



# BOSTON REGION METROPOLITAN PLANNING ORGANIZATION

State Transportation Building  
Ten Park Plaza, Suite 2150  
Boston, MA 02116-3968  
Tel. (617) 973-7100  
Fax (617) 973-8855  
TTY (617) 973-7089  
www.bostonmpo.org

Jeffrey B. Mullan  
MassDOT Secretary and CEO  
and MPO Chairman

Arnold J. Soolman  
Director, MPO Staff

The Boston Region MPO,  
the federally designated  
entity responsible for  
transportation decision-  
making for the 101 cities  
and towns in the MPO  
region, is composed of:

MassDOT Office of Planning and  
Programming  
City of Boston  
City of Newton  
City of Somerville  
Town of Bedford  
Town of Braintree  
Town of Framingham  
Town of Hopkinton  
Metropolitan Area Planning Council  
Massachusetts Bay Transportation  
Authority Advisory Board  
Massachusetts Bay Transportation  
Authority  
MassDOT Highway Division  
Massachusetts Port Authority  
Regional Transportation Advisory  
Council (nonvoting)  
Federal Highway Administration  
(nonvoting)  
Federal Transit Administration  
(nonvoting)

## Draft MEMORANDUM

**DATE:** December 16, 2010  
**TO:** Transportation Planning and Programming Committee  
**FROM:** Efi Pagitsas and Seth Asante  
**RE:** Federal-Aid-Eligible Boston Region MPO Roads: A Rough Estimate of Maintenance Costs for FFYs 2010–2014 and Recommendations on the Development of a Pavement Management System (PMS)

### STUDY PURPOSE AND SUMMARY OF FINDINGS

The purpose of this study is threefold:

- To develop a sense of the magnitude of the costs required to maintain the Boston Region MPO's Federal-Aid (FA) local roads
- To define and describe the principles of a pavement management system (PMS)
- To bring to the TPPC's attention the next steps in beginning to explore the development of a pavement management system that would facilitate informed decision making regarding pavement investment strategies

The study's conclusions may be summarized as follows:

- A PMS provides extremely important input for investment strategy decisions.
- The MPO should consider maintaining such a system in order to:
  - Estimate accurately the maintenance costs for FA-eligible roads in the region
  - Help develop and choose from maintenance strategies for the effective use of increasingly limited resources
  - Reduce the number of Transportation Improvement Program (TIP) "Reconstruction" projects that include a very costly deep pavement-reconstruction component
- In preparation for a possible PMS for the MPO region, the staff seeks authorization to begin planning for the development of such a system. The planning work this would include is specified in the final section of this memo.

## INTRODUCTION

In their October 2009 communication to the MPOs regarding the approval of the Massachusetts FFY 2010 Unified Planning Work Program (UPWP),<sup>1</sup> the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) recommended that "...the RPAs undertake a study to establish the cost of maintaining the roadway systems in the cities and towns that make up their regions. The interstate and the National Highway System arterials in each region have their own dedicated federal funding source and are largely the responsibility of Massachusetts Department of Transportation Highway Division. The remaining miles of arterials as well as the urban collectors in the regions are the responsibility of the cities and towns working in cooperation with the MPOs. As such, the MPOs need to know the cost of maintaining these roadways, and more importantly, need to ensure that priority is given to their maintenance. Many of the MPOs do not have a good handle on matters pertaining to the maintenance of roadways, and therefore it is necessary that priority be given to undertaking these studies. It is the expectation that the results of these studies will be used to inform MPO decision-making in the next major update of the Regional Transportation Plans to begin in FY 2010."

This memorandum essentially presents the analysis from and results of the study that the FHWA and the FTA recommended above and discusses issues related to the development of a Boston Region MPO PMS so that, in the future, analysis can be done more accurately and pavement maintenance priority decisions can be made explicitly.

## 2010 MARPA PAVEMENT MANAGEMENT/MAINTENANCE SUBCOMMITTEE

In response to the FHWA and FTA recommendation, the Massachusetts Association of Regional Planning Agencies (MARPA) and the Massachusetts Department of Transportation (MassDOT) Office of Transportation Planning formed the Pavement Management/Maintenance Subcommittee, which included representatives from most of the 13 RPAs in Massachusetts. The subcommittee's goal was to assist those RPAs that do not maintain a PMS with determining the cost of maintaining the FA-eligible local-roadway system and to ensure that priority is given to the maintenance of that system.

