

NCHRP 20-24(97)

**Advancing Performance Management
Under A National Framework**

Final Report

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Prepared for

The National Cooperative Highway Research Program

Prepared by

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SPECIAL NOTE: This report IS NOT an official publication of the National Cooperative Highway Research Program, the Transportation Research Board, or the National Academies of Sciences, Engineering, and Medicine.

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Disclaimer

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Executive Summary

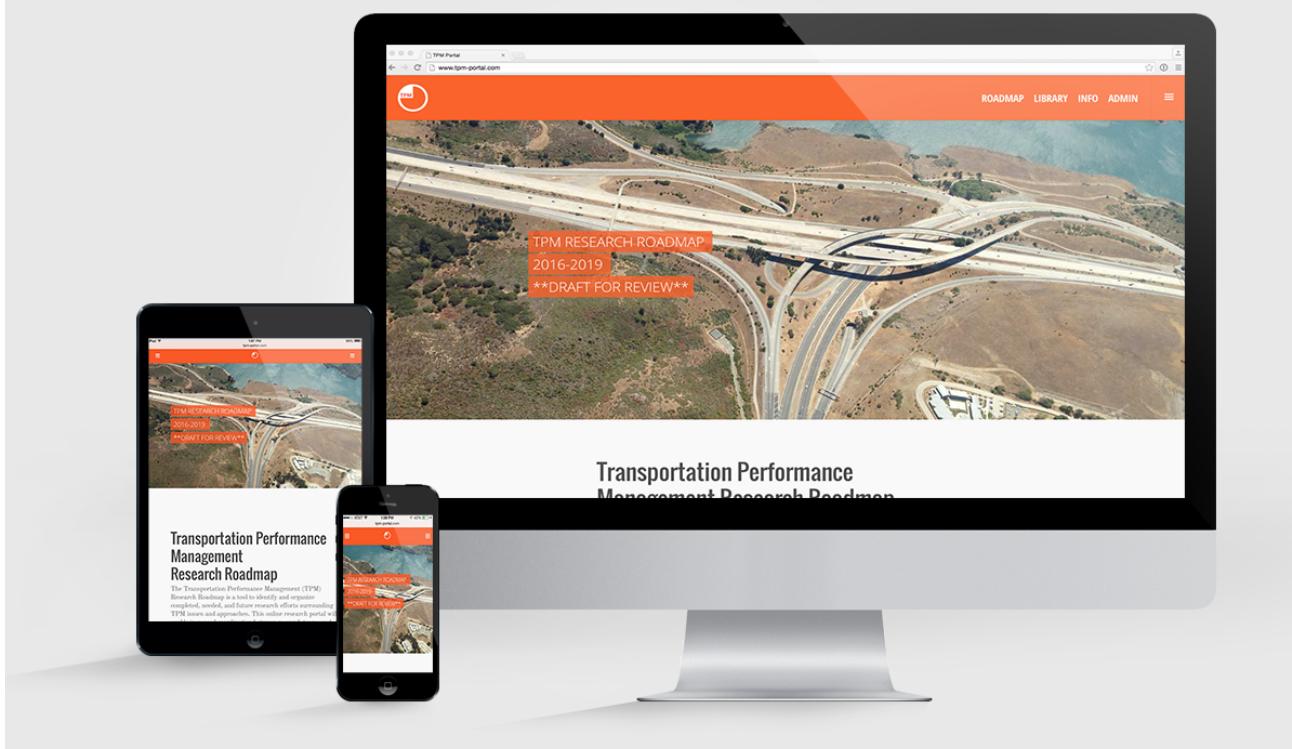
Transportation Performance Management Research Roadmap

Advancing Performance Management Under a National Framework

In order to inform performance management research and development activities to be undertaken by the transportation industry, the AASHTO Standing Committee on Performance Management (SCOPM) supported an effort to develop a transportation performance management (TPM) Research Roadmap. The Roadmap has been developed through a series of workshops and other activities conducted as part of NCHRP Project 20-24(97).

The Roadmap is hosted online and connected to a database of recent TPM research, providing an integrated entry point for practitioners to access a wide range of information on current, recent, and potential future TPM research. The Roadmap is a living document, intended to be regularly updated to provide a snapshot of the research status and needs surrounding TPM at a given time. In the coming years, the Roadmap will be updated on an ongoing annual basis.

Visit the website to learn more: <http://www.tpm-portal.com>



About the Research Roadmap Website

The TPM Research Roadmap Website is a tool to identify and organize completed, needed, and future research efforts surrounding TPM issues and approaches. This online research portal will enable increased coordination between research teams and AASHTO or TRB panel partners.

Researchers and practitioners alike can use the portal to help identify and respond to challenges and opportunities associated with the preparation and application of national-level transportation system performance information.

In the near term, the Roadmap will offer a consolidated set of resources on performance management. Transportation practitioners can use the Roadmap website to help plan future research and development activities to be undertaken by the transportation industry.

Over the long term, the Roadmap will help identify challenges and opportunities associated with preparation of national-level transportation system performance information – and identify research needs to improve the state of the practice in TPM.

Visit the site to learn more: [http://www\(tpm-portal.com](http://www(tpm-portal.com)

1. Introduction

1.1. Project Overview

1.1.1. Background

Transportation Performance Management (TPM) is an area of great importance to state departments of transportation (DOT) and a centerpiece of the transportation authorization legislation Moving Ahead for Progress in the 21st Century (MAP-21). TPM provides a set of approaches for enhancing our understanding of the nation's transportation system and a means for better targeting scarce resources to improve the system consistent with local, state and federal policy goals and objectives. Reflecting the importance of TPM, MAP-21 includes a series of requirements for states to report performance in areas including safety, pavements, bridges, freight, mobile source emissions, and congestion. MAP-21 is a fundamental shift in federal transportation funding by requiring DOTs to set targets based on the funds available and to report on the actual performance.

The American Association of State Highway and Transportation Officials (AASHTO) and Transportation Research Board (TRB) have been at the forefront of determining how best to improve and implement TPM practices at state DOTs. This work has been conducted through the AASHTO Standing Committee on Performance Management (SCOPM) and the research from the National Cooperative Highway Research Program. US DOT through its agencies has also been active in developing resources for TPM.

As federal rules on TPM are drafted and finalized, it will be vital to identify key issues regarding proposed nationwide TPM approaches, and recommend constructive approaches for addressing these issues that can be incorporated in the final rules. AASHTO's standing committees are key stakeholders with respect to these issues, and it is important that the research performed in this area be conducted in a collaborative manner, in which the project team and panel partner with AASHTO in conducting the research to achieve the best outcome.

1.1.2. Research Objectives

The objectives of this project were to:

- Identify the challenges and opportunities associated with data collection, data management, and analysis methodologies to support preparation of national-level transportation system performance information; and
- Develop a performance management research roadmap that will inform future research and development activities to be undertaken by the

transportation industry.

Through these activities the project helped inform development of data resources on national performance management in the near term, and helped identify research needs to improve the state of the practice in TPM over the longer term.

1.1.3. Project Scope and Methodology

The project was completed in six tasks split into two phases, shown below. Each of the steps shown below is described in more detail in subsequent sections.

- ***Task 1. Review of National-Level Performance Data Sets*** – The research team began with a detailed review of the NPMRDS and continued with a review of other relevant national-level datasets to support MAP-21 national performance reporting.
- ***Task 2. Workshop I*** – In this task the project team facilitated multiple sessions and a one-day workshop to review the results of the work to date and address the core questions posed in the RFP. Deliverables for this task included a workshop agenda, presentation materials, and workshop documentation.
- ***Task 3. Working Report I*** – In this task the project team prepared an interim report that summarized the research activities to date. The report included the review performed in Task 1, and documented the results of the workshop performed in Task 2 and the work conducted to identify research needs.
- ***Task 4. Review of Proposed Research Needs*** – The project team gathered information needed to develop the research roadmap, in preparation for the outreach to be conducted in Task 5.
- ***Task 5. Workshop II*** – The team organized and facilitated outreach activities to get input to help establish a meaningful, achievable TPM research road map. Deliverables for this task included an agenda, presentation materials, and documentation of outreach activities. A workshop was conducted at the TRB Annual Meeting in January 2015. A meeting with AASHTO SCOPM leadership was conducted in May 2015. A webinar was conducted in June 2015.
- ***Task 6. Working Report II*** – The Working Report II organized the results of the Task 5 activities, presenting a multi-year research roadmap for national transportation system performance measurement research. As part of this effort, the team developed an online tool to present the results of the research roadmap and facilitate its dissemination and ongoing maintenance: the TPM Portal.

The project team combined the work of all tasks and produced this Final Report for the project.

1.1.4. Document Overview

This is the Final Report for NCHRP Project 20-24(97) – “Advancing Performance Management Under A National Framework”. It summarizes the objectives, scope, methodology and deliverables of the project.

- The remainder of this section (**Section 1**) includes the project context, the research methodology, and outreach efforts.
- **Section 2** presents the results of the project team’s review of National-Level Performance Data Sets.
- **Section 3** provides a summary of the Research Roadmap, including research needs and problem statements.
- **Section 4** includes a description of the online Roadmap business structure. Also provides a site map and a description of the TPM portal including detailed breakdowns of the online Roadmap, the resource library, the submission tool, and the info page.
- **Section 5** provides a summary of the workshops conducted as Tasks 2 and 4.
- **Section 6** presents next steps including website stewardship.

1.2. Project Context

1.2.1. Moving Ahead for Progress in the 21st Century Act (MAP-21)

Performance management has come to the forefront with the passage of Moving Ahead for Progress in the 21st Century (MAP-21) and its requirement that the United States Department of Transportation (USDOT) identify national-level performance measures related to safety, pavements, bridges, freight, mobile source emissions, performance, and congestion.

The general requirements expressed in MAP-21 have been further refined through the rulemaking process. Proposed rules have previously been published addressing national performance measures for safety, bridge condition, and pavement condition. Most recently, a notice of proposed rulemaking (NPRM) addressing risk-based asset management plans and bridge and pavement management systems was released on February 20, 2015. USDOT is expected to publish further NPRMs in 2015. These will include national performance measures for system performance and for freight.

1.2.2. Outreach Efforts

A series of engagement activities were conducted during the project to engage the transportation community in the development of the Research Roadmap. These activities have been guided the staff at AASHTO and the task force leads on SCOPM. The following are a list of the activities that have been conducted along with the location of the summary of the events.

SCOPM/SCOP Summer Meeting (Scottsdale, AZ):

TPM Research Roadmap Session, June 18, 2014. Participants at this conference engaged in a session that produced a prioritized list of TPM research needs.

TPM Roundtable (Washington, DC):

TPM Research Roadmap Session, November 4, 2014. This group is made up of government and non-profit organizations in the DC area that are interested in TPM. This session produced a set of TPM communication related scenarios and the desired resources to support delivery of TPM communications.

AASHTO Annual Meeting (Charlotte, NC):

SCOPM Research Roadmap Workshop, November 20, 2014. This all day workshop included a majority of state DOT participants. Half of the workshop focused on sharing current activities in TPM research, building on the research needs identified to date, and identifying research projects. The second half of the day focused on TPM and communications –related practices, determining research needs, and identifying research projects. The workshop ended with a prioritization exercise of the identified research projects.

Additional files from this workshop are included in Appendix A.

TRB Annual Meeting (Washington, DC):

TPM Research Roadmap Workshop, January 15, 2015. This workshop focused on filling in gaps in TPM research needs and defining research projects.

Additional files from this workshop are included in Appendix B.

AASHTO SCOPM Leadership Meeting (Providence, RI):

SCOPM Research Roadmap Session, May 11, 2015. This all day session was attended by state DOT participants. The first half of the session focused on project progress to that date, including a demonstration of the Research Roadmap online tool. The second half of the session focused on generating research statements and identifying actions needed to complete the online tool.

2. Review of National-Level System Performance Data Sets

This section presents the review of national-level system performance data sets, prepared as part of Task 1 of the project. This review was undertaken as a discrete effort, rather than as a preliminary step in developing the Roadmap, and is presented here as a self-contained report.

Review of National-Level System Performance Data Sets

Introduction

One of the objectives of the research effort described in this report was to identify the challenges and opportunities associated with data collection, data management and analysis methodologies to support preparation of national-level transportation system performance information. In support of this objective the research team performed a review of national-level data sets that will or may be used to meet the performance reporting requirements developed as a result of MAP-21. For each of these data sets the research team provided an overview of the data set, detailed what data it includes, and assessed issues regarding use of the data set for national performance reporting. Data sets reviewed include:

- **National Performance Management Research Data Set (NPMRDS)** – this is a specialized subset of commercially available probe-based travel time data. It contains data on vehicle speeds by highway segment for highways across the U.S. This data was procured by FHWA for multiple uses, including to help agencies meet their MAP-21 congestion and emissions reporting requirements.
- **Highway Performance Monitoring System (HPMS)** – this data set contains details on highway performance, including network definition, traffic, and pavement condition. FHWA proposes to use HPMS to support pavement condition reporting, and it may be used in conjunction with NPMRDS and/or other data sources to support congestion reporting. In its Notice of Program Rulemaking (NPRM) for pavement measures FHWA recommended using HPMS in its current form, while expanding the set of highways treated as “sample sections” to include the entire National Highway System (NHS).
- **National Bridge Inventory (NBI)** – this data set details the inventory and conditions of bridges on the public road network. In its NPRM for bridge measures FHWA proposes to use the NBI without any changes to support bridge condition reporting.
- **Fatality Accident Reporting System (FARS)** - this system includes data on traffic fatalities. The NPRM on safety measures identifies use of FARS for safety performance reporting.

Review of National-Level System Performance Data Sets: NPMRDS

Background

With the federal legislation MAP-21 states will be required to report on the performance of their road networks in unprecedented ways. Congestion, Mobility, Safety, and the state of Infrastructure will need to be measured. Targets will be set. While many agencies are anxious to learn the details of federal reporting requirements, performance measurements as a core business practice will continue to be adopted to (1) demonstrate the benefits of transportation investments, (2) better identify areas where improvements need to be made, (3) be able to report on current conditions and trends, and (4) be able to demonstrate to the public that the government fully understands and is responding to transportation issues critical to the economy and mobility. An NPRM is expected in 2015 specifying proposed performance measures for congestion, emissions, systems performance, and freight. While agencies won't officially know what will be required for Congestion Reporting until the rules are released for review, the American Association of State Highway and Transportation Officials (AASHTO) has already provided a set of preliminary recommendations, and FHWA has procured a national dataset that is meant to help states calculate and report on their performance.

This document summarizes issues related to congestion performance reporting—specifically with respect to the current National Performance Measures Research Data Set (NPMRDS), which is a specialized subset of commercially available probe-based travel time data. This data was procured by FHWA for multiple uses, including to help agencies meet their MAP-21 congestion and emissions reporting requirements.

Congestion Performance Reporting

Although specific measures for national reporting have not yet been specified, it is anticipated that both Reliability and Delay will be included in some form. The overarching MAP-21 categories, FHWA's tasks, and AASHTO's high-level recommendations are summarized in Table 2.1 below.

Table 2.1. AASHTO Recommendations Related to Potential MAP-21 Congestion and Emissions Performance Measures

MAP-21 Measures Category	FHWA Tasks	AASHTO Initial Recommendations
<i>Performance of Interstate System – 150(c)(3)(A)(ii)(IV)</i>	Measures Being Defined <ul style="list-style-type: none"> • Agree on final measures • Identify approach to define corridors • Identify approach to define the “average” speed or maximum throughput speed • Document methodology to calculate measures • Establish data source to support measure 	<ul style="list-style-type: none"> • Annual Hours of Delay • Reliability Index (80th percentile) • Flexible target setting • Threshold recommendations are ambiguous. •
<i>Performance of Non-Interstate NHS – 150(C)(3)(A)(ii)(V)</i>	Measure Being Defined <ul style="list-style-type: none"> • Finalize interpretation of scope of CMAQ performance requirements • Develop candidate measures • Document methodology to calculate measures • Define data source and data collection needs 	
<i>On-Road Mobile Source Emissions – 150(C)(5)(B)</i>	Measures being defined <ul style="list-style-type: none"> • Finalize interpretation of scope of CMAQ performance requirements • Identify standards to use to model project benefits • Document methodology to calculate measure • Define data source and updating requirements 	<ul style="list-style-type: none"> • Reduction in VOC, NOx, PM, and CO • Flexible target setting • Required only for areas already required to report emissions reductions.
<i>Freight Movement on the Interstate System – 150(C)(6)</i>	Measures being defined <ul style="list-style-type: none"> • Agree on final measures • Identify approach to define corridors • Document methodology to calculate measures • Establish data source through new contract to support measure 	<ul style="list-style-type: none"> • Freight recommendations are similar to the congestion performance measures recommendations for passenger vehicles.

Current State of the Practice in Congestion Reporting

Congestion reporting is conducted largely by state DOTs or MPOs in large urban areas. Historically, states have been reliant on costly sensor networks, but today there are many lower-cost options that provide much greater temporal and spatial coverage. Private sector data providers like HERE, INRIX, and TomTom all now provide high quality data feeds at 1-minute intervals across millions of road

segments. However, understanding how to interpret these larger datasets, manage them, and create meaningful reports that can be communicated to various stakeholders can be challenging.

Some data vendors, third parties, and universities are even providing analytics tools that empower agencies to more easily manage these large datasets. However, the adoption of these data and tools is non-uniform across the United States. FHWA has recently purchased a national probe-based speed data archive from HERE, which is a subset of HERE's normal data offerings. FHWA's intent for this dataset was to have it be a resource for the states to make it easy to meet federal reporting requirements, and to do a better job of coordination at the national level.

Unfortunately, due to the nature of FHWA's procurement specifications, resulting data gaps, and other significant hurdles inherent to all probe-based datasets, the NPMRDS as it exists today is cumbersome to work with. There is a need to figure out a way to make these data and advanced analytics capabilities attainable by state and local agencies.

Issues with Third-Party Probe Datasets

HERE, INRIX, and TomTom each offer national speed and travel time data. Each of these providers have comparable offerings in terms of data coverage, temporal resolution, etc. Data is typically provided at 1-minute intervals. Now that states finally have access to the quality and coverage of data for which they've desired for decades, agencies are realizing they are underprepared to make use of them.

Very few federal, state, or local agencies are equipped to receive and archive even a fraction of this amount of data for various technical reasons. The analysis of these truly massive datasets require specialized software, infrastructure, skillsets, networks, and data mining techniques. Even certain commercially available relational databases can grind to a halt with this scale of data. As such, specialized research laboratories, servers or data centers, and consultants are typically needed.

Contracting for these specialized skillset and capabilities can be daunting for state and local agencies. Below is an expanded list of some of the common issues associated with all probe-based data sets.

1. **Size:** National probe-based datasets can easily amass 500+ Billion records per year which can add up to hundreds of terabytes of raw storage over multiple years. Because of size, the following problems exist:
 - a. **Capacity to store:** Transportation planners may no longer be able to perform analysis on their standard agency-issued desktop computer hard drives. Large capacity storage arrays may be required, especially for larger geographic analysis.

- b. **Capacity to analyze:** These datasets go well beyond the capacity of Excel and even some relational databases. More specialized software, statistical analysis packages, or consultant support may be required.
- 2. **Available Internet bandwidth:** Many agencies have invested heavily in high-speed, fiber for their intra-agency networks. However, these same agencies often have limited inter-agency networks and/or bandwidth out to the Internet. In some instances, these agencies struggle to handle the movement of large data sets across networks, especially when these networks are subject to hiccups or are competing with other traffic.
- 3. **Capacity to visualize/report:** There is still much work to be done in providing guidance on the best ways to visualize and report on the results of these analysis. Even with proper guidance, traditional graphing packages may be insufficient to process and deliver meaningful reports that communicate to both engineering and non-engineering audiences.
- 4. **Lack of transparency:** Agencies are struggling with fully trusting probe data provided by third party providers. No current data providers are willing to divulge the number of probes that are used in each measurement, nor are they willing to provide details regarding imputation and smoothing methodologies. Because agencies have had complete control over their own data and processing algorithms for decades, relinquishing control to a less transparent solution has been difficult for many even when rigorous independent data validation programs are put in place.
- 5. **Network segmentation standards:** All three major vendors of probe-based speed data use a proprietary standard for georeferencing road segments. Referred to as TMC segments, many agencies have difficulties matching these segments to agency defined segments and agency managed GIS networks. To further complicate matters, each probe data provider uses a slightly different basemap and slightly different TMC codes which leads to slight variations in starting and ending points for each road segment.
- 6. **Consistency in reporting (or standardization of calculations):** This subject merits further discussion, but to summarize, it is a misconception that standardized data leads to standardized reporting. Even with a uniform, national dataset, each agency may choose to implement subtle differences in their calculations which could lead to different results.

The NPMRDS

The NPMRDS is a dataset that was purchased by FHWA for use by both federal and

state agencies to analyze congestion. This dataset has been established per FHWA specifications by the NPMRDS contractor, HERE, using a subset of the contractor's typical data products. An overview of the data set and some basic issues associated with it are listed in Table 2.2.

The single most significant issue with respect to the NPMRDS data set is that it includes a speed/travel time reading if (and only if) there was an actual probe on a particular segment during a 5-minute time span. Whenever there is not an actual probe on a segment, no estimate of speed is provided. This means that the amount of "missing" speed readings will vary heavily across the country depending on the region and time of day. In some places this could be significant, while in other places it could be negligible.

For an agency to produce meaningful performance measures the agency will need to be able to "fill the gaps" or make some sort of estimates as to what these missing values should be. There is no way around this. All agencies will have to employ some sort of estimation, imputation, or aggregation algorithm to formulate the measures. This introduces two problems. First, there will be an added cost for developing and implementing an approach for imputing missing values. Second, if agencies developing their own approaches for imputing missing values, there will be a lack of standardization across agencies, even using data from the same data set. Other potential issues with NPMRDS data set are summarized in Table 2.2.

Table 2.2. Key Issues and Potential Means for Improvement

Element	Desired State	Current NPMRDS	Ways to Improve	Notes
Geographic Coverage	<ul style="list-style-type: none"> Full NHS coverage w/options to expand to other arterials at same quality and temporal resolution Sub-TMC resolution (min. segment length) 	NHS for all 50 States, DC, Puerto Rico crossings into Canada & Mexico covering 486,000 miles.	<ul style="list-style-type: none"> Sub-TMC resolution Provide mechanism for agencies to purchase non-NHS arterials for expanded coverage. 	Geospatial coverage in existing NPMRDS is good, but some states may wish to expand coverage and/or analyze higher resolution data (sub-TMC, ramps, interchanges, etc.)
Archive Timeframe	January 2011 onward	<ul style="list-style-type: none"> July 2013 for NHS. Oct. 2011 for IHS only Available each month 	Purchase and/or create additional years of data for backfill	Multiple years of archived data will make it easier to identify trends and more intelligently set targets.
Archive Access	<ul style="list-style-type: none"> Liberal Data Use Agreement (DUA) for States/MPOs Liberal DUA for researchers Publicly accessible for transparency 	<ul style="list-style-type: none"> Web accessible US divided into 4 regions License agreement req. Limits on users and use 	<ul style="list-style-type: none"> Allow agencies to download smaller subsets of data. Allow agencies to specify date ranges for download that are smaller (or larger) than one-month. Revamp DUA for more liberal access 	Because datasets are already extremely cumbersome due to their size, dividing the files, allowing agencies to specify TMC subsets, and even various timeframes would be helpful.
Temporal Reporting	<ul style="list-style-type: none"> 1-minute No gaps Interpolation and smoothing is acceptable so long as it is flagged as such 	<ul style="list-style-type: none"> 5-minutes if probe not present during the 5-minute period, then no data point will be provided. 	<ul style="list-style-type: none"> Fill Gaps: <ul style="list-style-type: none"> Procure interpolated “gap” data, or Fill gaps with national interpolation methodology. Procure higher resolution temporal data: 1-minute preferred. Trust data provider smoothing and filtering algorithms, but include data quality flags and metrics 	<ul style="list-style-type: none"> Procuring interpolated data from the vendor (or coming up with a uniform dataset that is “gap free”) is the easiest fix, and most-needed improvement. For yearly reporting, 5-minute data should be sufficient. However, if agencies wish to do more-frequent after action reviews, etc. then 1-minute data may provide more capabilities to look at the effects of events, shockwaves, driver behavior, etc.
Data Elements	<ul style="list-style-type: none"> Travel Times Speeds Data quality score(s) Imputation Flag TMC definitions Sub-TMC Volume 	<ul style="list-style-type: none"> Passenger Vehicle travel times Freight vehicle travel times Combined freight and passenger travel times TMC definitions 	<ul style="list-style-type: none"> Procure imputed data (speeds/travel times) Add flags for imputation Add sub-TMC segments Add interchange TMCs Add data quality measures National volume data will make some measures more reliable. 	
Data Accuracy / Validation	3 rd party validation provided monthly	<ul style="list-style-type: none"> 3rd party validation plan. Results provided quarterly 	Validation should occur more frequently, and vendor should be held accountable (forced to resolve data issues)	Monthly validation is important to allow for problem resolution prior to significant efforts being spent by agencies. Spending more on validation up-front will ultimately reduce long-term costs to agencies.

Review of National-Level System Performance Data Sets

Element	Desired State	Current NPMRDS	Ways to Improve	Notes
Confidence Indicator	Provided for imputed data	Not Applicable	Confidence scores need to be provided and well defined: <ul style="list-style-type: none"> • No imputation • Minimal imputation • Low confidence 	Confidence scores will be needed when imputation and smoothing is used.
Shape Files	<ul style="list-style-type: none"> • Provided per direction with TMC segments (and subsegments) cross-referenced. • Capabilities to map to state networks as-needed are desired but not necessary. 	Enhances NHS Shape files provided with TMC cross-referenced links	Current NPMRDS shape files are generally sufficient;	Some states will prefer higher resolution segments (sub-TMC data) and the ability to reference agency maps
Highway Segments	<ul style="list-style-type: none"> • Traffic Message Channel Codes • Both internal and external TMCs separated along with ramps. • Sub-TMC segments provided at some minimum distance 	<ul style="list-style-type: none"> • Traffic Message Channel Codes • Internal & external codes are blended into one. 	<ul style="list-style-type: none"> • Need both internal and external to allow for differentiating of problem locations. • Define sub-TMCs down to a minimum distance 	In rural areas, TMC segments can be many tens of miles long. This can result in the “averaging out” of certain low-performing segments.
Analysis Tools	One or more analytics tools provided freely to states, agencies, and researcher.	None provided. Burden is on agencies to do the analysis on their own.	FHWA should invest in existing analytics tools to empower agencies and encourage data use.	Most agencies are unable to handle large datasets which is why analytics tools are needed.

