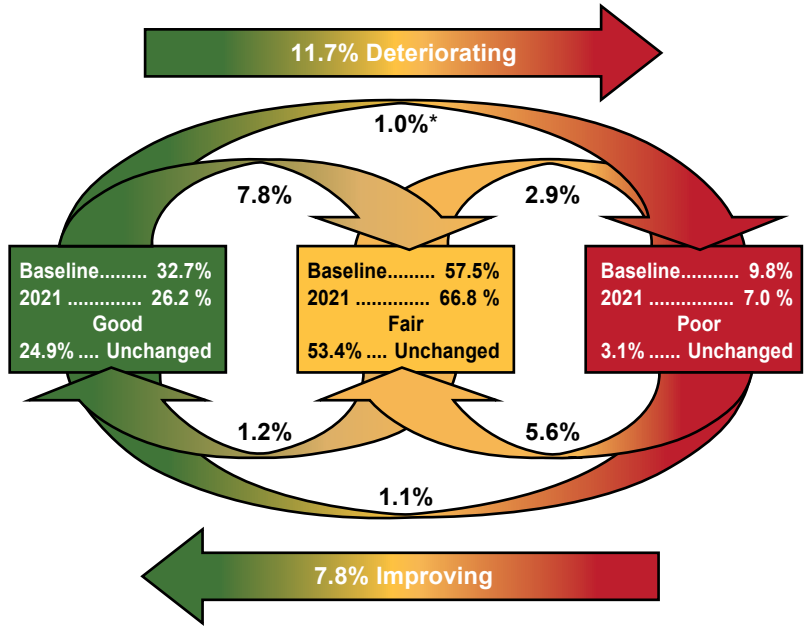
The NBIS defines a bridge as a structure carrying traffic with a span greater than 20 feet and requires that all bridges be inspected every two years to monitor and report condition ratings. The national bridge condition performance measures only apply to bridges carrying routes on the NHS, including bridge on and off ramps connected to the NHS. The regulation established minimum condition thresholds for substructure, superstructure, and deck or culvert, and requires calculating the condition by the respective deck area of each bridge and expressing condition totals as a percentage of the total deck area of bridges in a state. The area is calculated using the NBI structure length and deck width or approach roadway width (for some culverts).

The bridge performance team started the target-setting process by identifying the baseline for good and poor condition using NBI data submitted in 2018. The next step was to evaluate potential influences, not limited to deterioration rates and planned investments. As a bridge ages, its condition declines and an increasing amount of work is required to restore condition or extend the usable life of the bridge. By tracking the rate at which bridges have declined in the past, MDOT is able to predict the rate at which a bridge will decline in the future. MDOT has an

established process through which trends in bridge deterioration rates can be evaluated at regular intervals.

The cycle of life diagram (Figure 42) demonstrates the movement between categories. Overall, the number of bridges in good condition is expected to decline significantly as preservation efforts tend to extend life in fair condition. The first item to note is that only 1.1 percent of bridges in poor condition are classified in good condition following investment. At times, the best life cycle decision for the structure results in the condition status returning from poor to fair condition rather than good condition. Examples include a deck replacement while maintaining a superstructure or substructure in fair condition, or an overlay that improves the deck surface but, due to the deck soffit condition, the bridge remains in fair condition.

Figure 42: Cycle of Life Diagram



The baseline reflects NHS NBI data through March 15, 2018. FHWA will publish this as 2018 data.

**The 1% reduction in good condition and subsequent increase in poor condition account for uncertainties in deterioration rate or predicted improvements.*

Bridge Condition Targets

The MDOT TPM bridge team developed the federally required targets for all NHS bridges by NBI condition rating, which were submitted to FHWA on Oct. 1, 2018.

Figures 43 and 44 illustrate the targets MDOT set for the NBI condition measure on the NHS by deck area, compared to actual bridge condition data collected in 2018.

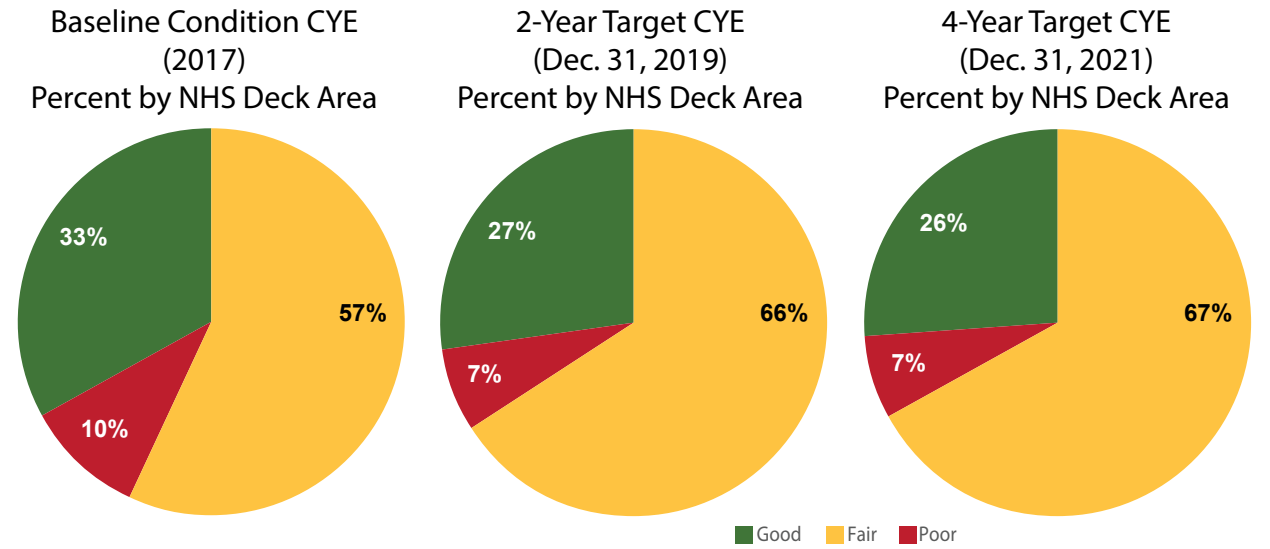
Figure 43: Percent NHS Deck Area in Good and Poor Condition

