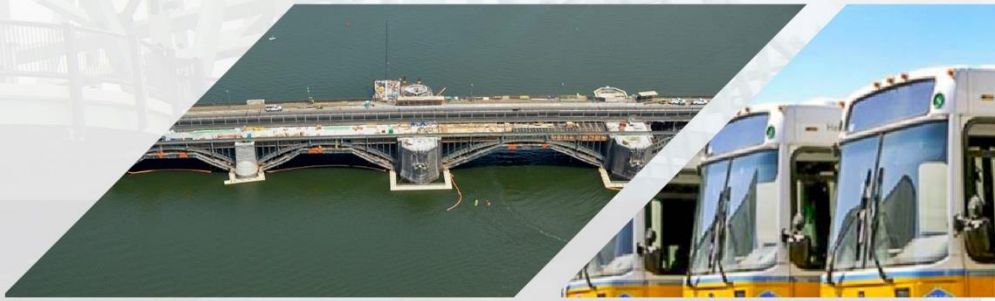
Progress Report of the

Performance and Asset Management Advisory Council



presented by

Patricia Leavenworth, P.E., Chair

September 2016

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Performance and Asset Management Advisory Council

September 30, 2016

The Honorable Karen E. Spilka
Chairwoman
Senate Committee on Ways and Means
State House, Room 212
Boston, MA 02133

The Honorable Brian S. Dempsey
Chairman
House Committee on Ways and Means
State House, Room 243
Boston, MA 02133

The Honorable Thomas M. McGee
Senate Chairman
Joint Committee on Transportation
State House, Room 109C
Boston, MA 02133

The Honorable William M. Straus
House Chairman
Joint Committee on Transportation
State House, Room 134
Boston, MA 02133

Members of the General Court:

On behalf of the Performance and Asset Management Advisory Council, I am pleased to submit this report in compliance with Chapter 46, Section 12 of the Acts of 2013 and as referenced in Chapter 6C, which requires the Council to report annually on progress by the Massachusetts Department of Transportation (MassDOT) to develop a mature asset management system.

Our first annual submission last year focused on asset management by MassDOT's Highway Division. This report expands that reporting to also include the asset management efforts of MassDOT's Aeronautics and Rail and Transit Divisions as well as the MBTA. Transportation Asset Management (TAM) enables "better decision-making based upon quality information and well-defined objectives," according to the American Association of State Highway and Transportation Officials. By including all of its divisions, MassDOT is moving significantly closer to the Legislature's goal of a fully integrated asset management system, with investment decision-making based on quality data from all divisions.

While more work remains to fully populate asset databases, MassDOT already has sufficient information to prioritize investments in basic assets, from MBTA signals and switches to non-Interstate pavement. Such prioritization is reflected in MassDOT's 2017-2021 Capital Investment Plan. That Plan organizes a portfolio of strategic investments into three priority areas of descending importance: system reliability, asset modernization, and capacity expansion. More than 60 percent of CIP spending is focused on system reliability. Such priorities form the foundation of not only the CIP, but of a vision for MassDOT and the MBTA where all Massachusetts residents and businesses have access to safe and reliable transportation options.

The Legislature also asked this Council to consider the asset management practices of municipalities. This report thus includes preliminary information about the universe of assets at the municipal level and current management practices. Noteworthy is MassDOT's newly funded Small Bridge Program, through which the Department will help localities address deteriorated structures through a needs-based application process. The Council also intends to work with MassDOT to explore treatment and investment options for municipalities to address pavement conditions.

The Council looks forward to such ongoing collaboration with MassDOT, local governments, and the Legislature in the upcoming year.

Respectfully submitted,

Patricia Leavenworth, P.E., Chair

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1 Introduction

Transportation infrastructure enhances the quality of life and economic competitiveness of the Commonwealth. Under the leadership of Secretary and Chief Executive Officer Stephanie Pollack and governed by the Department of Transportation Board of Directors and the Massachusetts Bay Transportation Authority (MBTA)'s Fiscal and Management Control Board (FMCB), MassDOT's four operating divisions (Figure 1.1) and the MBTA transparently plan, prioritize, and strategically invest in a multimodal vision to maintain and modernize assets while minimizing life cycle costs with the objective of better serving system users. In doing so, they share a set of three capital planning goals:

1 Reliability
Maintain and improve the overall condition and reliability of the transportation system

2 Modernization
Modernize the transportation system to make it safer and more accessible and to accommodate growth

3 Expansion
Expand diverse transportation options for communities throughout the Commonwealth

Transportation Asset Management (TAM) promotes key business practices to support these goals. The American Association of State Highway and Transportation Officials (AASHTO) Subcommittee on Asset Management describes TAM as "a strategic and systematic process of operating, maintaining, upgrading, and expanding physical assets effectively through their life cycle."

Figure 1.1 Divisions of MassDOT

Highway

Rail and Transit

Aeronautics

Registry of Motor Vehicles

The purpose of this document is to summarize progress toward implementing an integrated TAM system in MassDOT's Divisions: Highway, Rail and Transit, Aeronautics, and the MBTA. In addition, the report will address municipalities.

1.1 Purpose of this Report

The Performance and Asset Management Advisory Council was created by Chapter 46 of the Massachusetts General Law Acts of 2013, which charges:

- There shall be a performance and asset management advisory council charged with advising the board on the creation of an integrated asset management system.
- The council shall review the criteria required for the performance measurement system. The council shall make a report to the board on the following:
  - Improvements that can be made to ensure comprehensive multi-modal transportation planning and analysis;
  - Additional performance metrics, such as enterprise-wide measures across modes, contract management, procurement, project controls, financials, organizational and prioritization outcomes; and
  - Economic development impacts, and benchmarks measured against performance by other states and countries.

  The council shall make recommendations on the processes and tools needed to implement a strategy for the performance and asset management system.
- The council shall present minimum standards and guidelines delineating standardized data and information that shall be contained in the performance and asset management systems, including the complete integration of transit, highway, aeronautics, water and port assets, and the possible inclusion of municipal roadways. The minimum standards shall include:
  - The keeping of accurate and uniform records of real transportation assets;

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- The mileage and condition of each road and bridge system under various jurisdictions;
- The receipts and disbursements of road, street and transit funds;
- A multiyear compilation of projects anticipated to be contracted for or by the department or local transportation agencies that are funded in whole or in part with state or federal funds, and
- Any other categories established by the council.

The council shall recognize the differences in local, regional or other agencies' circumstances and nothing in this section shall prohibit a local transportation agency or other governmental agency from using a separate asset management process on any eligible system. All quality control standards and protocols shall, at a minimum, be consistent with any existing federal requirements and regulations and existing government accounting standards.

- On or before October 1 of each year, the council shall provide an annual progress report on the performance and asset management system to the House and Senate committees on ways and means and the Joint Committee on Transportation.

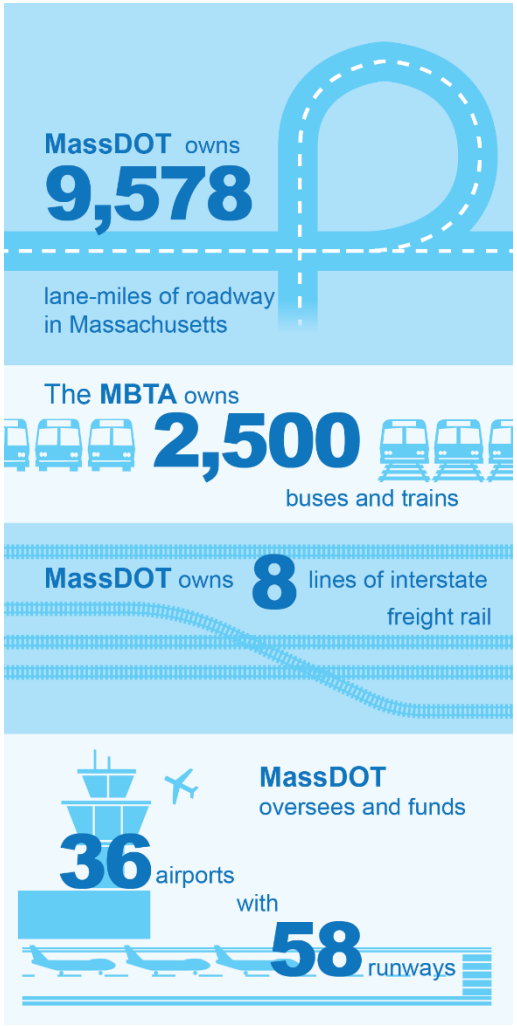
This report, submitted on September 30, 2016, satisfies the Council's legislative duty.

1.2 Context for This Report

MassDOT assets form the core of the Massachusetts transportation system, as summarized in Figure 1.2. The Department has made significant strides since its creation in 2009 to incorporate performance-based, data-driven planning principles to keep pace with innovation in the maintenance and operation of transportation systems.

In addition to this council, the Department charged its Office of Performance Measurement and Innovation (OPM&I) in 2011 with overseeing the development and communication of performance metrics to stakeholders and to the public. In 2013, the Legislature established an independent Project Selection Advisory Council to assist the Department in the development of a scoring system to assess capital projects based on

Figure 1.2 MassDOT Assets



weighted priorities. The recently completed 2017-2021 Capital Investment Plan (CIP) is the first to include the MBTA, bringing all of MassDOT's investment decisions under a single data-driven process, which is discussed in Chapter 7 of this report.

MassDOT's progress in implementing this forward-looking approach is keeping Massachusetts apace with federal requirements. Congress introduced the requirement for Transportation Performance Management (TPM) in 2012 with the *Moving Ahead for Progress in the 21st Century Act (MAP-21)*. Since 2012, the Federal Highway Administration (FHWA) has mandated – and the Federal Transit Administration (FTA) will recommend – that public transportation agencies issue official asset management plans. MAP-21 priorities have been carried forward in the *Fixing America's Surface Transportation Act (FAST Act) of 2015*.

As FHWA and FTA finalize asset management rules for highways and transit, they will include maximum asset condition thresholds and require MassDOT to set condition targets.

MassDOT recognizes the need to employ performance-based planning not only where it is mandated, but across all Divisions and all modes. To comply with MAP-21's asset management requirements for Highway and Transit, MassDOT has begun development of its first Highway Division Transportation Asset Management Plan (TAMP), which will complement the MBTA's initial Transit Asset Management Plan (TAM Plan), completed in 2014.

Over this past year, MassDOT has also implemented the geoDOT Geospatial Information System (GIS) tool, which provides the public with access to spatially-defined asset data and mapping tools to visualize it within a web browser. Existing datasets on roads and highways, bridges, transit, and rail, among others, are available through geoDOT and MassDOT is committed to expanding its offerings over time.

Figure 1.3 Timeline of TAM at MassDOT

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1.3 Describing Asset Management and Performance

1.3.1 Asset Management

An **asset** is any owned physical object that provides value to an organization. An **asset class** is a category of assets. **Asset Management** is knowing what you value, how many of those things you own, where they are located, their characteristics and conditions, as well as maintaining the coordinated business processes to minimize costs and maximize the useful life of these assets.

1.3.2 Performance Management

Performance management is a business process that aligns measures and investment with organizational goals and objectives. **Performance measures** provide data-based answers to the question, "How are we doing?" They can express asset condition, operational efficiency, and customer service, among other topics. They are used to establish targets and to assess progress toward achieving them. A **performance metric** is a quantifiable indicator of performance or condition.

1.3.3 An "Integrated Asset Management System"

MassDOT divisions use several asset management systems. The Highway Division tracks bridge inventory and condition in the Bridge Inspection Management System (4D) and manages pavement inventory, condition, and future deterioration in the Deighton Total Infrastructure Management System (dTIMS). The MBTA maintains asset records in its SGR Database. The RTAs have implemented TransAM to manage vehicles and facilities, and the Aeronautics Division is currently implementing AIR-Port to track airport inspections, assets, and projects.

For the 2017-2021 CIP, MassDOT integrated performance forecasts from these data systems into the Planning for Performance (PfP) tool. PfP allowed the Department to visualize the performance impacts of alternative funding scenarios and tradeoffs between programs. More detail on PfP and the CIP development process is provided in Chapter 7.

1.3.4 State of Good Repair and Backlog

The MBTA has for many years described its performance to the public using "State of Good Repair" (SGR) backlog. SGR is defined as the point at which assets are collectively in satisfactory shape. "Backlog" is defined as the amount of money required to move all assets into SGR and can be used over time as an indicator of whether an agency is keeping pace, improving, or struggling in the maintenance of its assets. It is also possible to compare backlog across asset categories if it is defined consistently.

Historically, no division or asset owner at MassDOT other than the MBTA has computed backlog or communicated it to the Legislature and to the public. The Council requested backlog estimates for the Highway Division, for the Rail and Transit Division, and for municipalities. The methodology for computing backlog for each of these asset owners, where available, is discussed in **Appendix A**.

1.3.5 Performance Targets and Performance Needs

Beginning in 2017, MassDOT will set **performance targets** and **performance needs**. Performance targets will be identified collaboratively by asset owners and OPM&I, with time-bound metrics for each asset category. The performance need is the annual spend required to meet the target in the horizon year. Targets can account for several metrics, and needs are implicitly comparable across asset classes and across years.

1.4 Structure of This Report

This report summarizes the TAM practice of the MassDOT Highway Division, the MBTA, the MassDOT Rail and Transit Division, the MassDOT Aeronautics Division, and Municipalities. For each of these groups, the report (Sections 2-6) addresses:

- Definition and hierarchy of assets;
- Quality of asset data – a high quality dataset is trusted to be accurate, covers the full geographic scope of the Commonwealth, includes all important attributes, and is kept updated on an established schedule;
- Past performance, investment levels, and future performance;

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- Status of a formal asset management plan; and
- Next steps to advance TAM practice.

Section 7 summarizes investment prioritization strategies, specifically those used to develop the 2017-2021 CIP.

Appendix A summarizes backlog methodologies. Appendix B lists Highway Division Assets. Appendix C provides a glossary of terms.

1.5 Policy Directive

The Council recommends that MassDOT clarify the Department's asset management policy in a formal directive that positions that policy as an integral component of MassDOT's capital planning process. Provisions of the directive could include requirements that:

- Divisions identify personnel (individuals or groups) to serve as champions for the asset management program;
- Each division develop an asset management strategic plan with an initial focus on defining asset inventory and evaluating condition;
- Divisions independently maintain complete, accurate, and up-to-date data on their assets, stored in sufficiently sophisticated systems;
- Divisions review the efficacy of their financial and contract management systems;
- Divisions model asset condition and performance where appropriate; and
- OPM&I and the Office of Transportation Planning assist the divisions as needed in fulfilling these requirements.

2 The MassDOT Highway Division

2.1 Highway Division Asset Hierarchy

Inventory and condition assessment of pavement, bridges, and tunnels is mandated by FHWA. The Highway Division TAM Steering Committee completed a prioritization exercise for all assets owned by the Highway Division. A table of 99 prioritized assets is available in **Appendix B.** Bridges and culverts were the highest-ranked assets, followed by tunnels and drainage pumps (lower than bridges because of their low probability of failure), ancillary structures (e.g., gantries and sign structures) and pavement.

The Highway Division's key assets include:

- **Pavement:** MassDOT owns 9,578 lane-miles of roadway in Massachusetts, including all interstates and limited-access freeways as well as many major arterials. The roadway includes the pavement, shoulders, and highway ramps.
- **Bridges:** The National Bridge Inventory Standards (NBIS) define a bridge as a structure with a span length of over twenty feet. More than 5,000 structures in the Commonwealth are thus defined as "NBI Bridges." MassDOT has capital responsibility for bridges owned by the Highway Division and by municipalities. Municipalities are responsible for preservation of their bridges.
- **Culverts:** Culverts are structures with a span less than 10 feet and a diameter greater than four feet (i.e., not pipes). To date, MassDOT has identified more than 3,000 culverts through the ongoing culvert inventory project.
- **Tunnels:** Tunnels include the structure, overhead elements (e.g., ceiling hangers and panels), and life safety and ventilation equipment. MassDOT owns tunnels in 13 locations.
- **Ancillary Structures:** Ancillary structures are vertical or overhanging and would impede the roadway if they fell. These include full and cantilever-span support structures for static and variable message signs, electronic tolling gantries, traffic signal supports, and lighting structures.

FAQs – Highway

What is going well?

- Management practices for bridges and pavement the highest priority and most valuable assets exceed Federal standards.
- The Highway Division has gone beyond bridges and pavement to begin managing other assets in the same fashion.

What can be improved?

- MassDOT is adjusting to FHWA bridge performance metrics.
- MassDOT will meet performance targets for Non Interstate Pavement through project selection and increased funding.

The bottom line?

MassDOT collects high quality data on its highway assets that supports data driven decision making.

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- **Signs and Signals:** MassDOT owns more than 250,000 signs and signposts and 1,531 traffic signals.
- **Pedestrian Ramps:** MassDOT owns more than 26,000 pedestrian ramps.
- **Bicycle and Sidewalk:** MassDOT owns sidewalks and bicycle lanes on many roadways. The Highway Division is required to construct and enhance these facilities through highway reconstruction projects.

2.1.1 Status of Highway Division Inventory and Condition Data

Inventory and condition data for the Highway Division's key assets is described below.

- **Pavement:** The Pavement Management Section of the Highway Division collects and reports pavement condition data in one- or two-year cycles. Currently, all MassDOT-owned roadways are surveyed, as well as any facilities owned by others that are listed on the National Highway System (NHS). Data are collected at highway speeds using a specially equipped vehicle and software application. The survey measures pavement roughness and distresses that include cracking, rutting, and raveling.

  Raw pavement data are analyzed and characterized by an overall "Pavement Serviceability Index" (PSI). Data is stored in the Pavement Management Section's Deighton Total Infrastructure Management System (dTIMS). A summary from dTIMS is included in the Road Inventory File (RIF), publicly available through MassDOT's geoDOT portal. This is a high-quality dataset.