Opportunities for Improvement

Table 2.2 indicates specific issues and opportunities for improvement. One major issue is addressing data gaps. Procuring interpolated “gap” data is one possible means of addressing this issue. Under this approach the data provider would include imputed data in the archive but would clearly flag these data as imputed. Other general improvement approaches of note are:

1. **Standardized Methodology:** Another potential solution would be to provide strict guidance on how each agency should impute data. If USDOT lays out strict guidelines, then the individual agencies will have to expend fewer resources researching the matter, and each agency will then presumably use the exact same method, and you'll have a true apples-to-apples comparison when agencies report on their measures. This is not as desirable as procuring interpolated “gap” data because:
 - a. it will take FHWA a long time to develop a universally accepted imputation algorithm, and
 - b. it will still place an extra burden on the state DOT to implement the algorithm which will be more costly than simply procuring the data from the provider.

2. **Provide Reporting Assistance:** FHWA could provide a service or clearinghouse that, as requested by state DOTs, would calculate the required performance measures using NPMRDS on their behalf. This consolidation of resources could represent significant cost savings and consistent reporting calculations. However, this would require additional resources, and states using this approach may be challenged to use the NPMRDS for other applications besides routine reporting.
3. **Develop Supplemental Analytical Tools:** FHWA could leverage existing probe data analytics tools, or develop new ones. These tools, if well implemented, would enable states to more easily manage the data, meet reporting obligations, and still allow them to use the data and analytics for non-MAP-21 purposes. This approach would also ensure that all agencies are using the same calculations and reporting methodologies, and would make it easier for multi-state comparisons and cross-border collaboration in problem identification.

Review of National-Level System Performance Data Sets: HPMS

Background

The Highway Performance Monitoring System (HPMS) is a national-level data repository with information on the U.S. highway network. It describes the extent of the network and details of its conditions, performance, use, and operating characteristics. HPMS data are used to support apportionment of federal highway funds, as well as to assess the condition and performance of the highway network. The data in the HPMS is provided by the States and updated on an annual basis.

The HPMS contains geospatial data detailing the highway routes on the public road system, and section-level details consisting of a number of data items. In populating its HPMS data a state provides varying amounts of data by highway section depending on how the section is classified. Some data are required for all sections or the “Full Extent.” Other data items are required for all sections of a given classification, termed “Partial Extent.” A number of items are required only for a randomly selected set of sample sections. Table 2.3 lists the section-level data items in the HPMS, indicating which are required only for sample sections.

A state’s HPMS submittal consists of the following components:

- Shapes catalog providing geospatial data describing the state’s routes
- Sections catalog detailing data by section and listing the state’s sample sections

- Summaries catalog with summary data at the following levels: statewide, vehicle, urban, county NAAQS
- Estimates catalog
- Metadata catalog

Table 2.3. HPMS Section-Level Data Items

Item Number	Item Description	Samp Only?	Values/Notes
1	Functional System		1 Interstate 2 Principal Arterial – Other Freeways and Expressways 3 Principal Arterial – Other 4 Minor Arterial 5 Major Collector 6 Minor Collector 7 Local
2	Urban Code		See Field Manual appendix for codes by urban area
3	Facility Type		1 One-Way Roadway 2 Two-Way Roadway 3 Couplet 4 Ramp 5 Non Mainline 6 Non Inventory Direction
4	Structure Type		1 Entire section is a Bridge 2 Entire section is a Tunnel 3 Entire section is a Causeway
5	Access Control		1 Full 2 Partial 3 None
6	Ownership		1 State Hwy Agency 2 County Hwy Agency 3 Town or Township Hwy Agency 4 City or Municipal Hwy Agency 11 State Park, Forest, or Reservation Agency 12 Local Park, Forest, or Reservation Agency 21 Other State Agency 25 Other Local Agency 26 Private (other than Railroad) 27 Railroad 31 State Toll Authority 32 Local Toll Authority 40 Other Public Instrumentality 50 Indian Tribe Nation 60 Other Federal Agency 62 Bureau of Indian Affairs 63 Bureau of Fish and Wildlife 64 U.S. Forest Service 66 National Park Service 67 Tennessee Valley Authority 68 Bureau of Land Management 69 Bureau of Reclamation 70 Corps of Engineers 72 Air Force 73 Navy/Marines 74 Army 80 Other
7	Through Lanes		Number of lanes
8	HOV Type		1 Full-time: Section has 24-hr exclusive HOV lanes (HOV use only; no other use permitted) 2 Part-time: Normal through lanes used for

Review of National-Level System Performance Data Sets

Item Number	Item Description	Samp Only?	Values/Notes
			exclusive HOV during specified time periods 3 Part-time: Shoulder/Parking lanes used for exclusive HOV during specified time periods
9	HOV Lanes		Number of lanes
10	Peak Lanes	Y	Number of lanes
11	Counter Peak Lanes	Y	Number of lanes
12	Turn Lanes R	Y	1 No intersections exist on the section 2 Turns permitted; multiple exclusive right turning lanes exist 3 Turns permitted; a continuous exclusive right turning lane exists from intersection to intersection 4 Turns permitted; a single exclusive right turning lane exists 5 Turns permitted; no exclusive right turning lanes exist 6 No right turns are permitted during the peak period
13	Turn Lanes L	Y	Same codes as Turn Lanes R
14	Speed Limit	Y	Daytime speed limit in mph
15	Toll Charged		1 Toll Charged in 1 direction only 2 Toll Charged in Both Directions
	Toll ID		Federally assigned ID for the toll facility
16	Toll_Type		1 This section has toll lanes but no HOT lanes 2 This section has HOT lanes
17	Route Number		Numeric portion of signed route number
	Fully Signed Route Number		Full signed route number
18	Route Signing		1 Not Signed 2 Interstate 3 U.S. 4 State 5 Off-Interstate Business Marker 6 County 7 Township 8 Municipal 9 Parkway Marker or Forest Route Marker 10 None of the Above
19	Route Qualifier		1 No Qualifier or Not Signed 2 Alternate 3 Business Route 4 Bypass 5 Spur 6 Loop 7 Proposed 8 Temporary 9 Truck Route 10 None of the Above
20	Alternate Route Name		
21	AADT		Average Annual Daily Traffic count
22	AADT Single Unit Truck		Count
23	Pct Peak Single Unit Truck	Y	Peak hour volume as a percentage of the total
24	AADT		Count

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Item Number	Item Description	Samp Only?	Values/Notes
	Combination Truck		
25	Pct Peak Combination Truck	Y	Peak hour volume as a percentage of the total
26	K-Factor	Y	Design hour volume as a percentage of AADT
27	Directional Factor	Y	Percent of design hour volume in the peak direction
28	Future AADT	Y	Count
	Future ADT Year	Y	Year
29	Signal Type	Y	1 Uncoordinated Fixed Time 2 Uncoordinated Traffic Actuated 3 Coordinated Progressive 4 Coordinated Real-time Adaptive 5 No signal systems exist
30	Pct Green Time	Y	Percentage
31	Signals	Y	Count
32	Stop Signs	Y	Count
33	At Grade Other	Y	Count
34	Lane Width	Y	Width in feet
35	Median Type	Y	1 None 2 Unprotected 3 Curbed 4 Positive barrier-unspecified 5 Positive barrier-flexible 6 Positive barrier-semi-rigid 7 Positive barrier – rigid
36	Median Width	Y	Median width in feet (to nearest foot)
37	Shoulder Type	Y	1 None 2 Surfaced shoulder exists – bituminous concrete (AC) 3 Surfaced shoulder exists – Portland Cement Concrete surface (PCC) 4 Stabilized shoulder exists – (stabilized gravel or other granular material with or without admixture) 5 Combination shoulder exists (shoulder width has two or more surface types; e.g., part of the shoulder width is surfaced and a part of the width is earth) 6 Earth shoulder exists 7 Barrier curb exists; no shoulder in front of curb
38	Shoulder Width R	Y	Width in feet
39	Shoulder Width L	Y	Width in feet
40	Peak Parking	Y	1 Parking allowed on one side 2 Parking allowed on both sides 3 No parking allowed or none available
41	Widening Obstacle	Y	X No obstacles A Dense development B Major transportation facilities C Other public facilities D Terrain restrictions E Historic and archeological sites

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Item Number	Item Description	Samp Only?	Values/Notes
			F Environmentally sensitive areas G Parkland
42	Widening Potential	Y	Number of lanes to which it is feasible to widen the road
43	Curves A-F	Y	Length of pavement by curve type (A-F)
44	Terrain Type	Y	1 Level 2 Rolling 3 Mountainous
45	Grades A-F	Y	Length of pavement by grade type (A-F)
46	Pct Pass Sight	Y	Percent of section meeting the sight distance requirement for passing
47	IRI		International Roughness Index (IRI) value
	IRI date		Date of IRI measurement
48	PSR	Y	Present Serviceability Rating
49	Surface_Type	Y	1 Unpaved 2 Bituminous 3 JPCP-Jointed Plain Concrete Pavement 4 JRCP-Jointed Reinforced Concrete Pavement 5 CRCP-Continuously Reinforced Concrete Pavement 6 Asphalt-Concrete (AC) Overlay over Existing AC Pavement 7 AC Overlay over Existing Jointed Concrete Pavement 8 AC (Bitum. Overlay over Existing CRCP) 9 Unbonded Jointed Concrete Overlay on PCC Pavements 10 Bonded PCC Overlays on PCC Pavements 11 Other
50	Rutting	Y	Average rut depth in inches
51	Faulting	Y	Average vertical displacement between adjacent jointed concrete panels in inches
52	Cracking Percent	Y	Percent of area with fatigue cracking
53	Cracking Length	Y	Relative length of transverse cracking in ft per mile
54	Year Last Improvement	Y	Year
55	Year Last Construction	Y	Year
56	Last Overlay Thickness	Y	Thickness in inches
57	Thickness Rigid	Y	Thickness in inches
58	Thickness Flexible	Y	Thickness in inches
59	Base Type	Y	1 No base 2 Aggregate 3 Asphalt or cement stabilized 4 Asphalt or cement stabilized with granular subbase 5 Hot mix AC (Bituminous) 6 Lean concrete 7 Stabilized open-graded permeable 8 Fractured PCC
60	Base Thickness	Y	Thickness in inches

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Item Number	Item Description	Samp Only?	Values/Notes
61	Climate Zone	Y	1 Wet-Freeze. 2 Wet-Non Freeze 3 Dry-Freeze 4 Dry-Non Freeze
62	Soil_Type	Y	1 Granular (35% or less passing the 0.075 mm sieve) 2 Fine (Silt-Clay) Materials (>35% passing the 0.075 mm sieve)
63	County Code		FIPS codes – see http://www.census.gov/datamap/fipslist/AllSt.txt
64	NHS		National Highway System (NHS) indicator
65	STRAHNET		Strategic Highway Network indicator
66	NTN		National Truck Network indicator
67	Future Facility		Unbuilt NHS section indicator
68	Maintenance and Operations		Same codes as Ownership
69	Capacity	Y	Estimated capacity as an hourly volume

The HPMS data model supports specification of the extent of each piece of data entered for a section. That is, one identifies each section-level datum by route, beginning milepoint, and ending milepoint. This means that items that change infrequently, such as lanes, may be specified for longer sections, while items that change more frequently may be specified for shorter sections. Note that a number of sample section-specific items are specified for an entire sample section, and that pavement condition items must be specified for sections of no greater than 0.1 miles.

General Issues

The following are general issues with respect to use of HPMS (not specific to either pavement condition or congestion measures):

- New data format:** The current format of the HPMS was first implemented in 2010 for reporting beginning in 2011. The current format, termed “HPMS 2010+,” represents a significant departure from previous versions of the HPMS, particularly with the introduction of a geospatial format and the ability to report data items at varying levels of detail. Also, many of the pavement condition items are new to HPMS (discussed further in the next subsection). A consequence of the newness of the format is that there may be issues in the dataset that have not yet been identified. Indeed, FHWA has made updates to the format since introduction of HPMS 2010+ to address various data issues. For instance, as HPMS 2010+ was originally specified, one could obtain different lengths for a state’s highway network, depending on how one queried the data, though this issue has since been addressed.

2. **Uncertain data quality:** Responsibility for ensuring quality of HPMS data lies mainly with the States submitting data and little information is available that either assesses or allows for independent assessment of the overall quality of the data set. The change in the HPMS format introduces additional concerns about data quality. Prior to introduction of HPMS 2010+, all data items were populated on a section-by-section basis, and the software provided by FHWA for populating the HPMS incorporated a number of data quality checks (for example, a route should be coded as being on the NHS if coded as an interstate). With the new format it is more difficult to perform such “cross checks,” and initial versions of the new submittal lacked these checks. Further, it is possible to have new types of errors, such as gaps in data coverage for individual items, and non-homogenous sample section data. The new submittal software does address these new issues, however. Nonetheless, even the data checks provided in the old or new versions of the submittal software provide only a basic level of quality assurance. The underlying issue is that there are many potential data quality issues in the HPMS, particularly with the newer, more flexible format, and the quality of the data across states is at present uncertain.
3. **Use of sampling:** Table 2.3 shows which data items are required only for sample sections. This includes all of the pavement condition measures with the exception of IRI and PSR, and many of the items related to traffic with the exception of AADT and truck AADT. Use of sampling helps reduce the overall data collection burden on the States but any use of sample data for national performance reporting would invite further scrutiny. In its NPRM for pavement and bridge measures FHWA has specified that all of the NHS should be treated as a sample section for the purpose of collecting pavement data. This increases the data collection burden, but obviates this issue, at least with respect to pavement condition measures.
4. **Unidirectional data:** In HPMS sections are unidirectional. That is, one record is reported for a pavement section combining information for both directions of travel. However, in practice, pavement conditions and traffic patterns may vary significantly in different directions of the same highway, particularly in the case of divided highways.
5. **Consistency in reporting (or standardization of calculations):** As discussed with respect to NPMRDS, even with a uniform, national dataset, each agency may choose to implement subtle differences in measurement approaches and calculations that could lead to different results. Specific issues are noted in following sections.

Use of HPMS for Pavement Condition Reporting

The HPMS includes six primary measures of pavement condition: roughness (measured using IRI); PSR; rutting; faulting; cracking percent; and cracking length. Somewhat different measures are reported depending on pavement type.

Roughness is measured for all pavements. PSR, which is a visual assessment of pavement condition, may be reported as an alternative to IRI (although the NPrM requires reporting of IRI rather than PSR). Rutting is measured only for asphalt pavement. Faulting is measured only for jointed concrete pavement. Cracking percent is measured differently depending on the type of pavement. For asphalt pavement cracking percent is measured as the percent of pavement area with fatigue cracking regardless of severity, while for concrete pavement it is measured as the percent of slabs with cracking. Cracking length describes the relative length (in feet per mile) of transverse cracking for asphalt pavements and reflection transverse cracking for composite pavements with a surface layer of asphalt.

There are two somewhat fundamental issues with the pavement measures in HPMS: there is no general consensus in the pavement community concerning how to use these measures to best characterize overall pavement condition, coupled with concern that the aforementioned measures tend to serve as lagging measures that do not provide a complete assessment of pavement structural health; and there are significant state-to-state differences in pavement data collection and quality assurance practices which complicate attempts to summarize conditions across states. Three reports from three recent NCHRP projects (which include reviews of other relevant literature) discuss these issues further and detail other issues regarding specific measures:

- NCHRP Project 20-24(37)B, Measuring Performance Among State DOTs: Sharing Good Practices – Pavement Smoothness (2008), performed by Spy Pond Partners, Applied Pavement Technology and the University of Michigan Transportation Research Institute.
- NCHRP Project 20-24(82), Increasing Consistency in the Highway Performance Monitoring System for Pavement Reporting (2013), performed by Parsons Brinkerhoff and Applied Pavement Technologies.
- NCHRP Project 20-24(37)J, Measuring Performance Among State DOTs: Sharing Good Practices – Pavement Structural Health (2013), performed by Spy Pond Partners, Applied Pavement Technology and ICF International.

Table 2.4 lists issues identified in one or more of these reports related to specific measures included in the HPMS data set. The table lists the applicable measure(s), short summary and longer description of each issue, and note on the issue source.

Table 2.4. Summary of Recently Identified Issues in HPMS Pavement Condition Measures

Measure	Issue	Description	Source
All	Low degree of confidence in state-to-state comparisons	Report includes analysis of HPMS versus state pavement management system data and found high correlation. However, a survey of state pavement engineers indicated a low degree of confidence in comparisons of HPMS pavement data between states.	NCHRP 20-24(82)
All	Different approaches for assessing overall condition	The reports note that states use different approaches for assessing overall condition, and factors such as level of aggregation may impact condition measures.	NCHRP 20-24(82) NCHRP 20-24(37)J
All	Level of effort required for data review	Report cautions that significant effort may be required for FHWA or state data review/verification	NCHRP 20-24(82)
IRI	Measurement error	Network-level IRI data from different states contain baseline measurement error on the order of 15% due to differences in equipment, calibration practices, and variations across operators. The report recommends various practices to reduce measurement error.	NCHRP 20-24(37)B
IRI	Differences in measurement approaches	The reports discuss varying approaches, such as use of half car rather than mean roughness, inclusion/exclusion of bridge data, and measurement of the “worst” rather than the outside lane. Note the HPMS references standards intended to improve consistency in approaches.	NCHRP 20-24(37)B, J
IRI	Impact of weather conditions	IRI measurements are sensitive to weather conditions and moisture. The report recommends documenting conditions when performing measurements.	NCHRP 20-24(37)B
IRI	Numerous factors impacting IRI	A number of factors impact both initial IRI after construction and IRI measured over time. These include pavement type, pavement design and material properties, construction methods, traffic loadings and environmental conditions. These all complicate interpretation of IRI data.	NCHRP 20-24(37)B
IRI	Not a comprehensive measure	IRI does not provide a complete picture of pavement condition. It is necessary to examine multiple measures to assess overall pavement condition	NCHRP 20-24(37)B, J NCHRP 20-24(82)
Cracking	Significant variations in state practices, low degree of confidence in	The NCHRP 20-24(82) report cites survey results concluding that there is a low degree of confidence in data quality for cracking data. Both reports describe that state practices for collecting cracking data vary significantly from state to state and from the HPMS	NCHRP 20-24(82) NCHRP 20-24(37)J

Measure	Issue	Description	Source
	data quality	standard.	
Faulting	Variations in data collection practices	Not all states collect this data and data collection practices vary significantly. The NCHRP 20-24(37)J report further concludes that faulting is a desirable measure for characterizing structural health, however.	NCHRP 20-24(82) NCHRP 20-24(37)J

Use of HPMS for Traffic Data

The HPMS includes six primary measures of traffic flow: non-directional AADT; single unit and combination truck counts; peak hour truck volumes; a K-factor, and a directional factor. It also includes an estimation of future AADT counts. HPMS traffic data is an important resource for national estimates of vehicle miles traveled (VMT). However, there are several fundamental issues with HPMS Traffic Data that make it difficult and/or inconsistent to use for national performance measures generation and reporting—especially when used in conjunction with other datasets. These issues include:

- **Sampled AADT Data:** AADTs are required for all highway sections, but States rely on sampling to calculate AADT. AADTs are calculated from a mix of both permanent and rotating sensors. The rotating sensors may take counts at a given location for a few days to a couple of weeks. These short-term measurements are then used to estimate AADT on the road yearly. The season, weather conditions, incident conditions, construction, other events, etc. can drastically affect the measurements, and applying these short-term measurements to performance measures covering larger date-ranges (like an entire year) can yield inaccurate results.
- **Modeled vs. Measured and Overall Transparency:** Many engineers consider HPMS to be some of the best data available today. This is in-part because the permanent count stations are usually well maintained, and the AADTs collected from the rotating (non-permanent) stations are carefully “sanitized” to remove outliers and aberrant data. However, when a dataset is sanitized it can become less a set of actual observations, and more a source of modeled data, and this is the case with AADT data in HPMS. This is particularly ironic given that FHWA has procured the NPMRDS with the stipulation that all data must be “observed” not imputed/modeled. In this sense, two very different standards are being applied to travel-time data and HPMS counts. Additionally, each state may have different standards, policies, and procedures for how they factor-up, impute, or otherwise sanitize their data prior to submission to FHWA. These methodologies can even change from year-to-year within an individual agency. Whenever and wherever you have

a lack of standardization on these policies and methodologies, you introduce error and variability that makes it much more difficult to use the data for national-level comparisons and/or cross-border performance measures.

- **Timeliness:** HPMS data is collected at the state level and reported up to the Federal Government. Once the data arrives at the Federal level, it is scrutinized and consolidated prior to release to the public. This reporting, evaluation, and consolidation process can introduce significant lag between the time at which data is collected and the field and when it is released to the public. The NPMRDS, however, is released at the national level only one-month after it is collected.
- **Conflation to State, Federal, or other Maps:** The spatial referencing system used for HPMS reporting is significantly different than the referencing systems used in other data sets—like the NPMRDS or other probe data providers' data. To integrate HPMS and NPMRDS or other data it is necessary to map HPMS sections to the referencing system of the NPMRDS, or the NPMRDS will need to be mapped to the referencing system of the HPMS. This conflation effort can represent a significant amount of work for both the Federal government and state DOTs.
- **Spatial Resolution:** While the HPMS provides AADT for all roads on the NHS, the segments can be quite long—covering many miles even when intersections along the route could drastically affect counts at different points along the segment.
- **Temporal Resolution:** Many newer datasets (like the NPMRDS and other probe speed and travel time datasets) are captured at 5-minute intervals (or even down to 1-minute intervals with some). Given that the HPMS is a daily value, a number of significant issues arise when trying to apply one dataset to the other to derive peak-period or hourly measures. If used for performance measures, the average speed and travel time conditions would need to be equally aggregated up to an average day or average weekday, and then have that applied to HPMS to avoid mathematical errors. However, rolling up travel time data to an average across an entire day is largely useless as congestion will be averaged out. Many agencies are attempting to apply factors and directionality to the HPMS to get hourly counts, and then they use this with highly granular probe-data speed and travel time data. However, doing so can create significant issues depending on the methodology used—especially when applied to delay metrics.
- **Directionality is largely missing:** As noted above, the HPMS is unidirectional, and includes a directional factor to account for directionality. In some cases local knowledge and heuristics may be used to calculation of

this factor. This can lead to differences in interpretation and errors, particularly if HPMS traffic counts are combined with bi-directional data.

Review of National-Level System Performance Data Sets: NBI

Background

The National Bridge Inventory (NBI) is a national-level data repository with inventory and condition data for all U.S. highway bridges. It includes all bridges and culverts 20 feet or longer that carry traffic on public roads. The data set includes one record for each structure, which details inventory and condition data for the bridge, as well as data concerning the route on the structure. The data set also includes records for routes under a structure (termed “under records”), though not all routes under structures need to be coded.

States are responsible for reporting data for the bridges in the state on an annual basis used the coding guidelines detailed in the FHWA publication *Recording and Coding Guide for the Structure, Inventory and Appraisal of the Nation’s Bridges*, also called the “Coding Guide.” Table 2.5 summarizes the items included in the NBI, indicating which of these are specifically related to the condition of the structure.