Measure	Baseline Condition*	Two-Year Target(s) CYE Dec. 31, 2019	Four-Year Target(s) CYE Dec. 31, 2021
Percent NHS Deck Area in Good Condition	32.7%	27.0%	26.0%
Percent NHS Deck Area in Poor Condition	9.8%	7.0%	7.0%

** The Baseline Condition reflects NHS NBI data through March 15, 2018. FHWA will publish this as 2018 data.*

Source: MDOT Bureau of Bridges and Structures

Figure 44: MDOT Targets on the NHS by Deck Area



Source: MDOT Bureau of Bridges and Structures

Target-Setting Coordination with MPOs

The rule requires that MDOT coordinate target establishment with MPOs for both pavements and bridges. MDOT's coordination strategy included adding MPO representatives to its TPM Pavement Implementation Team and meeting with MPOs to review the rule, discuss new data requirements, and to share data and methods. To prepare for the new rule, MDOT began collecting data for all the new pavement metrics on the entire NHS in 2016. This included data collection on the non-trunkline Non-Interstate NHS routes, which are under local government jurisdiction. Using these data, MDOT provided each MPO with a "report card" for pavement condition on the Interstate and Non-Interstate NHS in their metropolitan planning areas and how this condition compares to the statewide condition. A similar parallel effort occurred using the bridge target-setting data.

This effort reduced the burden of data collection and analysis on MPOs and ensured that they all have consistently measured and analyzed data.

MDOT and MPOs used these historical data to establish statewide targets and to understand which target option was appropriate for each MPO, whether it is to support the statewide targets or to establish their own. All of Michigan's 14 MPOs elected to adopt the statewide pavement and bridge targets.

The TPM Implementation Pavement team has been coordinating with the MTPA since April 2017 and has included members from three different MPOs as official team members.

Target Risk Assessment

After making condition projections, MDOT assessed risks to achieving pavement and bridge targets. Three major risk categories are considered potential hindrances to MDOT's ability to achieve performance targets for both pavements and bridges: climate impacts, funding uncertainty, and funding levels. For bridges, age of structures is also a risk factor. Additional risks may be considered as determined in the future.

Climate Impacts

In 2015, MDOT completed an FHWA-funded initial study on potential climate and extreme weather risks. Some of the asset management concerns included how increasing precipitation and temperatures might result in erosion, increased frequency of freeze/thaw cycles, and buckling resulting from heat. Increasing precipitation and temperatures could also result in impacts to scour susceptibility. While these factors might not directly impact deterioration, mitigating increased scour risks would divert resources that could otherwise be spent on preservation activities. Increased deterioration resulting from these climate impacts creates uncertainty in the target development process.

Funding Uncertainty

In 2015, a funding package increasing state transportation revenue was enacted, which began to go into effect in 2017. As part of the additional funding, appropriations from state income tax revenue began in 2019; however, these funds are not guaranteed going forward because they are subject to annual legislative appropriation. While MDOT is planning projects based on receiving this funding, the possibility that funding will not be appropriated creates uncertainty in the target development process because MDOT may not be able to complete all projects as planned.

Funding Levels

Even with the additional funding expected, MDOT's funding levels are not enough to maintain or improve current pavement conditions. MDOT currently uses RSL to forecast pavement condition and, based on current funding, including the new revenue and the income tax revenue appropriations, MDOT's trunkline system is projected to decline rapidly over the next decade. MDOT's current revenue will need to be considered and factored into forecasts as the department transitions into using the new metrics.

Bridges are just one of the many assets that are considered when managing funding for a transportation agency. Should other areas subject to performance measures encounter significant obstacles in meeting their minimum condition goals or performance targets, the agency will need to determine if funding should be shifted.

Age of Structures

MDOT's bridge network is continuing to age. MDOT's focus on preservation has extended the life of the average structure in the inventory and slowed the rate of structures falling into poor condition. However, the effectiveness of multiple preservation or rehabilitation projects on the same structure can diminish over time and could result in faster than expected deterioration rates or reducing the available repair options, which often leads to replacements. Any shift toward replacements, given constant fiscal constraints, would reduce the number of structures preserved each year and lead toward lower network conditions. This risk is minimal for the two-year target due to the slow deterioration of bridges; however, it is more of a concern for the four-year target and for long-term analysis and strategy setting.