The subcommittee met several times in the spring and summer of 2010. The discussion topics, which were recommended by the subcommittee chairperson, Charles Kilmer, OCPC, were specified by him as follows:

- "Existing methods and priorities of measuring pavement condition, maintenance, and level of investment
- Current pavement management practices
- Results and usage of existing PMSs, and what are the conditions and costs of maintaining the system
- Potential for prioritizing repairs by roadway type, and identifying funding sources

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<sup>1</sup> FHWA and FTA letter to EOT Secretary James A. Aloisi, Jr., October 1, 2009, regarding "Approval of the Massachusetts FY 2010 Unified Planning Work Programs."

- Opportunities for consistent methodologies, repair strategies, pavement management software, etc.”

The main findings from the subcommittee meetings were:

- Of the 13 RPAs in Massachusetts, the following 7 have a PMS to assist them with identifying and prioritizing pavement maintenance needs in their region:<sup>2</sup>
  - Central Massachusetts Regional Planning Commission (CMRPC)
  - Montachusett Regional Planning Commission (MRPC)
  - Merrimack Valley Planning Commission (MVPC)
  - Nantucket Planning and Economic Development Commission (NP&EDC)
  - Old Colony Planning Council (OCPC)
  - Pioneer Valley Planning Commission (PVPC)
  - Southeastern Regional Planning and Economic Development District (SRPEDD)
- The RPAs that have a PMS collect data on a two-to-five-year cycle at a cost of \$10,000 to \$45,000 annually, and apply a variety of PMS software to process and analyze the collected data.
- In 1986, the Metropolitan Area Planning Council (MAPC) developed a Pavement Management Program<sup>3</sup> manual to assist the region’s 101 cities and towns in the development of their own PMSs. In addition to the published manual, MAPC employed one staff person to manage the program, which focused on technical assistance to the region’s cities and towns. The MAPC program was discontinued in the early to mid-1990s. Presently, although every city and town’s public works director in the Boston Region MPO area makes pavement management priority decisions annually, it is unclear what kind of pavement management system each municipality relies on.
- For the MAPC/Boston Region MPO area and the rest of the RPAs that do not maintain pavement management systems, it is possible to employ sketch-planning-level methods and generic data from MassDOT and RPAs that maintain a PMS to make initial approximate calculations of the amount of funding required to maintain each region’s FA-eligible roads to a target level.
- In order to determine pavement management priorities and more accurately calculate maintenance cost for FA-eligible roads, RPAs that do not have a PMS should consider developing one. A PMS would allow for the analysis of investment strategies that most effectively match available funding.

Other information and findings from subcommittee meetings include the following:

- There are 3,463 FA centerline miles in the Boston Region MPO area, of which 694 (20%) are MassDOT-maintained and 2,768 (80%) are municipality-maintained.<sup>4</sup>

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<sup>2</sup> The 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) required states and MPOs to implement management systems, including a pavement management system. This requirement was modified in the FHWA and FTA 1996 Final Rule on Management and Monitoring Systems encouraging states and MPOs to selectively implement, rather than mandating that they implement, management systems, including a pavement management system, with the exception of the Congestion Management System (CMS).

<sup>3</sup> *Pavement Management: A Manual for Communities*, Metropolitan Area Planning Council, 1986.

<sup>4</sup> MassDOT Pavement Management System.

- For the rest of the planning regions in the commonwealth, the total centerline miles of municipally owned FA roads range from 253 to 1,002 miles.
- MassDOT has pavement condition data for a sample of 936 (34%) of the 2,768 centerline miles that are owned and maintained by cities and towns in the Boston Region MPO area. (Because these segments are between segments of MassDOT-maintained roadways, data on the former are captured during collection of data on the latter by MassDOT pavement management staff for MassDOT's PMS.) According to MassDOT, the pavement condition of the 936 sample centerline miles is as follows:<sup>5</sup>
  - 57 centerline miles (6%) excellent
  - 275 (29%) good
  - 284 (30%) fair
  - 319 (34%) poor
- Extrapolating from the MassDOT sample data in order to assess the pavement condition of all city- and town-owned FA roads in the commonwealth, the centerline miles are distributed as follows:
  - 12% excellent
  - 36% good
  - 28% fair
  - 24% poor
- Pavement condition distributions of FA-eligible local roads derived from MassDOT-collected data differ significantly from the distributions derived from data collected by the RPAs.
- The consensus was that RPAs with established PMSs should adopt pavement condition distributions derived from their PMS databases, while RPAs without PMS programs should consider using the condition distribution from the MassDOT sample or a weighted average based on neighboring RPAs.