- **Bridges:** FHWA requires that NBI structures – regardless of ownership – be inspected by MassDOT every two years. Structures with a span of between 10 and 20 feet are officially known as "Massachusetts Bridges" (BRIs), sometimes called "large culverts." MassDOT has committed to an inventory of BRIs. The initial round of inspections is currently 13% complete (109 of 1,705), though MassDOT anticipates finding previously unknown BRIs during the inspection process as well. Once complete, MassDOT will inspect BRIs on the same schedule and using the same method used for NBIs. Currently and moving forward, inventory and condition data on NBIs and BRIs are stored together in MassDOT's Bridge Inspection Management System, known as "4D". This is a high-quality dataset.

- **Culverts:** MassDOT began a culvert inventory project in spring 2016. The Department initially populated the inventory by identifying stream crossings on maps and plans, prioritizing culverts on higher functional class roadways. To date, more than 3,000 culverts have been identified. This dataset is still under development and is not yet of high quality. Phase II will confirm the data in the field.
- **Tunnels:** The MassDOT tunnel inspection program began in June 2016 and complies with the National Tunnel Inspection Standards (NTIS) released in 2015. Biennial inspections evaluate structural, mechanical, and electrical features. Internal policy directives require inspection of overhead elements (e.g., ceiling hangers and panels) annually and inspection of life safety and ventilation equipment on six-month intervals. Collection of NTIS inspection data is ongoing, with data recorded in 4D.
- **Ancillary Structures:** MassDOT has begun inspecting ancillary structures and is approximately 25% finished, recording location, physical characteristics, and condition using a method similar to that for bridges (i.e., an element-based scoring scale). Future inspections will be scheduled to reflect the level of risk uncovered during the first round. Data is recorded in 4D.
- **Signs and Signals:** MassDOT has implemented the VUEWorks asset management system for sign and signal inventory and condition. The system currently contains records for 100% of the Department's approximately 250,000 signs. VUEWorks also contains inventory, condition, and maintenance work orders for 100% of MassDOT's 1,531 traffic signals.
- **Pedestrian Ramps:** MassDOT has a 100% inventory of pedestrian ramp locations on state-owned roadways. Data on over 26,000 locations was collected through a detailed, multi-criteria field inspection process and housed in a custom-built web-based application.
- **Bicycle and Sidewalk:** MassDOT records data on sidewalks and bicycle facilities within the Road Inventory File. The confirmation and update of this data is a priority for Division.

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2.2 Performance, Investment, and Forecasts in the Highway Division

The Highway Division has mature processes for forecasting performance based on investment levels for state-owned pavements and bridges. Because it has not yet developed these processes for other asset classes, this section will discuss performance, investment, and forecasts for pavements and bridges only.

Pavement Condition Measures

Federal law requires that Departments of Transportation report percentage of NHS pavement in both "good" and "poor" condition to FHWA and that they define and work to achieve goals for those metrics over time. MassDOT defines pavement condition using PSI, defined in Figure 2.1. FHWA's Notice of Proposed Rulemaking establishes a maximum threshold of 5% for Interstate pavements in "Poor" condition (using each DOT's self-selected definition). States with more than 5% of their Interstate pavement in "Poor" condition for two consecutive years would be subject to restrictions on how Federal aid can be allocated. To reflect this standard, this document reports tolled and non-tolled Interstates together.

Bridge Condition Measures

MassDOT defines bridge condition using the nine-point NBIS scale shown in Figure 2.2 (next page), where higher values indicate better condition. "Good" condition begins at a rating of 7 and "Poor" is defined as "structurally deficient" (SD), a rating of 4 or lower.

FHWA's MAP-21 Notice of Proposed Rulemaking introduces a new performance metric for bridges: SD Deck Area on the NHS. This number is computed by dividing the total square footage of SD NHS bridges by the total square footage of all NHS bridges. FHWA has set a maximum threshold of 10% SD Deck Area. States with more than 10% for three consecutive years (note that the standard was two for pavement) would be subject to restrictions on how federal aid can be allocated.

Figure 2.1 Pavement Serviceability Index

Photo Credit: Oregon DOT and Iowa DOT

2.2.1 Historic Performance of Highway Division Assets

Historic Performance for Pavement

Tables 2.1 and 2.2 provide percentages of pavement in "Excellent/Good" and "Poor" condition for MassDOT Interstate and non-Interstate highways from 2012-2015.

Table 2.1 Condition of MassDOT Interstate Pavement, 2012-2015

Condition	2012	2013	2014	2015
Excellent/Good	82%	81%	80%	82%
Fair	15%	16%	18%	16%
Poor (5% FHWA max)	3%	3%	2%	2%

Table 2.2 Condition of MassDOT Non-Interstate Pavement, 2012-2015

Condition	2012	2013	2014	2015
Excellent/Good	62%	65%	64%	62%
Fair	21%	21%	23%	25%
Poor	17%	14%	13%	13%

A full description of MassDOT's approach to pavement backlog is included in this Council's January 2016 report *Progress by MassDOT Highway Division on Integrated Asset Management* (PAMAC 2015) and is provided in **Appendix A.1**. Estimated 2016 backlog for Highway Division Interstate pavement is $0.24 billion and estimated 2016 backlog for Highway Division Non-Interstate pavement is $1.3 billion.

Figure 2.2 NBIS Rating Scale

Photo Credit: Google

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Historic Performance for Bridges

Table 2.3 provides the percentage of deck area on Highway Division and municipal NBIs that was SD in the period 2013-2015. Approximately 44% of the MassDOT NBI inventory is on the NHS.

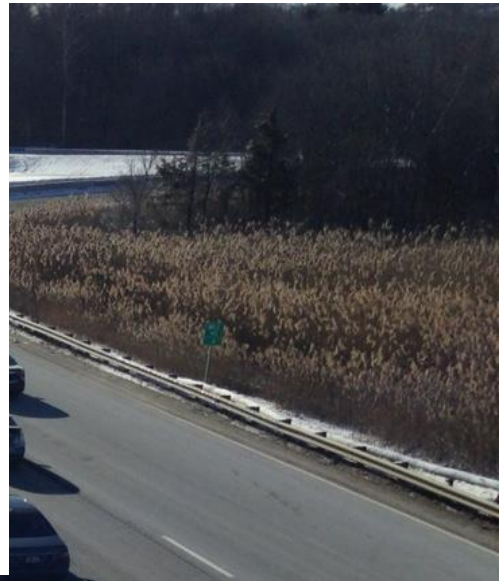


Table 2.3 Condition of Highway Division and Municipal NBIs, 2013-2015

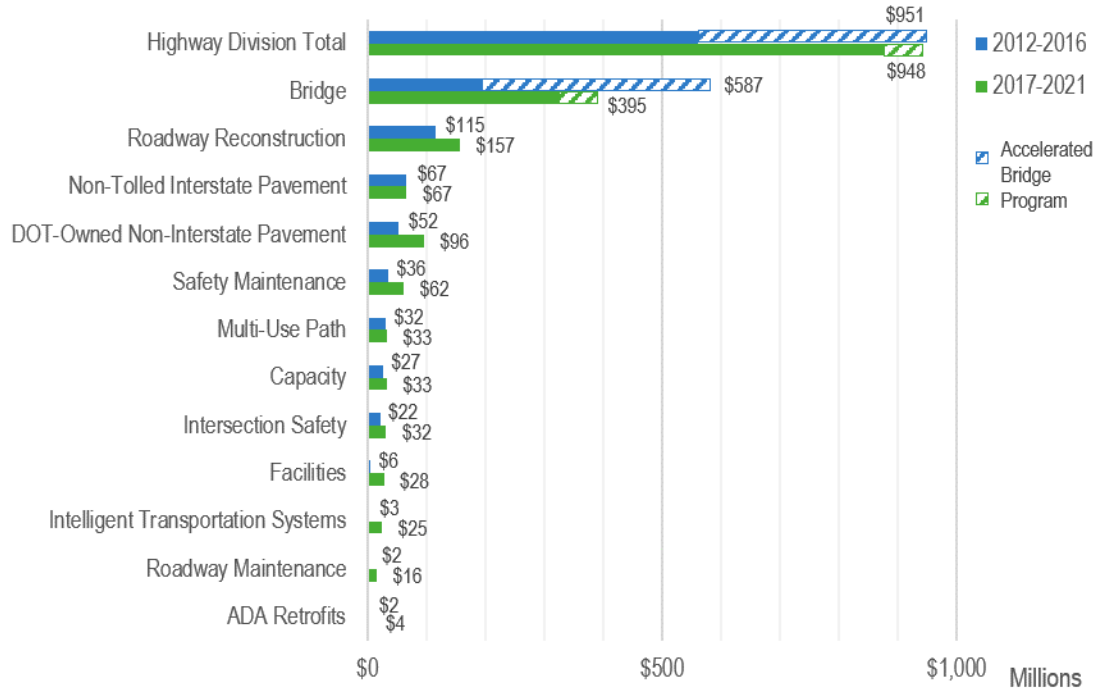
Metric	NHS	2013	2014	2015
% of NBI Deck Area SD	NHS (10% FHWA max)	13.46%	16.34%	16.86%
	Non-NHS	10.99%	10.29%	9.94%

The process for computing bridge backlog is described in **Appendix A.2**. Estimated 2016 backlog for Highway Division and municipal bridges is $3.75 billion.

2.2.2 Capital Investment in the Highway Division

Annual average investment in each Highway Division capital program from 2012-2016 and from 2017-2021 is shown in Figure 2.3. Note that capital programs do not perfectly align with asset classes.

Figure 2.3 Average Annual Highway Division Capital Investments by Asset Class, 2012-2016 and 2017-2021



The Accelerated Bridge Program expired in FY2016, with some residual spending in FY2017 and FY2018. Consequently, bridge funding declines despite the capital Bridge Program increasing in size. It should also be noted that municipal spending on bridge preservation can reduce MassDOT's capital investment in those same structures by resolving structural deterioration cost effectively before it requires significant intervention.

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2.2.3 Performance Targets and Forecasting in the Highway Division

Targeted and Forecast Performance for Pavement

MassDOT's first priority for pavement is to continue to meet the FHWA maximum threshold of 5% of Interstate pavement in poor condition. In addition, the Department has collaboratively set the following performance targets for pavement in good or excellent condition (2016 will serve as the base year, 2015 base year shown for reference):

- **Interstate Pavement in Good or Excellent Condition**
  - 3% improvement in two years, equating to 84% in 2018.
  - 6% improvement in four years, equating to 87% in 2020.
  - 8% improvement long-term, equating to 88%.
- **Non-Interstate Pavement in Good or Excellent Condition**
  - 3% improvement in two years, equating to 63% in 2018.
  - 6% improvement in four years, equating to 65% in 2020.
  - 20% improvement long-term, equating to 74%.

Tables 2.4 and 2.5 show condition forecasts for MassDOT Interstate and non-Interstate NHS pavement from 2016-2021, developed by the Pavement Management Section in dTIMS. MassDOT uses deterioration curves developed specifically for Massachusetts highways that relate pavement quality to repairs undertaken by the Department. Taken collectively, these curves relate overall condition of the Commonwealth's pavements to annual investments in capital projects and operational repairs. MassDOT also considers impacts on safety, bicycle and pedestrian mobility, and storm water management in selecting capital and maintenance work. The projections in Tables 2.4 and 2.5 assume the levels of investment in the CIP.

Table 2.4 Forecast Condition of MassDOT Interstate Pavement, 2016-2021

Condition	2016	2017	2018	2019	2020	2021
Excellent/Good	85%	87%	89%	92%	94%	95%
Poor (5% FHWA max)	2%	2%	2%	2%	1%	1%

Table 2.5 Forecast Condition of MassDOT Non-Interstate NHS Pavement, 2016-2021

Condition	2016	2017	2018	2019	2020	2021
Excellent/Good	54%	50%	46%	42%	38%	38%
Poor	18%	20%	22%	24%	26%	37%

Figures 2.4 and 2.5 show the percentage of pavement in "Good" and "Excellent" condition and in "Poor" condition between 2012 and 2015, and projected until 2021, assuming 2017-2021 CIP funding.

Figure 2.4 Condition of MassDOT Interstate Pavement Relative to Target, 2012-2021

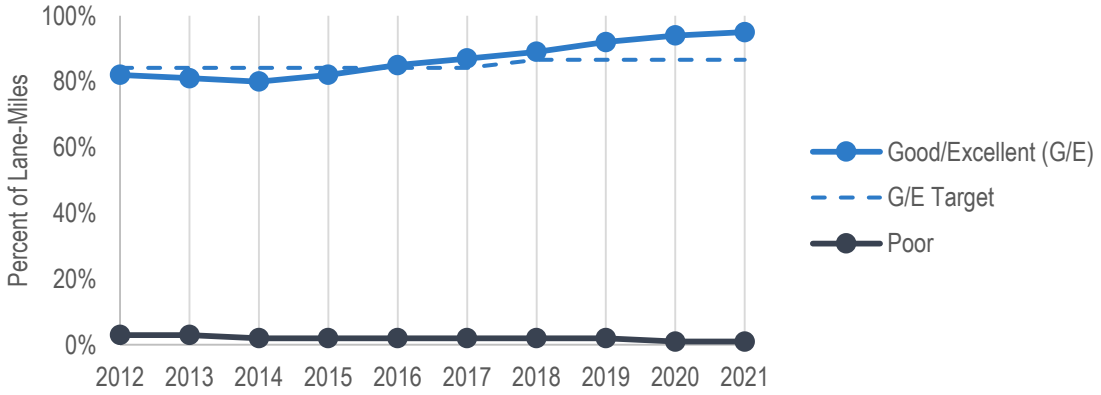

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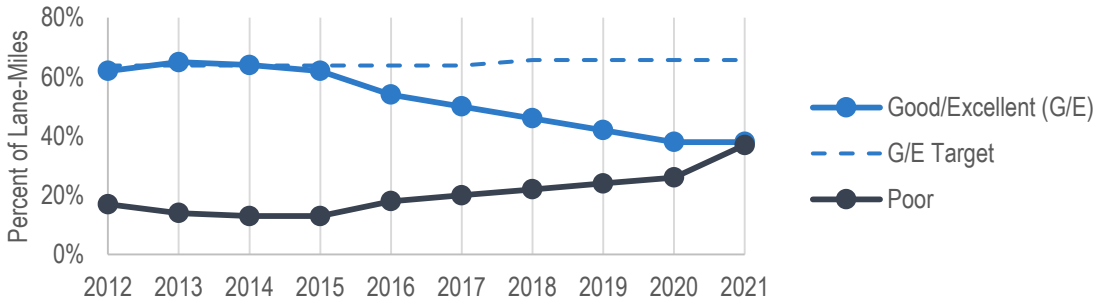
Figure 2.5 Condition of MassDOT Non-Interstate NHS Pavement Relative to Target, 2012-2021



MassDOT projects that it will exceed its performance targets for Interstate Pavement through 2020, but will miss its targets for Non-Interstate Pavement in both of those years.

The 2017-2021 CIP increased the funding to the non-Interstate pavements to stave off even more rapid deterioration. The inclusion of bicycle and pedestrian improvements (from the Healthy Transportation Directive) helps MassDOT meet one goal but also reduces its funds for pure pavement improvement. Non-pavement spending currently accounts for approximately one-third of pavement project costs (put another way, a 50% per-mile increase over the cost of pavement alone).

Forecast Performance for Bridges

MassDOT's first priority for bridges is to meet the FHWA maximum threshold of 10% of deck area on SD bridges. MassDOT has collaboratively set the following performance targets for bridge condition:

- **Structurally Deficient Deck Area on NHS Bridges**
  - 14% after two years (i.e., in 2018).
  - 13% after four years (i.e., in 2020).

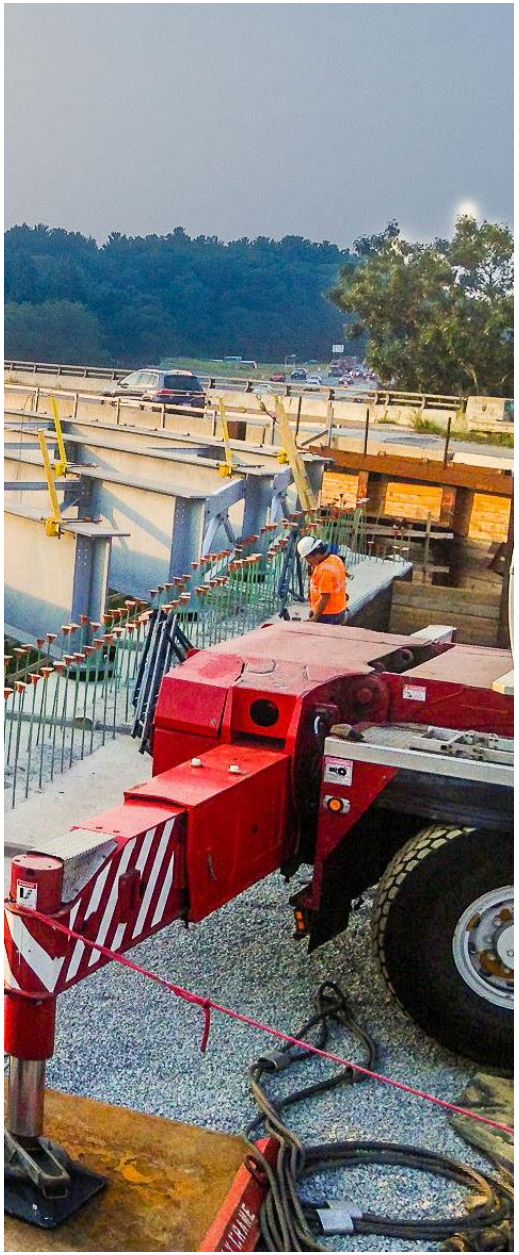
– Less than 10% (i.e., the FHWA maximum) in the long-term.