These risks decrease the chances MDOT will achieve targets. To account for this uncertainty, MDOT will select the most reasonably conservative targets based on trend forecasting. The largest percent changes that have occurred from year to year will be used to gauge what can be considered a reasonable conservative forecast from the baseline condition. Additionally, as part of the coordination process, MDOT will consult with MPOs on what is considered reasonably conservative. MDOT may need to adjust targets accordingly at the midpoint of the performance period.

Identifying Gaps in the Performance of the NHS That Affect Pavements and Bridges

The objective of performance gap analysis is to track performance compared to short-term targets and long-term performance goals for an SOGR. Information from the gap analysis will be used with life cycle and financial planning to develop alternative strategies that close or address the identified gaps to operate, improve or preserve existing assets.

The gap analysis requires, at a minimum, a comparison of the current condition of NHS pavements and bridges with MDOT's TAMP targets. The gap analysis should also explain how the current conditions compare to the state DOT's long-term performance goals for the SOGR.

MDOT also identified the performance gap (percentage point difference) between the constrained investment strategy condition and the state-identified TAMP target for each federal condition measure.

MDOT identified the performance gap (percentage point difference) between the constrained investment strategy condition and the MDOT long-term performance goals for the SOGR.

Pavement Gap Analysis Process

For both the Interstate and Non-Interstate NHS, MDOT has determined the current pavement condition (calculated as described in 23 CFR 490.313) for each condition measure (percent good and percent poor). MDOT's current long-term pavement condition goals are based on RSL and are 95 percent good/fair on the freeway and 85 percent good/fair on the non-freeway system. As the state and federal performance measures vary on measurement units, for gap analysis comparison purposes in the TAMP, it will be assumed that the percent SOGR good/fair goal on the Interstate is 95 percent and the percent good/fair goal on the Non-Interstate NHS is 85 percent.

Bridge Gap Analysis Process

MDOT has determined the current bridge condition by deck area carrying the NHS for each condition measure (percent good and percent poor). MDOT's current long-term bridge condition goals are based on count of bridges rather than deck area and are 95 percent good or fair on the freeway and 85 percent good or fair on the non-freeway system. The non-freeway goal has been exceeded since 2007 and the freeway goal was met for a period of time in 2016 and 2017.

As the Michigan inventory contains a few structures with exceeding large deck areas that can cause a noticeable swing in condition, the projections and measurements will be more sensitive to the condition of these large structures. Michigan's TAMP-reported targets to FHWA are a combination of trunkline, bridge authority, and local agency NHS bridge condition. Bridge authority bridges comprise 5 percent of the statewide NHS deck area and were all in good or fair condition in 2017. Local agency bridges comprise 6 percent of the statewide NHS deck area, with 16 percent of bridges in poor condition by deck area.

As the state and federal performance measures vary both on measurement units, as well as inventories, the assumption is made that maintaining current condition (which exceeds the state goal) is a reasonable conversion of aspirational goals. For gap analysis comparison purposes in the TAMP, it will be assumed that the combined statewide NHS percent good aspirational goal by bridge deck area on the NHS is 95 percent good or fair.

Process for Analyzing Gaps Regardless of Physical Condition

State DOTs are also required to have a process for analyzing gaps in the performance of the NHS that affect NHS pavements and bridges regardless of their physical condition. MDOT continues to analyze and address instances where the results or recommendations from other plans (Highway Safety Improvement Program, State Freight Plan, etc.) may affect NHS pavement and bridge assets. MDOT reviews these plans if there is a call for additions or changes to existing pavements or bridges in a manner beyond the current investment strategy. If significant, MDOT will identify the change in condition gap as a result of these strategies. Annual investment strategies are developed in cooperation with all transportation program managers during the annual CFP process. This assures that all resources which are invested in the NHS system have the maximum positive impact in improving physical condition along with addressing safety, congestion reduction, mobility, reliability, and environmental sustainability.

Developing Alternative Strategies to Close or Address the Identified Gaps

MDOT continues to develop and analyze alternative life cycle strategies and/or financial scenarios for closing or addressing gaps relating to the SOGR and any other identified gaps for pavements and bridges.

What are MDOT's Pavement and Bridge Goals?

STC Policy

Maintaining and growing Michigan's economy depends on the preservation, modernization, and efficient operation of its transportation system. To achieve the goals that have been set forth, it is necessary to benchmark and monitor the performance of the system. MDOT formalized its approach to improving, measuring, and reporting the condition of its transportation network with the STC's 1997 adoption of pavement and bridge condition goals.

> ***"MDOT is recognized nationally as one of the leading state transportation agencies in the practice of asset management. Not only is MDOT an important case study for the lessons learned with MDOT's experience with asset management, but department officials are pushing the boundaries of what future asset management applications should look like…"***
>
> *– National Cooperative Highway Research Program (NCHRP) 20-68 Domestic Scan Pilot Program – Best Practices in Asset Management, 2007*