Table 2.5. NBI Data Items

Item Number	Item Description	Condition -Related?	Values/Notes
1	State Code		See Coding Guide for codes by state
2	Highway Agency District		Two digit code for district in which bridge is located
3	County (Parish) Code		Identified using FIPS codes
4	Place Code		Identified using FIPS codes
5A	Record Type		1 Route carried “on” structure 2 Single route goes “under” structure A First of multiple routes under structure ... Z Twenty six routes under structure
5B	Route Signing Prefix		See Coding Guide for codes by route signing prefix
5C	Designated Level of Service		See Coding Guide for codes by level of service
5D	Route Number		Five digit route number of inventory route
5E	Directional Suffix		0 Not applicable 1 North 2 East 3 South 4 West
6	Features Intersected		Twenty four digits of names of features intersected by the structure
7	Facility Carried By		Name of facility being carried by the structure

Review of National-Level System Performance Data Sets

Item Number	Item Description	Condition -Related?	Values/Notes
	Structure		
8	Structure Number		Official structure number according to agency's internal procedures
9	Location		Narrative description of bridge location
10	Inventory Rte, Min Vert Clearance		Minimum vertical clearance over the route in meters
11	Kilometerpoint		Seven digit LRS that establishes location of bridge on Base Highway Network and matches what is reported in HPMS
12	Base Highway Network		0 Inventory Route is not on the Base Network 1 Inventory Route is on the Base Network
13A	LRS Inventory Route		Route number
13B	Subroute Number		
16	Latitude		Degrees/minutes/seconds
17	Longitude		Degrees/minutes/seconds
19	Bypass/Detour Length		Actual length to nearest kilometer of detour length
20	Toll		1 Toll bridge 2 On toll road 3 On free road 4 On Interstate toll segment under Secretarial Agreement 5 Toll bridge is a segment under Secretarial Agreement
21	Maintenance Responsibility		Two digit code of agency(s) responsible for maintenance of structure
22	Owner		Two digit code of owner(s) of bridge
26	Functional Class Of Inventory Rte.		Two digit code of functional classification. See Coding Guide
27	Year Built		Year of construction of the structure
28A	Lanes On Structure		Number of lanes carried by structure
28B	Lanes Under Structure		Number of lanes crossed over by structure
29	Average Daily Traffic		Six digit number of average daily traffic volume for route
30	Year Of Average Daily Traffic		Year represented by ADT in Item 29
31	Design Load		Indicate live load for which structure was designed
32	Approach Roadway Width		Normal width of usable roadway approaching the structure
33	Bridge Median		0 No median 1 Open median 2 Closed median with no barrier 3 Closed median with non-mountable barriers
34	Skew		Angle between centerline of a pier and line normal to the roadway centerline
35	Structure Flared		0 No flare 1 Yes flared
36A	Bridge Railings		0 Inspected feature does not meet standards 1 Inspected feature meets currently acceptable standards N Not applicable or safety feature is not required
36B	Transitions		
36C	Approach Guardrail		
36D	Approach Guardrail Ends		

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Item Number	Item Description	Condition -Related?	Values/Notes
37	Historical significance		See Coding Guide
38	Navigation Control		N not applicable, no waterway 0 No navigation control on waterway 1 Navigation control on waterway
39	Navigation Vertical Clearance		If Item 38 is coded as 1, record minimum vertical clearance imposed at site
40	Navigation Horizontal Clearance		If Item 38 is coded as 1, record horizontal clearance imposed at site
41	Structure Open/Posted/Closed		Operational status of structure. See Coding Guide
42A	Type of Service On Bridge		1 Highway 2 Railroad 3 Pedestrian-bicycle 4 Highway-railroad 5 Highway-pedestrian 6 Overpass 7 Third level 8 Fourth level 9 Building or plaza 0 Other
42B	Type of Service Under Bridge		1 Highway 2 Railroad 3 Pedestrian-bicycle 4 Highway-railroad 5 Highway-pedestrian 6 Overpass 7 Third level 8 Fourth level 9 Building or plaza 0 Other
43A	Structure Type, Main - Kind of Material/Design		Kind of material and/or design. See Coding Guide
43B	Structure Type, Main - Type of Design/Construction		Type of design and/or construction. See Coding Guide
44A	Structure Type, Approach Spans - Kind of Material/Design		Kind of material and/or design. See Coding Guide
44B	Structure Type - Approach Spans, Type of Design/Construction		Type of design and/or construction. See Coding guide
45	Number Of Spans In Main Unit		Number of spans in the main or major unit
46	Number Of Approach Spans		Number of spans in the approach spans to the major bridge
47	Inventory Rte Total Horz Clearance		Total horizontal clearance for inventory route identified in item 5
48	Length Of Maximum Span		Length of maximum span
49	Structure Length		Length of structure ot nearest tenth of a meter
50A	Left Curb/Sidewalk Width		Width of the left curb
50B	Right Curb/Sidewalk Width		Width of right curb
51	Bridge Roadway Width Curb-To-Curb		Most restrictive minimum distance between curbs or rails on structure roadway
52	Deck Width, Out-To-Out		Out-to-out width
53	Min Vert Clear Over Bridge Roadway		Actual minimum vertical clearance over the bridge roadway to any superstructure restriction
54A	Minimum Vertical Underclearance -		H Highway beneath structure R Railroad beneath structure

Review of National-Level System Performance Data Sets

Item Number	Item Description	Condition -Related?	Values/Notes
	Reference Feature		N Feature not a highway or railroad
54B	Minimum Vertical Underclearance		Minimum vertical clearance from roadway
55A	Min Lateral Underclear On Right - Reference Feature		Same as Item 55A
55B	Min Lateral Underclear On Right - Minimum Lateral Underclearance		Minimum lateral underclearance on the right
56	Min Lateral Underclear On Left		Minimum lateral underclearance on the left
58	Deck	Y	N Not applicable 9 Excellent condition 8 Very good condition 7 Good condition 6 Satisfactory condition 5 Fair condition 4 Poor condition 3 Serious condition 2 Critical condition 1 Imminent failure condition 0 Failed condition
59	Superstructure	Y	
60	Substructure	Y	
61	Channel/Channel Protection	Y	N Not applicable 9 No noticeable deficiencies 8 Banks are protected or well vegetated 7 Bank protection is in need of minor repairs 6 Bank is beginning to slump 5 Bank protection is being eroded 4 Bank and embankment protection is several undermined 3 Bank protection has failed 2 Channel has changed to the extent the bridge is near a state of collapse 1 Bridge closed because of channel failure. Corrective action 0 Bridge closed because of channel failure. Replacement necessary
62	Culverts	Y	N Not applicable 9 No deficiencies 8 No noticeable deficiencies 7 Shrinkage cracks 6 Deterioration or initial disintegration 5 Moderate to major deterioration or disintegration 4 Large spalls 3 Any condition described in Code 4 but excessive in scope 2 Integral wingwalls collapsed 1 Bridge closed. Corrective action 0 Bridge closed. Replacement necessary
63	Method Used To Determine Operating Rating		1 Load Factor 2 Allowable Stress 3 Load and Resistance Factor 4 Load Testing 5 No rating analysis performed
64	Operating Rating		Rating in metric tons
65	Method Used To Determine Inventory Rating		Same as Item 63
66	Inventory Rating		Rating in metric tons
67	Structural Evaluation		N Not applicable 9 Superior to present desirable criteria 8 Equal to present desirable criteria

Review of National-Level System Performance Data Sets

Item Number	Item Description	Condition -Related?	Values/Notes
			<p>7 Better than present minimum criteria 6 Equal to present minimum criteria 5 Somewhat better than minimum adequacy 4 Meets minimum tolerable limits 3 Basically intolerable, high priority of corrective action 2 Basically intolerable, high priority of replacement 1 This value of rating code not used 0 Bridge closed</p> <p>Note this item is calculated based on Table 1 in Coding Guide</p>
68	Deck Geometry		Same rating as Item 67 based on Tables 2A-E in Coding Guide
69	Underclear, Vertical & Horizontal		Same rating as Item 67 based on Tables 3A and 3B in Coding Guide
70	Bridge Posting		Rating of 0 (worst) to 5 (best) based on relationship of operating rating to maximum legal load
71	Waterway Adequacy		Same rating as Item 67 based on description in Coding Guide
72	Approach Roadway Alignment		Same rating as Item 67 based on description in Coding Guide
75A	Type of Work Proposed		See Coding Guide for two digit codes
75B	Type of Work - Work Done By		1 Work to be done by contract 2 Work to be done by owner's forces
76	Length Of Structure Improvement		Length of proposed bridge improvement
90	Inspection Date		Month and year that the last routine inspection of the structure was performed
91	Designated Inspection Frequency		Number of months between designated inspections of the structure
92A	Fracture Critical Details		Y for special inspection or emphasis needed N for not needed
92B	Underwater Inspection		
92C	Other Special Inspection		
93A	Fracture Critical Details Date		Code only if Item 92A, B, or C is coded Y for yes. Month and year that the last inspection of the denoted critical feature was performed
93B	Underwater Inspection Date		
93C	Other Special Inspection Date		
94	Bridge Improvement Cost		Estimated cost of the proposed bridge improvements in thousands of dollars
95	Roadway Improvement Cost		Cost of the proposed roadway improvement in thousands of dollars
96	Total Project Cost		Total project cost in thousands of dollars, including incidental costs not included in Items 94 and 95
97	Year Of Improvement Cost Estimate		The year that the costs of work estimated in Items 94, 95, and 96 were based upon
98A	Border Bridge - Neighboring State Code		Neighboring State code of structures crossing borders of States
98B	Border Bridge - Percent Responsibility		Percentage of total deck area of the existing bridge that the neighboring State is responsible for funding

Review of National-Level System Performance Data Sets

Item Number	Item Description	Condition -Related?	Values/Notes
99	Border Bridge Structure Number		Neighboring State's 15-digit National Bridge Inventory structure number
100	STRAHNET Highway Designation		0 The inventory route is not a STRAHNET route 1 The inventory route is on a Interstate STRAHNET route 2 The inventory route is on a Non-Interstate STRAHNET route 3 The inventory route is on a STRAHNET connector route
101	Parallel Structure Designation		R The right structure of parallel bridges carrying the roadway in the direction of the inventory L The left structure of parallel bridges N No parallel structure exists
102	Direction Of Traffic		0 Highway traffic not carried 1 1-way traffic 2 2-way traffic 3 One lane bridge for 2-way traffic
103	Temporary Structure Designation		T Temporary structures(s) or conditions exist
104	Highway System Of Inventory Route		0 Inventory Route is not on the NHS 1 Inventory Route is on the NHS
105	Federal Lands Highways		See Coding Guide
106	Year Reconstructed		The year of most recent reconstruction of the structure
107	Deck Structure Type		Record the type of deck system on the bridge. See Coding Guide
108A	Wearing Surface/Protective System - Type of Wearing Surface		Type of Wearing Surface. See Coding Guide
108B	Wearing Surface/Protective System - Type of Membrane		Type of Membrane. See Coding Guide
108C	Wearing Surface/Protective System - Deck Protection		Deck Protection. See Coding Guide
109	Average Daily Truck Traffic		Percentage of Average Daily Traffic that is truck traffic
110	Designated National Network		0 The inventory route is not part of the national network for trucks 1 The inventory route is part of the national network for trucks
111	Pier/Abutment Protection		If Item 38 has been coded 1, see Coding Guide to indicate presence and adequacy of pier or abutment protection features such as fenders
112	NBIS Bridge Length		Y Yes, structure meets or exceeds minimum length specified in National Bridge Inspection Standards N No
113	Scour Critical Bridges		See Coding Guide to identify the current status of the bridge regarding its vulnerability to scour
114	Future Average Daily Traffic		Forecasted average daily traffic for the inventory route identified in Item 5
115	Year of Future Avg Daily Traffic		Year represented by future ADT in Item 114
116	Minimum Navigational Clearance Vertical Lift		The minimum vertical clearance imposed at the site as measured above a datum that is specified on a navigation permit issued by a

Item Number	Item Description	Condition -Related?	Values/Notes
	Bridge		control agency

A key feature of the NBI is its longevity. The NBI was created in 1971 in response to the tragic collapse of the Silver Bridge in West Virginia in 1967. The coding guidelines were last substantially revised in 1995. FHWA posts NBI data dating back to 1992 on its website.

General Issues

A number of issues have been identified in the NBI over time. Major issues in the data set relevant with respect to national-level system performance include:

- **Limitations in condition data:** although the NBI contains a number of items, only a few of the items in the NBI are related to bridge condition, as shown in Table 2.5. The major condition-related items are Items 58, 59 and 60: the bridge deck, superstructure and substructure ratings, also termed “condition ratings.” These items describe overall conditions on a 10-point scale, and are populated based on visual inspections (conducted once every two years for most structures). FHWA’s research on these ratings suggests that the ratings for a bridge are subject to significant variability from inspector to inspector. The 2001 FHWA Report titled “Reliability of Visual Inspection for Highway Bridges” describes a set of inspections of seven bridges performed by 49 inspectors from 25 agencies. The report concludes:

Routine Inspections were completed with significant variability, and the Condition Ratings assigned varied over a range of up to five different ratings. It is predicted that only 68 percent of the Condition Ratings will vary within one rating point of the average, and 95 percent will vary within two points.

As for the causes of the variability, the report discusses various contributing factors, classifying these as physical, environment and management factors. Other potential issues include ambiguity concerning how to classify conditions, and different conventions between different agencies concerning what classifies as a “good” or “poor” bridge.

- **Issues Calculating Common Bridge Measures:** historically common bridge measures included Structurally Deficient (SD)/Functionally Obsolete (FO) bridge status and Sufficiency Rating. These measures were calculated by FHWA based on NBI data, but are not reported by the States. FHWA’s use of these measures technically ended when the Highway Bridge Replacement

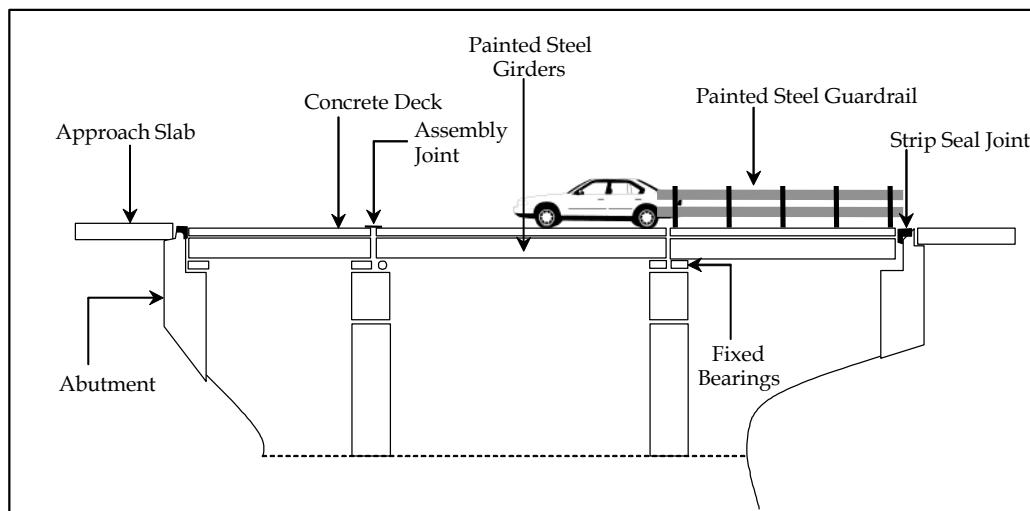
and Rehabilitation Program (HBRRP) was terminated with passage of MAP-21. However, MAP-21 makes reference to SD bridges, and the NPRM on bridge measures thus reinstates the definition of SD. A bridge is considered to be SD if one of its condition ratings (NBI Items 58, 59, 60, 62) is 4 or less (poor or worse condition), or if either the appraisal rating for Structural Condition (Item 67) or Waterway Adequacy (Item 71) is rated 2 or less. There exists some potential for confusion concerning this measure, given it is a calculated measure that requires evaluation of six different items. However, its calculation is more straightforward than either FO status or Sufficiency Rating, which have been discontinued.

- **Calculating Deck Area:** frequently bridge conditions are weighted by deck area, and this approach is recommended in the NPRM. However, deck area is not an item in the NBI, and the calculation of a bridge's deck area, though generally straightforward, can in some cases be ambiguous. One can approximate the deck area of a bridge by multiplying the bridge length (Item 49) by the deck width (Item 52). However, if a bridge is skewed (as indicated in Item 34) this should technically be considered in the calculation. Also, in some cases Item 52 is not populated. The NPRM hence describes using the roadway width as a proxy for deck width when Item 52 is not populated.
- **Legacy Data Issues:** a number of minor issues exist in the NBI due to the fact that it is a legacy standard that has remained largely unchanged over time. Together these issues conspire to complicate the task of analyzing and interpreting the data. For instance, for a number of fields missing values or out-of-range values are coded ambiguously either based on convention or coding guidelines (e.g., an unlimited vertical clearance is coded as 99.99 feet, and unknown dates are often coded as January 1, 1901). Also, some fields have been “overloaded,” representing different types of data depending on values in other fields. For example, the load rating fields typically contain a value in tons, but depending on the load rating method may instead contain a unitless rating factor.
- **Overlap/mismatches with the HPMS:** some of the data items in the NBI overlap with the HPMS, such as Item 26 – Functional Classification, Item 104 – Highway System of Inventory Route (which indicates whether the bridge is on the NHS), Item 29-30 for AADT and Item 114-115 for future AADT. Where these overlaps exist, one may conceivably obtain two different results to a data query using the NBI and HPMS. Also, in the case of Item 26, the NBI has not yet been updated to use functional classifications in the HPMS 2010+ standard described in the previous section.

Omission of Element-Level Data in the NBI

The section above discusses issues in the current NBI based on what data it contains. Equally important is the consideration of what data are available that are not currently in the NBI that may be relevant for characterizing bridge performance. The major issue in this regard is that MAP-21 required the States to begin collecting and reporting more detailed element-level condition data for bridges on the NHS using the National Bridge Elements (NBE) defined by AASHTO. However, this information is reported to FHWA independently from other NBI data and not yet included in the NBI data FHWA makes available on its web site.

Figure 2.1, reproduced from the FHWA National Bridge Investment Analysis System (NBIAS) technical manual, illustrates the structural elements on a typical highway bridge, such as the bridge deck, joints, girders, and bearings (note this example is illustrative and does not use specific NBE definitions). The NBE includes descriptions of the bridge elements that should be inspected, along with language describing four different condition states for each element. When performing an element-level inspection, a bridge inspector records the quantity or percentage of each element on the bridge by condition state.



Source: FHWA

Figure 2.1. Typical Bridge Elements

In theory element-level data provide a more detailed assessment of the bridge's condition than the bridge deck, superstructure and substructure ratings in the NBI. In practice, the States have only recently begun using the NBE, which replaced an early standard, the AASHTO Commonly Recognized (CoRe) elements. Further, as yet there exists no consensus in the bridge community concerning how best to aggregate NBE data to summarize bridge condition. Also, element-level data, like the existing NBI condition ratings, are collected through visual inspections, and thus subject to issues discussed above regarding the ratings inherent in visual

inspections.

Other major omissions in the NBI include data on seismic vulnerability and events such as floods or truck hits. These issues contribute to decisions concerning when to replace bridges, though there are no national data sets or standards concerning collection of this information. NCHRP Report 590, *Multi-Objective Optimization for Bridge Management Systems*, further details issues related to assessing bridge vulnerabilities.

Review of National-Level System Performance Data Sets: FARS

Background

The Fatality Analysis Reporting System (FARS) is a data set maintained by the National Highway Traffic Safety Administration (NHTSA) that details fatal traffic crashes in the United States. The system includes all crashes that involve a motor vehicle traveling on a public road (one that is customarily open to the public) that result in a fatality within 30 days of the crash. The FARS data set contains over a hundred different data items detailing fatal traffic crashes dating back to 1975. Table 2.6 lists the data tables in FARS, including the data file name, unique identifiers for the file, a brief description, and example fields from the table. Key data files include: Accident, which lists fatal traffic crashes; Person, which lists vehicle occupants and non-occupants (e.g., pedestrians) involved in a crash; and Vehicle, which details the motor vehicles involved in a crash.

States provide data to NHTSA to populate the system on a voluntary basis through cooperative agreements established between each state, as well as Washington, D.C. and Puerto Rico. FARS data are used for a wide variety of purposes by federal, state and local agencies, researchers, the insurance industry, the media, and various advocacy groups. NHTSA makes all FARS data available to the public, both through enabling download of the FARS data files, and providing a web query tool. The FARS data-set is well-established, and extensive training and documentation materials have been developed over time and updated on a continuous basis to support its use.

Table 2.6. FARS Data Files

Data File Name	Unique Identifiers	Description	Example Fields
Accident	ST_CASE	On details of the crash, such as date, number of vehicles, location, time	First Harmful Event: the first injury producing the event of the crash. A judgment call of FARS analysts based on the police report Manner of Collision: does not exist if the collision is not between two motor vehicles Drunk Driver: number of drunk drivers in the fatal

Review of National-Level System Performance Data Sets

Data File Name	Unique Identifiers	Description	Example Fields
			crash; alcohol data is often missing
Vehicle	ST_CASE, STATE, VEH_NO	On vehicle, such as model type, body, state registered	Travel Speed: estimate of vehicle's speed prior to crash. Reported by investigating officer Initial Contact Point: area on vehicle that first injured non-motorists or occupants Most Harmful Event: event resulting in most severe injury. A judgement call of FARS analysts based on the police report Driver Drinking: alcohol data often missing Speeding Related: whether driver's speed related to crash Speed Limit: of area
Person	ST_CASE, VEH_NO, PER_NO	On motorist and non-motorists	Person Type: distinguishes between pedestrian and bicyclist, for example Injury Severity: not always collected by States on persons in crash but not injured Police Reported Alcohol Involvement Related Factors, e.g., impairments, illegal driving, or giving wrong signal
Parkwork	ST_CASE, VEH_NO	Very similar to Vehicle data file	See Vehicle data file
CEVENT	ST_CASE, EVENTNUM	Harmful and non-harmful events in crash	Area of Vehicle Sequence of Events
VEVENT	ST_CASE, VEH_NO, VEVENTNUM	Harmful and non-harmful events for each in-transport motor vehicle	
VSOE	ST_CASE, VEH_NO, VEVENTNUM	Harmful and non-harmful events for each in-transport motor vehicle	
Damage	ST_CASE, VEH_NO	Area of damage	Damaged Areas
Distract	ST_CASE, VEH_NO, MDRDSTRD	On each driver distraction	Driver Distracted By
DRIMPARI	ST_CASE, VEH_NO, DRIMPARI	Identifies each driver impairment	Condition at Time of Crash- Driver
Factor	ST_CASE, VEH_NO, MFACTOR	Each vehicle factor	Contributing Circumstances, Motor Vehicle: a vehicle's possible preexisting defects
Maneuver	ST_CASE, VEH_NO, MDRMANAV	Each avoidance attempt	Driver Maneuvered to Avoid
VIOLATN	ST_CASE, VEH_NO, MVIOLATN	Each violation	Violations Charged: all violations charged to this driver
Vision	ST_CASE, VEH_NO, MVISOBSC	Visual obstruction	Driver's Vision Obscured by
NMCRASH	ST_CASE, PER_NO, MTM_CRSR	Each non-motorist action at time of crash	Non-Motorist Action at Time of Crash, e.g., Inattentive, Wrong-Way Riding, Not Visible

Review of National-Level System Performance Data Sets

Data File Name	Unique Identifiers	Description	Example Fields
NMIMPAIR	ST_CASE, PER_NO, NMIMPAIR	Each non-motorist impairment	Condition, e.g., Ill, Asleep, Deaf, Paraplegic
NMPRIOR	ST_CASE, PER_NO, MPR_ACT	Non-motorist action immediately prior to the crash	Non-Motorist Action Prior to Crash, e.g., Waiting to Cross, Jogging, Working in Trafficway
SAFETYEQ	ST_CASE, PER_NO, MSAFEQMT	Safety equipment of non-motorist	Non-Motorist Safety Equipment, e.g., Helmet, Lighting, Protective Pads
VINDECODE	ST_CASE, VEH_NO	Vehicle specification data for all vehicle types	

General Issues

As noted above, FARS is a well-established data set, FARS data are used to support a wide variety of applications, and NHTSA has worked extensively to improve the quality of FARS data and provide supporting training and documentation materials to support its use. There are nonetheless certain issues that bear consideration in using FARS data to support national performance reporting. These include the following:

- Due to the process NHTSA must follow for populating FARS (which requires combining data provided by the States from disparate systems) there is a significant lag between when fatalities occur and when data are recorded in the system. Consequently, FARS data for a given calendar year are not finalized until over a year after the end of the year (in other words, 2013 data were not available until 2015).
- By design the system is limited to fatal crashes. The system stores extensive data for all of the vehicles and people in a crash, including people injured but not killed, but the fact that only fatal crashes are included limits use of the dataset in certain key respects. NHTSA maintains other data sets with sample data on non-fatal crashes, but there exists no comprehensive source of national crash data outside of FARS.
- Fatalities are (fortunately) rare events, and thus there is large scatter in fatality data, necessitating use of techniques such as calculating moving averages to summarize fatality trends.
- FARS does not store data on vehicle miles traveled (VMT). Thus, in calculating crash rates it is necessary to combine FARS data with other data (e.g., HPMS).
- There is great interest in using FARS to analyze non-motorist fatalities, but certain limitations in performing such an analysis.
 - FARS does not detail when a non-vehicle occupant is involved in a crash, though many of the summaries of fatalities and fatality rates do not drill down to this level of detail.

- FARS does not capture fatalities that occur off of public roads or that do not involve motor vehicles.
- As noted above FARS does not provide VMT, or other data one might desire to calculate fatality rates (e.g., numbers of pedestrians or cyclists).
- In 2010 NHTSA added a PBTYP table with additional information on pedestrian and/or bicycle locations to help analyze non-motorist crashes. However, NHTSA subsequently removed this data from the data set based on data quality concerns.

3. Research Roadmap

3.1. Background

Transportation-related organizations – including AASHTO, TRB, FHWA, and others – have ongoing TPM research needs. Research products are developed through a variety of organizations and vehicles. One of the objectives of the research effort described in this report was to better coordinate these needs to deliver quality research products as efficiently as possible. This was accomplished through the activities and work products described in sections 3.2-3.4.

3.2. Research Needs

A series of outreach activities were conducted to generate and prioritize research needs. These activities are listed below and described in more detail in section 1.2.2 and section 5. Documents from the AASHTO Annual Workshop and the TRB Annual Meeting Workshop are included in Appendix A and B, respectively.

- SCOP/SCOPM Meeting Session Scottsdale, AZ June 2014
- TPM Roundtable Presentation Washington, DC August 2014
- TPM Roundtable Workshop Washington, DC November 2014
- AASHTO Annual Workshop Charlotte, NC November 2014
- TRB Annual Meeting Workshop Washington, DC January 2015

As a preliminary step in this research effort, a compilation of existing research – both completed and ongoing – was produced to better document the current body of resources. This review of existing research addressed TRB- and FHWA-sponsored performance management research. Additional sources including state DOTs and University Transportation Centers were also considered. The review had a five-year scope and resulted in a set of 67 matching documents and projects.

A heat map was produced that communicated the focus of current research. See Figure 3.1 on the following page.