Although MassDOT will not initially meet the FHWA target, it has begun to shift its practices to accommodate the FHWA standard. The loss of investment flexibility associated with missing the federal target will not impact MassDOT investments, as the Department has voluntarily adopted the required investment profile.

MassDOT has historically invested responsibly in its bridges, but the transition to SD deck area as the governing performance measure (from percentage of total bridges in SD condition) has required the Department to revise its approach. **The Highway Division is evaluating deck area-based modeling software and methodologies for implementation in 2017.** While the amount of SD deck area addressed is easy to predict – MassDOT knows what work it will perform and when – it is more difficult to predict the deterioration of deck area to SD status, particularly as it can be significantly impacted by a few large structures.

For instance, in 2014, the I-91 Viaduct in Springfield, the Gilmore Bridge in Boston, the General Edwards Bridge in Lynn and the I-190 Viaduct over MA-12 in Worcester added 2.5% of overall NHS deck area to the SD total (i.e., a quarter of the FHWA threshold in four bridges).

The 2017-2021 CIP includes the rehabilitation or replacement of 79 NHS SD bridges, accounting for 2.8 million SF of deck area (10% of the total inventory). A further 78 NHS SD bridges will be repaired, accounting for just over 1 million SF (3% of the total inventory). **In all, approximately 75% of the current NHS SD deck area in Massachusetts is scheduled for resolution in the 2017-2021 CIP, though sustained funding has not been identified for all of this work, and the progress will be countered by newly deteriorated deck area over that period.**



2.3 Status of the Highway Division Asset Management Plan

The Highway Division in 2015 completed a TAM Strategic Plan that introduces overarching implementation goals, objectives, and actions. The high-level goals touched on TAM practice, data collection and management, and technical architecture, and included:

- Develop, document, implement, and maintain **business processes** across the Highway Division that support TAM;
- Implement, utilize, and maintain a full suite of **asset management applications** to support defined TAM business processes;
- Collect, update, and share **asset management data**, adhering to an adopted data governance policy (expressed in the Highway Division's Data Governance Manual, completed in 2016); and
- Implement and maintain a **service-oriented information technology architecture** and its supporting infrastructure.

The Highway Division has initiated technical working groups to implement the plan's recommendations.

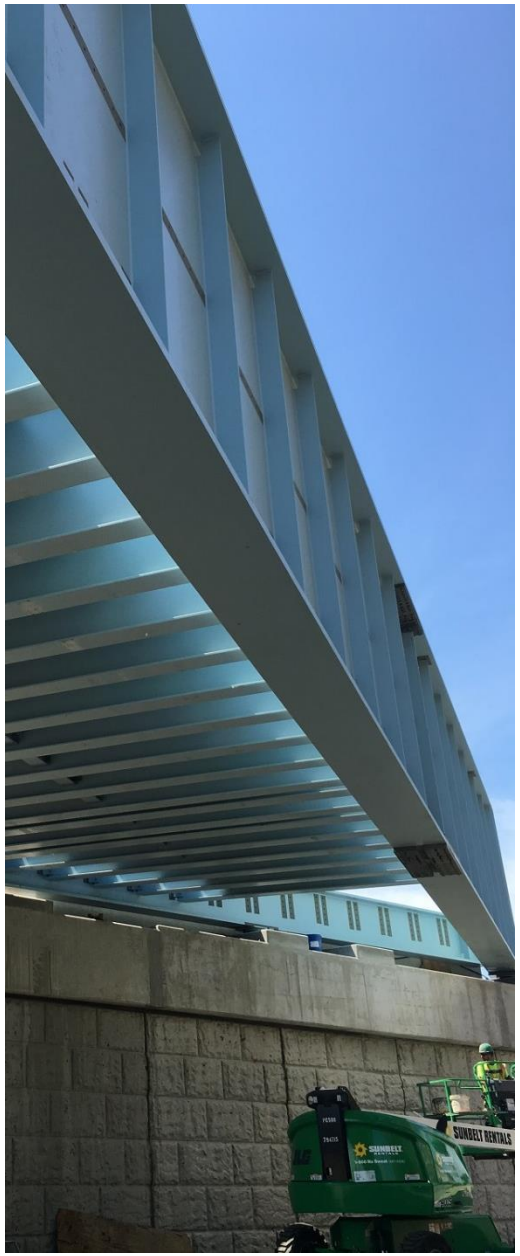
FHWA will require a Transportation Asset Management Plan (TAMP) that covers at least bridges and pavement and details inventory and condition, performance measures and gaps, life-cycle management and investment strategies, financial performance, risk management, and anticipated enhancements. DOTs will be required to update their TAMP on a five-year basis.

MassDOT is approximately 80% complete with the TAMP's risk assessment, financial plan, and life cycle management and investment chapters. The finalization of these and the completion of chapters on objectives and measures, system inventory and condition, and performance gap identification, as well as an enhancement plan for TAM processes, is expected in 2017.

2.4 Next Steps for the Highway Division

In 2017, MassDOT will continue to align its capital investment decisions with its performance goals:

- For **Interstate Pavement**, continue to meet the FHWA maximum of 5% of lane-miles in poor condition and then meet the targets defined in the MassDOT Tracker;



- For **Non-Interstate Pavement**, define and meet a maximum percent of lane-miles in poor condition and then meet the targets defined in the MassDOT Tracker;
- For **Bridges**, ensure that MassDOT is progressing toward the FHWA maximum of 10% of deck area on SD bridges and then meet the targets defined in the Tracker; and
- For all roadways, ensure that functional bicycle and pedestrian facilities are provided for users.

For pavement, MassDOT can best achieve these goals through a well-informed, transparent project selection and delivery process that ensures that available funds are spent completely and effectively. As with all multi-objective decision-making, however, MassDOT will need to make informed tradeoffs based on high-quality data. While pavement data support FHWA performance metrics in its current form, bridge data does not – MassDOT will implement a bridge model in 2017 that accommodates the new deck area metric.

In addition to these goals, the Highway Division expects to accomplish the following in 2017:

- Complete a TAMP;
- Begin to verify culverts identified on maps through inspections;
- Verify the remainder of the sign inventory and record additional tunnel, ancillary structure, sidewalk and bicycle facility assets, as well as utility structures on state-owned roads; and
- Expand the use of the geoDOT site for dissemination of data to the public.

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3 The MBTA

The MBTA is the fifth largest transit property in the United States, serving over 1.3 million passengers per day. It is also the most mature, having opened the first subway system in the country in 1897. It operates in 175 communities, an area of over 3,200 square miles, and provides passenger service through multiple modes, including heavy and light-rail rapid transit lines, bus routes, commuter rail lines, ferry routes, and para-transit services.

3.1 MBTA Asset Hierarchy

The MBTA's key assets include:

- **Bridges:** The MBTA owns 1,068 bridges. The SGR Database breaks a bridge's condition into deck, superstructure, and substructure.
- **Tunnels:** The MBTA's tunnel assets include walls, ceilings, signage, de-watering equipment, ventilation systems, and electrical and lighting systems.
- **Elevators and Escalators:** The MBTA owns and maintains 133 elevators and 161 escalators.
- **Stations:** The MBTA owns 66 subway stations, 61 light rail stations, 138 commuter rail stations, 116 bus shelters (out of 8,500 bus stops), and one ferry dock. Stations are comprised of building components (e.g., frame, foundation, walls) systems (e.g., mechanical, plumbing, HVAC, fire protection), and egress. They are inventoried with the components of major bus stops (e.g., shelters, signs, poles, benches).
- **Revenue Vehicles:** The MBTA owns 432 subway (i.e., the Red, Orange, and Blue Lines) revenue vehicles, 219 light rail (i.e., the Green and Mattapan Lines) vehicles, 500 locomotives and coaches, 991 buses, and 2 ferries. The oldest of these vehicles were purchased in 1946 (the oldest large fleet was purchased in 1969).

FAQs – MBTA

What is going well?

- SGR Score is a strong metric calculated for all assets in the SGR Database.
- The MBTA can predict the funding required to keep known assets in good repair.

What can be improved?

- Inventories are still in progress for some major asset classes.
- A continued institutional commitment is required to realize benefits of performance management.

The bottom line?

Investment required to "tread water" = $472 million per year.

CIP investment for 2017 2021 $767 million per year.

- **Non-Revenue Vehicles:** The MBTA owns over 1,000 non-revenue vehicles, including general-purpose fleet, operations and support equipment (e.g., aerial lifts, compressors, cranes, portable signs), operations and support vehicles (e.g., bucket trucks, fuel trucks, snow fighters, tow trucks), and police vehicles.
- **Track and Right-of-Way:** The MBTA operates 868 miles of track, 131 for subway and light rail and 737 for commuter rail. Its right-of-way assets include 356 revenue grade crossings, 195 miles of fencing and 25 miles of retaining walls.
- **Signals and Heaters:** The MBTA owns approximately 1,900 signaling, switching, and heating assets.
- **Communications:** The MBTA maintains a state-of-the-art Operations Control Center (OCC), as well as telephone equipment (including emergency phones and intercoms), automated management systems for life safety equipment, systemwide radio, a "wide area network" (i.e., intranet), and public address equipment and electronic signs.
- **Power:** The MBTA owns and maintains equipment to generate and distribute power to its subway, light rail, and trackless trolley systems, as well as to support its commuter rail and maintenance facilities. The largest of these assets are substations and two jet turbine backup generators to power the system if the outside grid fails.
- **Fare Equipment:** The MBTA owns approximately 1,600 fare boxes, 453 vending machines, and 611 gates. Overall, the automated fare collection (AFC) or "Charlie Card" system accounts for nearly 3,000 assets.
- **Parking:** The MBTA owns and maintains 56,000 parking spaces in lots and garages, many of which have enclosed booths.
- **Facilities:** Facilities include maintenance and administration buildings (as with stations, these include components), layover areas, and fueling and pumping stations.

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- **Technology:** The MBTA owns a diverse range of technology equipment, including computers, laptops, fax machines, printers, scanners, and data servers. The MBTA also operates several software applications that are treated as assets.

3.1.1 Status of MBTA Inventory and Condition Data

The MBTA continues to develop and populate its SGR Database. This database serves as a financial forecasting tool containing inventory and condition records and is able to predict the condition of assets using deterioration curves. The inventory in the SGR Database currently stands at over 7,000 records and roughly 230,000 assets. The SGR database has a nearly full dataset for the MBTA's most important assets (e.g., revenue vehicles and bridges) and the MBTA is working to check the quality of these data while developing more comprehensive inventories for the remainder of its asset classes.

Some types of assets (e.g., facilities, power, signals, communications, stations, and track) are recorded in the SGR Database at a lower level of "granularity." For example, the entire station would be tracked rather than the roof, platform, stairs, etc. The MBTA continues to catalogue non-vehicle assets in the commuter rail system, but this has proven difficult to complete given the scope and scale of the system.

Moving forward, the MBTA has required that capital and maintenance projects update the inventory as asset records change. This data would be transferred from an Enterprise Asset Management System (EAMS) – the MBTA currently maintains one EAMS for vehicles and is developing one for infrastructure.

As it completes its inventories, The MBTA will refine the granularity of the SGR Database. The vision is for that system to match the CIP's structure; assets funded by a single capital budget item (e.g., security cameras) would be grouped together in the database, while elements of "building-level" assets funded separately would be separated as elevators, escalators, and fare equipment currently are.

3.2 Performance, Investment, and Forecasts at the MBTA

SGR Score

The SGR Database combines asset-specific performance measures with age and a general sense of condition into an overall SGR Score for the individual asset. The grading scale for these components is provided in Figure 3.1.

Figure 3.1 Components of the MBTA State-of-Good-Repair (SGR) Scoring System

SGR Score		Life Cycle Rating (Age)	Condition	Functional Rating
Description	*Range*	*% of Useful Life Remaining*		*Performance*
Excellent	4.4 to 5.0	Asset NEW OR NEARLY NEW (0% - 25% useful life)	Asset NEW OR LIKE NEW; No visible defects or deterioration	Asset MEETS/EXCEEDS performance, reliability standards
Good	3.8 to 4.3	Asset NEAR/AT MIDLIFE POINT (26% - 50% useful life)	MINIMAL SIGNS OF WEAR; Slight defects or deterioration	Asset GENERALLY MEETS performance, reliability standards
Fair	3.2 to 3.7	Asset PAST MIDLIFE POINT (51% - 75% useful life)	MODERATELY DETERIORATED; Expected maintenance needs	OCCASIONAL ISSUES May be substandard in some areas
Marginal	2.6 to 3.1	Asset NEARING END-OF-LIFE (75% - 100% useful life)	INCREASINGLY DEFECTIVE; Growing maintenance needs	MORE FREQUENT ISSUES Substandard in some areas
SGR				
Substandard	1.8 to 2.5	Asset JUST BEYOND USEFUL LIFE (101% - 125% useful life)	SIGNIFICANT DEFECTS; Excessive maintenance needs	SERIOUS ISSUES Substandard in many areas
Poor	1.0 to 1.7	Asset WELL BEYOND USEFUL LIFE (125+% useful life)	CRITICALLY DEFECTIVE; In need of replacement/rehab	FREQUENT SERIOUS ISSUES Asset does not meet standards
Non-Operable				

The SGR database compiles the overall SGR score by weighting the 0-5 ratings for the three components. The weight indicates the relative confidence or influence that the MBTA feels one factor should have in relation to another. In cases where the ratings for condition and performance have not yet been determined, the SGR Score is equivalent to the age rating. Ratings for condition and performance exist for 83% and 79%, respectively, of asset records.

An asset is considered to be performing its required function without limitation when it exceeds an SGR Score of 2.5.

When an average SGR Score is computed across a group of assets, it is weighted by the replacement cost of the individual assets.

3.2.1 Current Performance of MBTA Assets

The MBTA currently has an average SGR Score of 3.02 across all of its assets and an estimated 2016 backlog of $7.3 billion. Table 3.1 breaks down SGR score and backlog by asset class.

Table 3.1 Current Condition of MBTA Assets

Asset Class	SGR Score	Replacement Value ($ mil)	Backlog ($ mil)	Backlog % of RV
Overall	**3.02**	**$23,809**	**$7,343**	**31%**
Fare Equipment	3.91	$64	$9	14%
Communications	3.5	$197	$35	18%
Elevators and Escalators	3.49	$51	$8	16%
Stations	3.38	$2,844	$391	14%
Bridges	3.22	$5,190	$260	5%
Signals and Heaters	3.09	$2,645	$1,033	39%
Facilities	3.09	$1,750	$497	28%

Asset Class	SGR Score	Replacement Value ($ mil)	Backlog ($ mil)	Backlog % of RV
Power	2.98	$856	$289	34%
Non-Revenue Vehicles	2.95	$77	$37	48%
Tunnels	2.94	$173	$93	54%
Revenue Vehicles	2.85	$7,342	$3,321	45%
Track and Right-of-Way	2.57	$2,269	$1,189	52%
Parking	2.36	$228	$102	45%
Technology	2.13	$122	$79	65%

Backlog

Backlog represents the total replacement costs of all assets that are not in a state-of-good-repair (i.e., they have a current SGR score that is less than or equal to 2.5). Backlog is theoretically tied to the size of the asset portfolio and the MBTA's backlog will increase each time new assets are added to the SGR Database. However, not all assets contribute to backlog (e.g., right-of-way and real estate) and asset classes in general do not contribute equally.

The largest contributor to backlog at the agency, revenue vehicles, is fully inventoried and its backlog well-informed. Data quality for track and signals – the next-largest contributors to backlog – trails behind but has seen significant progress. A description of the MBTA's backlog computation is provided in **Appendix A.2**.

3.2.2 Capital Investment in the MBTA

Prior to the 2017-2021 CIP, the MBTA reported capital investment using the asset categories described above. Annual average investment in each asset class from 2009-2016 is shown in Figure 3.2.