## **WHAT IS A PAVEMENT MANAGEMENT SYSTEM (PMS)?**

The condition of roads in a region is an important factor in the planning process, because roads are the foundation of any regional transportation system. Consequently, PMS strategies are needed as part of the planning process in order to inform the Long-Range Transportation Plan's (LRTP's) and the TIP's allocations of resources to long-term and short-term roadway projects. Effective fund allocation is especially important at times when funding is scarce and decision makers are looking to maximize the benefit of every dollar spent.

A PMS is a set of tools, methods, and processes to assist in overseeing the maintenance of a roadway network. Specifically, a PMS can assist decision makers in finding cost-effective

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<sup>5</sup> It is unclear whether the pavement condition distribution based on MassDOT's sample of local FA roads in the MAPC/Boston Region MPO area is accurate for the area's local FA roads overall. This is mainly because MassDOT's rating system for pavement conditions adheres to a higher standard than that for local roads. In the rough analysis presented later in this memo, staff decided to adopt a weighted average distribution of existing conditions based on the two neighboring RPAs, CMRPC and OCPC, as being more representative of the condition of the Boston Region MPO's local FA roads.

strategies for monitoring and evaluating road pavement and maintaining it in a state of good repair. A PMS system comprises two components:

- A detailed database that describes historical pavement condition, traffic levels, and pavement structure for predefined roadway segments. Most PMSs collect pavement condition information via a “windshield” or “photologging” survey of pavement roughness and distress. (MassDOT does this with an Automatic Road Analyzer, or ARAN.) The combined overall road pavement condition of a segment is assigned a rating from a road rating system. For example, MassDOT uses the PSI (Pavement Serviceability Index) rating system, which assigns values from 0.00 to 5.00 or the ratings “poor,” “fair,” “good,” and “excellent.” MassDOT’s target pavement value is “excellent” for both interstate and non-interstate roads, but the associated PSI targets differ slightly: 4.0 for interstate roads and 3.5 for non-interstate roads.<sup>6</sup>
- The second component of a PMS consists of a set of tools or models that determine existing and future pavement conditions and funding needs, and point to priority pavement-preservation projects. This is done through timelines that are built into the models to estimate at what pace the roadway will deteriorate. For example, for MassDOT’s FFY 2011–2015 Highway Capital Investment Plan (CIP), MassDOT pavement management staff applied associated models for pavement deterioration to estimate the cost of maintaining interstate and non-interstate roads in “excellent” condition. According to MassDOT’s CIP, it would require \$128 million annually to achieve the targeted PSI for interstate highways and \$185 million annually to achieve the targeted PSI for non-interstate roads.

A very important question PMS models can analyze is, Which roads should be maintained at a predefined target level, given the amount of funding available for a sequence of forecast years? To reach a conclusion, the PMS tool allows MPOs and state DOTs to define and “run” several “what if” scenarios to find the applicable optimum one.

## **ESTIMATING MAINTENANCE COSTS FOR FEDERAL-AID-ELIGIBLE LOCAL ROADS IN THE BOSTON REGION MPO AREA**

In order to begin developing a sense of the order of magnitude of pavement management costs for local roads in the region, staff selected the approach of answering the question, What would be the approximate cost of bringing to “excellent” condition the 2,768 centerline miles that are the responsibility of MPO communities? Note that, chances are, the preferred policy of the municipalities and the MPO would be one that defines different mixes of roadway types and target condition levels to implement annually. This is because the general theory and practice in asset management systems dictates that the least costly strategy is to exercise sufficient maintenance in order to prevent further deterioration of roads in “good” and “fair” condition as opposed to upgrading those which are in “poor” condition first. Therefore, analyzing the cost of bringing all 2,768 miles to “excellent” condition would yield an upper-bound estimate of maintenance cost.