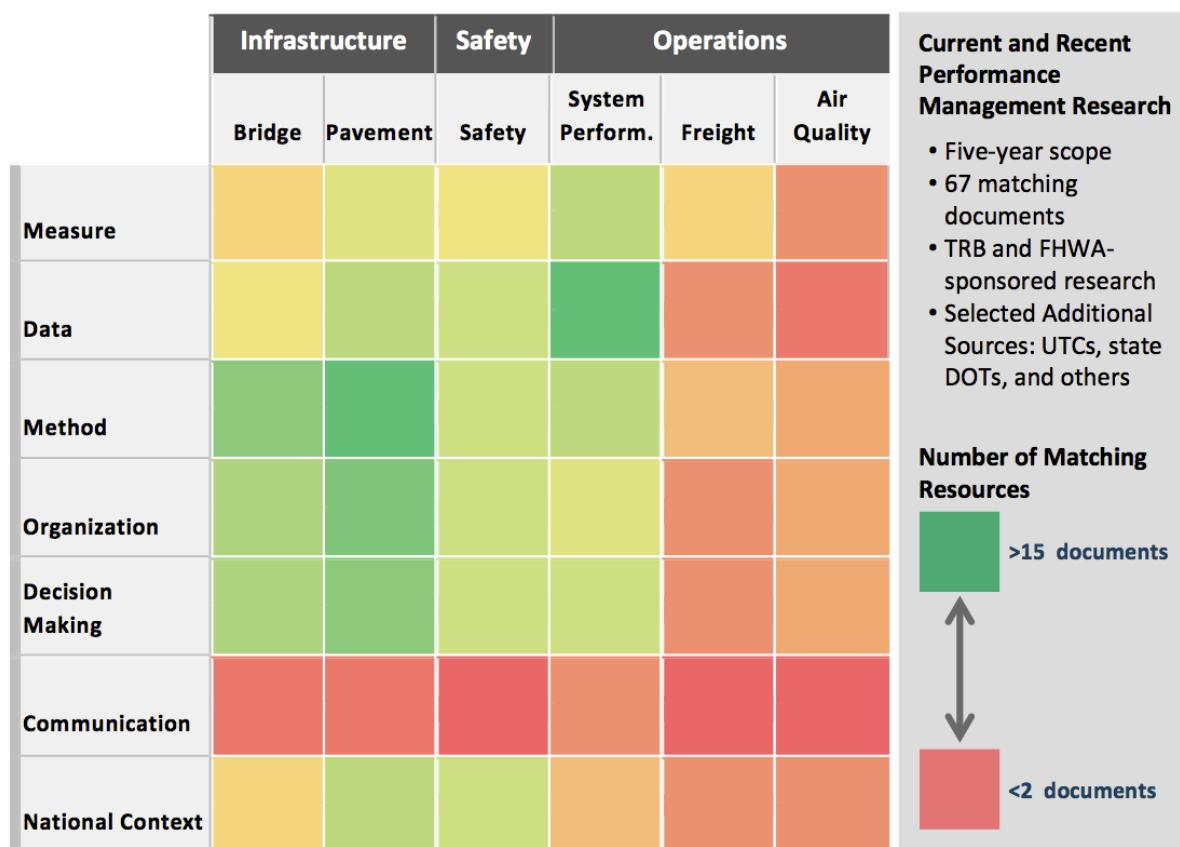


Figure 3.1 Performance Management Research Heat Map

The following is a summary of the research needs that were identified. The needs have been organized into the following categories:

- Measures
- Data, Methods, and Analysis
- Organizational and Institutional Issues
- Implementation (including decision-making)
- Communication
- Other

Measures

What are the measures of the future?

- Continue to refine MAP-21 measures
- Explore non-traditional measures

Develop operational measures

- Incident response measure
- Define reliability parameters and measures

- Develop measures for freight data
 - Peer exchanges for mobility-based performance measure areas including freight, congestion, and reliability
 - Real time vehicle occupancy measure / Explore how existing and emerging technologies can capture vehicle occupancy levels in real time
-
- Develop multimodal measures**
-
- Develop travel time reliability measures across modes
 - Explore how complete travel times can be recorded in real time for multi modal trips
 - Conduct research to calculate travel time reliability in a manner that is applicable to transit
 - Improve the coordination of fatality and serious injury measures for highways and rail/transit
-
- Develop subsurface pavement quality measure**

Data, Methods, and Analysis

- What are the best data tools? Need a "consumer report" of data tools**
 - Predictive tools, forecasting methods
 - Assess a data integration tool that allows states and MPOs to fuse their traffic travel time and volume data with the national private vendor data sets
 - Assess tools and methods to address data management including the collection, analysis, storage, QA/QC protocols and the value of data
 - Predictive condition tools for system performance based on multiple factors/modes
 - Develop a framework to better integrate planning, financial, project, inventory, and performance systems
 - Better tools and data to analyze multimodal capacity on corridors
- Research is needed to ensure the data and information developed through the performance management programs are available for use now and in the future - and facilitate exchange of data**
 - Hold a data summit to determine data needed for a national performance-based planning and programming process, review the data that is available, and prepare an agenda for filling the gaps. The outcome should answer: **What impact will big data have on current and future measures?**
 - Develop a user group that will look at the NPMRDS and address current National measures; measures for use by localities, etc.
 - Address availability and timeliness - the availability of information in national data sources typically lag in time
 - How can we get believable/credible/high quality VMT data across modes?
 - Need conflated VMT data (including bike & ped Phase 2) to assess and align with national travel data sets
 - How to handle ubiquitous real time volume data?
 - Need for better mobility data in smaller areas
- Creation of uniform quality assurance on third party data and agency data**

- Accessing proprietary information - freight
- What should be collected and managed in private vs public sector?

Development of data format standards

- Research is needed to address the balance between regional data needs and the consistency necessary to tell a national story

Use of linear regression for target setting

- Explore target setting methodologies beyond a 'line'

Develop a national data business plan

Integrate risk and data performance analysis

Quantify the relationship between system performance and economic impact/benefits across states

Explore the relationship between congestion and safety

Research on externalities and how they affect outcomes

Characterizing outcomes associated with a given level of performance

Conduct a review of the NTD that is modeled on the reviews of HPMS

Organizational and Institutional Issues

Positioning an agency for implementation considering different agency sizes and issues

- How to work with agency leadership to obtain full, not just verbal, commitment

- How do we change organizational culture to embrace performance management?
(top down and bottom up)

- Best practices for locating performance management responsibility in organization/agency

What are the best practices for collaborating with external agencies?

- Best practices - how are states and MPOs tying/aligning plans to make them relevant?

- State, MPO, and transit coordination in target setting

- Establish clearinghouse with dynamic information.

Develop resources to share lessons learned from implementing pavement and bridge performance management in ways that are applicable to less mature measurement areas (e.g. system performance & transit)

- Develop a guidebook for implementing performance management that is applicable to transit agencies.

How are we defining and measuring success of our organization?

What lessons can be learned from high performing companies?

Work is needed to understand the competencies critical to performance management decision making, to assess the gaps, and to identify strategies to address the gaps Add: ethics of responsibility

Identify roles and responsibilities for performance management information (reporting) at DOTs and MPOs

Implementation (including decision-making)

Assess effects of performance management on decision making

- Encouraging PM in decision-making
- How to systematically build risk management into decision making
- What are the best questions to answer to lead to decision making?
- What changes are needed at an organization to use PM in decision making?
- How do we match the data to the decisions being made?
- When is data "good enough" to use?

How to better integrate multiple required plans

- Research is needed to address how planners and decision makers can truly integrate plans (SHSP, TAMP, CMP, etc.) into the programming process
- Alignment of performance targets with LRP
- Implementation of freight performance measures and/or state freight plans
- For those who didn't do a freight plan - why?

Need guidance on managing and coordinating the timing/schedule of target setting

- Need to address the relationship between the predictability of investment sources and the target setting process
- Should develop a guidebook for the states and MPOs to have similar target setting approaches and outcomes
- How to balance financial and staffing resources against potentially competing performance targets

Prioritization vs tradeoffs?

- Need a study on the development of sound models that decision makers can use to assess investment returns and assess tradeoffs.
- There is a need to provide new tools that will assist decision makers in making investment tradeoffs across areas (e.g. reductions in serious injuries vs. improvements in mobility)

Research on effectiveness of performance measures based on availability of resources

- Maximizing funding impacts (special appropriations too)
- Need research to connect state of good repair measures to the quantifiable costs of not being in state of good repair

Does performance information truly change behavior?

How do externalities influence performance measures?

Share cases and examples of how to track measures in the “real world”

Consider how toolkits and incentives can promote relationship building

- Connecting performance management with asset management
- Implementation of conflicting performance measures for CMAQ
- How are states implementing MAP-21 national PMs

Communication

- What information do which stakeholders want – and in what format?
 - How to effectively use PM to make "the case"
 - Messaging of the benefits of improved performance
 - Guidance on how agencies can more effectively report on transportation performance
 - Economic and system benefits of transportation investment at a program and project level
 - Research is needed to find more effective methods to deliver personal and meaningful messages to a changing demographic
 - Messages for making performance data matter - put it in terms people can relate to and care about
 - How to determine the most effective message to influence audiences (decision makers, public)
 - Communicating success stories
 - Building an appreciation for a system everyone takes for granted as well as the costs associated with such a system. People do not realize what these things cost
 - Making the case for investing in transportation
 - Communicating why the work is being done. More than just "your tax \$ at work."
- How can info be presented so customers act upon it?
 - What are new and effective ways to visualize data?
 - Reaching broader audiences (silent majority, younger audiences) using non-traditional techniques (infographics, social media and viral marketing)
 - Tool box to better communicate the trade-offs and choices (links to having analysis of this - how to use once we have numbers)
- Need consistency in presenting PM results across agencies
 - Work is needed to improve how transportation agencies can communicate performance to tell a local, regional, and national story
 - How to explain the various roles of State DOT and the local system
- Work is needed now to prepare for the data that the performance measurement process will produce
 - Building trust in your data and information (transparency)
- Methods to advocate without lobbying
- Applying best practices from other fields (business, etc.)

- Driving people to your information - website hits from people who won't go there on their own (social media) and involvement in your work/plans**

Regional Context

How to provide context for looking at performance results across states

- Need research to provide examples of effective performance comparisons and detail all of the elements necessary to put performance comparisons into a valuable and reliable context
- Need research on how to identify peer agencies with whom to share best practices - and avoid simple national ranking of "best to worst"
- Research is needed to help the transportation community understand and improve benchmarking of performance
- Consider the establishment of a US-based benchmarking organization similar to CoMet and NOVA (international transit benchmarking effort of the Imperial College of London)

How do we create regional context?

- Interplay between national measures and regional, local concerns

Sharing best practices related to PM

When reporting of the cost of transportation, how to deal with varying responsibilities of DOTs

- Economic and system benefits of transportation investment at a program and project level

3.3. Research Roadmap Diagram

Figure 3.2 on the following page shows the diagrammatic version of the Research Roadmap. The full Roadmap is available at: <http://www.tpm-portal.com/tpm-roadmap/>.

Section 3.4 includes the full text of each of the 26 problem statements represented in the Roadmap.

3.4. Problem Statements

The team followed an iterative, four-step process to identify priority research needs and to generate draft research statements. First, the identified needs were prioritized through a series of exercises starting with the workshop that was held at the AASHTO Annual Meeting in Charlotte, NC in November 2014. Then, based on the identified priority needs, a preliminary set of research statements was generated in the spring of 2015 and presented to the AASHTO SCOPM leadership at a meeting in May 2015 in Providence, RI. At this meeting, the preliminary set of research statements was reviewed and edited. Finally, in order to address additional priorities identified at this meeting, a supplemental set of research statements was drafted. Together, this process yielded the full set of 26 problem statements that comprise the Research Roadmap.

The following is the set of 26 problem statements that have been developed by the project team with panel assistance. The statements are organized according to three groupings characterizing their suitability for funding and implementation over a four-year timeframe (calculated from a July 2015 starting point).

- Short-Term: Projects suitable for funding within a 12 month horizon
- Mid Term: Projects suitable for funding within a 12-24 month horizon
- Long-Term: Projects suitable for funding within 24-48 month horizon

3.4.1. Short-Term Problem Statements

TITLE
Creating the Correct Communication for Each Stakeholder
BACKGROUND
<p>Increasingly, DOTs view effective communication of agency performance, mission, goals and objectives, as being of critical strategic importance. However, agency staff are often challenged to develop effective business cases to justify investments in communications. Part of the challenge is that research indicates DOTs' message is not resonating with the public. In order to improve and justify communications, agencies need to understand:</p> <ul style="list-style-type: none">• Does communication really make a difference? Does communications have a return on investment?• How to make a message resonate with the public?• What new tools can lead to improvement?
OBJECTIVE
This research will provide examples of communications efforts as well as models of how to assess them and tools for maximizing the value and impact of each type of effort. It will:

- Develop evaluation methods and techniques to estimate value of communications investment
- Assess the experience of selected agencies that have invested in communications efforts, in terms of the investments made and returns realized
- Develop guidance and associated tools for maximizing the value of communications investments by considering factors such as language and terminology, audience segmentation, media type/format, subject/topic, etc.

POTENTIAL BENEFITS

With tools and guidance to better understand market segmentation and what makes communications strategies successful, and what kind of return on investment to expect, DOTs can be more effective in communications efforts and in achieving internal support for investing in them.

RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE

This effort builds directly upon:

- NCHRP Report 742: Communicating the Value of Preservation
- NCHRP 20-24(62): Making the Case for Transportation Investment and Revenue. It seeks to extend the guidance developed through this effort and to assess the results of its practical application.
- NCHRP Report 666: Target-Setting Methods and Data Management to Support Performance-Based Resource Allocation by Transportation Agencies.

In addition, a small number of closely-related research efforts addressing communications and performance management are currently underway or have been recently completed. This effort should be coordinated with the following active projects:

- NCHRP Project 20-24(93)B(02): Successful Practices in Communicating Performance Management
- NCHRP Project 20-24(93)B(01): Improving Public Communication Influence and Effectiveness Through Better Understanding of Transportation Users' Expectations and Language – Public Outreach

TASKS

1. Literature and Practice Review
 - Synthesize lessons from communication specialists
 - Catalogue of candidate successful practices
2. Regional stakeholder workshops
 - Two workshops with DOT communications staff to assess current practices, needs
 - Develop evaluation methods and techniques to estimate value of communications investment
3. State DOT case studies

- Apply methods to estimate communications ROI (how much agencies spent on communication efforts and what were the benefits)
If possible, include a DOT that is applying guidance derived from *Words that Work*
4. Develop tools for maximizing the value of communications investments
 - An online glossary or lexicon that reflects market segmentation
 - Develop guidance for applying tools to maximize the value of communications investments
 5. Create and present webinar to present research results
 6. Final report

FOLLOW-ON AND IMPLEMENTATION ACTIVITIES

Training and implementation support for the guidance and tools will be needed.

ESTIMATED FUNDING REQUIREMENTS

\$350,000

AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT

TBD

POSSIBLE FUNDING VEHICLE(S)

NCHRP 20-24

NCHRP Full

TITLE
Organizational Models, Roles, and Training for Transportation Performance Management
BACKGROUND
<p>Transportation performance management (TPM) offers agencies an array of opportunities to increase positive outcomes with available resources. These opportunities include:</p> <ul style="list-style-type: none"> • Application of performance measures that relate performance outcomes to investments • Deployment of applications that support enhanced decision-making • Streamlining of processes to expedite program and project delivery • Prioritizing needs to allocate resources where they are most needed • Enabling better collaboration amongst stakeholders <p>As tools and techniques advance, organizational capabilities in transportation agencies must also advance to realize the benefits of TPM. Many organizational models and role types exist for TPM programs. Matching the right model and role types with people are integral ingredients for realizing the positive outcomes that are possible with TPM. Transportation agencies today need assistance in improving organizational capacity to adopt TPM benefits.</p>
OBJECTIVE
<p>This research will produce resources to help transportation agencies improve organizational capabilities needed to implement TPM. These resources will be designed to supplement work being developed by the FHWA for its TPM Technical Assistance Program and is intended to be available on the AASHTO Standing Committee on Performance Management website. Three concepts will be produced through this research:</p> <ol style="list-style-type: none"> 1. Organizational models for TPM programs 2. TPM roles and responsibilities 3. Training needs for TPM roles
POTENTIAL BENEFITS
<p>Most of the research being conducted for TPM is focused on the content of transportation performance. This research would focus on the people and organizations that are delivering transportation performance. It would help guide agencies to strengthen the staff and organizations so that they are better stewards of TPM programs and implementation.</p>
RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE
<p>The FHWA Office of TPM is actively involved in developing tools and trainings for TPM. The current NHI trainings that are being developed is focused on the “how to’s” of TPM. The trainings envisioned for this project will be focused on TPM roles and how to do the best job in the role. It will reference the NHI training course.</p>
TASKS
<ol style="list-style-type: none"> 1. Organizational Models for TPM Programs <ul style="list-style-type: none"> • Research domestic and international models for TPM program organizations and develop a set of example models that represent the various approaches

- Describe these models in useful detail with accompanying diagrams for DOTs to use to outline TPM program organization improvements
2. TPM Roles and Responsibilities
 - Develop a list of roles in TPM programs
 - Roles should represent roles described in all of the organizational models developed in the previous task
 - Produce a set of responsibilities for each of the roles and indicate with organizational model(s) the role supports
 3. Training Needs for TPM Roles
 - Develop a list of training needs to strengthen DOT staff capabilities to deliver TPM roles
 - List existing trainings as well as new trainings needed to support roles developed in Task 2 above
 - The new trainings should be described in sufficient detail so that it is clear what the contents of the training should be

The research team should identify existing resources that will support the development of these research products so that there is not duplication of effort.

FOLLOW-ON AND IMPLEMENTATION ACTIVITIES

The training needs will need to be converted to training programs. Recommendations on how to implement the trainings will need to be provided.

ESTIMATED FUNDING REQUIREMENTS

\$200,000

AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT

TBD

POSSIBLE FUNDING VEHICLE(S)

NCHRP Full Program

NCHRP 20-24

TITLE
Decision-Making Framework for Performance and Data
BACKGROUND
<p>Under MAP-21, performance management will provide a means to more efficient investment of Federal transportation funds in part by improving transportation investment decision-making. However, the data needs and framework to inform those decisions still needs to be defined and improved. This research asks the questions:</p> <ul style="list-style-type: none"> • To what extent have transportation policy makers analyzed the correlation between investment and performance? • If fully armed with perfect performance or other data, would two different policy makers land on the same investment decision? • Evolutions of federal authorization have helped shape the transportation data landscape. Fatalities, condition of pavement and bridge elements, and travel time delays are widely reported and relied upon for program-level and project-level investment criteria. But what other information and qualitative factors help guide executives and policy makers? • With endless data points but without the ability to verify, synthesize, or analyze it, how can the information be useful? <p>The term DRIP, or Data Rich and Information Poor, resonates with many Chief Executive Officers. A framework for better connecting data to performance-based decisions is needed to add strength to performance management efforts and value to our transportation system.</p>
OBJECTIVE
<p>This research endeavors to guide transportation officials in better aligning technology, data, and analytic resources with their most important investment decisions through the following:</p> <ol style="list-style-type: none"> 1. Understand the relationship between performance, decision-making, and data in order to develop a framework that transportation agencies can use for improved decision-making and optimizing data investments. 2. Develop a framework for performance-based decision-making that transportation agencies can use to establish good business processes, produce good data, and yield good performance. <p>As a military leader, Colin Powell applied a doctrine of 40-70. Making a decision with less than 40% of the available information was premature. Waiting for more than 70% of the available information, however, can prove costly from the standpoints of data collection and time lost for implementation. This research will seek to determine whether such a rule be applied in transportation to capacity-adding projects or operational improvements. This will assist agencies in determining when existing data is adequate to make investments at various levels.</p>

POTENTIAL BENEFITS

This research will help agencies understand the connection between investing resources in gathering data and the quality and scope of the decisions they can make. Without this understanding, agencies may cut costs on data tasks that can cause problems later.

For example, a transportation agency may hire several engineering consultants to refine design plans and cost estimates for a large infrastructure project, only to witness cost savings evaporate as interest rates rise and financing costs consume all value engineering. Or it may deploy bare bones technology resources to inform travelers of delays on its network only to watch travelers use more reliable privately funded applications.

RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE

The area of highway safety is an area of transportation that relies heavily on data-driven decision making is the area of highways safety. National Highway Safety Transportation Administration (NHTSA) requires for grant eligibility that benefit-cost calculations be performed using NHTSA standards.

- NCHRP 667 examined core competencies required for highway safety and discussed “the environment in which road safety decisions often take place and data supported decision-making in terms of problem identification, intervention planning, and evaluation.” This research could serve as a representative sample of decision making research needed across transportation agencies.
- NCHRP 8-92 *Implementing Transportation Data Program Self-Assessment* tests the feasibility of the data program self-assessment process and seeks to operationalize the framework and produce a guide for transportation agencies to implement a data self-assessment.
- FHWA’s *Performance Based Planning and Programming Guidebook* is designed to highlight effective practices to help transportation agencies in moving toward a performance-based approach to planning and programming.
- International Roughness Index has long been a data gathering requirement for the Highway Performance Monitoring System. FHWA examined disparities in data gathering and reporting for three states along a common Interstate. Beginning with this and related studies, this research could explore whether executives in similar situations with comparable data are making like decisions.
- Several academia and private sector studies may also support this research, such as the *Empirical analysis of transportation investment and economic development ... by Berechman, Ozmen, and Ozbay.*

TASKS

1. Develop a framework including key elements for a business model with minimum data/information needed to make good, defensible decisions. The framework would include (a)
 - a. Performance measures

- b. The range of performance results likely depending on data availability (i.e. better data would yield more certain target setting)
 - c. An agency's analytic maturity
2. Scan data gatherers and information owners to determine relative costs of data – performance and otherwise – by data category (e.g. Safety vs. Traffic vs. Infrastructure Condition vs. Customer Satisfaction vs. Environmental Impact).
 3. Survey transportation executives on the role and importance of performance and other data in decision making.
 - a. Assess whether the most crucial decisions are made quantitatively or qualitatively.
 - b. Determine gaps in both necessary information and staff skill sets in effectively delivering that information.
 - c. Group decision types by those that most heavily rely on data and those that least heavily rely on data.

FOLLOW-ON AND IMPLEMENTATION ACTIVITIES

1. Build a “New Executive Handbook to the Use of Transportation Information in Decision Making”
2. Analyze correlations between transportation investments and resulting performance; leveraging existing studies in this area, determine whether states that spend the most relative to their size are, over time, achieving higher performance
3. Comparing states with similar performance in commonly measured performance areas, determine whether those states are making similar investment decisions. Develop a structure including template job descriptions and hiring practices for developing a Business Analysis Unit inside a public transportation agency
4. Examine state DOT processes to determine when and where most critical resource allocation decisions are made (Long-range plan, Statewide Transportation Improvement Program, Annual budgeting, Statewide or district project selection, etc.)
5. By logical grouping (e.g. seven national performance areas), offer best practices in data gathering, reporting, and analysis among public transportation agencies in the U.S. and abroad. Where applicable, offer case studies from the private sector (e.g. shipping company analysis of logistics and travel delay and costs)
6. Survey cross-asset or other resource allocation tools

ESTIMATED FUNDING REQUIREMENTS

\$250,000

AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT

TBD

POSSIBLE FUNDING VEHICLE(S)

NCHRP 20-24

TITLE
Communicating the Importance of Establishing Performance Targets
BACKGROUND
<p>Performance management (PM) is of growing importance to help transportation agencies deliver greater value for the resources available, and to communicate what will be delivered, with transparency and accountability.</p> <ul style="list-style-type: none"> • Communicating performance measures, targets, and results is an essential ingredient to a successful PM program. • Publishing targets will become more common forcing agencies to deal with challenging situations (e.g., declining targets)
OBJECTIVE
<p>This project should identify and document current leading state DOT practices in communicating performance targets. The project should develop materials such as text/graphics displays that present guidance for DOTs to address communications challenges including:</p> <ul style="list-style-type: none"> • Complex target-setting methodologies, • Declining performance targets, • Divergence between states' targets, • Impact of investment tradeoffs on targets <p>The effort should address target-setting with respect to MAP-21 requirements. Addressing target-setting outside the scope of MAP-21 requirements may also be valuable but is of secondary importance.</p>
POTENTIAL BENEFITS
<p>Increasingly, DOTs are challenged to effectively communicate performance information. This project will provide guidance and useful tools to reduce the burden on DOTs associated with communicating performance targets. In addition, the guidance and tools will help DOTs to produce more effective communications products.</p>
RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE
<p>A small number of closely-related research efforts addressing communications and performance management are currently underway or have been recently completed. This effort should be coordinated with the following active projects</p> <ul style="list-style-type: none"> • NCHRP Project 20-24(93)B(02): Successful Practices in Communicating Performance Management • NCHRP Project 20-24(93)B(01): Improving Public Communication Influence and Effectiveness Through Better Understanding of Transportation Users' Expectations and Language – Public Outreach <p>This effort should build upon the work of :</p>

- NCHRP Report 666: Target-Setting Methods and Data Management to Support Performance-Based Resource Allocation by Transportation Agencies
- NCHRP Report 742: Communicating the Value of Preservation
- NCHRP 20-24(62): Making the Case for Transportation Investment and Revenue

TASKS

1. Review literature and practice
 - a. Build catalogue of candidate practices
2. Create framework for Assessing Target-Setting Practices
 - a. Develop criteria for evaluating practices
 - b. Develop standard format for presenting successful practices
3. Gather lessons-learned from review of successful practices
4. Draft guidance for DOTs on communicating performance targets
 - a. Draft report and “executive” presentation materials
5. Webinar to present research results
6. Final report

FOLLOW-ON AND IMPLEMENTATION ACTIVITIES

ESTIMATED FUNDING REQUIREMENTS

\$150,000

AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT

TBD

POSSIBLE FUNDING VEHICLE(S)

NCHRP 20-24

NCHRP Full

TITLE
Establishment of Performance Data Collection and Reporting Standards
BACKGROUND
<p>In an era of increased demand for transparency and accountability, transportation agencies are embracing performance management practices. A key component of this approach is the tracking and reporting of a wide range of performance measures. The recent passage of MAP-21 will add a set of national performance measures to the body of performance data being publically released. In order to realize the notable benefits from the increased monitoring and sharing of performance results, the industry must address:</p> <ul style="list-style-type: none"> • The current absence of performance data collection and reporting standards • The need to build a foundation for effective performance management approaches through quality data • Without data collection and reporting standards, publically available performance information that appears to be the same can in fact be an “apples to oranges” situation <p>Given this, there is a vital need to work towards ensuring that transportation agencies can consistently obtain quality data for use in performance management practices.</p> <p>“Quality data” can be succinctly described as data exhibiting the following six characteristics:</p> <ul style="list-style-type: none"> • Timely (available within a reasonable timeframe) • Complete (all required data elements included) • Accurate (free of errors) • Consistent (same definitions and collection standards applied) • Integrated (linking different pieces of data straightforward) • Accessible (data is easily retrieved by all potential users). <p>The creation of quality data is dependent on the data supply chain steps:</p>  <pre> graph LR A[Definitions] --> B[Acquisition] B --> C[Processing] C --> D[Validation] D --> E[Reporting] </pre> <p>Given that agencies with varying transportation systems, technological capabilities and staff resources will be adopting performance management principles, it will be important to establish data collection guidelines that can reasonably fit within existing agency practices. For data to be used smoothly and effectively, strong communication is essential among data producers, analysts and decision makers.</p> <p>Establishing data collection standards will also prepare agencies for MAP-21 requirements to establish performance targets, prioritize resource allocation decisions and report on results.</p>

OBJECTIVE

The purpose of this project is to:

1. Recommend data collection and reporting standards
2. Develop an implementation plan to improve data quality across all transportation agencies
3. Provide standardized reporting guidelines

POTENTIAL BENEFITS

- Establishing data collection and reporting standards will clarify the necessary steps, roles and overall workflow to obtaining quality data.
- Developing and documenting standards will also help identify points of risks. By identifying risks, future data discrepancies can be avoided and the data supply chain can provide guidance on “why” the discrepancies occur when they do. In essence this research will help prevent a “garbage in- garbage out” situation.
- By advancing good data business management practices, performance management practices will improve.

RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE

- NCHRP 8-92 *Implementation Transportation Data Program Self-Assessment*
- State DOT Strategic Business Plans, the comparative performance measurement effort for state DOTs initiated in 2004 (NCHRP 20-24 (37))
- The recently established AASHTO communications portal to assemble examples of noteworthy practices in reporting performance (www.communicatingperformance.com)

TASKS

1. Document recommended data collection and reporting standards: Conduct literature review and draft technical memorandum containing descriptions of reviewed documents and relevance to establishing data collection and reporting standards; include summary of issues that may impact data collection standard recommendations
2. Data Collection and Reporting Standards Implementation plan: Given variable characteristics of transportation agencies, the implementation plan will not be a “one-size fits all” approach, but provide a range of recommendations to improve the data quality while balancing the need for nationwide consistency and agency technology, staff capability and resource constraints. The implementation plan will be specific to the five steps in the data supply chain:
 - a. Data definitions: Do clear data definitions exist? Where is there a need for further clarification?
 - b. Data acquisition: What type of data collection methods are used by the agency? How frequently is the raw data collected? How comprehensive is the data collection coverage?
 - c. Data processing: How are agencies compiling the raw data and turning it into daily,

- monthly or annual data? What processing techniques are used ? Where is the data stored? What documentation exists for what is excluded from computations?
- d. Data validation: What cross checks are used to validate data? Is there a max/min threshold value used to flag data? What certification procedures are followed?
 - e. Data reporting: For each metric what are the procedures for internal reports, stakeholder reports and federal requirements? Does documentation on data submission processes exist?
3. Reporting Templates: Conduct a scan of existing performance reports to develop recommended standardized reporting templates and presentation examples for a range of performance information.

FOLLOW-ON AND IMPLEMENTATION ACTIVITIES

Conduct a pilot to test the recommended implementation plan and usability of the reporting templates.

ESTIMATED FUNDING REQUIREMENTS

\$200,000

AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT

TBD

POSSIBLE FUNDING VEHICLE(S)

TITLE
Implementation of Target Setting Practices: A Guidebook
BACKGROUND
<p>Performance management is gaining national attention as Moving Ahead for Progress in the 21st Century Act (MAP-21) requires agencies to adopt performance management principles to increase accountability and transparency and improve decision-making. A key component of performance management and the MAP-21 requirements is setting performance targets. The majority of transportation agencies have experience with developing performance measures and reporting on condition/performance, but experience is much more limited in setting performance targets and making adjustments based on the achievement (or not) of those targets. As stated in the recently released NCHRP 8-36 Task 113: <i>Meeting the Challenges of the 21st Century</i>, “Understanding how to establish reasonable targets for transportation measures is in its infancy.”</p>
OBJECTIVE
<p>This research will produce resources that focus on “how to” set performance targets. Three products are sought through this research:</p> <ol style="list-style-type: none"> 1. Quick Turnaround “How To” Guidance for meeting MAP-21 target setting requirements 2. Scan Workshop focused on bringing together agencies that have successfully conducted target setting 3. A practical step-by-step guide to setting performance targets.
POTENTIAL BENEFITS
<p>With the passage of MAP-21, there is an immediate need for transportation agencies to have access to guidance on how to set targets. In addition, effectively setting targets can</p> <ul style="list-style-type: none"> • Provide guidance on the prioritization and allocation of resources • Establish a connection between actions and results • Clarify outcomes the agency is trying to achieve • Expose data issues • Highlight where more resources are needed • Manage expectations
RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE
<p>The research proposed will be designed to build on the TPM Technical Assistance Program (TPM TAP) sponsored by the FHWA Office of TPM. Relevant products of the TPM TAP</p>

include a TPM Capability Maturity Model and a TPM Implementation Guidebook both of which will address target setting.

In addition, a new NHI course is under development: “Steps to Effective Target Setting and Progress Assessment.” The proposed guidebook in this research would serve as a written resource for the new NHI course.

Additional research exists on desirable characteristics of targets (e.g., NCHRP 551 *Performance Measures and Targets for Transportation Asset Management* and NCHRP 666 *Target Setting Methods and Data Management to Support Performance-Based Resource Allocation by Transportation Agencies*), but these resources contain limited “how to” guidance.

TASKS

1. Quick Turnaround “How To” Guidance for meeting MAP-21 target setting requirements (after national performance rules are finalized)
 - Create a stand-alone short “how to ” guide for setting targets for each of the national performance measures
 - Each guide will address the unique requirement of each measure (e.g., data sources, calculations, etc)
 - Tips on how to address challenges (e.g., missing data) will be included
2. Scan Workshop focused on bringing together agencies that have successfully conducted target setting
 - Identify candidate agencies to participate in scan
 - Draft amplifying questions to guide discussion toward identification of what lead to successful target setting practices
 - Conduct workshop and document results
3. A practical step-by-step guide to setting performance targets. Guide will cover the following key target setting elements:
 - A. Technical Approach
 - Assemble baseline data and develop trend lines.
 - Identify and assess factors influencing target (e.g., resource constraints, capital project commitments, planned operational activities, and anticipated future economic, environmental and social trends)
 - Define purpose: who is end-use of target, what used for?
 - Set target parameters (type of target, time horizon, scope)
 - B. Business process
 - Internal business process
 - External collaboration
 - C. Monitoring & Adjustment
 - Tracking achievement of target.
 - Establishing feedback loop to adjust targets.
 - D. Reporting & Communicating results

- Internal Reporting and Communication
- External Reporting and Communication

FOLLOW-ON AND IMPLEMENTATION ACTIVITIES

- Conduct a pilot at several agencies to test the feasibility of implementing the recommendations outlined in the guidebook.
- Update the “short” guidebooks for setting MAP-21 targets as requirements change.

ESTIMATED FUNDING REQUIREMENTS

\$200,000

AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT

TBD

POSSIBLE FUNDING VEHICLE(S)

TBD

TITLE
Guidance, Methodologies and Tools for Supporting Implementation of MAP-21 Performance Reporting Requirements
BACKGROUND
<p>The transportation legislation Moving Ahead for Progress in the 21st Century (MAP-21) contains a number of important new requirements for state transportation departments to track and report performance, as well as to use performance targets to help guide investment decisions and support transportation planning. Although all states track and report performance in a number of areas already, many are nonetheless challenged to meet the specific requirements of MAP-21, often resulting from lack of guidance, calculation tools and/or calculation methodologies for supporting MAP-21 requirements. In particular, it can be difficult to project future performance given a set of assumptions concerning available funding, as required in several areas by MAP-21.</p> <p>Research is needed to address the gaps in performance measure guidance on tools and methodologies for supporting MAP-21 requirements. This research should:</p> <ul style="list-style-type: none"> • Detail the existing resources for helping agencies meet the performance reporting requirements of MAP-21 • Describe how these can be leveraged • Develop new guidance on tools and methodologies for processing national data sets required to support MAP-21, such as data sets with details on measures of congestion, safety, pavement condition and bridge condition.
OBJECTIVE
<ul style="list-style-type: none"> • Develop guidance for transportation agencies to use addressing the tools and methodologies for supporting implementation of MAP-21 performance management requirements • Develop new guidance, tools, and/or methodologies where feasible to address gaps, such as for performing analysis of national-level data to be reported based on MAP-21 requirements
POTENTIAL BENEFITS
<p>The research will assist transportation agencies in meeting the requirements of MAP-21, helping save time and money through development of improved guidance, tools and methodologies. It will also help agencies at the state and federal level make better use of available performance data, yielding improvements to performance analysis and decision making.</p>
RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE
<p>The research will build upon previous NCHRP research efforts, such as:</p> <ul style="list-style-type: none"> • NCHRP Report 551, <i>Performance Measures and Targets for Transportation Asset Management</i>

- NCHRP Report 660, *Transportation Performance Management: Insight from Practitioners*
- NCHRP Project 20-24(37) (ongoing), *Measuring Performance among State DOTs: Sharing Good Practices*

TASKS

The proposed research will include the following activities:

- Review available guidance, tools and methodologies for supporting MAP-21 performance management requirements
- Prepare a compendium of information on existing resources for use in predicting and reporting performance at a state or national level.
- Identify key gaps that need to be addressed to support fulfillment of MAP-21 requirements and/or allow state and federal agencies to leverage performance data reported as a result of MAP-21
- Where feasible, develop improved guidance, tools and/or methodologies for addressing the gaps
- Conduct a project workshop to preview the results of the project and collect additional information on agency needs and perspectives
- Prepare a final report detailing the research performed as part of the project

FOLLOW-ON AND IMPLEMENTATION ACTIVITIES

TBD

ESTIMATED FUNDING REQUIREMENTS

\$350,000

AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT

TBD

POSSIBLE FUNDING VEHICLE(S)

TBD

3.4.2. Mid-Term Problem Statements

TITLE
MAP-21 Implementation Survey of Practice and Guidance for State DOTs
BACKGROUND
After the signing of MAP-21, agencies have begun developing programs meet the Performance Management requirements of the legislation. This research will document good and bad practices in implementing the MAP-21 PM requirements, aiming to: <ul style="list-style-type: none">• Develop a body of information on how these programs have been implemented differently and what their different strengths and weaknesses may be• Understand positive and negative experiences in implementation• Examine regional context in terms of different FHWA Division Offices implementing the federal requirements differently• Develop step by step guidance on how an agency can build a productive program to implement the requirements
OBJECTIVE
This research will: <ol style="list-style-type: none">1. Determine the current status of the implementation of MAP-21 PM requirements. What have agencies experienced so far?2. Provide guidance on best practices and allow those undertaking a Performance Management program to avoid pitfalls and learn from the experiences of others
POTENTIAL BENEFITS
This survey and report will share best practices and potential pitfalls in order to allow agencies to build better Performance Management programs; and by gathering a resource documenting the experience of many different agencies, the research will build an understanding of what is needed in the industry to make better progress in MAP-21 implementation.
RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE
This survey should be built on FHWA Office of Transportation Performance Management work. It should be coordinated with the Transportation Performance Management Capability Maturity Model Guidebook survey currently in development.
TASKS
<ol style="list-style-type: none">1. Identify related efforts and develop a survey with content that builds on existing work2. Identify who and what will be involved (level of organizations, which MAP-21 performance areas)3. Implement survey and gather feedback to understand user rationale and good/bad experiences

4. Draft guidance based on survey results and identify strategies to enhance the development of performance management programs given regional context and other factors

FOLLOW-ON AND IMPLEMENTATION ACTIVITIES

Based on feedback during survey process, identify further research needs.

ESTIMATED FUNDING REQUIREMENTS

\$175,000

AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT

TBD

POSSIBLE FUNDING VEHICLE(S)

NCHRP 20-24

AASHTO Pooled Fund Project

TITLE
Research of Effectiveness of Performance Management as a Program
BACKGROUND
<p>An evolution of performance management initiatives that began more than half a century ago in Japanese, American, and other private industries as quality assurance and quality control programs has now worked its way into federal law in the United States. Moving Ahead for Progress in the 21st Century (MAP-21) contains more than 100 instances of the word ‘performance,’ expanding from prior federal transportation authorization of the reporting and management requirements of state agencies.</p> <p>Now three years after adoption (as of July 2015), how effective has performance management been as a program for transportation agencies? Is performance management driving the intended result?</p>
OBJECTIVE
<p>This research accepts that performance management is and will remain a federal requirement in how state and local transportation agencies conduct business. With the working assumption that most agencies will meet the minimum rules requirements, this research seeks to help guide the next generation of performance managers in part by measuring the effectiveness of the first generation. Specifically, it will:</p> <ol style="list-style-type: none"> 1. Examine and compare early implementers of MAP-21 performance reporting and monitoring requirements to determine what, if any, tangible improvements have been made to organization performance as measured within the seven national performance areas, and other areas as practical. 2. Recommend existing performance management practices for broader implementation and propose new practices for state DOT or other agency consideration.
POTENTIAL BENEFITS
<p>As demands on transportation agencies have grown without a corresponding increase to revenues and resources, effectively managing constrained funding has become more critical. One might argue that communicating the effectiveness of that management is equally critical.</p> <p>The results of this research will help demonstrate how state and local transportation agencies have used best practices in performance management to both improve operational effectiveness and articulate those successes to their stakeholders. But perhaps more beneficially, the research should recommend how future generations of these programs focus resources to achieve desired performance improvement outcomes.</p>
RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE
<ul style="list-style-type: none"> • The federal government has dedicated the Office of Performance Management to improving organizational effectiveness in the accomplishment of agency mission and goals. It offers an abundance of reference materials. • NCHRP offers several studies on performance management including

- NCHRP 551, *Performance Measures and Targets for Transportation Asset Management*
- NCHRP 660, *Transportation Performance Management: Insight from Practitioners*.
- The *International Journal of Productivity and Performance Management* regularly publish articles relevant to the public sector.
- An enormous body of work exists outside transportation from authors such as Porter, Drucker, Covey, and Gladwell.

Note: Check on FHWA cost-benefit analysis of the NPRM of evaluation effectiveness

TASKS

1. Define the baseline framework of a state DOT performance management program under MAP-21, as implemented rather than as mandated by legislation.
2. Find at least three state DOTs that have mostly followed that framework for at least the past three years. Compare how they have implemented performance management.
 - a. Organizational structure and support
 - b. Reporting and monitoring practices
 - c. Rewards and penalties
 - d. Reliance on Six Sigma, Lean, or other established programs
 - e. Communication
3. Conduct a SWOT analysis of that baseline framework, noting at least the top three strengths, weaknesses, opportunities, and threats
4. Highlight three industries – at least one from private sector manufacturing and one from private sector service – renowned for performance management programs.
 - a. Detail their measurements of effectiveness.
 - b. Highlight elements of manufacturing and of service most applicable to transportation agencies.
5. Note keys to success and largest barriers to implementation such as agency culture or capacity.
6. Recommend how a second generation of performance management in United States public sector transportation might improve effectiveness on the first generation, including a comparison with the renowned practices from private industry.

FOLLOW-ON AND IMPLEMENTATION ACTIVITIES

This research should be part of a rolling effort to assess Performance Management Programs as agencies' efforts mature and as potential changes to requirements are made.

ESTIMATED FUNDING REQUIREMENTS

\$175,000

AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT

TBD

POSSIBLE FUNDING VEHICLE(S)

TITLE
Development of a Performance Management Data Tool
BACKGROUND
Transportation agencies seeking to strengthen performance measurement need a variety of data to understand both performance trends and causal factors. Some performance data are collected directly by agencies, but there are a variety of existing and emerging data sources that can be used to supplement agency-collected data. These include data from federal, state and regional governmental agencies as well as data available from commercial sources. Transportation agencies would benefit from a tool that helps them to assess the applicability and usefulness of potential available data sources to support their performance management program. In turn, this would allow them better ways to report performance using available data.
OBJECTIVE
The objective of this research is to develop a data assessment tool that helps a transportation agency to systematically evaluate an external data source for supporting performance measurement and management.
POTENTIAL BENEFITS
Availability of a data evaluation tool would provide a uniform method for evaluating and comparing different potential data sources. It would help transportation agencies to better understand and anticipate relative strengths and weaknesses in data sources in order to make well-informed choices, and plan steps to compensate for identified data source limitations.
RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE
Previous work on data include: NCHRP Report 666: Target-Setting Methods and Data Management to Support Performance-Based Resource Allocation by Transportation Agencies - Volume I: Research Report, and Volume II: Guide for Target Setting and Data Management provides a framework and specific guidance for setting performance targets and for ensuring that appropriate data are available to support performance-based decision making.
TASKS
<ul style="list-style-type: none"> • Define a set of criteria for evaluating suitability of data sources for performance management. These criteria should consider data content, scope, level of spatial and temporal granularity, collection method, availability of documentation and metadata, distribution format, availability of support, cost and stability of provider • Identify rating scales and categories based on the criteria • Select a diverse sample of data sources, and develop ratings based on the established criteria and rating scales • Review the examples with a stakeholder group, and revise based on feedback

- Develop a graphical method for presenting data source ratings (for example, using the approach found in Consumer Reports)
- Produce a guide that provides agencies with instructions on how to apply the rating methodology

FOLLOW-ON AND IMPLEMENTATION ACTIVITIES

- Disseminate the data rating guidance
- Assess further applications of the ratings methodology – e.g. an annual ratings report, a self-reporting process, etc.

ESTIMATED FUNDING REQUIREMENTS

\$250,000

AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT

AASHTO

POSSIBLE FUNDING VEHICLE(S)

NCHRP 20-24

TITLE
Enhanced Tools and Approaches for Assessing Economic and System Benefits of Transportation Investments
BACKGROUND
<p>Transportation projects provide a wide range of economic and non-economic benefits. These include measures of traveler impact such as reduced travel time and costs, as well as wider but more indirect benefits that stem from gains in business productivity. Transportation agencies face many challenges in determining the full range of benefits for transportation investments, and communicating those benefits to stakeholders and decision makers to help support investment decisions.</p> <p>Recently, SHRP 2 Project C11 developed a set of tools for predicting the wider economic benefits of transportation, followed by SHRP 2 Report S2-C11-RW-1. This research focused on three classes of transportation system impacts:</p> <ul style="list-style-type: none"> • Travel time reliability • Intermodal connectivity • Market access <p>While this research provides an important foundation for improved calculation of transportation benefits, further work is needed to expand it to provide transportation agencies with a complete and comprehensive set of tools and approaches for calculating economic benefits of transportation. Specifically, more work is needed to complete and test the tools developed through the SHRP 2 project, and to expand the tools and approaches to address other important components of economic benefit, such as supply chain costs, logistics costs, and benefits of improved productivity. This project will expand upon the SHRP 2 and other related research to develop an improved set of tools and approaches for calculating economic benefits of transportation.</p>
OBJECTIVE
<p>Expand upon the research detailed in SHRP2 Report S2-C11-RW-1 to improve the tools and approaches for assessing economic benefits of transportation. The research should address:</p> <ul style="list-style-type: none"> • Incorporation of measures of economic valuation, such as supply chain and logistics costs. • Addition of benefits of productivity and competitiveness. • Guidance on how to communicate results • Pilot testing of the tools and approaches developed through the research.
POTENTIAL BENEFITS
<p>The research has the potential to help agencies better calculate and communicate the economic benefits of investments in transportation, and in so doing, help anticipate additional system-wide benefits and support for ongoing and future investments.</p>
RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE

The research will build upon previous NCHRP research efforts, such as:

- SHRP2 Report S2-C02-RR: *Performance Measurement Framework for Highway Capacity Decision Making*
- SHRP2 Report S2-C11-RW-1: *Development of Tools for Assessing Wider Economic Benefits of Transportation*
- NCHRP Project 20-100 (ongoing), *Return on Investment in Transportation Asset Management Systems and Practices*

TASKS

The proposed research will include the following activities:

1. Review prior research in developing tools and approaches for assessing economic benefits of transportation with a focus on areas not addressed in SHRP2 Report S2-C11-RW-1
2. Identify specific measurement areas and measures to add to tools and approaches developed previously
3. Develop improved tools and approaches for assessing economic benefits of transportation in the targeted areas
4. Perform pilot testing of the tools/approaches
5. Prepare a final report incorporating detailing the research performed as part of the project.

FOLLOW-ON AND IMPLEMENTATION ACTIVITIES

TBD

ESTIMATED FUNDING REQUIREMENTS

\$250,000

AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT

TBD

POSSIBLE FUNDING VEHICLE(S)

TBD

TITLE
Developing National PM Data Strategies to Address Data Gaps, Standards, and Quality
BACKGROUND
The availability and cost of obtaining meaningful, consistent, timely and accurate data is a limiting factor for transportation agencies seeking to strengthen their use of performance management. Data are needed both to measure performance indicators of interest as well as to understand how performance trends are impacted by exogenous factors outside of agency control.
OBJECTIVE
The objective of this research is to identify common data gaps across agencies seeking to enhance performance management capabilities, and to develop a set of national strategies for filling these gaps. National strategies would potentially achieve: <ul style="list-style-type: none"> • A more efficient approach to meeting common performance management data needs, • A more consistent and sustainable data collection and management approach than would be possible from individual uncoordinated agency efforts
POTENTIAL BENEFITS
A stronger national approach to developing data collection and management strategies and standards for performance management could be beneficial in several respects: <ol style="list-style-type: none"> 1. Provide a more economical way to address common data gaps across agencies 2. Save effort required for each agency to develop its own data requirements in support of performance management 3. Provide the impetus for pooling resources to provide consistent national data sources that multiple agencies could use 4. Support consistency in measurement and analysis practices across agencies, which would enable aggregation of data across agencies, benchmarking and development of common analysis tools
RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE
The national data plan should consider several existing national data programs such as the National Household Travel Survey (NHTS) and the National Performance Management Research Data Set (NPMRDS). It should also utilize the rich body of knowledge related to approaches to data collection and management for performance measurement and monitoring including: <ul style="list-style-type: none"> • TRB Special Report 304, "How We Travel" – defines a sustainable approach to national travel data monitoring • NCHRP Project 20-24(37)G <i>Technical Guidance for Deploying National Level Performance Measurements</i> • University Transportation Research Center No: 49111-25-23 <i>Data Driven Performance</i>

<i>Measures for Effective Management of Complex Transportation Networks</i>
<ul style="list-style-type: none"> • SHRP 2 L02 <i>Establishing Monitoring Programs for Mobility and Travel Time Reliability</i> • WA-RD 748.1 / TNW 2010-02 <i>Developing a GPS-Based Truck Freight Performance Measure Platform</i>
TASKS
Possible tasks to be included are: <ul style="list-style-type: none"> • Identify common gaps in data to support performance management • Conduct a data summit to discuss possible national strategies for filling these gaps • Develop a national data plan incorporating the most promising strategies – consider the following for each strategy: <ul style="list-style-type: none"> – Business case for a national approach – Use cases – how would agencies make use of the data – Data access/distribution methods – Opportunities to piggyback on existing national, regional and state data programs – Opportunities to leverage commercial data sources – Data collection approach – e.g. centralized collection or decentralized with consistent data specifications, formats and quality assurance standards – Data updating approach – Oversight and stewardship options
FOLLOW-ON AND IMPLEMENTATION ACTIVITIES
<ul style="list-style-type: none"> • Seek endorsement and sponsorship for plan elements • Develop implementation roadmap • Initiate individual implementation projects
ESTIMATED FUNDING REQUIREMENTS
\$300,000
AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT
AASHTO and USDOT partnership
POSSIBLE FUNDING VEHICLE(S)
NCHRP 20-24
FHWA

TITLE
Estimation of Performance for Proposed Projects and Programs
BACKGROUND
<p>Frequently transportation agencies must communicate the benefits of performing a proposed project or program of projects, such as through reporting predicted reduction of delay, change in asset conditions, safety benefits, emissions reductions, or other types of performance impacts that may result from a project or program. Further, including information on performance for a proposed project or program can be an effective way to build support for a project or program, and can help support investment prioritization. However, there is little consistency between transportation agencies concerning what performance measures are calculated for proposed projects or programs, or how common measures are calculated.</p> <p>Research is needed to develop guidance concerning reporting of predicted performance for proposed projects and programs. The research should help transportation agencies determine:</p> <ul style="list-style-type: none"> • What performance measures to calculate • How to calculate them • How best to report predicted performance for multiple projects and programs over time. <p>The research should address performance measures related to</p> <ul style="list-style-type: none"> • Congestion • Safety • Asset conditions • Emissions • Additional measures, such as measures of sustainability and livability.
OBJECTIVE
<p>This research will develop guidance for transportation agencies to use in predicting performance for proposed projects and programs, including guidance on:</p> <ol style="list-style-type: none"> 1. What performance measures to calculate 2. How to address common challenges that may impede predicting performance, such as limitations in available data 3. How to report performance
POTENTIAL BENEFITS
<p>The research has the potential to help agencies obtain better predictions of future performance, and as a result, may be useful in support decisions concerning what projects to fund and/or how projects should be prioritized.</p>
RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE
<p>The research will build upon previous NCHRP research efforts, such as:</p>

- NCHRP Report 551, Performance Measures and Targets for Transportation Asset Management
- NCHRP Report 660, Transportation Performance Management: Insight from Practitioners
- NCHRP Report 708, A Guidebook for Sustainability Performance Measurement for Transportation Agencies
- SHRP2 Report S2-C02-RR: Performance Measurement Framework for Highway Capacity Decision Making
- NCHRP Project 20-24(37) (ongoing), Measuring Performance among State DOTs: Sharing Good Practices
- NCHRP Project 25-39 (ongoing), Environmental Performance Measures for State Departments of Transportation

TASKS

The proposed research will include the following activities:

1. Review existing and best practices for calculating performance measures for proposed projects and programs
2. Develop a framework for project/program performance that details
 - What measures to calculate in a range of performance areas
 - How to address common challenges in performance measures prediction
 - Considerations in reporting predicted performance
3. Perform a series of pilots illustrating the proposed framework
4. Prepare a guidance document
5. Prepare a final report incorporating the guidance document and detailing the research performed as part of the project

FOLLOW-ON AND IMPLEMENTATION ACTIVITIES

TBD

ESTIMATED FUNDING REQUIREMENTS

\$350,000

AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT

TBD

POSSIBLE FUNDING VEHICLE(S)

TBD

3.4.3. Long-Term Problem Statements

TITLE
Effective Performance Benchmarking Practices for the Transportation Sector
BACKGROUND
As transportation agencies are pressed to publicly release additional performance data, the potential for erroneous comparison and incorrect conclusions will increase. Many “best to worst” lists of transportation agencies do not control for characteristics that may vary greatly between states (e.g., vehicle miles traveled); a state’s individual characteristics can be highly influential in determining how transportation decisions are made and funds are spent. The potential for false comparisons will only grow with the establishment of national performance measures as required in MAP-21. Instead, the expansion of available performance information could be used to promote the exchange of best practices through benchmarking. A key to effective benchmarking is the identification of peer agencies.
OBJECTIVE
This research will outline effective benchmarking practices agencies can readily adopted by transportation agencies and describe a process by which these benchmarks can be used to share and compare between peer agencies. The research will also include a systematic methodological framework for identifying peer states that have similar attributes.
POTENTIAL BENEFITS
As transportation agencies mature their performance management practices, benchmarking creates a valuable venue through which agencies can share lessons learned, compare results, and identify strategies to overcome challenges.
RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE
This research will build upon:
<ul style="list-style-type: none">• NCHRP 20-24 (37), the comparative performance measurement effort for state DOTs initiated in 2004• TCRP Report 141, A Methodology for Performance Measurement and Peer Comparison in the Public Transportation Industry
TASKS
<ul style="list-style-type: none">• Research and document successful benchmarking practices (e.g., international transit peer-comparison organizations)• Identify what characteristics should be used to identify peer agencies (e.g., age, asphalt vs.