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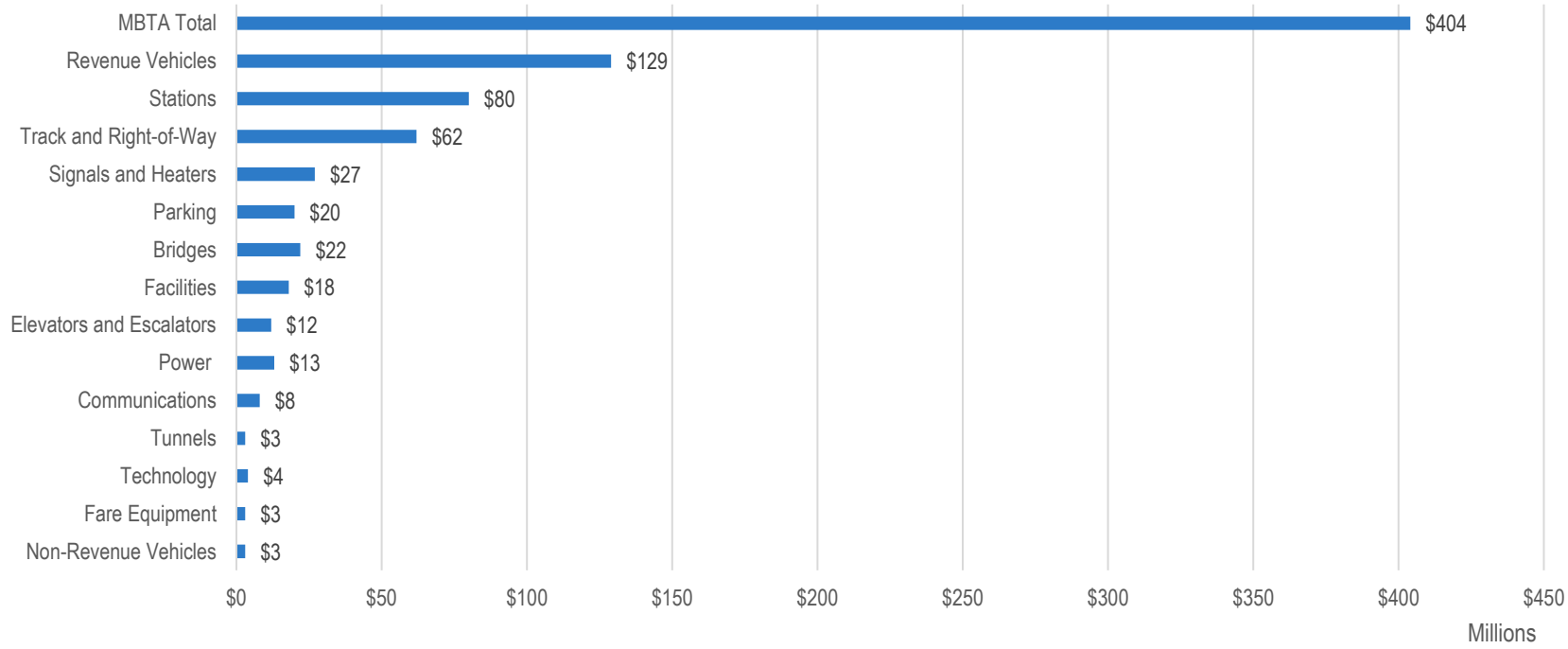
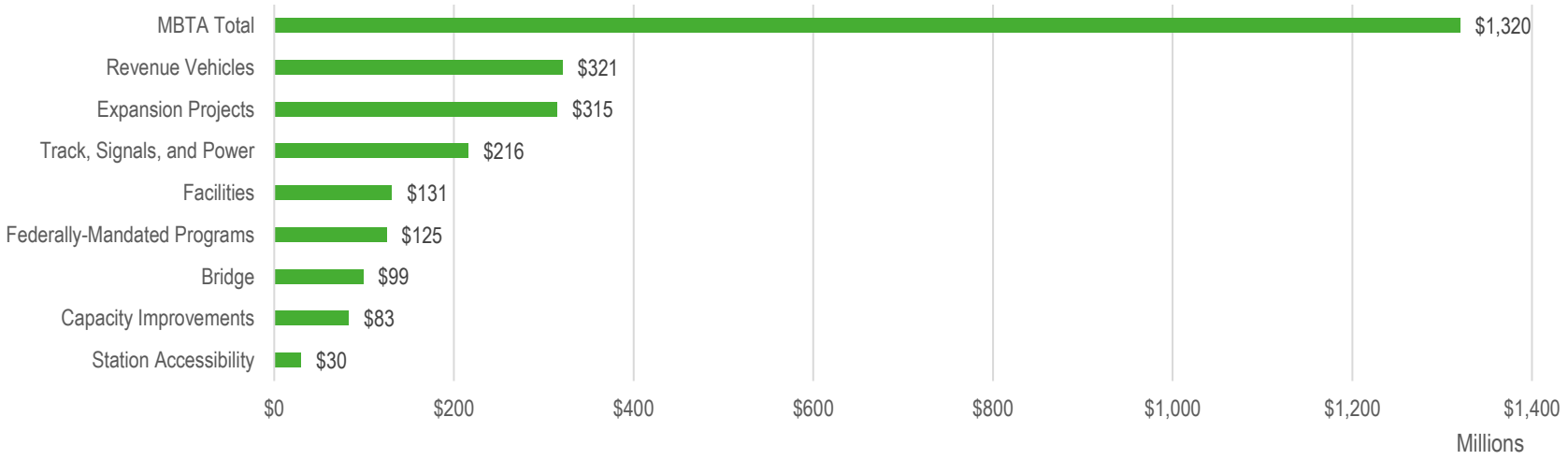
Figure 3.2 Average Annual MBTA Capital Investments by Asset Class, 2009-2016



In addition to the asset classes shown, the 2016 CIP included one-year totals of $322 million for Expansion and $214 million for enhancement projects.

Beginning with the MassDOT-wide 2017-2021 CIP, the MBTA now reports capital spending using a smaller set of programs that align with MassDOT's general priorities of reliability, modernization, and expansion. The annual average spending in each of these categories from 2017 to 2021 is shown in Figure 3.3. Note that the vast majority of Expansion funding included in the CIP is for the Green Line Extension to Somerville and Medford.

Figure 3.3 Average Annual MBTA Capital Investments by Program, 2017-2021



3.2.3 Performance Forecasting at the MBTA

MassDOT is in the process of collaboratively setting performance targets for the MBTA that are to be released in late 2016 and applied in 2017.

The MBTA has not yet produced forecasts of average SGR Score for asset classes or for the agency. Nor has backlog served as an appropriate proxy for condition forecasting (i.e., how much will it cost to reduce the number of assets in poor condition to an acceptable threshold). As the MBTA continues to inventory and assess the condition of additional assets, its performance targets in general have been shifting. The MBTA is currently in the process of setting thresholds relative to SGR Score and other performance metrics through a collaboration with OPM&I.

In 2015, the MBTA estimated that a $472 million annual investment will maintain current state SGR, a forecast which will be refined as better data becomes available. The CIP has called for a $760 million annual investment to be spent primarily on improving the reliability of the core system.

3.3 Status of the MBTA Asset Management Plan

In October 2016, the FTA will require Tier I agencies to begin work on a Transit Asset Management Plan (or "TAM Plan"). The MBTA is a Tier I transit agency, as it operates a large bus and rail network. The MBTA completed an Asset Management Plan (AMP), in 2014 while work on the Federal rule was still ongoing. This plan will be revised to meet the Federal rule that was released in July 2016.

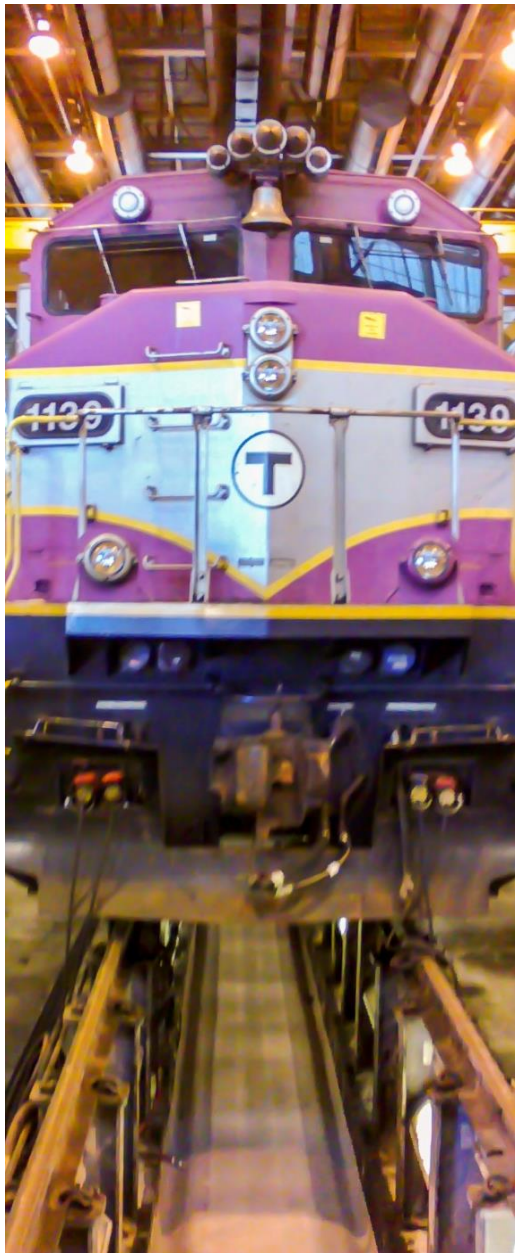
The 2014 AMP included the following elements:

- **A baseline assessment** that evaluates the agency's current performance against a five-point maturity scale. A self-assessment survey found that the MBTA scored 52% maturity for Asset Management ("process occurring effectively, but inconsistently"). A gap assessment conducted by the TAMP authors found a lower score of 40% ("potential for process to be effective");
- **Goals and objectives**, developed from interviews, workouts, and breakout sessions, included the following:
  - **Policy**: Provide agency-wide direction and leadership to increase the MBTA's asset management maturity.
  - **People**: Establish asset management culture and support it through talent management practices.
  - **Tools:** Provide infrastructure and tools to support data-driven decision-making for asset management.
  - **Business Practices:** Manage whole lifecycle costs, risks, and performance to achieve cost savings, improve service reliability, and contribute to customer safety.
- **A roadmap** including specific actions to be taken within the first 24 months and beyond into the first five years;
- **A policy statement**; and
- **An organizational structure** to support asset management.

3.4 Next Steps for the MBTA

The MBTA expects to accomplish the following in 2017:

- Establish performance targets for key asset classes;
- Verify additional data in the SGR Database;
- Add inventory for additional assets to the SGR Database; and
- Fully implement the EAMS system for infrastructure.



4 The MassDOT Rail and Transit Division

The MassDOT Rail and Transit Division oversees and funds the multi-modal transportation network outside of the MBTA's service area. It both owns and oversees railroads used for passenger and freight service. It also collaborates with 15 regional transit authorities (RTAs) that use buses, vans, and para-transit vehicles to serve 26 million annual passenger trips on 258 routes in 231 communities.

4.1 Rail and Transit Division Asset Hierarchy

The Rail and Transit Division assets include:

- **Statewide Rail:** The Rail and Transit Division owns 294 route-miles of active rail lines (i.e., not abandoned or in use as a rail trail). The mileage is divided among 10 lines across all regions of the Commonwealth. MassDOT and its predecessor agencies have been acquiring rail lines since 1982 and has acquired 195 active route-miles acquired since 2010. Assets associated with the rail lines owned by MassDOT include:
  - **Track and Right-of-Way:** Track is classified by the Federal Railroad Administration (FRA) from one-to-five, which determines speed limits for freight and passenger trains. Speed limit rises with classification. The Connecticut River Main Line is the Rail and Transit Division's only Class 4 track (60mph for freight, 80mph for passenger), with the remainder mostly in Class 1 or 2. Additional higher-class lines are managed by the MBTA.
  - **Grade Crossings:** A grade crossing is where a roadway crosses a rail line "at-grade" (i.e., on the same level). The FRA keeps a national database of both public and private grade crossings.
  - **Bridges:** Rail bridges are inventoried, inspected, and managed using a process that conforms to FRA regulations. They are rated for a maximum weight that also controls the maximum weight on sections of line. The FRA and the industry have established 286,000lb per car (i.e., "286K") as an ideal standard. While some MassDOT-owned lines meet it, others are rated for 263,000lb.

FAQs – Rail + Transit

What is going well?

- MassDOT has high quality data for rail lines that it owns, with the exception of a single newly purchased line.
- The RTAs adopted TransAM in May 2016 to manage inventory and condition of assets.

What can be improved?

- MassDOT needs to establish performance measures for statewide rail assets.

The bottom line?

MassDOT will change its focus from acquiring new rail lines to maintaining the rail lines it already owns.

MassDOT and the RTAs are preparing to meet new FTA rules for asset management.

  - **Culverts:** Culverts are structures with a span less than 10 feet and a diameter greater than four feet (i.e., not pipes). They allow water and wildlife to pass beneath the tracks. MassDOT has identified more than 800 culverts using plans and records.
  - **Interlockings and Switches:** An interlocking is a where one track merges into another, or where trains can pass between parallel tracks. Switches direct trains as they either remain on their current track or transfer to the other.

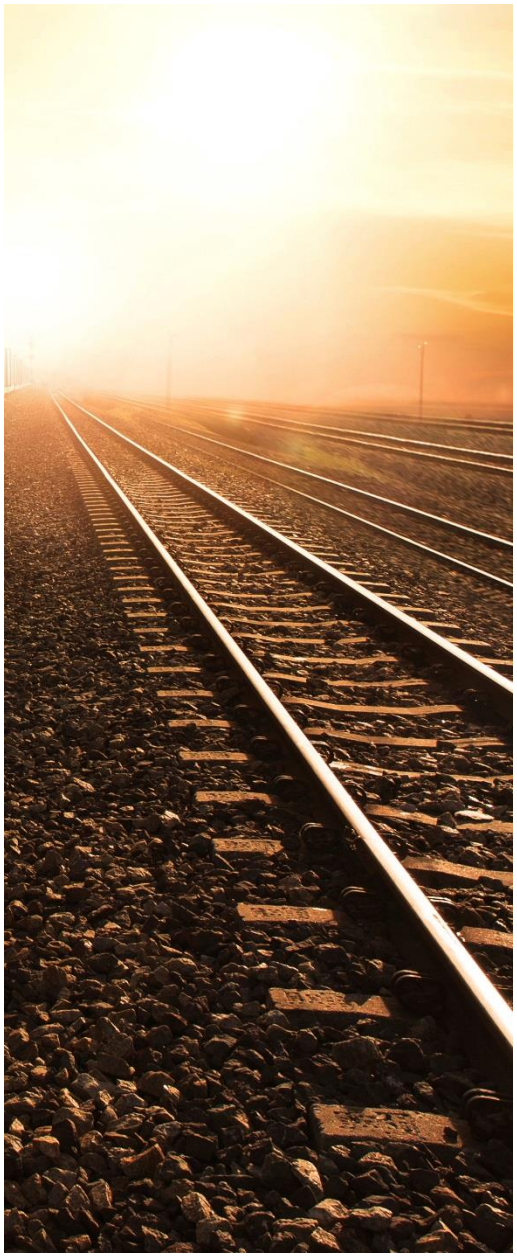
- **Transit:** The 15 RTAs own the following key assets:
  - Approximately 1,400 revenue vehicles;
  - Non-revenue vehicles; and
  - Maintenance facilities and administration buildings.

4.1.1 Status of Rail and Transit Division Inventory and Condition Data

Inventory and condition data for the Rail and Transit Division and the RTAs is assessed below:

- **Rail:** MassDOT hires a contractor to perform an annual visual inspection of all key rail assets on its own lines to ensure the safe operation of the system, as required by FRA. Inventory and condition data collected in these inspections are managed by a different contractor on MassDOT's behalf.
- **Transit:** The RTAs have adopted Transportation Asset Manager (TransAM), an open-source asset management platform. The system went live in May 2016 and contains an inventory of revenue and support vehicles, facilities, and equipment. TransAM includes age and condition of assets as fields and can forecast SGR and compute backlog.

  The RTAs have complete datasets for revenue and non-revenue vehicles in TransAM. Given the small number of RTA maintenance facilities, the age and condition of each facility are well-known and will be included in TransAM moving forward. The RTAs also are required to submit an annual inventory of revenue vehicles to the National Transportation Database (NTD).



4.2 Performance and Investment in the Rail and Transit Division

MassDOT is in the process of defining performance measures for its rail assets. RTAs are subject to FTA performance management requirements adopted in July 2016 and active in October. One element of the FTA rule is the set of performance metrics shown in Figure 4.1, though the use of these measures in Massachusetts is still uncertain.

4.2.1 Current Performance of Rail and Transit Division Assets

Because the TransAM database is not yet available for publication, performance data is not available for non-revenue vehicles and facilities. In the most recent NTD revenue vehicles dataset – 2014 – **93% of RTA revenue vehicles are within their 12-year service life.**

4.2.2 Capital Investment in the Rail and Transit Division

Historic and projected (2017-2021 CIP) investment for the Rail and Transit Division is shown in Table 4.1. It should be noted that RTAs receive funding from multiple MassDOT programs. The program shown is applied primarily to bus purchases; vans and handicapped-accessible vehicles may be funded from other sources.

Figure 4.1 FTA Performance Metrics

	Performance Measure
Non-Revenue Vehicles	Percent of vehicles met or exceeded useful life.
Revenue Vehicles	Percent of vehicles met or exceeded useful life.
Facilities	Percent of facilities with a TERM rating below 3.

"Useful life" is defined by each agency.

"TERM" = Transit Economic Requirements Model.

A rating below 3 corresponds to "marginal or poor": Defective or damaged components in need of replacement.

Table 4.1 Investment in Statewide Rail and Transit – 2012-2021 ($ millions)

Program	Actual				Projected (5 year average)				
	2013	2014	2015	2016	2017	2018	2019	2020	2021
Statewide Rail Program	$9.2	$6.8	$18	$30	$63	$63	$63	$63	$63
RTA Transit	$6.1	$5.5	$25	$32	$46	$46	$46	$46	$46

4.2.3 Performance Forecasting in the Rail and Transit Division

MassDOT is in the process of collaboratively setting performance targets for Statewide Rail to be released in late 2016 and applied in 2017.

4.3 Status of Asset Management Planning in the Rail and Transit Division

The MassDOT Statewide Rail Plan will be completed in 2017. This document will feature an in-depth evaluation of the Commonwealth's freight and rail system, regardless of ownership.

The 2016 FTA rule will require the RTAs to develop Transit Asset Management Plans (TAM plans) in some form. Tier I agencies must complete an individual TAM plan. Tier II agencies (i.e., many RTAs) may complete a group TAM plan in cooperation with a sponsor. **MassDOT will be a sponsor and will collaborate with Tier II RTAs as needed to interpret and implement these requirements.** Required elements of a TAM plan are summarized in Figure 4.2.

Figure 4.2 TAM Plan Elements

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4.4 Next Steps for the Rail and Transit Division

In 2017, the Rail and Transit Division will:

- Develop an new Statewide Rail Plan;
- Continue to perform work to better the condition of all rail lines;
- Verify RTA asset inventories;
- Collaborate with Tier II RTAs to interpret and implement FTA guidance, including performance measures and TAM Plans; and
- Establish performance targets for key assets.