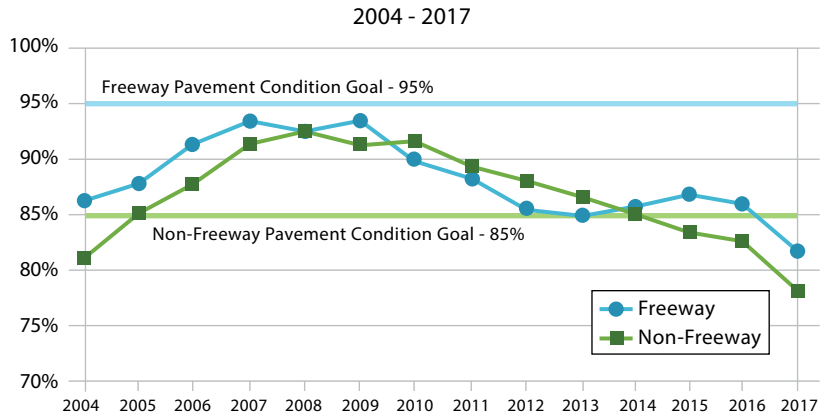
Timeline	
1997	STC sets performance goals for state highway pavements
1998	STC sets performance goals for state bridges
2001	Act 51 Funding Study Committee recommends expanding MDOT's asset management approach to local agencies.
2002	Michigan State Legislature creates TAMC
2004	TAMC issues its first annual report on the condition of Michigan's FAE highways and bridges
2007	MDOT achieves STC pavement performance goal
2008	MDOT achieves STC bridge non-freeway performance goal
2008	Transportation Funding Task Force (TF2) recommends doubling investment in transportation
2015	A state transportation funding package is enacted, to be implemented beginning in 2017 and gradually increasing to $1.2 billion over five years
2016	MDOT achieves STC bridge freeway performance goal
2017	$600 million in transportation user fee increases required by the 2015 state law go into effect beginning in the second quarter of the fiscal year
2018	The Michigan Infrastructure Council and Water Asset Management Council are created by state law to promote an asset management approach for water infrastructure
2019	The first $150 million installment of income tax funds for transportation promised in the 2015 law is distributed to road agencies

Pavement Condition Commission Goals

In 1997, the STC adopted the long-term goal of having 95 percent of freeways and 85 percent of MDOT non-freeways in good or fair condition based on the RSL performance measure. RSL measures a pavement's overall condition and is defined as the estimated remaining time in years until a pavement's most cost-effective treatment requires either reconstruction or major repair. When pavements reach an RSL of two years or less, the pavement is considered poor.

Figure 45 represents historic MDOT system condition based on RSL (rather than the new federal PCM that the department began using in 2018). In 2005, MDOT surpassed the non-freeway goal of 85 percent pavement in good or fair condition and maintained this condition through 2014. Freeway condition peaked at 93 percent good or fair condition in 2007. Pavement condition deterioration is forecasted to accelerate considerably in the coming years.

Figure 45: Historic MDOT Trunkline Freeway and Non-Freeway RSL Pavement Condition

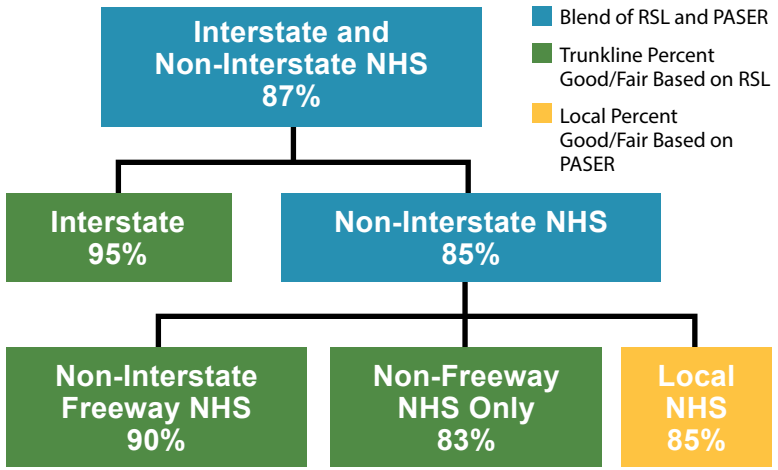


Source: MDOT Bureau of Transportation Planning

Pavement Condition SOGR Goals

In 2017, MDOT SOGR goals for each of the pavement networks, as well as local NHS routes, were as shown in Figure 46.

Figure 46: MDOT State of Good Repair (SOGR) Goals



The long-term SOGR goal for the Interstate system is consistent with the national minimum condition level of no more than 5 percent in poor condition. The long-term SOGR goal for Non-Interstate NHS routes is 85 percent in good/fair condition.

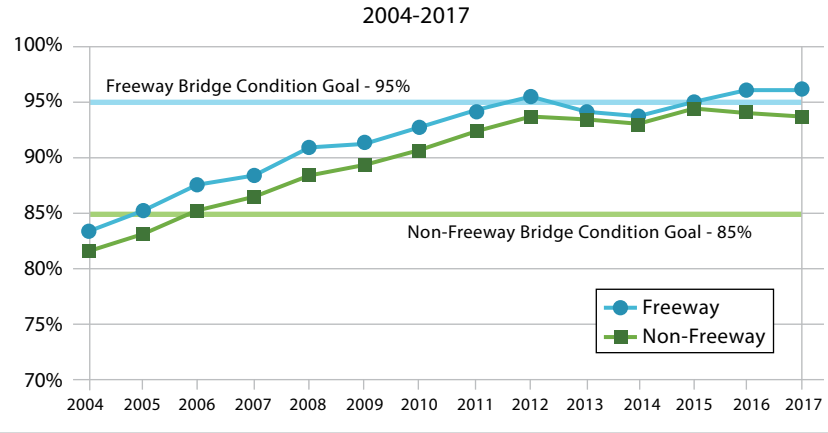
Bridge Condition Commission Goals

In addition to the pavement goals adopted by the STC in 1997, MDOT bridge condition goals were established one year later. MDOT's current long-term bridge condition goals are based on count of bridges and are 95 percent good or fair on the freeway system and 85 percent good or fair on the non-freeway system.