<p>concrete, weather, population density)</p> <ul style="list-style-type: none"> • Assess if the feasibility of benchmarking across agencies varies by performance measures • Outline strategies to respond to misleading and inappropriate comparisons of publically reported performance data
FOLLOW-ON AND IMPLEMENTATION ACTIVITIES
To promote benchmarking activities and test the feasibility of embracing benchmarking practices, a pilot effort with a small number of agencies should be conducted.
ESTIMATED FUNDING REQUIREMENTS
\$200,000
AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT
TBD
POSSIBLE FUNDING VEHICLE(S)
NCHRP 20-24

TITLE
Comparative Performance Management – Non-Motorized Measure
BACKGROUND
<p>Previous work by the National Cooperative Highway Research Program (NCHRP) has demonstrated the value of comparative performance measurement. It has helped the transportation community move towards improved performance-based decision-making. The previous projects have involved compilation of detailed performance data for multiple DOTs, calculation of performance measures for each agency, composition of peer groups for comparative analysis, identification of the top tier of agencies with respect to the selected measures, and interviews to determine practices that may be related to exemplary performance.</p> <p>Non-motorized modes of transportation (i.e., walking and biking) are increasingly becoming choices for personal travel. Understanding how much of an impact this mode is having on meeting transportation agency objectives is needed.</p>
OBJECTIVE
<ul style="list-style-type: none"> • Conduct a comparison of state departments of transportation (DOTs) regarding a set of non-motorized performance metrics and then report on successful techniques employed by the leading agencies. • Understand data and calculation issues related to the performance metrics chosen. • Communicate lead practices of high performing states
POTENTIAL BENEFITS
<ul style="list-style-type: none"> • Improve impact of non-motorized transportation impact by sharing lead practices. • Understanding data and calculation issues for peer to peer performance management for non-motorized performance metrics.
RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE
NCHRP 20-24(37) series of projects.
TASKS
FOLLOW-ON AND IMPLEMENTATION ACTIVITIES
ESTIMATED FUNDING REQUIREMENTS
\$100,000
AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT
POSSIBLE FUNDING VEHICLE(S)
NCHRP 20-24

TITLE
Comparative Performance Management – Environmental Measure
BACKGROUND
<p>Previous work by the National Cooperative Highway Research Program (NCHRP) has demonstrated the value of comparative performance measurement. It has helped the transportation community move towards improved performance-based decision-making. The previous projects have involved compilation of detailed performance data for multiple DOTs, calculation of performance measures for each agency, composition of peer groups for comparative analysis, identification of the top tier of agencies with respect to the selected measures, and interviews to determine practices that may be related to exemplary performance.</p> <p>Understanding the impacts of transportation on the environment is a major challenge for state departments of transportation (DOTs). A major focus of measuring environmental impact has been on vehicle emissions in congested locations.</p>
OBJECTIVE
<ul style="list-style-type: none"> Conduct a comparison of DOTs regarding a set of environmental-related metrics and then report on successful techniques employed by the leading agencies. Understand data and calculation issues related to the performance metrics chosen. Communicate lead practices of high performing states
POTENTIAL BENEFITS
<ul style="list-style-type: none"> Reduce the negative impact of motorized transportation by sharing lead practices. Understanding data and calculation issues for peer to peer performance management for environmental performance metrics.
RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE
NCHRP 20-24(37) series of projects.
TASKS
FOLLOW-ON AND IMPLEMENTATION ACTIVITIES
ESTIMATED FUNDING REQUIREMENTS
\$100,000
AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT
POSSIBLE FUNDING VEHICLE(S)
NCHRP 20-24

TITLE
Establishment of SCOPM Research Program
BACKGROUND
<ul style="list-style-type: none"> Some AASHTO Standing Committees have dedicated research programs for quick turnaround research. These include NCHRP 20-07 for Standing Committee on Highways, NCHRP 08-36 for the Standing Committee on Planning and NCHRP 25-25 for the Standing Committee on Environment. Transportation Performance Management is of growing importance nationally and is the underpinning of the federal transportation legislation – Moving Ahead for Progress in the 21st Century (MAP-21).
OBJECTIVE
<ul style="list-style-type: none"> The Standing Committee on Performance Management is seeking to create a dedicated research program for quick turnaround research for transportation performance management.
POTENTIAL BENEFITS
<ul style="list-style-type: none"> Meet state departments of transportation needs for improved performance management.
RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE
TASKS
FOLLOW-ON AND IMPLEMENTATION ACTIVITIES
ESTIMATED FUNDING REQUIREMENTS
AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT
POSSIBLE FUNDING VEHICLE(S)

TITLE
State of Practice in use of Continuous Improvement to Support Performance Management Practices
BACKGROUND
Continuous Improvement is a management philosophy first employed in Japan that dates back decades. Its use in the private sector is well-established. In recent years, individual state departments of transportation (DOT) have begun process measurement and improvement efforts using a performance management framework. This research effort will provide a state of current practice and provide a foundation for future research.
OBJECTIVE
This research will:
<ul style="list-style-type: none"> • Determine current practice in the use of Lean, Lean Six Sigma and other continuous improvement methodologies to support ongoing, active performance management within agencies. • Provide Best Practices to assist agencies in implementing continuous improvement programs aimed at affecting performance.
POTENTIAL BENEFITS
<ul style="list-style-type: none"> • The survey and report will share Best Practices and potential lessons learned to assist agencies in establishing continues improvement programs to support their performance management programs.
RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE
TASKS
<ul style="list-style-type: none"> • Literature review to establish background in use of continuous improvement in transportation agencies • Survey to assess the current state of practice • Report with survey results and identify Best Practices.
FOLLOW-ON AND IMPLEMENTATION ACTIVITIES
<ul style="list-style-type: none"> • Based in results, identify future research • Develop communication plan • Update results in future study of practice • Link to future SCOPM task force?
ESTIMATED FUNDING REQUIREMENTS
AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT

Lori Richter, Wisconsin DOT; Gary Vansuch, Colorado DOT

POSSIBLE FUNDING VEHICLE(S)

TITLE
Competencies in Transportation Performance Trend Analysis and Communication
BACKGROUND
<p>Trend analysis in performance management can be used to learn lessons from past performances and to predict future performance. It is especially valuable in setting targets for future performance. There is experience in various areas of transportation performance on how trend analyses are conducted and are communicated.</p> <p>An agency's ability to communicate performance trends depends upon staff's ability to interpret, analyze and communicate short- and long-term trend information.</p>
OBJECTIVE
<p>This research is aimed at:</p> <ul style="list-style-type: none"> • Enhancing agency understanding of performance trends, especially related to the horizons • Providing practical guidance to practitioners in establishing trends • Effectively communicating trends.
POTENTIAL BENEFITS
<p>The research will assist transportation agencies in using trend data to predict future events and analyze past events. It will provide comprehensive guidance trend analysis development within performance management.</p>
RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE
TASKS
<p>The proposed research will:</p> <ul style="list-style-type: none"> • Conduct a literature search of trend analysis studies • Survey states for understanding of current practices • Develop guidance targeted at helping practitioners conduct trend analyses and communicate the results • Produce a final report
FOLLOW-ON AND IMPLEMENTATION ACTIVITIES
<ul style="list-style-type: none"> • Training • Webinar
ESTIMATED FUNDING REQUIREMENTS
AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT
Lori Richter, Wisconsin DOT
POSSIBLE FUNDING VEHICLE(S)

TITLE
Framework for Connecting Across Federal Transportation Performance Reporting Requirements
BACKGROUND
State DOTs utilize a variety of methods, systems, and tools to report on the performance of the federal aid system. Different systems exist such as ARNOLD, FIMS, HPMS, NBI, FARS, etc. Each of these systems its own set of requirements for data reporting. In addition to these requirements, MAP-21 requires states to report performance for six areas – bridges, pavements, safety, traffic congestion, on-road mobile source emission, and freight movement.
OBJECTIVE
This research will:
<ul style="list-style-type: none"> • Review and document all federal reporting requirements that state DOTs do on the condition, performance, and fiscal sustainability of their federal programs • Assess the effectiveness and opportunities to better integrate across federal reporting requirements to better inform and improve performance management efforts • Document/ recommend a framework for their leveraging federal reporting requirements for state performance management
POTENTIAL BENEFITS
State DOTs could utilize results to better leverage/improve federal reporting requirements, especially as they relate to supporting DOT TPM activities.
RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE
TASKS
FOLLOW-ON AND IMPLEMENTATION ACTIVITIES
The framework could be moved forward for consideration by USDOT. State DOTs may find the results useful so they can improve/leverage federal reporting requirements.
ESTIMATED FUNDING REQUIREMENTS
AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT
Coco Briseno, California DOT
POSSIBLE FUNDING VEHICLE(S)
AASHTO Pooled Fund Project
NCHRP Full Program

TITLE
Development of Multimodal Measures
BACKGROUND
<p>It is increasingly necessary to make investments in multiple modes of transportation to meet agency objectives, regardless of funding sources, to maximize the return on investment. Examples include improving bike/pedestrian access with integrated transit facilities and roadway improvements at port/inland and port bottlenecks.</p>
OBJECTIVE
<p>The objective of establishing and monitoring multimodal waves is to explore the importance and benefit of these investments and encourage the prioritization of additional investment.</p>
POTENTIAL BENEFITS
<ul style="list-style-type: none"> • Better communicate the importance of multimodal investment • Better document the value of enhanced multimodal services
RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE
Supplemental
TASKS
<ul style="list-style-type: none"> • Literature review • Examples of best practice • Gaps • Brainstorming of additional ideas
FOLLOW-ON AND IMPLEMENTATION ACTIVITIES
ESTIMATED FUNDING REQUIREMENTS
AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT
POSSIBLE FUNDING VEHICLE(S)
NCHRP Full Program

TITLE
Non-Motorized Performance Measures
BACKGROUND
<ul style="list-style-type: none"> • Bicycle, pedestrian and other non-motorized modes of transportation provide benefits to both the users of those modes and to the entire network, but their benefits to the network are not well measured or documented. • Safety performance measures involving non-motorized modes are generally better developed than are data and measures concerning traffic counts, origin-destination, mobility, or satisfaction. • Technology is now emerging to better measure performance for bicycle, pedestrians, and other modes, but has not achieved significant penetration for meaningful analysis or comparisons between agencies.
OBJECTIVE
<ul style="list-style-type: none"> • This project should identify and document current leading state DOT or other country practices in measuring performance of non-motorized modes. • The project should suggest cost-effective mechanisms for gathering data needed to measure: <ul style="list-style-type: none"> – Volumes or counts (e.g. bicycle ridership) – Speeds or reliability – Sensitivity to weather or other external elements beyond the control of the user – Impact to the motorized portion of the system • The results should offer a means for analysis of key variables in performance such as connectivity of a non-motorized network, connectivity to transit or other motorized modes, climate, safety of facilities, favorability of laws and regulations.
POTENTIAL BENEFITS
Without common standards for measurement or shared data sets, agencies may struggle to understand the value of investment in non-motorized facilities. Enabling agencies to compare performance of bicycle, pedestrian, or related networks will aid in the understanding of improving performance for these modes. Developing data collection standards and benchmarks will better enable owners and maintainers of such facilities to invest in capital improvement and maintenance while also demonstrating the impacts of policy decisions.
RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE
TBD
TASKS
<ol style="list-style-type: none"> 1. Literature and Practice Review <ul style="list-style-type: none"> - Catalogue of Candidate Practices

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| <ul style="list-style-type: none">2. Identification of Best Practices3. Development of Performance Measure Candidates4. Standards for Data Collection5. Assessment of Available Technology6. Recommendations for Target Setting7. Webinar to present research results8. Final report |
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FOLLOW-ON AND IMPLEMENTATION ACTIVITIES
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ESTIMATED FUNDING REQUIREMENTS

\$150,000

AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT

POSSIBLE FUNDING VEHICLE(S)

TBD

TITLE
Getting Credible VMT Data
BACKGROUND
<ul style="list-style-type: none"> Vehicle Miles Traveled (VMT) is a frequently reported data point, but the accuracy of this data is not always clearly understood or articulated. Technology development has increased the sources by which agencies may capture VMT but has not necessarily increased the credibility of this data. VMT today may rely on data from third parties such as INRIX, HERE, or WAZE. It may rely on HPMS reporting. It may rely on Intelligent Transportation System devices. Few if any sources could actually count every mile traveled by all vehicles, and statistical interpolation must often help complete VMT data sets. Users of those data sets often do not know the margin of error in their analysis.
OBJECTIVE
<ul style="list-style-type: none"> This project should survey the means by which VMT data is gathered, assimilated, and analyzed. The research should analyze similarities and differences in the means by which VMT is gathered and reported. The analysis should highlight gaps or shortcomings for each widely deployed mechanism. The project should compare factors such as accuracy, cost, and timeliness between various data-gathering and reporting mechanisms. This project should highlight best practices for gathering VMT data and various subsets of such data including trucks, motorcycles, etc.
POTENTIAL BENEFITS
VMT is used in many transportation agency applications: traffic studies and travel demand modeling, revenue forecasting, federal reporting, construction and closure planning, access permitting, and more. Periodically verifying or calibrating data collection will help ensure accuracy and enable users of the data to determine what levels of precision are needed.
RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE
TBD
TASKS
<ol style="list-style-type: none"> 1. Literature and Practice Review <ul style="list-style-type: none"> - Catalogue of Candidate Practices 2. Examine and compare VMT data gathering and reporting practices 3. Statistical analysis of data generated by most commonly used five to ten sources <ol style="list-style-type: none"> a. Correlation between data sources b. Data gaps in each source c. Approximate cost of collection

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| 4. Survey Current Uses of VMT Data |
| 5. Webinar to present research results |
| 6. Final report |

FOLLOW-ON AND IMPLEMENTATION ACTIVITIES

ESTIMATED FUNDING REQUIREMENTS
\$125,000

AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT

POSSIBLE FUNDING VEHICLE(S)
TBD

TITLE
TPM Implementation Guidebook
BACKGROUND
<ul style="list-style-type: none"> Transportation agencies are increasingly focusing on transportation performance management (TPM) to get greater results from the resources they have. The Moving Ahead for Progress in the 21st Century (MAP-21) legislation is requiring state departments of transportation (DOTs) and metropolitan planning organizations (MPOs) to become more performance driven. There are many important national and international lessons learned and good practices that have been used that can help agencies improve TPM. The Asset Management Guide that was developed via NCHRP and now published as an AASHTO document is a good model for how a guidebook can help DOTs improve practice.
OBJECTIVE
<ul style="list-style-type: none"> Provide state DOTs and other transportation agencies with process, procedures, and “how to’s” for efficient TPM implementation. Develop a guidebook using lessons learned and good practices to assist with implementing TPM. Compile existing best practices, review resources that have been developed and translate into guidebook components.
POTENTIAL BENEFITS
Obtain greater transportation performance by applying leading practices for TPM.
RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE
AASHTO TAM Guide.
TASKS
FOLLOW-ON AND IMPLEMENTATION ACTIVITIES
ESTIMATED FUNDING REQUIREMENTS
\$500,000
AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT
POSSIBLE FUNDING VEHICLE(S)
NCHRP Full

TITLE
Linking the Strategic Performance Management Framework with an Agency's Operational Framework
BACKGROUND
<ul style="list-style-type: none"> • Federal Authorization (MAP-21) and, more broadly, transportation performance management have influenced state transportation agencies to focus on outcome-based performance measures such as fatalities, pavement condition, or congestion. • These outcome-based measures do not often align directly with the framework or organization chart of the state agency. How the agency manages daily operations and decision making, therefore, may not directly support achieving these higher level performance targets. • Metrics that better assess operational performance may be necessary to help modify practices or re-allocate resources. Staff are better able to target metrics that they can directly influence (e.g. Schedule Performance Index for their projects) in their daily behavior than they are to work and manage to fatalities or congestion. • Linking such operational metrics to the outcome metrics mandated by MAP-21 and desired by other stakeholders can be challenging.
OBJECTIVE
<ul style="list-style-type: none"> • This project should identify agencies that report not only common, outcome-based metrics such as fatalities, infrastructure condition, and congestion, but also operational metrics such as On Budget, On Schedule, Contract Processing Times, or Lane Closure Response Times. • The study should examine the ability of agencies to connect high level organizational goals to operational metrics, and operational metrics to performance of groups within the agency's organization framework. • The study should highlight best practices of internal and external reporting, focusing on agencies that are able to readily adapt behavior to achieve desired operational performance. • The study should draw conclusions of appropriate organizational structures that support differing priorities from agency to agency. For example, does an agency with a stated vision of improving mobility structure itself to clearly define ownership for each of the various aspects of improving mobility?
POTENTIAL BENEFITS
<p>This project will enlighten agencies on the benefits of recognizing and linking input, output, and outcome measures. Lead and lag indicators will empower managers to better communicate with staff the importance of focusing on lead indicators with an understanding of their impact on lag indicators. Individual performance plans can begin to better quantify quarterly or annual targets for staff, and demonstrate how achieving those targets can help a work group achieve its goals and a department achieve its vision.</p>

RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE
TBD
TASKS
<ol style="list-style-type: none"> 1. Literature and Practice Review <ul style="list-style-type: none"> - Catalogue of Candidate Practices 2. Template Org Charts that support different priorities 3. Survey of placement for key positions (e.g. What percent of Safety Officers report to the Chief Executive Officer when the agency has “Safety” stated in its vision or mission statement?) 4. Best practices in linking operational activities to outcome metrics through tools such as annual work plans, dashboards, or performance reviews. 5. Final Report
FOLLOW-ON AND IMPLEMENTATION ACTIVITIES
ESTIMATED FUNDING REQUIREMENTS
\$200,000
AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT
POSSIBLE FUNDING VEHICLE(S)
TBD

TITLE
Compendium of TPM Best Practices
BACKGROUND
<ul style="list-style-type: none"> Transportation agencies are now required under Federal Authorization to measure and report performance in seven national goal areas. Several agencies have reported performance for two decades or more. Managing performance involves many staff and many steps: <ul style="list-style-type: none"> Defining goals and objectives Determining how to measure progress toward goals and objectives Gathering data Managing and analyzing data Setting targets Publishing quantitative analysis (e.g. graphs and charts) Publishing qualitative analysis or narrative around the results Monitoring trends Reassessing metrics and targets Modifying behavior to influence performance No state agency excels in every aspect of Total Performance Management. Several state agencies excel in one or more areas. Highlighting best practices could help states move toward certain standards consistent with the intent of MAP-21.
OBJECTIVE
<ul style="list-style-type: none"> Determine the five to 10 key aspects of TPM. Demonstrate two to three best practices for each aspect. Demonstrate three to five best practices in all aspects of TPM, from beginning to end.
POTENTIAL BENEFITS
RELATIONSHIPS TO THE EXISTING BODY OF KNOWLEDGE
TBD
TASKS
<ol style="list-style-type: none"> 1. Literature and Practice Review <ul style="list-style-type: none"> - Catalogue of Candidate Practices 2. Framework for Assessing Target-Setting Practices <ul style="list-style-type: none"> - Criteria for Evaluating Practices - Standard Format for Presenting Successful Practices 3. Lessons-Learned from Review of Successful Practices 4. Guidance for DOTs on Communicating Performance Targets

Report and “Executive” Presentation Materials
5. Webinar to present research results
6. Final report
FOLLOW-ON AND IMPLEMENTATION ACTIVITIES
ESTIMATED FUNDING REQUIREMENTS
\$225,000
AUTHOR/STEWARD OF THE RESEARCH PROBLEM STATEMENT
POSSIBLE FUNDING VEHICLE(S)
TBD

4. TPM Portal / Online Roadmap

4.1. Background

One of the objectives of the research effort described in this report was to develop a TPM research roadmap to inform future research and development activities to be undertaken by the transportation industry. In order to further this objective, the Roadmap presented in Section 3 of this report was developed as part of an online web application: the TPM Portal. This allows transportation practitioners to access an interactive version of the Research Roadmap. As part of this web application, the Research Roadmap is also connected to a database of recent TPM research, providing an integrated entry point for practitioners to access a wide range of information on current, recent, and potential future TPM research. In the coming years, the Roadmap will be updated on an ongoing annual basis.

In the near term, the Roadmap offers a consolidated set of resources on performance management. Transportation practitioners can use the Roadmap website to help plan future research and development activities to be undertaken by the transportation industry

Over the long term, the Roadmap will help identify challenges and opportunities associated with preparation of national-level transportation system performance information – and identify research needs to improve the state of the practice in TPM.

The TPM Portal is available at: <http://www.tpm-portal.com> .

4.2. Online Roadmap Business Process

The online Research Roadmap included in the TPM Portal is a living document, intended to be regularly updated to provide a snapshot of the research status and needs surrounding TPM at a given time. Capabilities have been included in the online Research Roadmap that will help to support tracking and management of potential research projects – starting from the earliest stages of concept development and extending through the lifecycle of a potential project. The TPM Portal uses a generic model for the lifecycle of a research project. It includes six steps:

- Idea/Concept
- Candidate Research
- Prioritized Research
- Pending Research
- Active Research
- Completed/Archived Research

This generic model can easily be updated to match actual business processes as needed as the Portal and Roadmap are adopted by AASHTO SCOPM.

A conceptual sketch of the business processes related to tracking research projects through the generic project lifecycle is presented below.

Idea/Concept

- An authorized user creates a new concept enters limited information (a title is required a short description or notes are optional.) A flexible field exists for track of the source of the idea/concept.

Candidate Research

- An authorized user edits the a research statement and sets the status to Candidate
- This enables the display of additional fields and allows the Candidate to be migrated to the Research Roadmap from the Concept Pool

Prioritized Research

- Priority status can be added to Candidates – which can be designated as Prioritized.
- Reports can be generated based on these values and data can be exported to Microsoft Excel (or similar applications) as a comma separated value file (CSV file)

Pending Research

- Pending research projects that are being funded from other sources (FHWA TPM, FTA TPM, etc.) can be entered for inclusion in the Roadmap
- Reports similar to prioritized research can also be generated

Active Research

- For active projects a start and end date can be added/edited

Completed Research

- For completed projects a final end date can be added/edited

4.3. Online Roadmap Structure

Figure 4.1, below, shows the basic organization of the online research Roadmap and supporting website. As indicated in the figure, the online research Roadmap (1) shares a common database (8) with a searchable index of past and current PM research (2). The site also supports the ability to upload suggested research needs and/or research statements (3) for review by the site administrators (7).

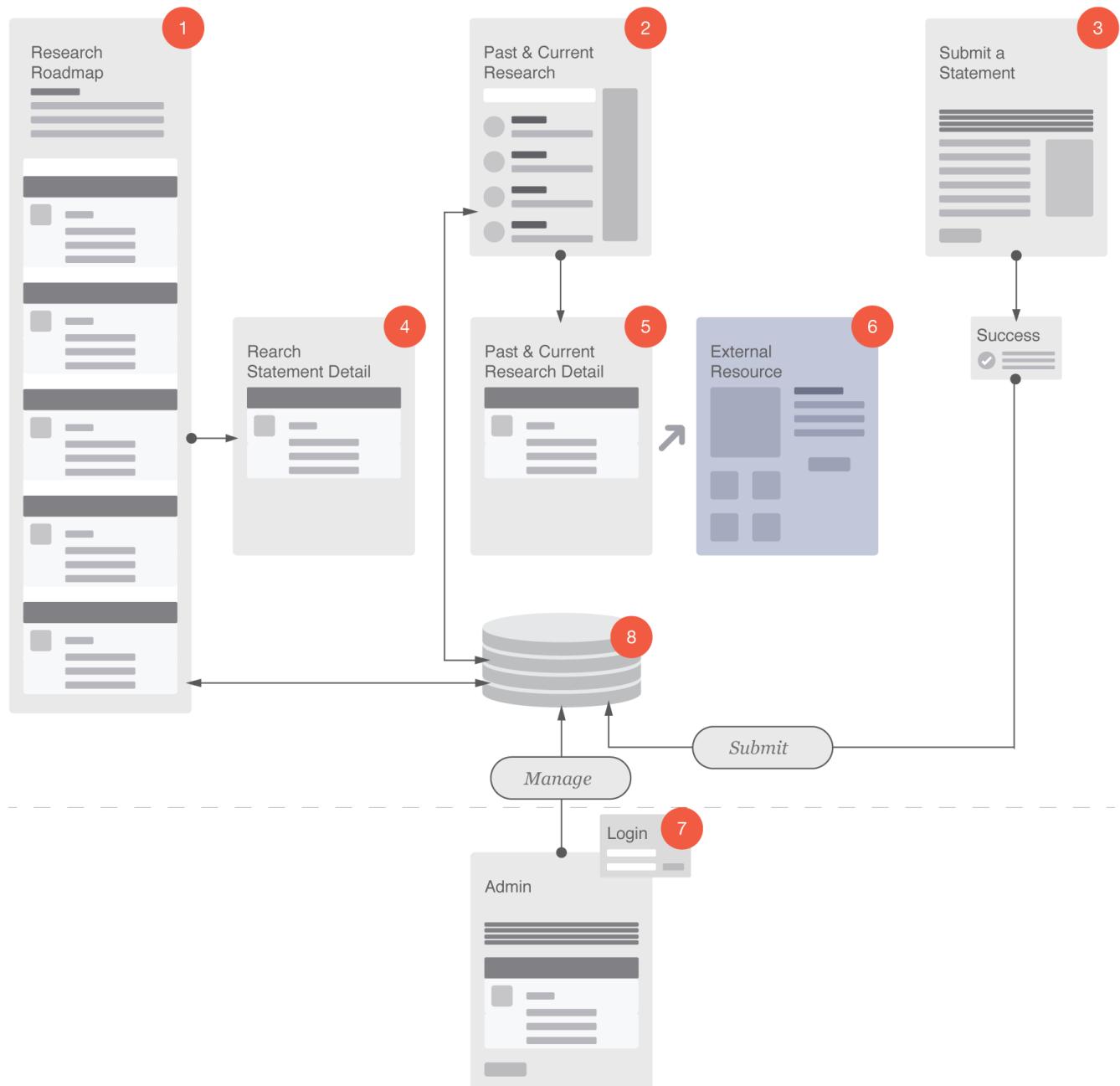


Figure 4.1 Roadmap Structure

1. Research Roadmap. Graphical representation of the Research Roadmap. Includes

capsule summaries of research statements. Options to sort and filter research statement summaries by performance management processes, performance management areas, year, status, funding. Links to **4. Research Statement Detail**.