5 The MassDOT Aeronautics Division

Airports are a critical element of Massachusetts' intermodal transportation system. The MassDOT Aeronautics Division is a steward for 36 public use airports across the Commonwealth. The Massachusetts Port Authority (Massport) owns and operates Boston Logan International Airport, Hanscom Field, and Worcester Regional Airport independently of MassDOT. In addition to the public use facilities, the Aeronautics Division oversees a variety of private landing strips, seaplane bases, and heliports.

While the Aeronautics Division performs top-down planning and makes recommendations to individual airports, it does not own facilities; 22 of the public-use airports under its purview are managed by cities and towns, while 14 have private owners. MassDOT provides grants of mostly federal aid to airports through the CIP process. Publicly owned airports can also apply directly to the FAA Airport Improvement Program for projects identified and justified in master plans, environmental analyses, airport inspections and financial evaluations.

FAQs – Aeronautics

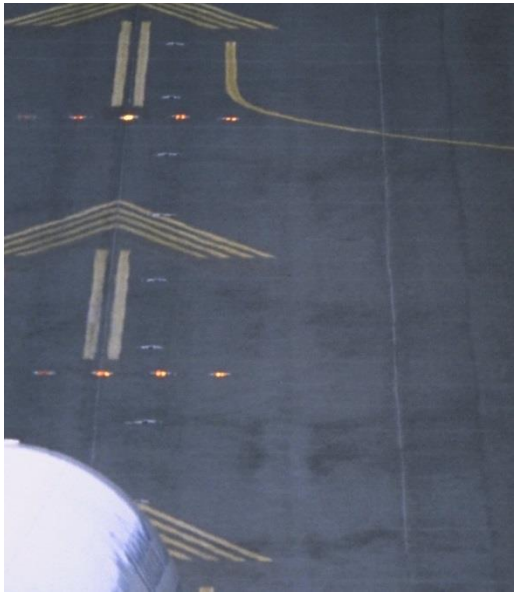
The bottom line?

- MassDOT is developing the AIR Port asset inventory and project management system.
- MassDOT has committed to annual verification and triennial updates for its pavement inventory.

5.1 Aeronautics Division Asset Hierarchy

The Aeronautics Division does not directly own assets but funds improvements to airports in response to performance metrics. Airport assets of programmatic importance to MassDOT include:

- **Airport Pavement:** The Federal Aviation Administration (FAA) will fund pavement projects on runways, taxiways, and aprons based on their existing condition and useful service life. . Airports overseen by MassDOT own over 40 million square feet of pavement.
- **Vegetation Management Areas:** Airports receive funding to clear trees and brush from areas in and adjacent to runway approaches, in order to remove hazards to flight.
- **Fencing and Gates:** In 2001, the Massachusetts Aeronautics Commission, (forerunner to the MassDOT Aeronautics Division) issued a security directive (AD-001a) requiring the installation of security fencing and access gates at public use airports (where appropriate) to restrict access to an airport's Air



Operations Area (AOA), and to protect other sensitive areas (such as fuel farms) located on airport property. The security directive was adopted by MassDOT in 2009 when the Aeronautics Commission was disbanded.

- **Security Cameras: The aforementioned 2001 security directive** (AD-001a) also called for the installation of video surveillance cameras to monitor access gates leading to an airport's AOA. The provision is mandatory for airports with commercial air passenger service, and the remaining airports are encouraged to comply with the directive as funding permits.
- **State Airport Administration Buildings:** MassDOT funds the rehabilitation of general aviation administration buildings, which often serve both customer service and operational functions.

5.1.1 Status of Aeronautics Inventory and Condition Data

The Aeronautics Division has initiated a three-airport pilot project for a new Airport Information Resource Portal ("AIR-Port"). In addition to managing MassDOT-funded on-airport projects, AIR-Port will track inspection reports and asset data collected. Airports, management, and contractors populate asset data which is validated by MassDOT. AIR-Port is currently planned for statewide implementation in late 2017.

The FAA requires that pavements be inspected every 3-5 years. Pavement condition assessment was last conducted in 2013. In FY2017, a new three-year cycle begins with the next planned independent pavement assessment. In the intervening years (FY2018/2019), MassDOT Aeronautics staff will accomplish annual in-house assessments to ensure annual tracking of pavement condition data.

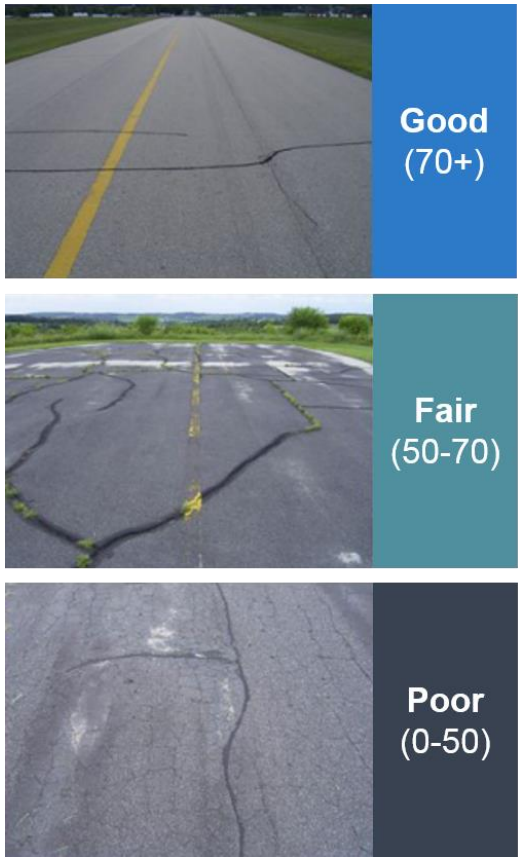
5.2 Performance and Investment in the Aeronautics Division

The Aeronautics Division identified Runway Pavement Condition as a primary asset-driven metric for use in the CIP process.

Pavement represents one of the largest capital investments in the Massachusetts statewide airport system, and the condition of these pavements is important both from cost-effectiveness and safety standpoints. Timely airport pavement maintenance and rehabilitation are crucial because repairs are much more costly once the condition deteriorates below a certain level. Additionally, airport pavement weaknesses, such as cracks and loose debris, pose a significant safety risk to aircraft.

Recognizing a need to protect this critical investment, the Aeronautics Division established a statewide airport pavement management system (APMS) in 2013 to monitor condition and to proactively plan for preservation. The APMS uses a Pavement Condition Index (PCI), described in Figure 5.1. PCI was developed and proposed by the FAA and ranges from zero to 100 – "good" PCI is defined as 75 and above for runways. Statewide, MassDOT measures the percent of system airports with overall good PCI across all their runways.

Figure 5.1 Airport Pavement Condition Index



5.2.1 Current Performance of Aeronautics Division Assets

Runway Pavement Condition

MassDOT has not conducted a pavement condition survey since 2013. At that time, the statewide average PCI was 70.

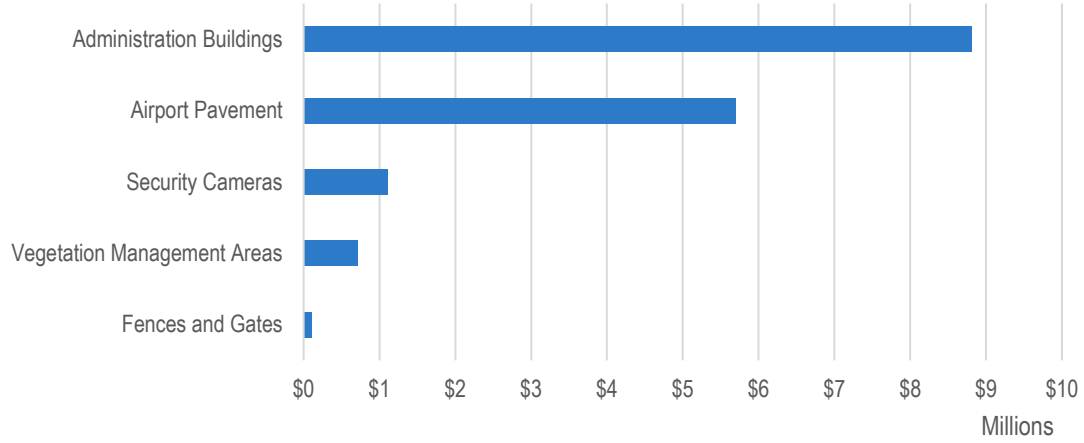
5.2.2 Capital Investment in Airports

Massachusetts relies heavily on matching grants from the FAA's AIP, as do all states. Recognizing that not all airport sponsors are eligible for federal funding, MassDOT initiated the Airport Safety and Maintenance Program (ASMP), which can provide state-funded grants-in-aid to close the gap for these sponsors.

The ASMP serves to leverage funds for safety, maintenance, and security projects that have been selected for the CIP. ASMP typically supports a state share of 80% and a local airport share of 20% with no federal participation. These projects are often routine maintenance that addresses deficiencies noted in MassDOT airport inspections (such as pavement condition, security issues and vegetation overgrowth). Airport planning and new construction and equipment grants are also eligible.

Planned annual average investment in each asset class from 2017-2021 is shown in Figure 5.2.

Figure 5.2 Average Annual Aeronautics Division Capital Investments by Asset Class, 2017-2021



5.2.3 Performance Targets and Forecasting in the Aeronautics Division

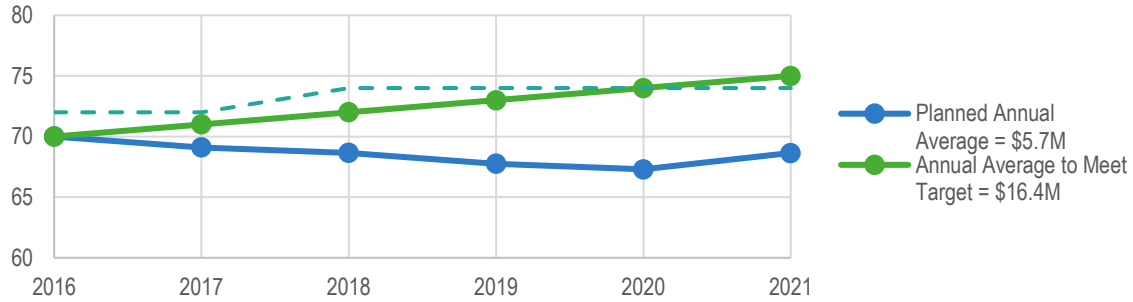
Runway Pavement Condition

MassDOT has collaboratively set performance targets for Statewide PCI of 72 in 2018, 74 in 2020, and 75 in the long-term.

As an element of the 2013 Pavement Survey, the Aeronautics Division projected condition under different annual funding levels from 2012 to 2018. Using this model, PCI under MassDOT's planned funding level was forecast from 2016 to 2021. It is shown in Figure 5.3, alongside the annual funding required to achieve MassDOT's target of 75 in that year.

Note that current PCI is 70. MassDOT will acquire new data in 2017.

Figure 5.3 Condition of MassDOT Airport Pavement (2016-2021)

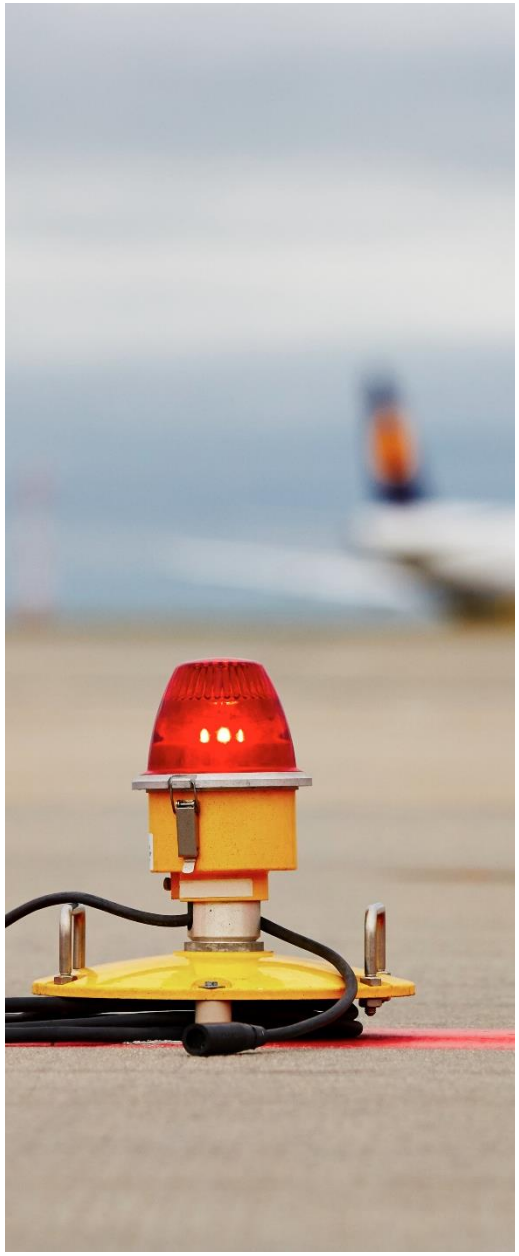


The 2013 Pavement Survey found that an annual investment of $10.4M is required to maintain a PCI of 70 statewide. With current funding levels, overall PCI is expected to slightly decline by 2021.

5.3 Status of Asset Management Planning in the Aeronautics Division

State DOTs are required to produce an Airport System Plan that documents inventory and condition, investment strategies, and other elements of asset management for airports. The 2010 Massachusetts Statewide Airport System Plan (MSASP) is the most recent MassDOT document that serves this purpose. Specifically, it includes:

- An inventory of airports, including:
  - Runway length, direction, material, and lighting;
  - Navigation aids (NAVAIDs);
  - Landside facilities such as perimeter roads, terminals, and vehicle parking;
  - Aircraft parking aprons, hangars, and tie-downs;
  - Fueling capacity and service characteristics;
  - General buildings, services, and accommodations;



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  - Commercial and general aviation operations, and based aircraft;
  - Airport-driven studies, environmental plans, outreach efforts; and
  - Airport development potential.

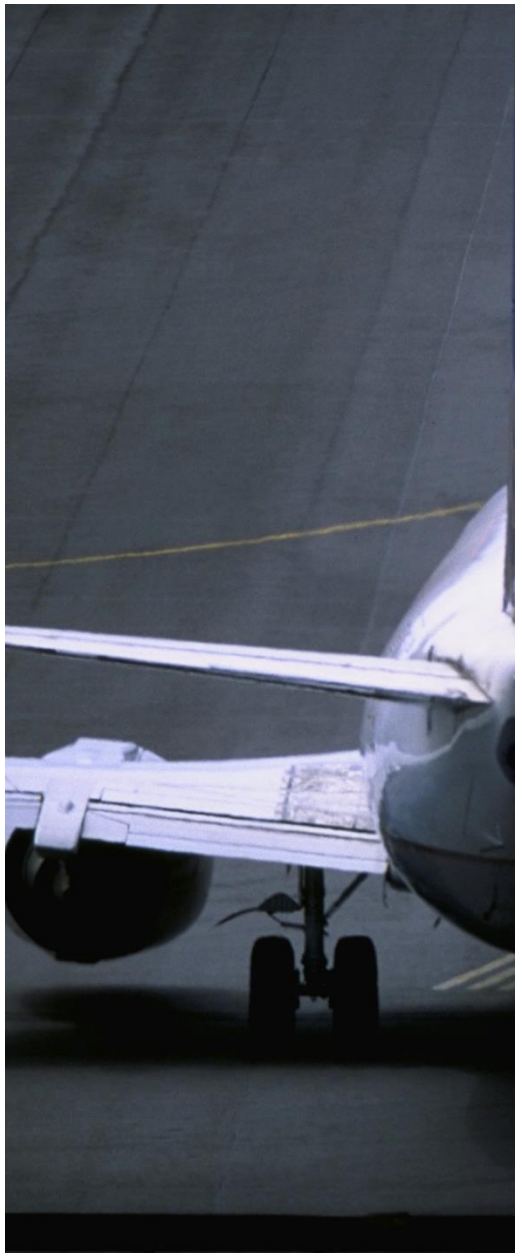
- A description of the role and needed investment for each of airports included in the 2010 MSASP plan. Massport purchased Worcester Regional Airport just after the completion of the 2010 MSASP, so MassDOT's oversight now includes 36 airports).
- Aviation demand forecasts.
- System-wide performance metrics including pavement condition and the age and condition of the facilities included in the Statewide Airport Administration Building (SAAB) program. Metrics not related to asset management touch on economic impacts, pilot training services, and environmental sustainability, among other topics.
- Projected funding needs.

The MSASP was intended not as a programming or implementation effort but as a document that can be referenced over many programming cycles. As such, MassDOT continues to utilize the MSASP as a critical resource in planning investments in aeronautics and plans to update the system plan on a seven-year interval, with the next update to begin in 2017 (likely to be published in 2018).

5.4 Next Steps for the Aeronautics Division

The Aeronautics Division expects to accomplish the following in 2017:

- Advance statewide implementation of the AIR-Port system;
- Perform the first of the triennial field surveys of airport pavement condition; and
- Begin the process of developing the successor to the 2010 MSASP.



6 Municipalities

Massachusetts is comprised of 351 cities and towns (collectively "municipalities"). The Commonwealth provides aid to municipalities to support the upkeep of their pavement assets, primarily through the "Chapter 90" reimbursement program. Municipalities fund preservation on their bridges, while MassDOT manages and funds replacement and rehabilitation directly. In addition to funding received through MassDOT, municipalities are allocated Federal aid through metropolitan planning organizations (MPOs) that cover urban regions.