Bridge condition is based on NBI minimum condition ratings. Minimum condition ratings are found by taking the lowest condition of either the deck, superstructure, substructure or culvert ratings. A bridge is considered poor when one of these ratings is 4 or less.

MDOT bridge conditions were close to 95 percent good or fair at the end of 2013. They declined slightly in 2014 and 2015 but increased again in 2016 and met the freeway bridge condition goal of 95 percent at the end of 2016. However, as projections indicated, the freeway bridge condition has declined and bridge conditions are below the freeway bridge goal. As shown in Figure 47, MDOT has met and sustained the non-freeway bridge goal of 85 percent good or fair condition since 2006.

Figure 47: Number of Bridges in Good or Fair Condition



Source: MDOT Bureau of Bridges and Structures

Pavement and Bridge Condition Performance Gaps

National Minimum Condition Level for Interstate Pavement Condition Gap

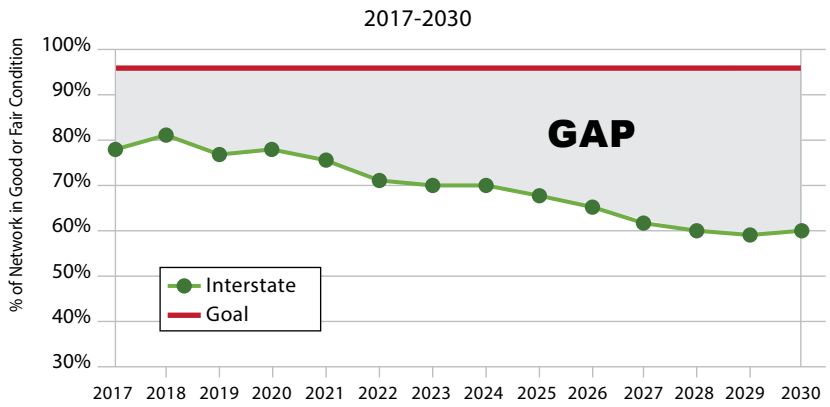
The measure for percent poor on Interstates fell below 5 percent in 2017, attaining the threshold established by FHWA and meeting the national minimum condition level for the Interstate. Based on federal goals, there is no gap.

Short-Term Targets for Pavements and Bridges Condition Gap

As mentioned earlier, MDOT has established short-term targets for pavement condition measures on the Interstate and Non-Interstate NHS based on the four condition metrics outlined in federal regulations.

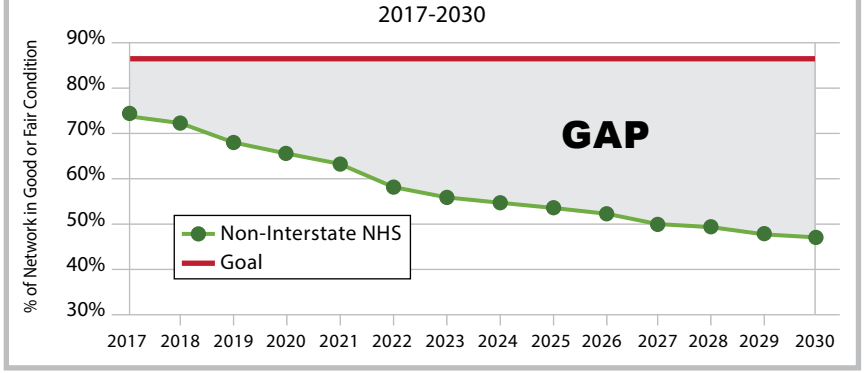
Similar to the pavement process, MDOT has established short-term targets for bridge condition measures on the NHS. These targets are based on the NBI minimum condition ratings. Since both the short-term pavement and bridge targets were developed based upon the constrained investment strategy included in this TAMP, they do not represent any gap in performance at this time.

Figure 48: Projected MDOT Interstate RSL Pavement Condition



Source: MDOT Bureau of Transportation Planning

Figure 49: Projected MDOT Non-Interstate RSL and PASER Condition



Source: MDOT Bureau of Transportation Planning

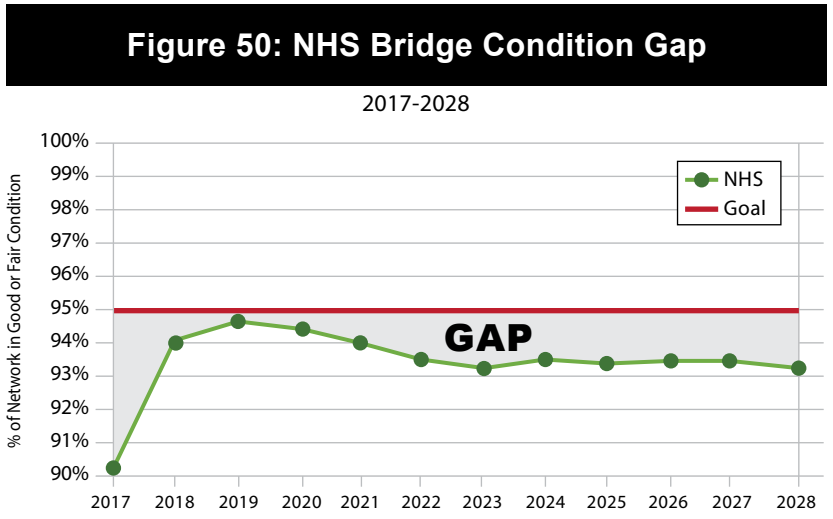
Long-Term SOGR Goals - Pavement Condition Gap