2. Past and Current Research Library. Searchable library of past and current performance management research. Options to sort and filter results by performance management processes, performance management areas, year. Additional data includes: title, publisher, url, author(s), publication date, abstract. Links to **5. Past and Current Research Detail**.

3. Submit a Statement. Input form to submit a statement or an idea for a statement for review by the site administrator. This option is only available to registered users.

4. Research Statement Detail. Full research statement page – one page for each statement included in **1. Research Roadmap**. Page includes additional data items such as status, timeframe, key dates, etc.

5. Past and Current Research Detail. One page for each research project included in **2. Past and Current Research Library**. Page includes a summary, additional data items, and a direct link to **6. External Resource**, if available.

6. External Resource. Externally-hosted past and current research products.

7. Admin Page. Controls to manage the online Research Roadmap.

8. Database. Single database that drives Research Roadmap, current and recent research, and submission tool.

4.3.1. Roadmap

Background

The Research Roadmap is intended to communicate the current status of research needs in the area of transportation performance management. The Roadmap is depicted online as a database of research project ideas in various stages of development or approval. Each project in the database is tagged based on four criteria: project status, time frame, funding source, and TPM categories. A search interface allows users of the Roadmap to sort projects according to any combination of selected criteria. Only projects that meet the criteria selected by a user will be shown in the list of results. The list of results offers a brief summary of each project; users can choose to read more by accessing the “Background” or “Objectives” expansion boxes for each project. Clicking on a project title brings the user to that project’s page – which includes background, objectives, proposed research, potential benefits, implementation and follow-on activities, and related research.

Screens

Figure 4.2 shows the browser element of the Roadmap. The four sorting criteria of the Roadmap are based on the tags applied to submissions by contributors and staff. Clicking on any of those criteria updates the list of matching projects shown below. Nested within each project result listed are subheadings for “Background” and “Objectives”. Clicking on these subheadings expands them into text boxes, allowing the user to read more about a project without leaving the browser interface, as shown in Figure 4.3. Clicking on the title of the list items brings the user to a detailed page about the project, as shown in Figure 4.4.

The screenshot shows the 'Transportation Performance Management Research Roadmap *DRAFT*' interface. At the top, there are three filter sections: 'Project Status' (Concept, Candidate, Prioritized, Pending), 'Funding Source' (NCHRP Full Program, AASHTO Committee Research, NCHRP 08-36, NCHRP 20-24, NCHRP 25-25, FHWA, Transportation Pooled Fund Project), and 'TPM Categories' (Organization, National Context, Method, Measure, Decision Making, Data, Communication). Below these are 'CLEAR' and 'SUBMIT' buttons. The main area is titled 'Results' and shows a single project entry: 'Status: Candidate' with a star icon, 'Timeframe: Short-Term', 'Funding Estimate: \$200,000', 'Research period: 12 months', and 'Potential Funding: AASHTO Committee Research, FHWA, NCHRP 08-36, NCHRP 20-24, NCHRP 25-25, NCHRP Full Program'. To the right of this entry is a blue callout box containing the title 'Organizational Models, Roles, and Training for Transportation Performance Management' and a descriptive paragraph about the project's objective. Below the title are two expandable sections: 'BACKGROUND' and 'OBJECTIVES', each preceded by a plus sign.

Figure 4.2 Research Roadmap Browser

Figure 4.3 shows an example of a project in the Research Roadmap list with its text boxes expanded. Clicking on the title of a project will bring the user to the individual project page, an example of which is shown in Figure 4.4.

Results

The screenshot displays a research project titled "Organizational Models, Roles, and Training for Transportation Performance Management". The project status is "Candidate" with a blue star icon. Key details include a "Timeframe: Short-term", "Funding Estimate: \$200,000", and a "Research period: 12 months". Potential funding sources listed are AASHTO Committee Research, FHWA, NCHRP 08-36, NCHRP 20-24, NCHRP 25-25, and NCHRP Full Program. The main content area is divided into sections: "BACKGROUND" (describing TPM's opportunities and benefits) and "OBJECTIVES" (listing three concepts: organizational models, TPM roles and responsibilities, and training needs). The background of the main content area is light blue, while the section headers have orange backgrounds.

Status: Candidate

Timeframe: Short-term

Funding Estimate: \$200,000

Research period: 12 months

Potential Funding:

AASHTO Committee Research,
FHWA,
NCHRP 08-36,
NCHRP 20-24,
NCHRP 25-25,
NCHRP Full Program

Organizational Models, Roles, and Training for Transportation Performance Management

The objective of this research will be to produce resources to help transportation agencies improve capabilities needed to implement TPM. This includes examples of organizational models, setting roles and responsibilities, and determining training needs.

BACKGROUND

Transportation performance management (TPM) offers agencies an array of opportunities to increase positive outcomes with available resources. These opportunities include:

- Application of performance measures that relate performance outcomes to investments
- Deployment of applications that support enhanced decision-making
- Streamlining of processes to expedite program and project delivery
- Prioritizing needs to allocate resources where they are most needed
- Enabling better collaboration amongst stakeholders

As tools and techniques advance, organizational capabilities in transportation agencies must also advance to realize the benefits of TPM. Many organizational models and role types exist for TPM programs. Matching the right model and role types with people are integral ingredients for realizing the positive outcomes that are possible with TPM. Transportation agencies today need assistance in improving organizational capacity to adopt TPM benefits.

OBJECTIVES

This research will produce resources to help transportation agencies improve organizational capabilities needed to implement TPM. These resources will be designed to supplement work being developed by the FHWA for its TPM Technical Assistance Program and is intended to be available on the AASHTO Standing Committee on Performance Management website. Three concepts will be produced through this research:

1. Organizational models for TPM programs
2. TPM roles and responsibilities
3. Training needs for TPM roles

Figure 4.3 Research Roadmap Result Expanded

Figure 4.4 is an example of a research resource page, accessed by clicking on a title of a project from the Roadmap. The page summary includes the project title, status, potential funding sources, timeframe, research period, funding estimate, and potential sponsors.

A number of subheadings below can be expanded into text boxes with additional project details, including background, objectives, proposed research, potential benefits, implementation and follow-on activities, and related research. An example project page with all subheadings expanded is shown in Figure 4.5

Organizational Models, Roles, and Training for Transportation Performance Management

Status: Candidate

Potential Funding Sources: AASHTO Committee Research / FHWA / NCHRP 08-36 / NCHRP 20-24 / NCHRP 25-25 / NCHRP Full Program

Timeframe: Short-Term	Research Period: 12 months	Potential Sponsors:
Funding Estimate: \$200,000		

The objective of this research will be to produce resources to help transportation agencies improve capabilities needed to implement TPM. This includes examples of organizational models, setting roles and responsibilities, and determining training needs.

- ⊕ BACKGROUND
- ⊕ RESEARCH OBJECTIVES
- ⊕ PROPOSED RESEARCH
- ⊕ POTENTIAL BENEFITS
- ⊕ IMPLEMENTATION AND FOLLOW-ON ACTIVITIES
- ⊕ RELATED RESEARCH

Figure 4.4 Research Resource Example

Figure 4.5 shows the expanded details of a project page. Background and Objectives are the same as shown in the results list. Proposed Research, Potential Benefits, Implementation and Follow-On Activities, and Related Research display new content.

Timeline: Short-Term	Research Period: 12 months	Potential Sponsors:
<p>Funding Estimate: \$200,000</p> <p>The objective of this research will be to produce resources to help transportation agencies improve capabilities needed to implement TPM. This includes examples of organizational models, setting roles and responsibilities, and determining training needs.</p>		
● BACKGROUND		
<p>Transportation performance management (TPM) offers agencies an array of opportunities to increase positive outcomes with available resources. These opportunities include:</p> <ul style="list-style-type: none"> • Application of performance measures that relate performance outcomes to investments • Deployment of applications that support enhanced decision-making • Streamlining of processes to expedite program and project delivery • Prioritizing needs to allocate resources where they are most needed • Enabling better collaboration amongst stakeholders <p>As tools and techniques advance, organizational capabilities in transportation agencies must also advance to realize the benefits of TPM. Many organizational models and role types exist for TPM programs. Matching the right model and role types with people are integral ingredients for realizing the positive outcomes that are possible with TPM. Transportation agencies today need assistance in improving organizational capacity to adopt TPM benefits.</p>		
● RESEARCH OBJECTIVES		
<p>This research will produce resources to help transportation agencies improve organizational capabilities needed to implement TPM. These resources will be designed to supplement work being developed by the FHWA for its TPM Technical Assistance Program and is intended to be available on the AASHTO Standing Committee on Performance Management website. Three concepts will be produced through this research:</p> <ol style="list-style-type: none"> 1. Organizational models for TPM programs 2. TPM roles and responsibilities 3. Training needs for TPM roles 		
● PROPOSED RESEARCH		
<ol style="list-style-type: none"> 1. Organizational Models for TPM Programs <ul style="list-style-type: none"> • Research domestic and international models for TPM program organizations and develop a set of example models that represent the various approaches • Describe these models in useful detail with accompanying diagrams for DOTs to use to outline TPM program organization improvements 2. TPM Roles and Responsibilities <ul style="list-style-type: none"> • Develop a list of roles in TPM programs • Roles should represent roles described in all of the organizational models developed in the previous task • Produce a set of responsibilities for each of the roles and indicate with organizational model(s) the role supports 3. Training Needs for TPM Roles <ul style="list-style-type: none"> • Develop a list of training needs to strengthen DOT staff capabilities to deliver TPM roles • List existing trainings as well as new trainings needed to support roles developed in Task 2 above • The new trainings should be described in sufficient detail so that it is clear what the contents of the training should be <p>The research team should identify existing resources that will support the development of these research products so that there is not duplication of effort.</p>		
● POTENTIAL BENEFITS		
<p>Most of the research being conducted for TPM is focused on the content of transportation performance. This research would focus on the people and organizations that are delivering transportation performance. It would help guide agencies to strengthen the staff and organizations so that they are better stewards of TPM programs and implementation.</p>		
● IMPLEMENTATION AND FOLLOW-ON ACTIVITIES		
<p>The training needs will need to be converted to training programs. Recommendations on how to implement the trainings will need to be provided.</p>		
● RELATED RESEARCH		
<p>The FHWA Office of TPM is actively involved in developing tools and trainings for TPM. The current NHI trainings that are being developed is focused on the "how to's" of TPM. The trainings envisioned for this project will be focused on TPM roles and how to do the best job in the role. It will reference the NHI training course.</p>		
<p>No related research found</p>		

Figure 4.5 Research Resource Example Expanded

Summary

Project ideas are tagged according to various criteria and added to the Roadmap. Users can browse the Roadmap and sort projects using the search interface. The list of projects displayed will update depending on which criteria are selected. Users can read more about projects in the results list by opening the text boxes “Background” and “Objectives”. Clicking on a project title opens the individual project page which has additional details.

4.3.2. Library

Background

The library is a database of active and complete transportation performance management research projects. All projects in the portal are tagged according to seven TPM categories and seven TPM areas. The search interface allows users to sort projects according to the tagged categories and areas, as well as by keyword. A list of results will be shown below the search interface. Users can also toggle “View Active Research Only”, choosing to filter out completed projects from the results list.

Screens

The browser interface page shown in Figure 4.6 sets out all the options which a user can use to search for a relevant project. The categories and areas are based on the tags applied to submissions by contributors and staff. Clicking on any of the factors updates the list of matching project below. Clicking on one of those list items brings you to a page summarizing the project.

The screenshot shows a web-based library browser interface. At the top, there is a header with the title "Search the library of TPM research". Below the header, there are three main sections: "TPM Categories", "TPM Areas", and "Keyword Search".

- TPM Categories:** A list of categories including Communication, Data, Decision Making, Measure, Method, National Context, and Organization.
- TPM Areas:** A list of areas including Air Quality, Asset Management, Bridge, Pavement, Freight, Safety, and System Performance.
- Keyword Search:** A text input field with a placeholder "SEARCH THE LIBRARY OF TPM RESEARCH", a "SUBMIT" button, and a "CLEAR" button. To the right of the input field is a link "VIEW ACTIVE RESEARCH ONLY".

Below these sections is a heading "Results" followed by a numbered list of 20 research projects. Each project entry includes a title, a status indicator (e.g., "/ Active"), and a date (e.g., "TRB / NCHRP 20-24(58) / 2010").

1. Improving FHWA's Ability to Assess Highway Infrastructure Health: Development of Next Generation Pavement Performance Measures / Active
2. Toward Developing Performance Based Federal-Aid Programs TRB / NCHRP 20-24(58) / 2010
3. Development of an Electronic Performance Reporting Template FHWA / TBD / Active
4. TPM CMM Guidebook, Assessment, and Web Tool FHWA / TBD / Complete
5. Advanced Data Analysis and Visualization Capability FHWA / TBD / Active
6. Review of State DOT Economic Investment Programs FHWA / Active
7. Development of Performance Reporting Templates FHWA / TBD / Complete
8. Consequences of Delayed Maintenance TRB / NCHRP 14-20 / 2012
9. Role and Value of Transportation for US Industries and Sectors TRB / NCHRP 20-24(89) / Active
10. Alternative State DOT Organizational Models for Delivering Services TRB / NCHRP 20-24(83) / 2012
11. Integrating Individual Transportation System-Level Performance Programs to Determine Network Performance TRB / NCHRP 08-67 / 2010
12. Sustainability Performance Measures for State Departments of Transportation and Other Transportation Agencies TRB / NCHRP 08-74 / 2011
13. Guidelines for Evaluation and Performance Measurement of Congestion Pricing Projects TRB / NCHRP 08-75 / 2011
14. Workshop on Transportation-System Performance Measures Suitable for National Use TRB / NCHRP 20-24(37)H / 2011
15. Integrating Performance Measures into a Performance-Based Planning and Programming (PBPP) Process TRB / NCHRP 08-36/Task 104 / 2012
16. Increasing Consistency in the Highway Performance Monitoring System for Pavement Reporting TRB / NCHRP 20-24(62) / 2013
17. Transportation Performance Management: Insight from Practitioners TRB / NCHRP 08-62 / 2010
18. Supplement to the AASHTO Transportation Asset Management Guide: Volume 2 – A Focus on Implementation TRB / NCHRP 08-69 / 2010
19. Guide for Selecting Level-of-Service Targets for Maintaining and Operating Highway Assets TRB / NCHRP 14-25 / 2014
20. Methodology for Estimating Life Expectancies for Highway Assets TRB / NCHRP Project 08-71 / 2012

At the bottom left, there is a small navigation bar with a page number (1), a dropdown arrow, and the text "of 4".

Figure 4.6 Library Browser

Figure 4.7 shows an example of a project page accessed from the library. The page contains fields such as abstract, external link, publisher, report number, year published, and related research. Active and completed projects have the same fields. An external link for a completed project is likely a link to the report resulting from that project, while an external link for an active project may lead to that project's page on TRID.

Consequences of Delayed Maintenance

Abstract: Various maintenance treatments are employed by highway agencies to slow deterioration and restore condition of highway pavements, bridges, and other physical assets. However, budget constraints and other factors have often led to delaying or eliminating the application of these treatments. Such actions are expected to adversely influence the condition and performance and lead to a reduced level of service, to early deterioration, and eventually to the need for costly rehabilitation or replacement. Analytical tools are currently available to quantify the consequences of delayed application of maintenance treatments for highway pavements, bridges, and other assets. However, processes for using these tools to demonstrate the potential savings and performance enhancement resulting from applying maintenance treatments at the right time are not readily available. Research is needed to develop such processes. This information will help highway agencies better assess the economic benefits of maintenance actions and their role in enhancing the level of service of the highway system. In addition, incorporating these processes in asset management systems would provide a means for optimizing the allocation of resources. The objective of this research is to develop a process for quantifying the consequences of delayed application of maintenance treatments. The process shall be applicable to highway pavements, bridges, and other physical assets. Consequences shall be expressed in terms of performance indicators (e.g., distress and level of service), costs to owners and road users, and other relevant factors. Delayed maintenance applications may be defined by (1) the inability to meet the agency-defined application schedule or (2) the available budget relative to an unconstrained budget (i.e., availability of the funds required to perform all needed maintenance).

External link: http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP14-20_ProcessDocument.pdf

Publisher: TRB

Report number: NCHRP 14-20

Year published: 2012

Related Research:

1. [Issues and Practices in Performance-Based Maintenance and Operations Management](#)
2. [Target-Setting Methods and Data Management To Support Performance-Based Resource Allocation by Transportation Agencies](#)
3. [Best Practices in Selecting Performance Measures and Standards for Effective Asset Management](#)
4. [Transportation Performance Management: Insight from Practitioners](#)

Figure 4.7 Example Library Resource

Summary

Active and completed projects are tagged using the seven categories and seven areas. Users can sort and search the projects using these criteria as well as keywords. Each project listed has its own page with additional details, including an external link to the project page (if an active project) or the project report (if completed).

4.3.3. Info

Background

The Info page gives users a numerical summary of the online Roadmap. The projects in the Roadmap are broken down by status and also by TPM category.

Screens

As shown in Figure 4.8, projects in the Roadmap are organized by status: active, prioritized/pending, concept/candidate, or submitted concepts/pool. By clicking “More Info”, a user can view a matrix that shows the distribution of projects by status and by TPM category.

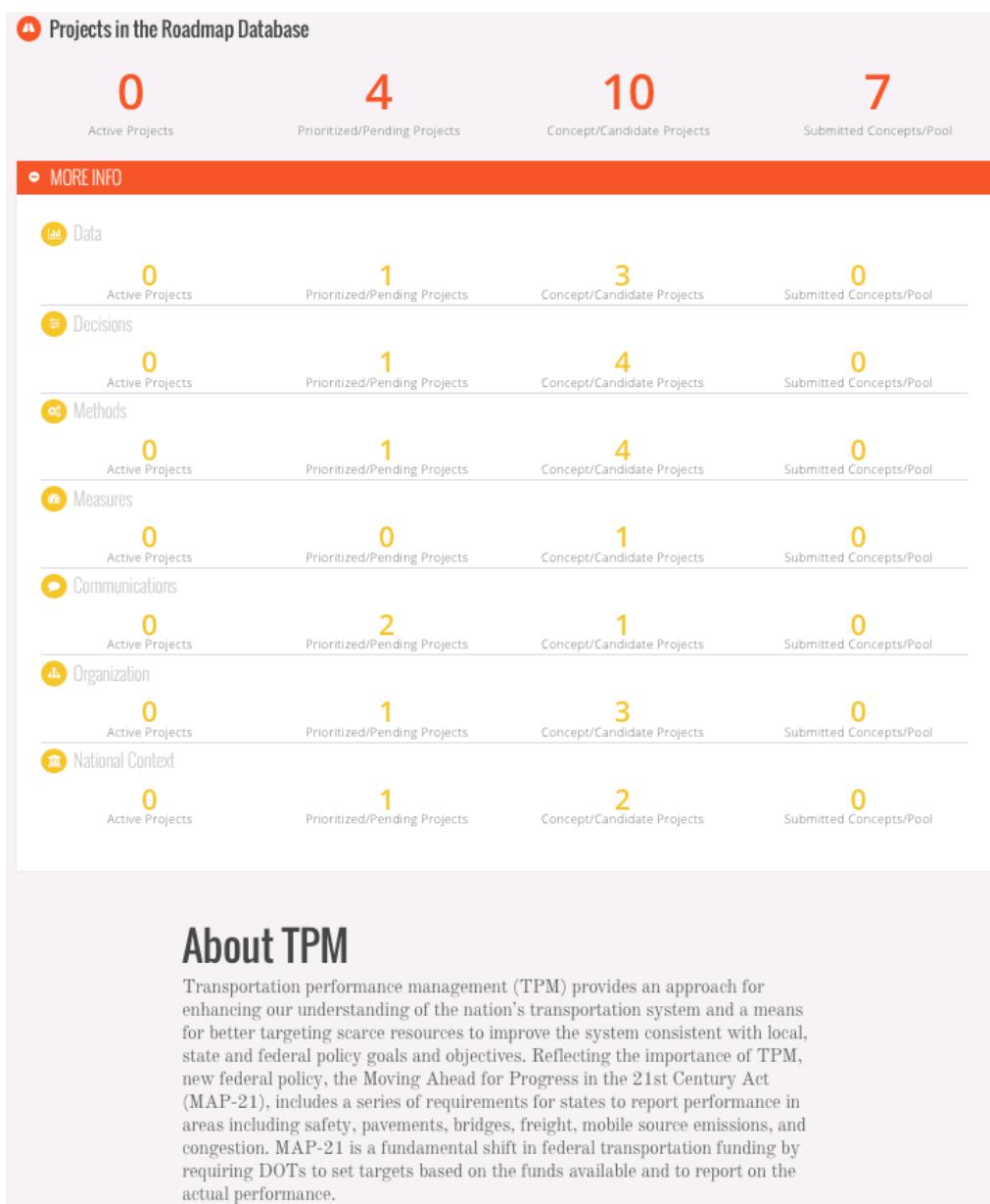


Figure 4.8 Roadmap Info

Summary

The info page provides a quick and useful summary of the online Roadmap for users. It shows the relative allocation of research projects by category.

4.3.4. Concept Submission and Concept Pool

Background

The Concept Pool provides a means to collect potential problem statements that may be considered for inclusion in the Research Roadmap. This function is currently restricted to site administrators. A concept submittal tool has also been created to support this function. This submittal tool is likewise restricted to site administrators. Authorized users can easily edit concept details and migrate a concept from the Concept Pool to the Roadmap.

Screens

The screenshot displays the Concept Pool interface. At the top, there is a navigation bar with a circular icon containing the letters 'TPM'. Below this, the main content area is divided into three sections: 'TPM Categories', 'TPM Areas', and 'Keyword Search'. The 'TPM Categories' section lists: Communication, Data, Decision Making, Measure, Method, National Context, and Organization. The 'TPM Areas' section lists: Air Quality, Asset Management, Bridge, Pavement, Freight, Safety, and System Performance. The 'Keyword Search' section features a search input field and two buttons: 'SUBMIT' and 'CLEAR'. Below these sections, a heading 'Concept Pool' is followed by a numbered list of six concepts: 1. Improving VMT Data, 2. Linking the Strategic Performance Management Framework with an Agency's Operational Framework, 3. Non-Motorized Performance Measures, 4. Development of Multi-Modal Measures, 5. Framework for Connecting Across Federal Reporting Requirements, and 6. Placeholder for the Concept Pool. At the bottom of the page is a yellow button labeled 'ADD A CONCEPT TO THE POOL'.

Figure 4.9 Concept Pool

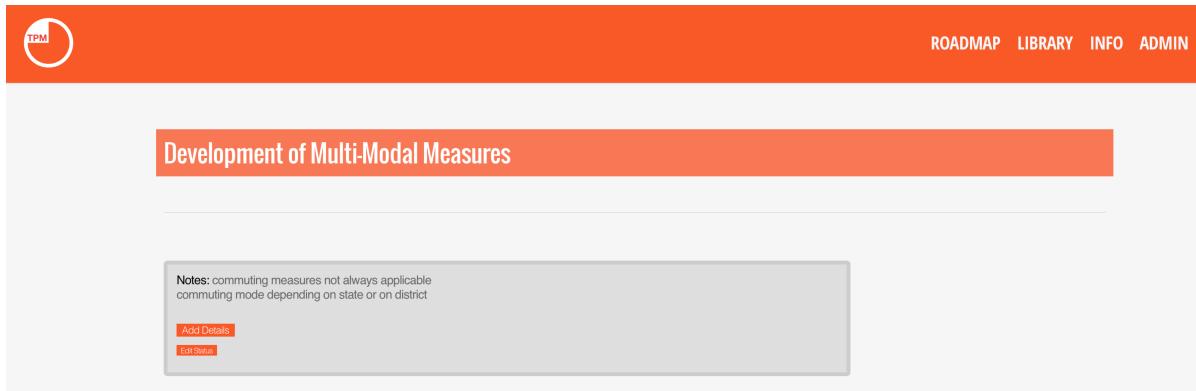


Figure 4.10 Example Concept Stub

This screenshot shows the 'Development of Multi-Modal Measures' editing screen. It features three main sections: 'Estimated Timeframe', 'Research period', and 'Funding Sources'.
Estimated Timeframe: A section where users can select an estimated timeframe (Year One=1; Year Two=2; Years Three-Four=3). Radio buttons for '1', '2', and '3' are shown, with '1' selected.
Research period: A section where users enter the estimated research period in months. An input field is provided for this purpose.
Funding Sources: A list of funding sources with corresponding checkboxes:

- AASHTO Committee Research
 - NCHRP 08-36
 - NCHRP 20-24
 - NCHRP 25-25
 - NCHRP Domestic Scan
 - NCHRP Full Program
 - NCHRP Synthesis
 - Other
 - Transportation Pooled Fund Project
 - USDOT
 - FHWA

Below the funding sources is a 'Submit' button.