6.1 Municipal Asset Hierarchy

Municipalities own many of the same assets and asset classes as MassDOT; in addition to bridges and pavement, they may be responsible for signs and signposts, streetlights, sidewalks, ramps for the disabled, traffic signals, retaining walls, and maintenance vehicles and equipment. While many of these assets can be affected by a Chapter 90-funded roadway project, this report focuses on the two classes most commonly associated with TAM: pavement and bridges.

- **Pavement:** Municipalities own approximately 30,000 centerline miles of pavement (municipal data on lane-mileage is not universally available). Of these, only a small portion – 1,106 miles – is on the NHS. Some roadways under local jurisdiction are numbered as state highways.
- **Bridges:** Municipalities own 1,569 NBI bridges, 70 of which are on the NHS. Municipalities are responsible for 885,000 square feet of NHS deck area.

  In addition to NBIs, there are 1,209 known BRIs recorded in MassDOT's 4D system. It currently is verifying the inventory and expects the number to increase as inspections continue. MassDOT's long-term goal is to inspect BRIs as regularly as NBIs.

6.1.1 Status of Municipal Inventory and Condition Data

Inventory and condition data for municipal bridges and pavement is kept to varying degrees within the municipalities, within MPOs and by MassDOT. Specifically:

FAQs – Municipalities

What is going well?

- The condition of 87% of municipally owned NHS pavement is tracked in the MassDOT Road Inventory File.
- The condition of 100% of municipally owned NBI bridges is tracked by MassDOT.

What can be improved?

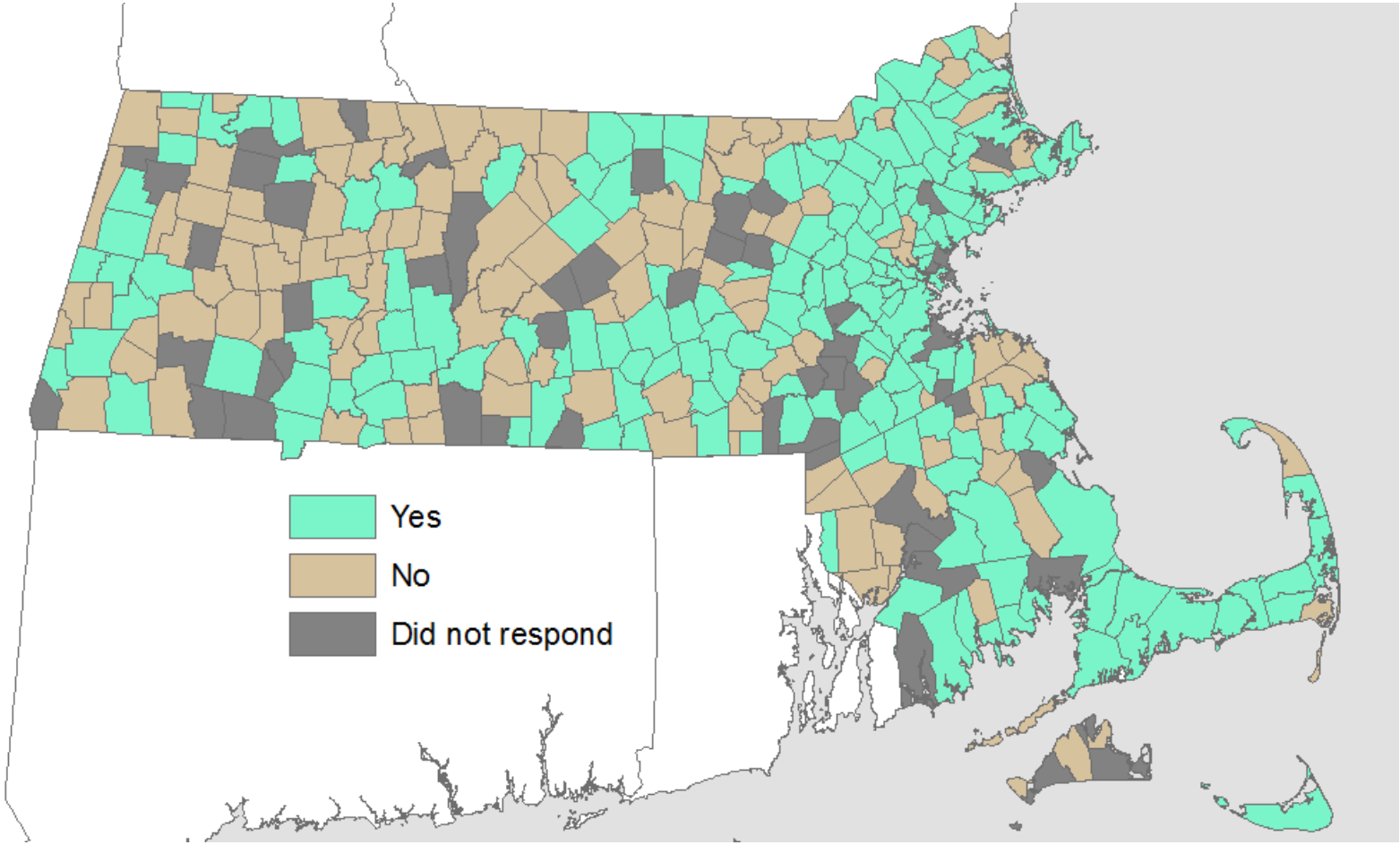
- Two thirds of local roads are maintained using a pavement management application, but performance is not tracked using consistent metrics.
- MassDOT is developing inventory for municipally owned BRIs.

The bottom line?

MassDOT and municipalities must collaborate to ensure that local spending supports MassDOT s goals.

- **Pavement:** In a survey conducted by the Massachusetts Municipal Association (MMA) in 2014, 171 of 297 (58%) responding municipalities reported that they either currently used or were implementing a pavement management application (PMA). Communities with a PMA account for 58% of the overall centerline mileage and 65% of the NHS centerline mileage across all responding municipalities. A map of communities by PMA usage is shown in Figure 6.1.

Figure 6.1 PMA Usage in Municipalities from 2014 Survey



In general, it can be said that PMA usage is stronger in dense urban areas (i.e., Boston, Worcester, Fitchburg/Leominster, and Pittsfield) and weaker in rural communities that have fewer resources and smaller networks.

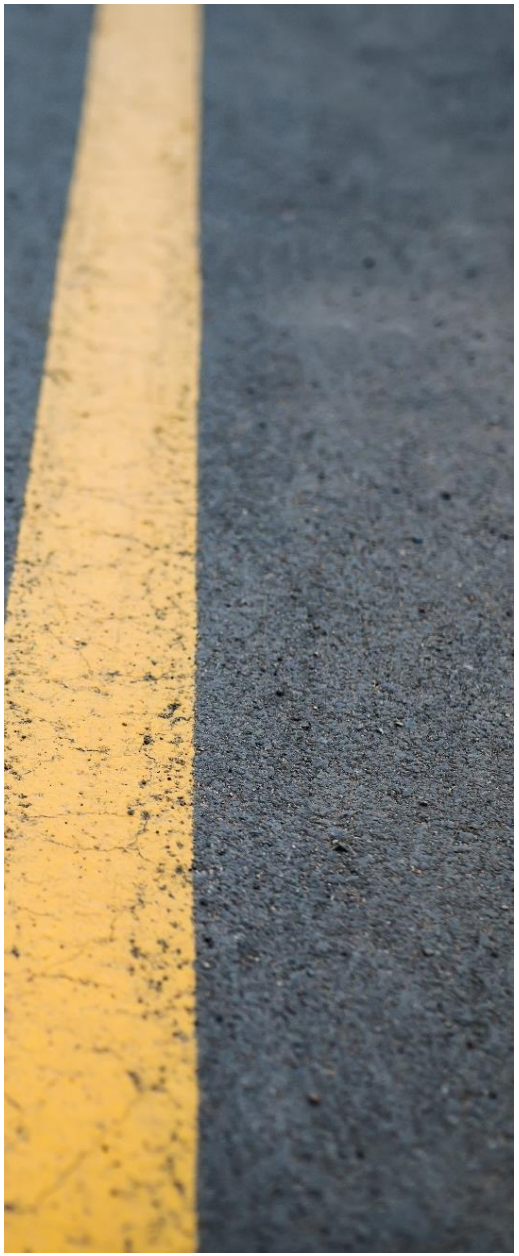
MassDOT maintains a geospatial database of all road segments in the Commonwealth in the Road Inventory File (RIF), including municipal roads. While all records in the RIF include geometry (e.g., shoulder length, curb, roadway width, number of lanes), the RIF includes pavement serviceability index (PSI) for only 8% of municipal mileage. However, 87% of municipal NHS pavement has PSI data in the RIF.

- **Bridges:** FHWA mandates that the MassDOT Highway Division inspect NBI structures in the same manner regardless of ownership. Consequently, data on these municipal structures is of high quality. Historically, municipalities tracked data for their own short-span bridges (BRIs) but this data is incomplete and dated. Recently, MassDOT has begun to include BRIs in the NBI inspection program. Over the last 18 months, it has inspected more than 140 of the 1,209 (12%) known municipally owned BRIs.

6.2 Performance and Investment in Municipalities

Federal law requires that DOTs report percentage of NHS pavement in both "good" and "poor" condition to FHWA regardless of jurisdiction and that DOTs define and work to achieve goals for those metrics over time. As discussed in Chapter 2, MassDOT defines pavement condition using PSI, where higher values indicate better condition. "Good" condition begins at a PSI of 3.0 for Interstates and 2.8 elsewhere (there is an "Excellent" rating), and "Poor" is defined as less than or equal to 2.5 for Interstates and 2.3 elsewhere. Municipal pavement management systems sometimes use unique pavement condition indices.

Federal law also requires that DOTs report percentage of NBIs on NHS highways in both "good" and "poor" condition to FHWA and that DOTs define and work to achieve goals for those metrics over time. MassDOT defines bridge condition using the nine-point NBIS scale discussed in Chapter 2, where higher values indicate better condition. "Good" condition begins at a rating of 7 and "Poor" is defined as SD – a rating of 4 or lower. The BRI inspection program shows that 31 of the 140 inspected municipally owned structures are SD.



FHWA's MAP-21 Notice of Proposed Rulemaking (NPRM) introduces a new performance metric for bridges: SD Deck Area on the NHS. This number is computed by dividing the total square footage of SD NHS bridges by the total square footage of all NHS bridges.

6.2.1 Historic Performance of Municipal Pavement and Bridges

NHS pavement condition data for municipalities is available in the MassDOT Road Inventory File. As of 2015, 373 centerline-miles (39%) is rated excellent or good, 325 miles (34%) is rated fair, and 259 miles (27%) is rated poor. The process for computing municipal pavement backlog is described in **Appendix A.4**. The estimated backlog for municipal NHS pavement is $0.31 billion.

Table 6.1 summarizes the condition of municipal NBI and NHS bridges between 2013 and 2015.

Table 6.1 Condition of Municipal NBIs, 2013-2015

Metric	NHS	2013	2014	2015
% of NBI Deck Area SD	NHS	39%	27%	18%
	Non-NHS	14%	11%	10%

Backlog for municipal bridges is accounted with the Highway Division in Section 2.2.1. For clarity, the municipal subset is repeated here. The estimated subset of the 2016 backlog from Chapter 2 that represents municipal bridges is $0.32 billion.

6.2.2 Capital Investment in Municipal Pavement and Bridges

The MMA found in 2014 that cities and towns across the Commonwealth need to spend at least $639 million annually to maintain and bring 30,000 miles of local roads into a state of good repair.

MassDOT provides municipal aid for roadway projects through the Chapter 90 Program. Chapter 90 projects are 100% reimbursable, meaning that municipalities are not required to contribute to them, though municipalities may contribute significantly to the general upkeep of their roadway network. Permissible uses

include resurfacing and related work (e.g., bridges, right-of-way acquisition, shoulders, side road approaches, landscaping, drainage, sidewalk, traffic control and service facilities, and lighting).

Municipalities are allocated Chapter 90 funds based a composite of three factors:

- Road miles – 58.33%;
- Population – 20.83%; and
- Employment – 20.83%.

After the total apportionment for a city or town is calculated, municipalities apply for reimbursement against it on a project-by-project basis. Table 6.2 provides **the amount MassDOT actually reimbursed for Chapter 90** from 2012-2015 and the amount it plans to spend under the 2017-2021 CIP. Note that municipalities can choose to spend additional funds at the local level.

Table 6.2 Investment in Municipal Aid (Chapter 90) – 2012-2021 ($ millions)

Program	Actual					Projected				
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Capital Spending on Municipal Aid	$200	$175	$189	$211	$200	$200	$200	$200	$200	$200

MassDOT manages and funds rehabilitation and replacement of municipally-owned bridges, and as of 2016 has allocated $50 million in general obligation bonds for municipal BRIs over the next five years. However, municipalities manage and fund preservation of these structures. Because preservation is a cost-effective means to resolve structural deficiencies before they require significant investment, **dollars spent by cities and towns can have a noticeable impact on MassDOT's capital bridge program.**

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6.2.3 Performance Forecasting in Municipalities

There are several systems for municipal pavement management, many of which use similar but unique pavement condition indices and decision-trees for making decisions. MassDOT plans to begin working the municipalities and MPOs to achieve greater consistency in methodology and approach.

6.3 Status of Municipal Asset Management Planning

Municipalities are not required to produce formal Asset Management Plans, but MassDOT is required to account for the inventory, condition, and life-cycle management of NHS pavement and NBI bridges in the Highway Division TAMP (see Section 2.3 for details).

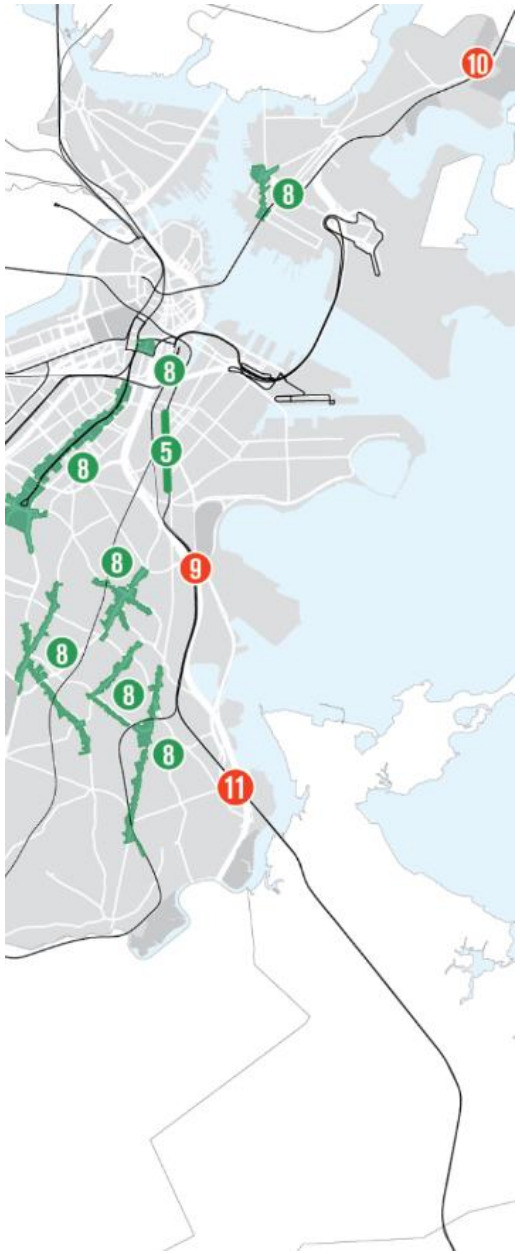
MPOs produce annual transportation improvement plans (TIPs) that inform MassDOT's State TIP (STIP) that identifies projects to receive federal funds over the upcoming four-year period. MPOs – or Regional Planning Commissions (RPCs) or Councils of Governments (COGs) – are encouraged to implement performance-based planning principles in the development of the TIP. These TIPs include pavement and bridge projects.

Federal law requires that MPOs set regional performance targets using the same measures required of DOTs within 180 days of the establishment of DOT targets, including those for bridge and pavement condition. These regional targets and the applicable state targets must be included in the TIP, the STIP, and the TAMP. This target-setting exercise gives MPOs and their municipalities and opportunity to manage their assets strategically together with MassDOT.

6.4 Next Steps for Municipalities

MassDOT will launch a version of the geoDOT site geared toward MPOs and municipalities in fall 2016. The site is envisioned as a platform for exchange of map data between MassDOT and their local partners. Local users will ultimately be able to update the RIF and initiate roadway projects.

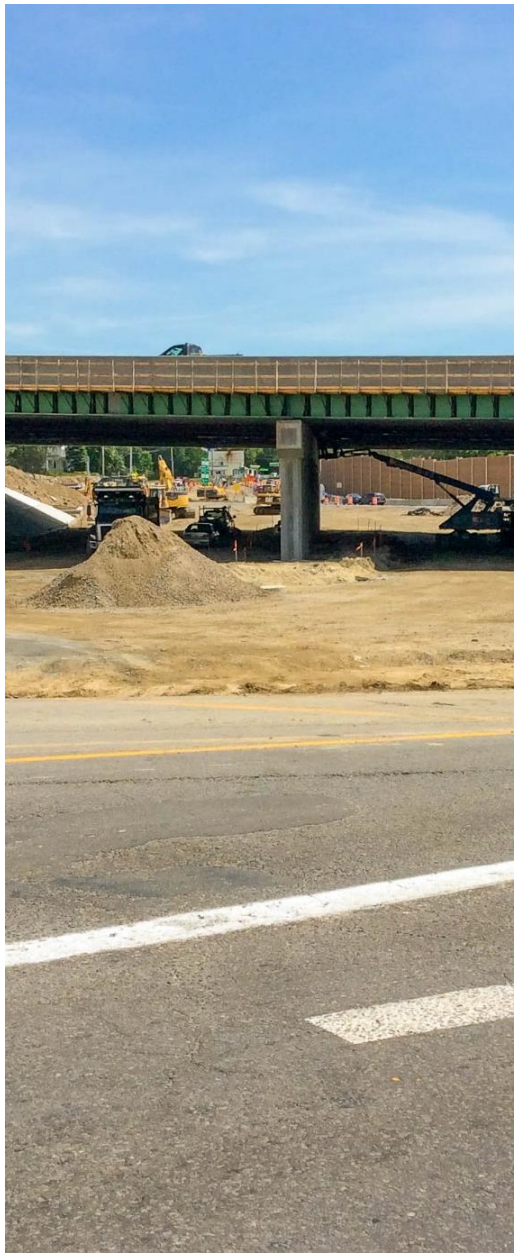
In 2017, MassDOT will collaborate with municipalities to improve the sharing of pavement data and asset management resources with MassDOT, with other municipalities in a region/MPO, and across the



Commonwealth. This is especially important for small communities without the resources to fully manage their pavement. Strategies could include a voluntary or incentivized submission of pavement data to MassDOT for storage and analysis, a model system procured by MassDOT and made available to local governments, a program to assist communities in accessing specialized vehicles for pavement inspection, and training sessions on how to approach pavement management system procurement, among others.