Figures 48 and 49 depict the gap in condition between the long-term SOGR pavement goals and the current and/or projected future pavement condition for the Interstate and Non-Interstate NHS networks. Future condition is forecasted based on the "constrained" investment strategy discussed in the Investment Strategies chapter of this plan.

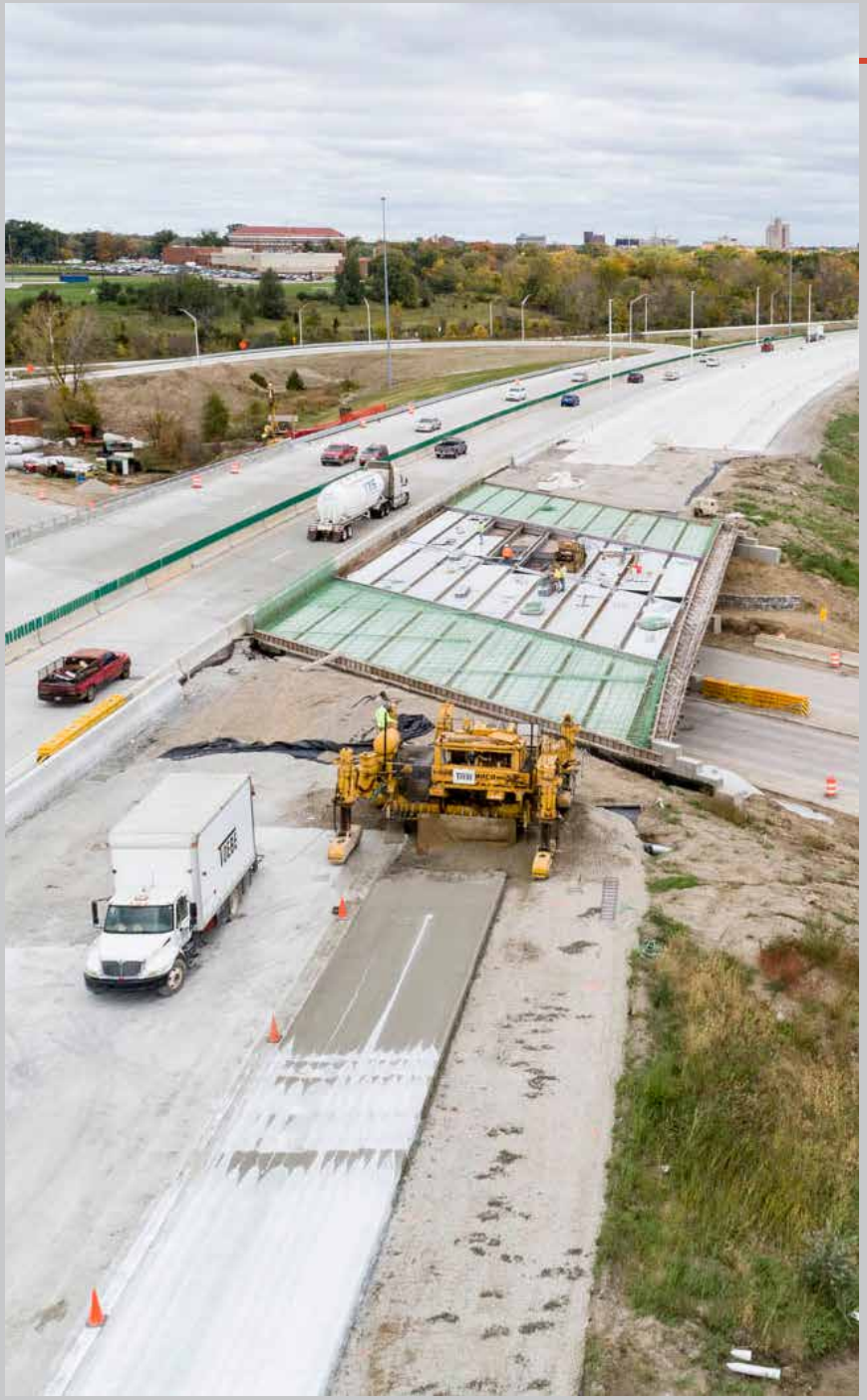
Long-Term SOGR Goals – Bridge Condition Gap

Figure 50 depicts the gap in condition between the long-term SOGR bridge goals and the current and/or projected future bridge condition for the NHS network. This condition is statewide NHS and includes local agency and bridge authority bridges. Future condition is forecasted based on the "constrained" investment strategy discussed in the Investment Strategies chapter of this plan. It is important to remember that NHS bridges represent just more than half of the total bridge deck area statewide and a little more than a quarter of the number of bridges statewide. The gap identified in this plan focuses on the condition of the bridges carrying the NHS and does not address the non-NHS assets.