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<sup>6</sup> Draft FFY 2011–2015 Highway Capital Investment Plan, MassDOT, Office of Transportation Planning, May 2010.

Staff used two different methods to estimate the annual cost of bringing all FA-eligible local roads in the Boston Region MPO area to “excellent” pavement condition over the course of FFYs 2010–2014:

*Method 1: Applying Weighted Average Pavement Conditions and Average Pavement Repair Cost per Centerline Mile from Neighboring RPAs’ Data*

Staff calculated the annual maintenance cost for FFYs 2010 to 2014 by making assumptions based on neighboring RPAs’ pavement condition and cost data. The method applied was based on a modified sketch-planning tool<sup>7</sup> presented at one of the MARPA pavement management subcommittee meetings. The following assumptions and calculations were made:

- All cost calculations are for bringing pavement condition to “excellent.”
- The weighted average existing pavement condition distribution of OCPC and CMRPC was assumed as this region’s pavement condition distribution: 20% excellent, 29% good, 25% fair, and 26% poor.<sup>8</sup>
- The total cost for all the FA-eligible local roads in the Boston Region MPO area was calculated by applying the weighted average cost per centerline mile (\$306,746, the weighted average for the two neighboring RPAs) to the total FA local miles in our area, 2,768 miles, which yields \$849,072,928. See Table 1A.
- Reflecting the assumption of a five-year maintenance cycle, the total cost was distributed over five years, yielding \$169,814,586 annually. See Table 1B.

In summary, this analysis points to a \$169.8 million annual cost over five years to bring all FA-eligible local roads in the Boston Region MPO area to “excellent” pavement condition.<sup>9</sup>

*Method 2: Applying Weighted Average Pavement Conditions from Neighboring-RPA Data and Average Pavement Repair Cost per Lane-Mile from Compatible MPOs’ Data*

In this method, staff calculated the annual maintenance cost for FFYs 2010–2014 by making the same assumptions about the distribution of pavement condition as those made in Method 1, but estimating cost per lane-mile<sup>10</sup> based on compatible MPOs’ data and taking into account the varying types of maintenance required. First the distribution of pavement condition (excellent,

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<sup>7</sup> Charlie Kilmer, Old Colony Planning Council, 2010

<sup>8</sup> Staff applied the weighted average of actual existing pavement condition data from CMRPC and OCPC because they are neighboring MPOs, they have established PMS systems, and their travel and land use characteristics are similar to those of the Boston Region MPO area. The rest of the MPOs that maintain PMSs are more rural, and their roads would be expected to exhibit different deterioration characteristics. Note that the existing pavement condition distribution for the entire state, as estimated from the MassDOT sample, is 12% excellent, 36% good, 28% fair, and 24% poor. The MassDOT sample distribution for the Boston Region MPO area is 6% excellent, 29% good, 30% fair, and 34% poor. This distribution was not used in the present analysis because it appears to reflect mostly higher-classification roads, which MassDOT maintains at a higher pavement condition standard. The distribution that was used is not likely, of course, to match the region’s actual distribution exactly.

<sup>9</sup>The cost would of course be lower if the target pavement condition were lower than “excellent”—say, “good”—or if the existing pavement condition distribution assumed for the region had a higher proportion of roads in “excellent” condition.

<sup>10</sup> While centerline miles are used in Method 1, lane-miles are used in Method 2 because input data are in lane-miles.

**Table 1A**  
**Federal-Aid (FA) Local Road Maintenance Costs**  
*(to bring all roadways to “excellent” condition)*  
**as Estimated by Method 1,**  
**Boston Region MPO, FFYs 2010-2014**

Centerline Miles	Weighted Average Cost per Mile	Total Cost	Annual Cost
2,768	\$306,746	\$849,072,9284	\$169,814,586

**Table 1B**  
**Annual Federal-Aid (FA) Local Road Maintenance Costs**  
*(to bring all roadways to “excellent” condition)*  
**as Estimated by Method 1,**  
**Boston Region MPO, FFYs 2010-2014**

	FFY 2010	FFY 2011	FFY 2012	FFY 2013	FFY 2014
Required funding	\$169,814,586	\$169,814,586	\$169,814,586	\$169,814,586	\$169,814,586

good, fair, or poor) was estimated for FA-eligible local roads in the Boston Region MPO area from the weighted average of OCPC and CMRPC pavement condition data.