In 2017, MassDOT will continue to populate and verify its inventory of BRI bridges, including those owned by municipalities. As of 2016, MassDOT has allocated $50 million in general obligation bonds for municipal BRIs over the next five years.

7 Investment Strategies



Resource allocation is an essential task for any public agency, especially as needs outpace resources. Transportation agencies face a particularly difficult task in balancing investment among a diverse set of needs while maintaining the existing system. This chapter summarizes the capital resource allocation process that MassDOT used to produce the 2017-2021 CIP. Shaped by careful planning and prioritization work as well as by public participation and comment, the CIP represents a significant and sustained investment in the transportation infrastructure that serves residents and businesses across the Commonwealth. It reflects a transformative departure from past CIPs as MassDOT, including the MBTA, worked to reinvent capital planning for the Commonwealth's statewide, multi-modal transportation system.

7.1 The 2017-2021 CIP Process

This CIP contains a portfolio of strategic investments organized into three priority areas of descending importance: system reliability, asset modernization, and capacity expansion. These priorities form the foundation of not only the CIP, but of a vision for MassDOT and the MBTA where all Massachusetts residents and businesses have access to safe and reliable transportation options.

For the first time, formal evaluation and scoring processes were used in selecting which transportation investments to propose for construction, with projects prioritized based on their ability to efficiently meet the strategic goals of the MassDOT agencies. The result is a higher level of confidence that capital resources are going to the most beneficial and cost-effective projects.

The ultimate goal is for the Commonwealth to have a truly integrated and diversified transportation investment portfolio, not just a "capital plan." Although the full realization of this reprioritization of capital investment is an ongoing process that will evolve through several CIP cycles, this 2017-2021 Plan represents a major step closer to true performance-based capital planning.

The 2017-2021 CIP is fundamentally different from its predecessors: it is informed by a strategic vision; influenced by public and stakeholder input sought from the beginning of the process; built around funding

programs; and projects were selected based on an objective and comparative evaluation. Figure 7.1 describes this process.

Figure 7.1 The Capital Investment Planning Process

1 **Strategic priorities** come first, expressing the DOT's **broadest goals**.

Reliability	Modernization	Expansion
Maintain and improve the overall condition and reliability of the transportation system.	Modernize the transportation system to make it safer and more accessible and to accommodate growth.	Expand diverse transportation options for communities throughout the Commonwealth

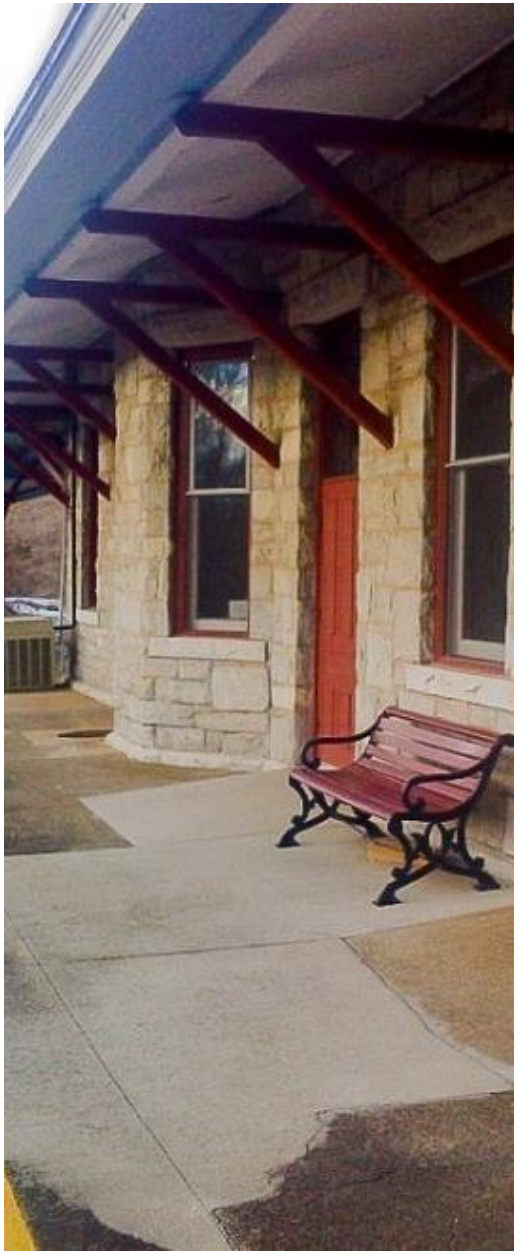
2 Next, each Division develops **Programs** to guide specific types of investment.

e.g., Highway Bridges	**e.g., Industrial Rail Access Program**	**e.g., Transit RTA Fleet Expansion**

3 Finally, CIP **project** lists were identified from **within programs.**

Project	Project	Project	Project	Project	Project	Project	Project	Project

MassDOT produces two work plan documents on a biannual basis: The Federally-mandated five-year STIP and the five-year CIP. Where the STIP includes only highway and transit projects, the CIP includes projects for the MBTA, Rail and Transit Division, Aeronautics Division, and RMV as well.



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7.2 Technical Inputs for the 2017-2021 CIP

Because state and certain federal monies can be spent across modes, the development of a single CIP required value comparisons across individual investments and across modes. To that end, MassDOT utilized two key resources to help determine how funding can be best allocated: the Planning for Performance tool (PfP), a scenario-planning tool that helps highlight the consequences of prioritizing one investment over another; and investment criteria established by the Project Selection Advisory Council (PSAC) to assess all investments against a similar set of mobility, economic, and environmental goals. Asset management systems, including those for highway, bridge, and pavement, also contributed to this process.

7.2.1 Project Selection Advisory Council

In 2013, the Massachusetts Legislature established the independent PSAC to develop "uniform project selection criteria to be used in the development of a comprehensive state transportation plan." In recommending project selection criteria, PSAC received public input, considered legislative requirements, and leveraged the professional expertise of Council members. The uniform criteria are listed in Figure 7.2.

The 2017-2021 CIP is the first to prioritize projects using their recommendations, which entailed scoring projects with a set of weights and criteria based on the project type and goal. This scoring approach was used across all the Divisions, helping to establish a systematic way to more transparently advance the projects that best achieve the desired goal.

Investments benefiting the Department's most important goal – Reliability – were not scored through the evaluation system recommended by PSAC. Rather, such investments are prioritized using existing asset management systems that help each MassDOT division and the MBTA monitor system conditions and prioritize investments based on, among other factors, condition, usage, asset criticality, and maintenance and life-cycle cost impacts. Over time, MassDOT plans to increase both the rigor and the transparency of these asset management systems so that Reliability programs and projects can be more easily prioritized and compared to other types of projects.

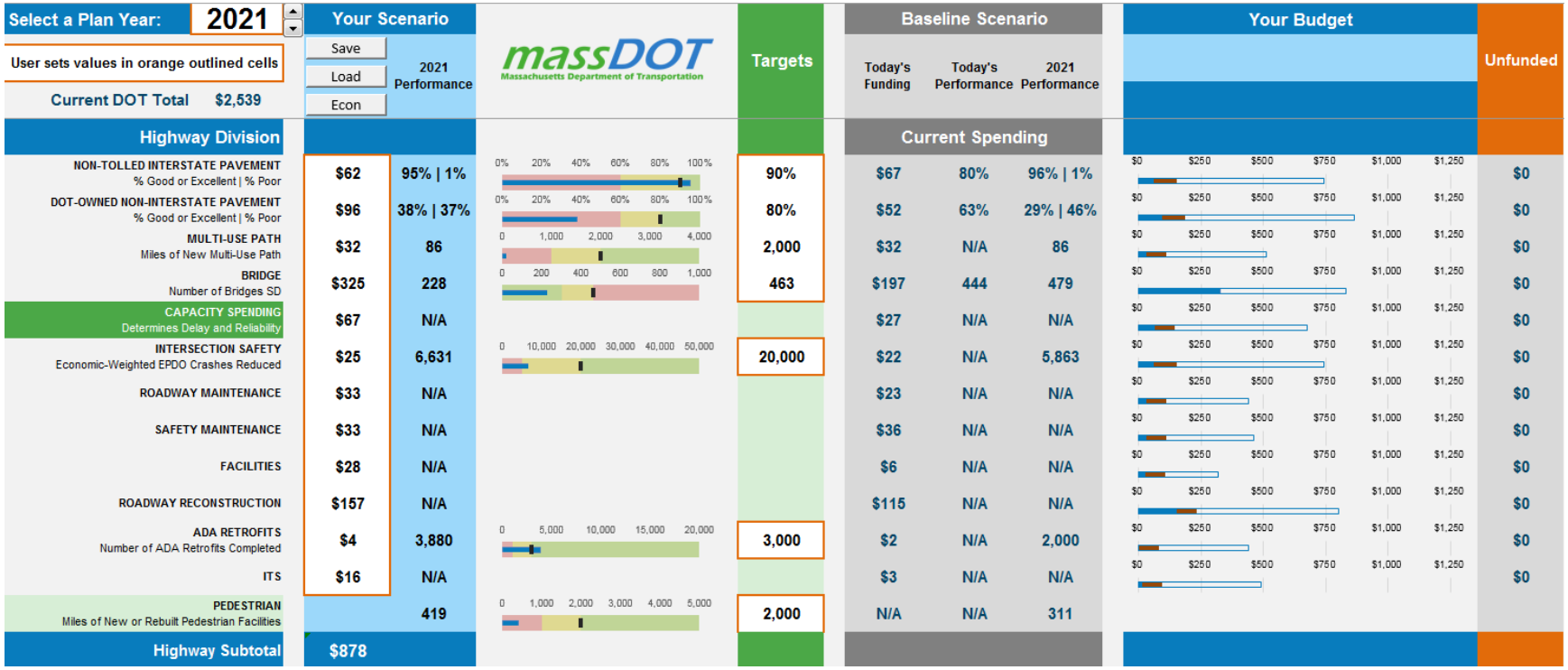
Figure 7.2 Uniform Project Selection Criteria

Evaluation Criteria	Description
System preservation	*Projects should contribute to a state of good repair on the transportation system*
Mobility	*Projects should provide modal options efficiently and effectively*
Cost effectiveness	*Projects should result in benefits commensurate with costs and should be aimed at maximizing the return on the public's investment*
Economic impact	*Projects should support strategic economic growth in the Commonwealth*
Safety	*Projects should contribute to the safety and security of people and goods in transit*
Social equity & fairness	*Projects should equitably distribute both benefits and burdens of investments among all communities*
Environment and health impacts	*Projects should maximize the potential positive health and environmental aspects of the transportation system*
Policy support	*Projects should get credit if they support local or regional policies or plans; or state policies not addressed through the other criteria*

7.2.2 Planning for Performance Tool

The PfP tool uses MassDOT asset performance data and models as well as national data commonly used by the transportation industry to predict the performance of assets over time. By making it possible to evaluate the impact of different funding levels on long-term asset condition, PfP provides MassDOT staff with key insight for the allocation of funding across programs. A screenshot of the tool is shown in Figure 7.3. **The PfP integrates the results of MassDOT's asset management systems to assess the performance of an integrated TAM investment portfolio.**

Figure 7.3 The Planning for Performance (PfP) Tool



PfP is sensitive to limitations on how funding can be used based on its source, allowing for real-world scenario planning. Performance-based planning and the PfP tool allow MassDOT to use performance data to compare the impacts of investments across Divisions, asset types, and modes in order to better understand the most efficient and strategic allocation of resources to achieve goals for the Commonwealth's transportation system.

The PfP tool will evolve over time as MassDOT continues to improve and expand its asset management data. Over the life of the CIP, PfP can be used to anticipate performance outcomes and to monitor performance and adjust models accordingly.

The "Your Scenario" column shows how much this CIP funds on an average annual basis and the anticipated outcome in five years, assuming continued spending at the same rate. The "Baseline Scenario" shows recent historical spending levels on an annual basis and estimates what the performance outcomes would be if that same amount were spent annually for the next five years. For the Highway Division, all outcomes improve over the baseline scenario, except for non-tolled Interstate pavement, which the model indicates will not vary from the baseline, despite a reduction in funding.

Moving forward, MassDOT will fully integrate the performance targets identified by OPM&I into PfP. This can result in more refined program sizing in future CIPs. MassDOT is also working to update the MBTA models and measures to correspond with models that are being revised in the SGR Database so that future CIPs will offer a more refined comparison across modes. For more information about model assumptions, please see the PfP Manual on the MassDOT website.

7.2.3 Additional Strategic Planning Inputs

While PSAC and PfP have been instrumental in helping the 2017-2021 CIP identify investment criteria and priorities, other tools can be utilized as MassDOT develops future CIPs.

The proposed purchases of new MBTA vehicles, for example, may require adjustments to align with the MBTA fleet plan, which is still in development. More broadly, MassDOT and the MBTA will consider developing the capacity to more fully utilize scenario planning in making investment decisions, especially when a proposed

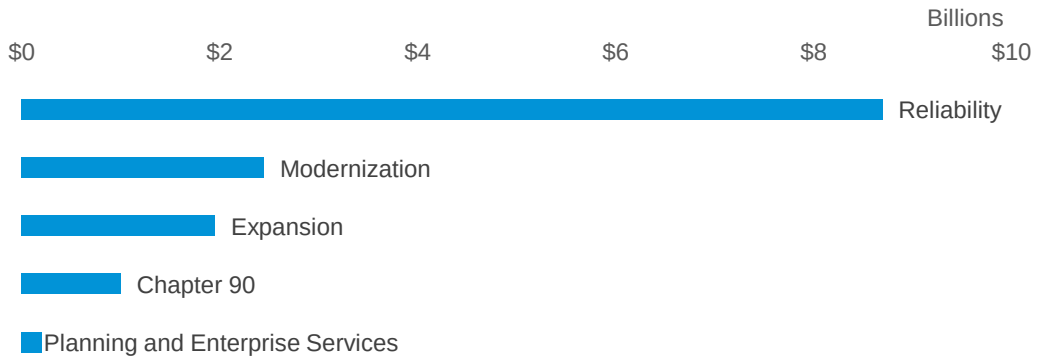
investment falls in a grey area between priorities. Considering multiple investment scenarios could help clarify decisions.

For example, this plan makes investments in MBTA signals. But looking forward, one hypothetical scenario might call for a level of investment to just get power and signals to SGR, while another scenario could suggest higher spending for more future-proof signal technology that could improve headways immediately.

7.2.4 Results

The 2017-2021 CIP reflects the importance of a reliable transportation system. Approximate spending by priority is illustrated in Figure 7.4.

Figure 7.4 Approximate 2017-2021 CIP Spending by Priority



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8 The Road Ahead

In 2017 MassDOT will carry forward its best practice bridge and pavement inspection programs. It will develop a new bridge condition model in response to new Federal metrics and will assess how best to meet Federal thresholds for bridge condition. In addition, it will continue to collect and verify inventory for small bridges, culverts, ancillary structures, bicycle facilities, and sidewalks.

In 2017, MassDOT will complete its first Highway Division TAMP. This document will communicate the Department's practice for data collection and management, risk management, and performance-driven investment, as established in 2015's TAM Strategic Plan.

In 2017 the MBTA will continue to populate and verify the asset data in in its SGR database, and will continue to develop record-keeping standards for its widely-varying asset base. As it collects more inventory, it will continue to use national best practices to update lawmakers, customers, and the public on its performance and funding requirements.

In 2017 the MBTA will update its Transit Asset Management Plan to contain all information and analysis required by the Federal Government, including asset management policies and practices, investment strategies, and identification of resources.

In 2017 MassDOT will continue data collection on newly-purchased rail lines. It will maintain its database of grade crossings to help ensure their ongoing safety.

In 2017 MassDOT will support the RTAs as they fully implement the TransAM database. MassDOT will collaborate with the RTAs to interpret and implement new FTA guidance, including the development of Transit Asset Management plans.

In 2017 MassDOT will expand its pilot implementation of the AIR-Port statewide database to store airport inspection records, asset data, and project documentation. MassDOT will begin updating its 2010 State Airport System Plan with the support of the Federal Aviation Administration.

In 2017 MassDOT will implement its triennial pavement survey update plan. Once the first survey is established, MassDOT staff will perform annual verification and revisions based upon photographs and project records.

In 2017 MassDOT will expand efforts to collaborate with municipalities and MPOs to improve data collection and performance management for municipal pavement. The objective of these efforts will be to…

- Improve communication and share resources among local government organizations;
- Share MassDOT's asset and performance management tools with local government; and
- Provide MassDOT with high-quality statewide condition data for municipal pavement.