Figure 50: NHS Bridge Condition Gap



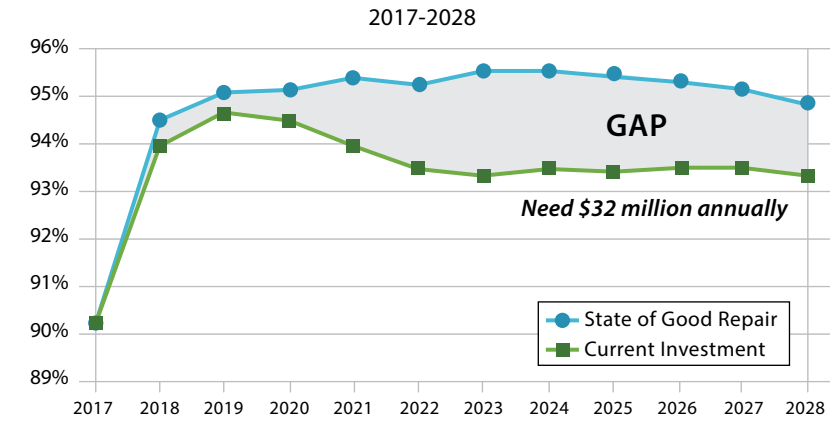
Source: MDOT Bureau of Bridges and Structures



Conclusion: Closing the Gap

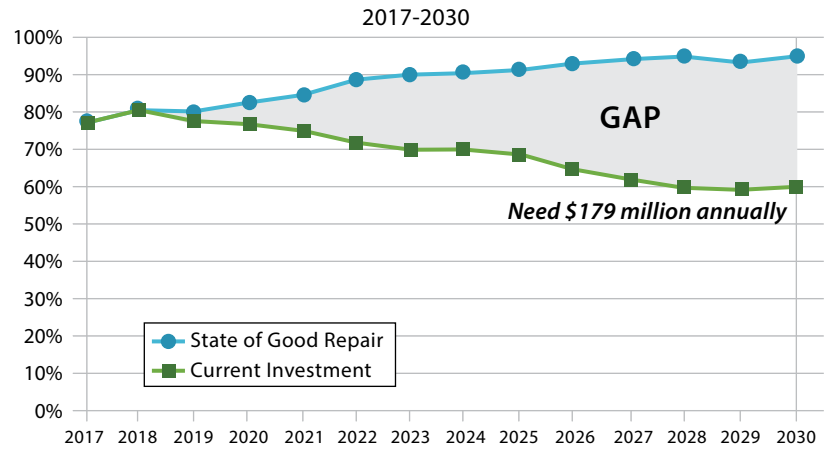
Figure 51 shows the bridge condition curves for meeting the SOGR for Michigan's NHS bridges. Figures 52 and 53 represent the two pavement condition curves for meeting the SOGR for the Interstate system and Non-Interstate NHS.

Figure 51: Michigan NHS Bridge Condition Forecast Comparison



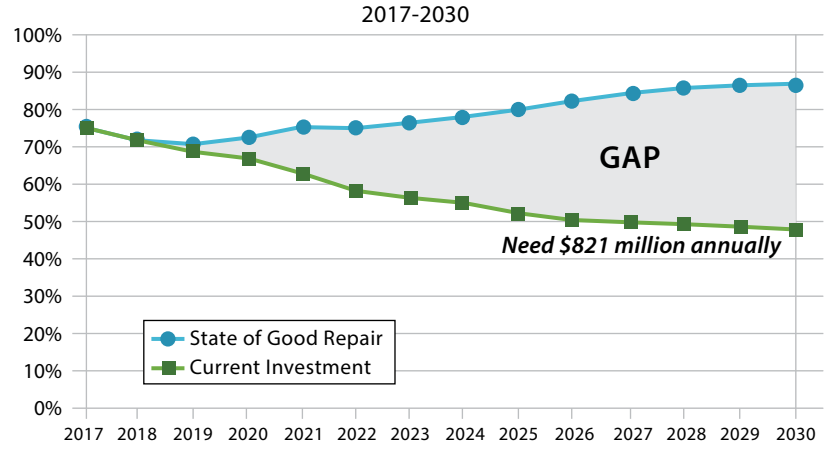
Source: MDOT Bureau of Bridges and Structures