To determine the total cost of repairs, staff applied estimates of per-lane-mile costs by type of repair (preventative maintenance for pavement in good condition, rehabilitation for pavement in fair condition, and reconstruction for pavement in poor condition) to the corresponding number of miles in each type of condition. As reliable information on cost by type of repair was not available for Massachusetts, staff applied corresponding data from the Southeastern Michigan Council of Governments (SEMCOG), which appears to employ a well-established PMS. Tables 2A and 2B show the results of this estimation approach, which points to a cost of approximately \$1.6 billion, or \$324 million annually for FFYs 2010–2014, to bring FA local roads in the Boston Region MPO area to “excellent” pavement condition.

**SUMMARY AND NEXT STEPS**

The Boston Region MPO does not presently maintain a PMS. Consequently, it is impossible to estimate reliably the cost of maintaining the region’s FA local roads. The following information essential to traditional pavement management analysis is unavailable:

- Accurate knowledge of existing pavement conditions
- A forecasting tool that, based on existing conditions, is able to evaluate investment strategies
- A policy that details how to maintain these roadways (target condition levels)

**Table 2A**  
**Federal-Aid (FA) Local Road Maintenance Costs by Current Pavement Condition**  
*(to bring all roadways to “excellent” condition)*  
**as Estimated by Method 2,**  
**Boston Region MPO, FFYs 2010-2014**

<b>Current Pavement Condition</b>	<b>PSI Range</b>	<b>% of Region’s Lane-Miles</b>	<b>Number of Lane-Miles</b>	<b>Type of Maintenance Required</b>	<b>Generic Cost per Lane-Mile<sup>11</sup></b>	<b>Total Cost</b>	<b>Annual Cost</b>
Excellent	3.50 - 5.00	20%	1,169	None	0	0	--
Good	2.80 - 3.49	29%	1,637	Preventive	\$32,525	\$55,140,934	--
Fair	2.30 - 2.79	25%	1,462	Rehabilitation	\$239,500	\$350,029,250	--
Poor	0.00 - 2.29	26%	1,520	Reconstruction	\$798,500	\$1,213,688,060	--
<b>Total</b>			5,846			\$1,618,858,244	\$323,771,649

**Table 2B**  
**Annual Federal-Aid (FA) Local Road Maintenance Costs**  
*(to bring all roadways to “excellent” condition)*  
**as Estimated by Method 2,**  
**Boston Region MPO, FFYs 2010-2014**

	<b>FFY 2010</b>	<b>FFY 2011</b>	<b>FFY 2012</b>	<b>FYY 2013</b>	<b>FFY 2014</b>
Required funding	\$323,771,649	\$323,771,649	\$323,771,649	\$323,771,649	\$323,771,649

Furthermore, in order to determine costs in a “targeted” manner, one must be able to identify the investment strategies that are most effective for this region’s existing pavement conditions, funding levels, and desired maintenance level. However, it is unrealistic to do this without actual data from a PMS and software which, applying the data, model alternative investment strategies and corresponding costs.

From this study, staff concluded the following:

- A PMS is extremely important for investment strategy decisions
- The MPO should consider maintaining such a system in order to:
  - Estimate accurately maintenance costs for FA-eligible local roads in this region

<sup>11</sup> Southeastern Michigan Council of Governments, Transportation Investment Prioritization Process, Cambridge Systematics, Inc., June 30, 2009.

- Help develop and choose from maintenance strategies for the effective use of increasingly limited resources
- Reduce the number of TIP “Reconstruction” projects that include a very costly deep pavement-reconstruction component
- To this end, staff seeks concurrence from the TPPC to begin planning for the development of a PMS, including:
  - Leading a discussion at the TPPC level regarding the current practice of not using “target” funding for resurfacing projects
  - Exploring pavement management policies, with associated funding, that would promote effective investments in pavement maintenance and would be included in the 2035 LRTP
  - Defining how an MPO-maintained PMS would relate to the PMSs of municipalities in the region
  - Identifying the UPWP funding commitment required to develop and maintain a PMS

EP/SAA/ep/saa