The Council recommends that MassDOT clarify the Department's transportation asset management (TAM) policy in a formal directive. Among others, provisions could include requirements that:

- Divisions identify personnel to serve as TAM champions;
- Each division develop a TAM strategic plan with an initial focus on inventory and condition;
- Divisions independently maintain high-quality asset data in sophisticated systems;
- Divisions review the efficacy of their financial and contract management systems; and
- Divisions model asset condition and performance where appropriate.

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A Methodology for Computing Backlog by Asset Owner

A.1 Highway Division

A.1.1 Pavement Backlog

To calculate backlog, a separate lane mile cost is used for the Interstate and non-Interstate inventory.

MassDOT rarely advertises projects with scope of work limited solely to pavement. Typically, pavement management projects are used to address other deficiencies found within the project corridor. In the case of Interstate and freeway projects, work can include bridge preservation activities, safety systems (guardrail and barrier, shoulder widening), drainage upgrades, reestablishing clear zones and intelligent transportation systems (cameras etc.). On non-Interstate projects, pedestrian and bicycle accommodations are considered, which can result in modifications to the roadway cross-section, drainage reconstruction and other impacts to project scope. In the case of both Interstate and non-Interstate projects, incidentals also include traffic control and police work zone enforcement.

This holistic approach to highway maintenance effectively shares project dollars between pavement and other highway assets. To adequately represent non-pavement-related project costs, per-lane mile costs are derived from program history. The values in Table B.1 are average costs from the previous five years of the Interstate Maintenance and National Highway System paving programs.

The lane-mileage and backlog for interstate and non-interstate fair and poor-rated pavement is provided in Table B.2.

Table A.1 Assumptions for Valuation of Repair Backlog

Initial Condition	Interstate	Non Interstate
Fair	$465,500/lane-mile	$500,000/lane-mile
Poor	$731,500/lane-mile	$557,000/lane-mile

Table A.2 MassDOT Lane-Mileage and Backlog

	Fair Lane Miles	Poor Lane Miles	Backlog
Interstate	516	70	$239,999,963
Non-Interstate	1,641	803	$1,268,231,260

The current total estimated pavement repair backlog is **$1.51 billion, with $240 million required for the Interstates and $1.3 billion for the non-Interstate network.**

A.1.2 Bridge Backlog

Assumptions for computing SD bridge backlog are shown in Table B.2. Replacement costs are provided each year as part of the FHWA National Bridge Inventory (NBI). FHWA assumes that rehabilitation costs are 68% of replacement costs based on analysis of the national dataset. MassDOT assumes a project cost of twice the replacement/rehab cost to account for inherent non-structural costs of the work.

Table A.3 Cost Assumptions for SD Bridges

	FHWA Cost	MassDOT Cost
Replacement	$342/ft^2	$683/ft^2
Rehabilitation	$232/ft^2	$465/ft^2

Source: FHWA, weighted average of NHS and non-NHS costs by SD ft^2

Both replacement and rehabilitation resolve SD status and return a bridge to "like-new" condition. MassDOT's decision about which to pursue can be based on many factors beyond condition, including potential disruption to traffic, site conditions, and the historic status of the bridge (e.g., the Longfellow).

Since 1985, of projects on SD bridges, MassDOT has conducted 77% replacements and 23% rehabilitations. When these findings are applied to the costs in Table B.1, the assumed cost for resolving SD bridges is computed to be **$632 per square foot**.

Backlog NBI bridges **for which capital responsibility rests with the Highway Division (i.e., Highway Division and municipal)** is shown in Table B.4.

Table A.4 MassDOT SD Deck Area and Backlog

	SD Deck Area (ft^2)	Backlog
NHS	5,031,835	$3,181,499,197
Total	5,931,857	$3,750,559,842

A.2 MBTA

The MBTA computes backlog within the SGR Database. Three factors affect the calculation of backlog.

- Backlog represents the total replacement costs of all assets that are not in a state of good repair, i.e. they have a current SGR score that is less than or equal to 2.5.
- An increase in backlog is based on the calculation of the unfunded portion of an asset's cash flow for a future replacement. For example, assume that an asset's SGR score falls below 2.5 in 2017. Also assume that this asset has a five-year replacement cash flow, with 20% of the asset's replacement cost distributed equally in each of the five years. According to these assumptions, the replacement of the asset should have begun in 2013 in order to be completed by 2017. Therefore, three years – 2013, 2014, and 2015 – of the asset's cash flow – or 60% of the asset's replacement cost –would count toward backlog.
- A reduction in backlog is made for any spending on the replacement of an asset that has occurred in the MBTA's capital program. Taking the example just presented, assume that 50% of the asset's replacement cost had been spent to date. After making this adjustment, only 10% – 60% minus 50% – of the asset's replacement cost would count toward backlog.

Both the SGR score and backlog represent statistics for the current asset inventory. This inventory is continually changing as new assets are added and inventory information is edited.

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The MBTA aims to provide the option of annually updating the inventory to asset managers at a prescribed time. Asset information can also be edited or added to the inventory throughout the year on an individual basis as an asset's replacement is completed or a new asset is purchased.

A.3 Municipalities

A.3.1 Municipal Pavement Backlog

Municipal pavement backlog is calculated using the cost factors in Table B.1. NHS lane-mileage in fair and poor condition is taken from the RIF.

Note that because high quality municipal pavement data off the NHS is not available for all communities, backlog is derived only for NHS pavement cataloged in the RIF. To convert from lane-miles to centerline-miles, it is assumed that all municipally-owned NHS roadways have two lanes.

Fair and poor lane-mileage and backlog are provided in Table B.7.

Table A.5 Municipal Centerline-Mileage and Backlog

	Fair Centerline Miles	Poor Centerline Miles	Backlog
NHS	325	259	$307,146,317

A.3.2 Municipal Bridge Backlog

Because MassDOT has capital responsibility for municipally-owned bridges, backlog for these structures is a subset of MassDOT's bridge backlog. The NBI database includes a field that identifies ownership of structures. The SD deck area of municipal structures is multiplied by the cost factors in Table B.3 to produce the backlog in Table B.8.

Table A.6 Municipal SD Deck Area and Backlog

	SD Deck Area (ft^2)	Backlog
Total	498,656	$315,287,277

B List of Prioritized Highway Division Assets

The list of assets in the grid is derived from best practices nationwide, with some alterations to reflect MassDOT's internal terminology. The lists of ITS and traffic operations equipment were derived from internal MassDOT documents and MassDOT's list of tunnel-related safety and operations equipment was included verbatim.

Overall, the grid includes 99 types of assets. These fall into 11 asset classes:

- Ancillary Structures;
- Bridges;
- Drainage;
- Equipment;
- Facilities;
- ITS and Tolling Devices (Surface);
- Mixed-Use Paths;
- Pavement;
- Roadway;
- Traffic Operations;
- Tunnels;

Priority is derived from the five component scores, all assigned on a zero-to-five scale. They include:

- **Likelihood of Performance Failure (L):** The likelihood that an asset will fail in such a way that it can no longer perform its intended function. This score is assigned qualitatively, relative to the full set of assets – scores are not tied to numerical odds or historic data.
- **Life Safety Impact of Failure (S):** A score of five indicates that fatalities could occur in the event of failure; a score of one indicates that any injury is unlikely.
- **Customer Impact of Failure (C):** A score of five indicates significant volumes of traffic would be diverted or otherwise inconvenienced, at the cost of economic activity; a score of one indicates that a failure would go unnoticed by travelers.
- **Regulatory Concern (R):** A score of five indicates that MassDOT has regulatory or legal obligations in regard to the asset, imposed by the Commonwealth, the Federal Government, or a judge. A score of zero indicates that no oversight exists.
- **Budget Footprint (B):** A score of five indicates that the asset is a primary target of MassDOT capital and operating funds.

The asset list was finalized, and component scores were assigned, through a collaborative discussion of the Highway Division Transportation Asset Management Steering Committee in mid-2015. Overall priority scores fall over the range 0⟶20 and are determined by the equation:

$$Overall\ Score = \frac{L(2S + C)}{5} + \frac{R + B}{2}$$

Note that life safety is given twice the weight of customer service, and that regulatory concern and budget footprint are given less weight than failure impacts.

Asset Class	Asset	Priority Component Scores					Overall Priority Score
		Likelihood of Performance Failure	*Life Safety Impact of Failure*	*Customer Impact of Failure*	*Regulatory Concern*	*Budget Footprint*	
Ancillary Structures	High-Mast Lighting Structures (>45')	2	5	5	3	3	10.5
	Lighting Mounts	2	4	4	3	2	8.8
	Noise Barriers	1	1	3	0	2	2.0
	Overhead Structures	2	5	5	3	3	10.5
	Retaining Walls	2	5	3	5	1	10.7
Bridges	Bridges	4	5	5	5	5	19.5
	Culverts (10-20' span)	4	3	5	5	1	14.3
Drainage	Best Management Practices (BMPs)	3	1	2	5	2	8.4
	Culverts (<4' span)	5	2	5	1	1	10.5
	Culverts (4-10' span)	5	3	5	1	1	12.5
	Detention Basins	3	1	1	1	1	3.3
	Drop Inlets	3	1	2	1	1	3.9
	Gates and Sluices	3	1	2	1	1	3.9
	Gutter	3	1	2	1	1	3.9
	Lined Channels	2	1	3	1	1	3.5
	Pumps	5	3	5	5	3	17.5
	Slotted Drains	3	1	3	1	1	4.5
	Stormwater Controls	3	1	2	1	1	3.9
	Stormwater Outfalls	3	1	3	5	2	9.0
	Unlined Ditches	3	1	3	1	1	4.5

Asset Class	Asset	Priority Component Scores					Overall Priority Score
		Likelihood of Performance Failure	*Life Safety Impact of Failure*	*Customer Impact of Failure*	*Regulatory Concern*	*Budget Footprint*	
Equipment	Drain Cleaning Rigs	3	1	2	1	2	4.4
	Drilling Rigs	3	1	1	1	2	3.8
	Forklifts	3	1	1	1	2	3.8
	Graders	3	1	1	1	2	3.8
	Loaders	3	1	1	1	2	3.8
	Mowers	3	1	1	1	2	3.8
	Other Equipment	3	1	1	1	2	3.8
	Painting Equipment	3	1	3	1	2	5.0
	Paving Equipment	3	1	2	1	2	4.4
	Rollers	3	1	2	1	2	4.4
	Safety Vehicles	3	3	2	1	2	6.8
	Snow Blowers	3	3	5	1	2	8.6
	Snow Plows	3	3	5	1	2	8.6
	Sweepers	3	1	1	1	2	3.8
	Trailers	3	1	1	1	2	3.8
	Trucks	3	1	2	1	2	4.4
Facilities	Commuter and Tandem Parking	1	1	4	0	1	1.7
	Equipment Node Buildings	1	1	3	0	1	1.5
	Fuel Facilities	1	1	3	0	1	1.5
	Laboratories	1	1	2	0	1	1.3

Asset Class	Asset	Priority Component Scores					Overall Priority Score
		Likelihood of Performance Failure	*Life Safety Impact of Failure*	*Customer Impact of Failure*	*Regulatory Concern*	*Budget Footprint*	
Facilities	Maintenance Depots	1	1	3	0	1	1.5
	Materials Storage Sheds	1	1	3	0	1	1.5
	Rest Areas and Welcome Centers	1	1	4	0	1	1.7
	Sand/Salt Sheds	1	2	3	1	1	2.9
	Toll Plazas	1	1	4	0	1	1.7
	Traffic Operations Center	1	4	5	0	1	3.1
	Weigh Stations	2	1	2	0	1	2.1
ITS and Tolling (Surface)	AM/FM Override	2	1	1	3	1	4.7
	Bluetooth Detectors	2	1	1	0	1	1.7
	Citilog Cameras	2	1	1	0	1	1.7
	Contin. Operating Ref. Stations (CORS)	3	0	3	3	1	5.3
	Electronic Tolling Devices	2	1	5	0	1	3.3
	Highway Advisory Radio	2	1	2	2	1	4.1
	Overheight Detectors	4	3	4	1	1	9.5
	RWIS	2	1	2	0	1	2.1
	Smart Work Zones	2	3	1	3	1	6.3
Mixed-Use Paths		2	3	4	3	1	7.5
Pavement	Paved Shoulders	2	2	3	0	1	3.3
	NHS Pavement	2	3	5	5	5	11.9
	Non-NHS Pavement	2	3	5	5	5	11.9

Asset Class	Asset	Priority Component Scores					Overall Priority Score
		Likelihood of Performance Failure	*Life Safety Impact of Failure*	*Customer Impact of Failure*	*Regulatory Concern*	*Budget Footprint*	
Roadway	At-Risk Hillsides	4	5	3	0	1	10.9
	Curb	3	3	3	1	1	6.9
	Curb Ramps	2	1	5	5	1	8.3
	Fencing	2	2	1	0	1	2.5
	Front, Back, Side Slopes and Median	2	1	1	0	1	1.7
	Hydrants and Standpipes	2	3	1	4	1	7.3
	Guardrail and Barriers	2	5	1	1	1	5.9
	Landscaping Areas	2	1	1	0	1	1.7
	Lighting - Bridge	3	2	3	0	1	4.7
	Lighting - Roadway	3	2	3	0	1	4.7
	Lighting - Tunnel	3	5	3	0	1	8.3
	Mowable Areas	2	1	2	1	2	3.6
	Rock Cuts	3	5	3	0	1	8.3
	Sidewalk	4	2	4	3	1	9.9
	Sign Posts	2	1	3	0	2	3.0
	Truck Escapes	2	5	1	5	1	9.9
	Unpaved Shoulders	2	2	3	0	1	3.3
Traffic Operations	Blank-Out Signs	2	1	4	0	1	2.9
	CCTV Traffic Cameras	2	1	2	0	1	2.1
	Crash Attenuators	2	5	1	5	1	9.9

Asset Class	Asset	Priority Component Scores					Overall Priority Score
		Likelihood of Performance Failure	*Life Safety Impact of Failure*	*Customer Impact of Failure*	*Regulatory Concern*	*Budget Footprint*	
Traffic Operations	Delineators	2	2	4	0	1	3.7
	Intersection Equipment Cabinets	1	1	1	0	1	1.1
	Object Markers	2	3	2	0	1	3.7
	Pavement Markings	2	3	3	0	2	4.6
	Reflective Highway Signs	2	3	3	5	2	9.6
	Sign Ground Mounts	2	1	3	0	2	3.0
	Traffic Data Collection Equipment	2	1	3	0	1	2.5
	Traffic Signals	3	3	5	3	2	10.6
	Ground Mount Variable Message Signs	2	1	5	3	1	6.3
	Overhead Variable Message Signs	N/A	N/A	N/A	N/A	N/A	N/A
	Wiring and Utility Culverts	1	2	2	0	1	1.7
Tunnels	Emergency Strobe Lights	3	5	2	5	3	13.7
	Facility Sensors	3	2	3	0	3	5.7
	Fire Alarm and Suppression Systems	3	5	5	5	3	15.5
	Security Alarms	4	3	1	3	3	10.1
	Security Cameras	4	3	1	3	3	10.1
	Tunnel Electrical System Devices	3	5	5	5	3	15.5
	Vehicular Tunnel Structures	3	5	4	5	5	15.9
	Ventilation Fans	3	5	3	5	3	14.3

Glossary

4D	MassDOT Bridge Inspection Management System
AASHTO	American Association of State Highway and Transportation Officials
AFC	Automated Fare Collection
AIP	FAA Airport Improvement Program
AIR-Port	Airport Information Resource Portal
Airport Pavement Management System	APMS
AMP	MBTA Asset Management Plan
ASMP	Airport Safety and Maintenance Program
BRI	Massachusetts Bridge Structure (small bridge)
CCRTA	Cape Cod Regional Transportation Authority
CIP	Capital Investment Plan
COG	Council of Governments
DTIMS	Deighton Total Infrastructure Management System
EAMS	Enterprise Asset Management System
FAA	Federal Aviation Administration
FAST Act	Fixing America's Surface Transportation Act
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration

FTA	Federal Transit Administration
GATRA	Greater Attleboro-Taunton Regional Transportation Authority
GIS	Geospatial Information System
LiDAR	Light Detection and Ranging
MAP-21	Moving Ahead for Progress in the 21st Century Act
MassDOT	Massachusetts Department of Transportation
MBTA	Massachusetts Bay Transportation Authority
MMA	Massachusetts Municipal Association
MPO	Metropolitan Planning Organization
MRTA	Montachusett Regional Transportation Authority

MSASP	Massachusetts Statewide Airport System Plan
NAVAID	Navigation aid
NBI	National Bridge Inventory (large bridges)
NBIS	National Bridge Inventory Standards
NHS	National Highway System
NPRM	Notice of Proposed Rulemaking
NTD	National Transportation Database
NTIS	National Tunnel Inspection Standards
OCC	MBTA Operations Control Center
OPM&I	MassDOT Office of Performance Measurement and Innovation

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PAMAC	Performance and Asset Management Advisory Council
PCI	Pavement Condition Index (airports)
PfP	Planning for Performance
PMA	Pavement Management Application
PSAC	Project Selection Advisory Council
PSI	Pavement Serviceability Index (highways)
PVTA	Pioneer Valley Transportation Authority
RIF	Road Inventory File
RPC	Regional Planning Commission
RTA	Regional Transit Authority
SAAB	State Airport Administration Building
SGR	State-of-Good-Repair
STIP	State Transportation Improvement Plan
TAM	Transportation Asset Management
TAM Plan	Transportation Asset Management Plan (FTA requirement)
TAMP	Transportation Asset Management Plan (FHWA requirement)
TIP	Transportation Improvement Plan
TPM	Transportation Performance Management
TransAM	Transportation Asset Manager (software)