Figure 52: Michigan Interstate RSL Pavement Forecast Comparison

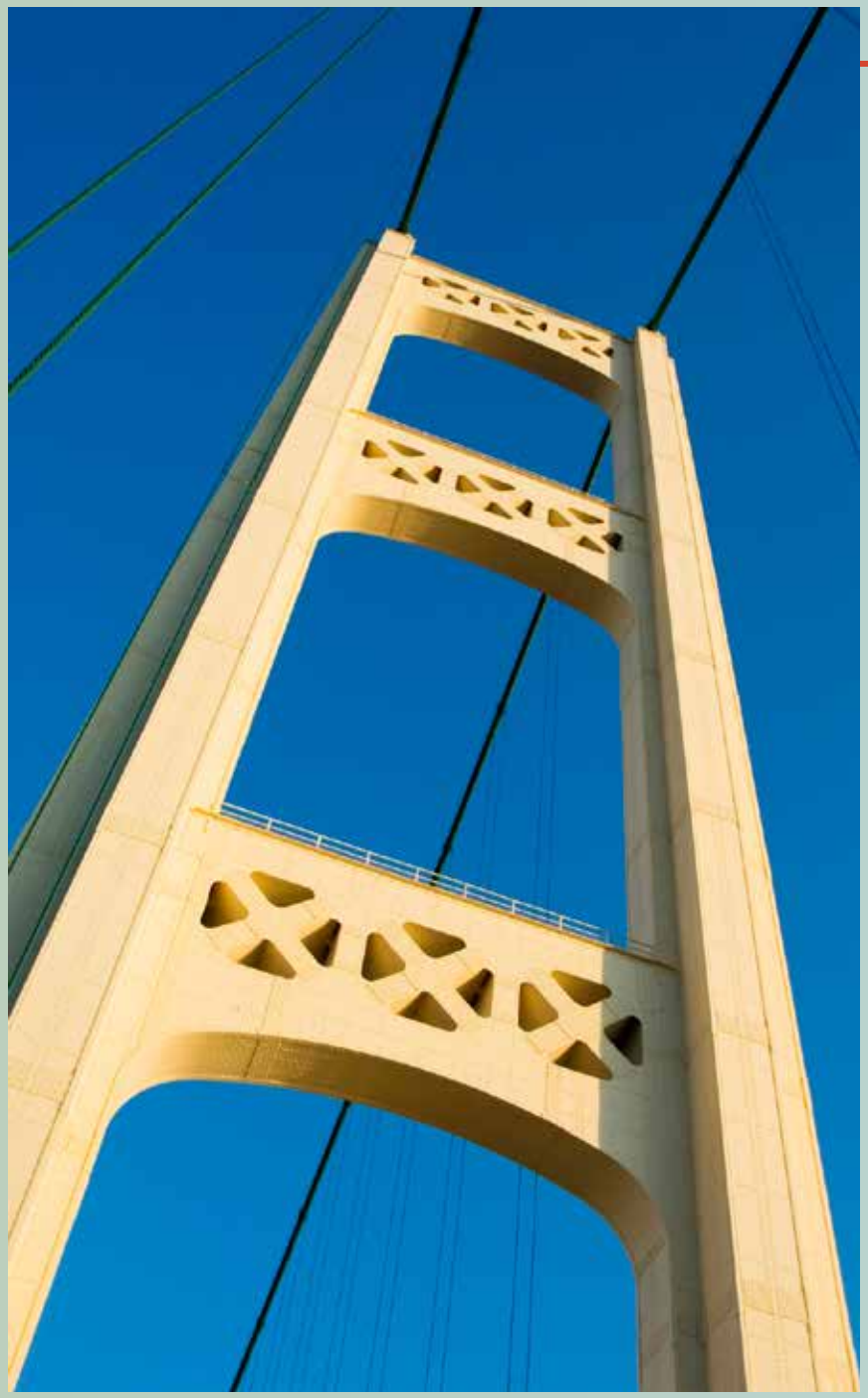


Source: MDOT Bureau of Transportation Planning

Figure 53: Michigan Non-Interstate NHS RSL/PASER Pavement Condition Forecast Comparison



Source: MDOT Bureau of Transportation Planning



Summary

To meet the SOGR for NHS bridges, an average additional investment of $32 million per year would be needed through 2028. This investment improves the condition of NHS bridges to 95 percent good or fair based on deck area.

To meet the SOGR for NHS pavement, an average additional investment of $1 billion per year would be needed through 2028. This is comprised of an additional $179 million per year for the Interstate system and an additional $821 million per year for the Non-Interstate NHS. This investment improves the condition of the Interstate routes to 95 percent good or fair, based on RSL, and improves the Non-Interstate NHS pavement conditions to 85 percent good/fair, based on RSL and PASER. Under the constrained investment strategy, however, the condition of Interstate pavement would fall to just 60 percent good or fair and Non-Interstate NHS condition would fall below 50 percent good or fair, based on their respective condition measures.

TAMP Webpages

Initial TAMP –
https://www.Michigan.gov/documents/mdot/Initial_Transportation_Asset_Management_Plan_622319_7.pdf

Final TAMP –
https://www.Michigan.gov/MDOT/0,4616,7-151-9621_15757---,00.html

MDOT NHS Inventory and Condition Homepage –
https://mdot.maps.arcgis.com/apps/MapSeries/index.html?appid=be36cb6ba7884298b4341aa93d6e6096

Michigan Bridge Conditions –
https://mdot.maps.arcgis.com/apps/MapSeries/index.html?appid=fb70725b2be04dc7b01703d0b6c91bb6

MDOT Featured Maps –
http://featuredmaps-mdot.opendata.arcgis.com/

2019-2023 Five-Year Transportation Program –
https://www.Michigan.gov/documents/mdot/MDOT_5_Year_Plan_2019-23_DRAFT_628310_7.pdf

Michigan Hazard Analysis –
https://www.Michigan.gov/documents/msp/Doc1_394216_7.pdf

State Transportation Commission –
https://www.Michigan.gov/MDOT/0,4616,7-151-9623_31969_31970---,00.html

Transportation Asset Management Council –
https://www.Michigan.gov/TAMC/

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Michigan Department of Transportation