Figure 4.11 Concept Editing Screen

The screenshot shows a web-based application interface for adding a new research statement. At the top right, there is a circular profile icon with the letters 'TPM'. To its right, a horizontal menu bar contains the links: ROADMAP, LIBRARY, INFO, and ADMIN. Below the menu, the title 'Add a New Research Statement' is displayed in white text on an orange background. The main content area has a light gray background and contains three input fields: 'Post Title' (a single-line text input), 'Statement/Resource Title' (a single-line text input), and 'Summary and Notes' (a multi-line text area). At the bottom left of this area, there is a dark gray 'Submit' button.

Figure 4.12 Submittal Tool

Summary

The Concept Pool provides a simple summary of research statements submitted to the TPM Portal along with controls that allow authorized users to supply additional details to a concept before adding it to the Research Roadmap.

5. Workshops

5.1. Background

Two workshops were delivered as part of the work plan. The first workshop took place on November 20, 2014 as part of Task 2. The second workshop took place January 14, 2015 as part of Task 5.

The project team organized and facilitated the workshops of transportation researchers and practitioners to help establish a meaningful, achievable performance measures research road map: a multi-year plan for potential NCHRP research projects that responds to existing knowledge gaps, drives continuing improvement, and affords agencies freedom to set and achieve performance targets.

The project team worked with the panel to establish the set of workshop invitees. Invitees included panel members, stakeholders, and representatives of relevant AASHTO subcommittees and committees as determined by the panel. The project team worked with participants to support travel logistics including identifying cost-effective travel options and coordinating reimbursements. The project team also provided full logistical support for participants' accommodations and the coordination of local travel options.

5.2. Workshop 1

This workshop took place on November 20, 2014 in Charlotte, North Carolina at the AASHTO Annual Meeting. The purpose of the workshop was to obtain input on the review of national-level performance data sets and address questions about the national-level data sets which had been established in the RFP.

This all day workshop included a majority of state DOT participants. Half of the workshop focused on sharing current activities in TPM research, building on the research needs identified to date, and identifying research projects. The second half of the day focused on TPM and communications –related practices, determining research needs, and identifying research projects. The workshop ended with a prioritization exercise of the identified research projects.

See Appendix A for workshop notes.

5.3. Workshop 2

This workshop took place on January 14, 2015 in Washington, DC as part of an AASHTO SCOPM Leadership Meeting. The workshop was designed to provide an opportunity to present, discuss, and refine observations, insights, and guidance

drawn from the review performed in Task 4.

The workshop was attended by state DOT participants. The first half of the workshop focused on project progress to that date, as well as updates from AASHTO, TRB, and FHWA about PM research efforts. The second half of the workshop focused on generating research statements and reviewing research needs.

See Appendix B for workshop notes.

6. Next Steps

6.1. Overview

This section presents next steps for extending the NCHRP Project 20-24(97) research products after the conclusion of the project. It contains two sections addressing: 1) the ongoing stewardship of the TPM portal and 2) the potential for expanding the TPM portal by introducing additional problem statements. The TPM portal was designed expressly to support these extensions with minimal administrative burden.

6.2. Website Stewardship Options / Plan

AASHTO SCOPM has agreed to take ownership on disseminating the products of this research and stewarding the use of the products. At the conclusion of NCHRP Project 20-24(97), the hosting of the TPM portal will be transferred to AASHTO. This transferal can be effected immediately upon the formal conclusion of the project, based on the priorities of AASHTO SCOPM. In order to support this capability, the portal has been developed and is currently maintained as a free-standing web application. All files necessary for the ongoing maintenance of the portal are currently collected online and can be provided to AASHTO in a single self-contained package.

The portal and each of its key components have been designed to be easily maintained and updated by AASHTO. These key components include the research statements, the library of research projects, and the framework (tagging structure). This flexibility and extensibility is important in order to reflect the advancing state of the practice – particularly given rapid developments in response to MAP-21 rulemaking and implementation.

The user guide included as an appendix provides instructions on maintenance and upkeep. These instructions have been drafted in a clear style and at a level of detail sufficient to ensure that site maintenance can be managed by junior-level AASHTO staff, as appropriate.

Appendix A. Workshop 1

REPORT

AASHTO Performance Management Research Roadmap Workshop

Thursday, November 20, 2014

Workshop Purpose: Continue work on the development of the AASHTO SCOPM Research Roadmap by providing an update on work-to-date and get input on priority research needs and begin the development of research need statements.

I. Introduction and PM Resources Panel

Jim Ritzman (Pennsylvania DOT): introduction to workshop

- Before we can identify what performance management research needs exist, we need to first figure out where we are and what are the gaps
- Everyone can be good at “being busy” but the challenge is answering are we being busy on the right stuff?
- “Heat map” of current and recent research clearly showed a gap in “communication” hence the afternoon focus

Mark Swanlund (FHWA): rulemaking status update

- Emphasized the importance FHWA has placed on getting stakeholder input
- Final rules completed late summer/early Fall 2015.... when real work begins (implementing TPM, technology transfer, etc)
- Intention is to still have one effective date

Performance Area	NPRM Date	Comment Period	Final Rule
Safety Performance Measures	March 11, 2014	Closed	Sept, 2015
Highway Safety Improvement Program	March 28, 2014	Closed	Aug, 2015
Statewide and Metro Planning	June 2, 2014	Closed	Sept, 2015
Pavement and Bridge Performance Measures	November, 2014	90 days	
Asset Management Plan	January, 2015	60 days	
System Performance Measure	March, 2015	90 days	

Matt Hardy (AASHTO): overview of related research and means to funding research

- Pointed out that AASHTO started discussion about national performance measures before MAP-21 with the comparative measure series NCHRP 20-24 (37))
- With emphasis on communications, Lloyd Brown, AASHTO Director of Communications attended workshop
- NCHRP Recent and Current Research on Performance Management

NCHRP Current and Recent Research on Performance Management

- *Integrating Performance Measures into a Performance-Based Planning and Programming Process*
Project 8-36/Task 104, 20-24(78)
- *Transportation Outcomes and Other Strategic Performance Impact Measures: A Framework for State Departments of Transportation*
Project 20-24(20)
- *Toward Developing Performance Based Federal-Aid Highway Programs*
Project 20-24(58)
- *Executive Summit on Performance Based Maintenance and Operations Practices*
Project 20-24(61)

NCHRP Current and Recent Research on Performance Management

- 20-24(37) *Measuring Performance among State DOTs: Sharing Good Practices*
 - Repeat/Update Construction Schedule and Budget Performance — 20-24(37)A1 / B1
 - Safety (crash statistics) — 20-24(37)C
 - Operations Performance Using Incident Response Time — 20-24(37)D
 - Bridge Conditions — 20-24(37)E
 - Establishment of Comparative Performance Measures Program Infrastructure to Support National System Performance Data Collection and Analysis — 20-24(37)F
 - Technical Standards and Guidance for Deploying National Level Performance Measurements — 20-24(37)G
 - Workshop on Transportation-System Performance Measures Suitable for National Use — 20-24(37)H
 - Congestion — 20-24(37)I
 - Pavement Condition—Structural Health Index — 20-24(37)J
 - Safety—Serious injuries — 20-24(37)K
 - National Report on Transportation System Performance – State DOTs Telling the Story — 20-24(37)L

NCHRP Current and Recent Research on Performance Management

- ***State DOT CEO Leadership Forum- Spring/Summer 2009 Pilot Study of State Driven Performance Based Management Reporting***
Project 20-24(67)
- ***Increasing Consistency in the Highway Performance Monitoring System for Pavement Reporting***
Project 20-24(82)
- ***Alternative State DOT Organizational Models for Delivering Services***
Project 20-24(83)
- ***Role and Value of Transportation for U.S. Industries and Sectors***
Project 20-24(89) • Active •

NCHRP Current and Recent Research on Performance Management

- ***Advancing Performance Management under a National Framework***
Project 20-24(97) • Active •
- ***Public Communication – 20-24(93)***
 - *Public Communication - Public Outreach* Project 20-24(93)A
 - *Public Communication - Management Planning* Project 20-24(93)B(01)
 - *Communicating Performance Management State DOTs Continuing to "Tell Their Story"* Project 20-24(93)B(02) • Active •
 - *Public Communication – Outreach* Project 20-24(93)C • Active •
- ***Data Self Assessment Guide***
 - *Transportation Agency Data Management Self Assessment* - Project 8-92 • Active •

Susanna Hughes-Reck (FHWA): update on training and capacity building resources

- New NHI courses include “Transportation Performance Management Awareness” and “Introduction to Performance Measures”
http://www.nhi.fhwa.dot.gov/training/course_search.aspx?tab=0&key=performance+management&res=1
- TPM Digest: <http://www.fhwa.dot.gov/tpm/resources/digest/>
- FHWA Performance Reporting Project: Design an ideal transportation performance report that tells transportation stories in a visually compelling way that the target audience cares about
- Future efforts:
 - Guidance for (a) significant progress determination, (b) target setting and (c) evaluating strategies
 - Future Measures: next evolution of measures and improved data sources and quality
 - Training: MAP-21 101 & 201 (System Specific) Implementation; Target Setting; Data Quality/integration; Collaboration/Coordination Toolkit
- FHWA PM website: <http://www.fhwa.dot.gov/tpm>
- FHWA recently started a new Transportation Performance Management (TPM) Technical Assistance Program (see flyer pasted below)

Transportation Performance Management

Technical Assistance Program

Overview

The TPM Technical Assistance Program (TAP) is a 5-year Task order, with a base period of 24 months, and two 18-month option periods. The TPM TAP will be comprised of three parts:

- ⇒ Technical Assistance Resources
- ⇒ National TPM Implementation Assessments and Reviews
- ⇒ On-Site Assistance and Action Planning

Part 1: Technical Assistance Resources

Example:		
	Assessment Elements	
Assessment Areas: TPM Programs	Governance	Management
Agency-wide	2-Aware	Not Assessed
Safety	3-Optimizing	4-Proficient
Pavements	1-Basic	3-Optimizing
Bridges	4-Proficient	4-Proficient
Investment Analysis	1-Basic	3-Defined

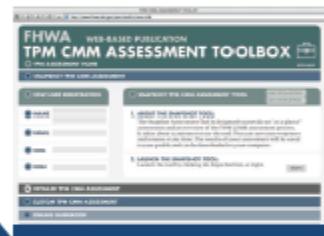
Phase 1: Early Spring 2015

The TPM Capability Maturity Model will be



Phase 2: Early Fall 2015

The TPM Guidebook will be



Phase 3: Late Fall 2015

The TPM TAP Toolbox will be

- ⇒ Used by transportation agencies to assess their TPM implementation progress, capabilities, and gaps.
- ⇒ Designed in a flexible manner to meet different agency characteristics, priority focus areas, and levels of maturity.
- ⇒ Applicable to both State Transportation Agencies (STAs) and Metropolitan Planning Organizations (MPOs)
- ⇒ A practical and useful resource that meets the needs of the leadership, management, and staff in both SHAs and MPOs.
- ⇒ Designed to include useful templates "how to" guidance on techniques to improve TPM .
- ⇒ Designed to link to the TPM CMM so that agencies can apply the guidance to improve TPM maturity and address TPM implementation gaps.
- ⇒ An interactive operationalization of the TPM CMM and TPM Guidebook.
- ⇒ Used to establish agency-level TPM and performance-based planning maturity according to the TPM CMM model.
- ⇒ A portal to available TPM technical assistance resources.



Part 2 :National TPM Implementation Assessments and Reviews

Division TPM Readiness Assessment

The objective of this task is to design and administer an internal FHWA Division Office assessment that assesses the abilities of FHWA Division Offices to oversee and provide support in the implementation of MAP-21 performance provisions. The assessment will be administered in early 2015.

National TPM Implementation Review

The objective of this task is to design and administer a national review that examines the degree to which State DOTs and MPOs have implemented MAP-21 performance provisions. The review will be administered twice; first after rulemaking and again in either 2017 or 2018. The findings from the review will be used in a report to Congress on the effectiveness of performance-based planning and programming processes and transportation performance management.

FHWA TPM CMM SURVEY									
Implementation									
Area	Policy	Planning	Program	Budget	Management	Implementation	Monitoring	Reporting	Improvement
A	Policy	Planning	Program	Budget	Management	Implementation	Monitoring	Reporting	Improvement
Strategic planning and budgeting									
Performance-based planning and programming									
Performance-based budgeting									
Performance-based reporting									
Performance-based improvement									

Part 3: On-Site Assistance and Action Planning

State TPM Capability Maturity Model and Assessment Workshops

The objective of this task is to develop, coordinate, and deliver eight, one and a half day workshop at stakeholder agencies to conduct a TPM assessment using the TPM CMM and Guidebook. In FY2016, up to eight states and their sub recipients will pilot this workshop. The workshop will be used to help FHWA's partners and stakeholders develop and identify approaches to successfully implement MAP-21 performance management and performance-based planning and programming provisions.

TPM Capability Maturity Model and Assessment Peer Exchange

The objective of this task is to plan and deliver a TPM Capability Maturity Model and Assessment Peer Exchange to share the experiences on the use of the assessment tools and guidance. The exchange will help agencies learn from each other on better ways to apply and use best practices to improve TPM. One pilot Peer Exchange is scheduled for FY2016.

Point of Contact for TPM Technical Assistance

Program:

Michael Nesbitt

Assessment and Reporting Team

Office of Transportation Performance Management

Michael.Nesbitt@DOT.GOV



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Mara Campbell (TRB PM Committee Chair, HERE): update on TRB activities

- Committee scope
 - Encourages the use of performance management with regards to system efficiency, functionality, condition, operation and non-traditional measures of sustainability and system externalities

- Implementing PM including definition of performance data needs, data collection, analysis, reporting and communication.
- Principle clearinghouse for the integration of activities and exchange of information among TRB committees and other organizations.
- How: Robust partnering (State DOTs, FHWA, FTA, AASHTO), maintain list of research needs, focuses sessions/workshops/conferences
- PM Conference: June 1-2, 2015 Denver, CO
<http://www.trb.org/Main/Blurbs/169382.aspx>

Michael Pack (University of Maryland CATT Lab): update on academic resources

- Academic resources by measure category

Program	Measure Category	Academic Resources
Status I	Serious Injuries per VMT	Nearly all major University Transportation Centers & Institutes
	Fatalities per VMT	
	Number of Serious Injuries	
	Number of Fatalities	
Status II	Pavement Condition on the Interstates	Georgia Tech Purdue
	Pavement Condition on the Non-Interstate NHS	
	Bridge Condition on NHS	
Status III Performance of the Interstate System	Traffic Congestion	Services: Purdue Texas A&M Trans. Institute (TTI) Univ. of MD CATT Lab Univ. of Michigan
	On-road mobile Source emissions	
	Performance of Interstate System	
	Performance of Non-Interstate NHS	
	Freight Movement	UW-Madison, TTI,

- Academic products by measure category

Program	Measure Category	Products
Status I	Serious Injuries per VMT	CATT Lab EVC & ICE Suites UF Signal Four Analytics Many many more
	Fatalities per VMT	
	Number of Serious Injuries	
	Number of Fatalities	
Status II	Pavement Condition on the Interstates	
	Pavement Condition on the Non-Interstate NHS	
	Bridge Condition on NHS	
Status III Performance of the Interstate System	Traffic Congestion	CATT Lab Probe Data Analytics Suite TTI Urban Mobility Report
	Performance of Interstate System	
	Performance of Non-Interstate NHS	
	On-road mobile Source emissions	
	Freight Movement	Vanderbilt FPMweb

- Note: it is a misconception that standardized data leads to standardized reporting. Even with a uniform, national dataset, each agency may choose to implement *subtle* differences in their calculations which could lead to different results.

- A range of academic products were reviewed
- Users of academic suites: 4,100+

DOTs							
Federal	State	Local	MPOs	Universities	Consultants	Public Safety & Military	Transit
5%	52%	8%	6%	9%	7%	11%	2%

Commercial Resources: Open floor for private firms to describe available resources

- Overviews provided by HERE, Iteris and DecisionLens

II. Research Roadmap Ideas: What does a research roadmap look like to you?

RR should focus on: IDENTIFICATION AND ORDERING	
Identification of a logical sequence of activities to accomplish the program objective; identification of activities underway and planned so sponsors can create a program with minimal duplication	A document that identifies a sequence of research projects that will collectively address a defined set of needs. It may serve as a framework for coordination of research among multiple sponsors.
A strategic plan identifying a coordinate series of research projects and timeframes in order to advance the state of the practice	A comprehensive, data driven, results oriented program with clear, defined goals designed to solve a spectrum of transportation issues
A categorical, searchable, accessible outline of projects	A long-term guide to ensure that performance research addresses all areas of need
Provides a framework to highlight areas to explore idea that might fail initially but will eventually lead to useful ideas that are widespread in practice	States across the country develop their wish list of research needs/wants and a roadmap is developed to complete the desired research projects
Coordinate effort in order to create efficiency	In order to better determine what is needed, first need to know what is happening today
Outlines shifting trends, needs, technologies and practices; define approaches and projects to address needs that involve researchers, public agencies and industry experts; pilot of ideas and potential solutions	An outline that progresses us towards a common end goal; identification of common measures for assets; standardize performance standards
A logical set of research projects that show interrelationships between projects and a schedule based on how projects feed into other projects	A long range plan that identifies research questions and identifies funding. But unlike roadmaps, research roadmaps must be flexible and dynamic, building upon the broader collective knowledge

A filter of a brainstorm of ideas into a funnel that links research need to potential funding source (e.g., AASHTO committee) resulting in applied research	"Is like a box of chocolate- you never know what you are going to get" Forrest Gump
A logical and adjustable path that organizes based on needs that are updated as the process moves	A list of project descriptions in an order that shows how they relate, build on each other and move forward in a logical way
RR should focus on: HOW TO DO TPM	
A business plan that identifies that path forward and expectations for the successful developments and implementation of PM	Not just a list of anticipated research needs to bring the industry to a certain level of capabilities but a plan of action for how to get to that desired end state
Informed vision of what states need to advance performance management in their areas. Addresses short term and long term information needs	A near and long term vision and description of research plans and needs that will support innovation and advancement of performance management
Longer term goal/concept for measures and targets	A defining of the areas where more information is needed to know how we can reach our goals
Direction and guidance to further enhance/mature performance management	A plan to research the effectiveness of performance measures and reporting
Sets the direction and destination. But keeping in mind "it's about the journey" continuous process of maturation/management. For decision support prioritization, planning, AM, innovation, agile implementation etc.	A plan that identifies the types of ideas that will be reviewed to provide best practices on how DOT's are using particular performance measures to improve processes
Short, medium and long term research projects that need to be initiated to ensure we are on the cutting edge (proactive) with regard to TPM; Identification of data needs: what is currently available and how to use and what is needed for future	Identification of a "critical path" research needs for PM and in what order those topics should be explored. Explain the value/how those research needs begin met will help us meet our goals for PM. Identification of interim milestones/set of achievable goals in a finite time period
RR should focus on: COMMUNICATING	
Communicating a MAP-21 performance areas, media for communication, understanding the audience, messaging, delivery, making data common	A long term plan to identify research needed to support DOT discussion with stakeholders regarding transportation funding needs, benefits, etc.
A process of explaining the complexities of TPM to the general public	Include how to communicate value of research being conducted

III. PM Research Needs: What are pressing needs?

- In addition to the research needs identified to date from this project, workshop participants identified the following:

MEASURES	
New/improve measures for:	
<ul style="list-style-type: none"> – Incident response – Operational measures – Real time vehicle occupancy (especially when use probe data) 	<ul style="list-style-type: none"> – Subsurface pavement quality – Non-traditional (e.g., sustainability, livability, economy, vitality) – Travel time reliability across modes
Agreed upon definitions, meaning and calculations behind each measure	Need a synthesis of what environmental measures agencies are using- what are the next environmental measures going to be?
FHWA will continue to focus on sharing best practices (Egan Smith) and acknowledge that MAP-21 measures will not be perfect (Mark Swanlund)	Need to think about what are the measures of the future? E.g., what will the impact be of autonomous vehicles/connected driving? (Mara Campbell)
DATA & ANALYSIS	
Big Data: develop tools and provide expertise <ul style="list-style-type: none"> – How should it be collected and stored? – How can it be processed, manipulated and analyzed? – What is its impact on PM? <i>Overall: new data great but overwhelming to agencies</i>	Tools: <ul style="list-style-type: none"> – Better tools and data to analyze <u>multimodal</u> capacity on corridors – Predictive condition tools for system performance based on multiple factors/modes – What are the best data tools? Need a “consumer report” of data tools with pro/con and what tool could be used for (Daniela Bremmer)
What should be collected and managed in private vs. public sector?	We need conflated VMT data (including bike & ped- Phase 2) to assess and align with national travel data sets
What impact will big data have on what measures we use today and tomorrow? Ex: new types of data emerging from connected vehicles	How handle ubiquitous real time volume data? With probe data getting better, agencies starting to trust this (vs. sensors) but not volume data. How can we get VMT data (across modes) in a way that is believable/credible/high enough quality (Michael Pack)

DECISION MAKING	
Does performance information truly change behavior? What changes are needed at an organization to use PM in decision making?	When is data “good enough” to use? Modelers will push to say need X more months to get “perfect” data, but is this necessary? ¹ How good will likely depend on how data will be used. (Scott Omer)
How do we match the data to the decisions being made? (Matt Hardy)	Connecting the performance management with asset management. How do we make the connection?
How to systematically build risk management into decision making (Neil Pedersen)	How to better integrate multiple required plans and programming
Making tradeoffs—across multiple performance areas	State, MPO, transit coordination in target setting
COMMUNICATIONS	
Need some unification on how PM results are presented. Currently agencies are all over the map with dashboards, charts, infographics—need some common language	What are new and effective ways to visualize data? How to effectively use PM to make “the case”
How do we explain the various roles of State DOT and the local system (in particular transit)	Economic and system benefits of transportation investment at a program and project level
Understanding stakeholders <ul style="list-style-type: none">– What information do they want?– In what format? (Web, face-to-face, charts, infographics, PDF, interactive)– How does this change by type (e.g., executive, legislature, public, media)– What frequency & does this change by type of format? Stakeholder? Topic?– How does this change by scope (e.g., national, regional, city/town)– How does what the stakeholder wants related to what the agency wants to communicate– How can info be presented so customers act upon it? (e.g., use real time information?)	
NATIONAL CONTEXT	
How do we create regional context (e.g., for NE aged infrastructure)? (Dave Kuhn)	When reporting of the cost of transportation, how deal with the varying responsibilities of DOTs? E.g., different road ownership between NJ and PA (Dave Kuhn, Kevin Gantt)
Interplay between national measures and regional, local concerns	How provide context for looking at performance results across states (e.g., system size, age, agency responsibility, budget, environment)

¹ Quoted Colin Powell's 40-70 rule which states that every time you face a tough decision you should have no less than forty percent and no more than seventy percent of the information you need to make the decision. If you make a decision with less than forty percent of the information you need you are shooting from the hip and you will make too many mistakes.

IV. Development of Research Project Topics

- Based on identified research needs, workshop participants developed 5 draft research projects (Note: highlighted topics indicate a high level of participant interest)

Topic #1: Using Performance Measures to Drive Organizational Change (28 votes)

Problem	Elements
<ul style="list-style-type: none"> Given the cultural resistance, structural barriers (aka “red tape”) and silos, how are agencies using performance measures to change business practices and behavior? PM in the end don’t matter if organizations don’t have processes to USE them... but is there a way to push this change? 	<ul style="list-style-type: none"> How have organization realigned to become “performance-driven” What procedures/processes have to change to become “performance-driven” Does which PM using matter? If so, which ones should agencies adopt and why? Document agencies that have changes to become performance drive: success & failures (e.g., how assure “owners” of PM that they are not solely responsible Gather lessons learned from private sector (especially those that are highly regulated)

Topic #2: Systematic Approach to Calculating Benefits of a Project (14 votes)

Problem	Elements
<ul style="list-style-type: none"> Unclear how to calculate multiple types of project benefits (e.g., delay, emissions, reliability, jobs lifecycle costs, other social/happiness/livability benefits) Once calculated, what is the best way to communicate the benefits? 	<ul style="list-style-type: none"> Method to calculate each benefit Data needed to calculate each benefits Tools to improve ease of calculations Effective and consistent communication techniques for expressing benefits to decision makers and the public How make outputs understandable

Topic #3: Creating the Correct Communication for Each Stakeholder (13 votes)

Note: this project combined three similar project proposals

Problem	Elements
<ul style="list-style-type: none"> People don’t understand “bang for buck” they get with transportation- why is our message not resonating? Lack of understanding what resonates with stakeholders With a better understanding, we can be more effective in our communication of performance results 	<ul style="list-style-type: none"> 3M: message, method , messenger What information do stakeholders want (e.g., conduct focus groups with elected officials, public, media) Test various forms of communication (Web, face-to-face, charts, infographics, PDF, interactive)to create a lexicon of what is most effective (by stakeholder) What frequency is appropriate and does this change by type of format? Stakeholder? Topic? Test what agencies using to discover, “are

	<p>stakeholders hearing what agencies think they are”? What is lost in translation? E.g. does red, yellow, green resonate?</p> <ul style="list-style-type: none"> – How does this change by scope (e.g., national, regional, city/town) – How does what the stakeholder wants related to what the agency wants to communicate (e.g., tradeoff across multiple measures) – Pull in lessons from communication specialists (marketing and branding professionals)
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Topic #4: Framework for Decision-Making Process (7 votes)

Problem	Elements
<ul style="list-style-type: none"> – Unclear linkage between the vast data we have and the decisions being made. – At times, it is uncertain the value performance information plays in decision making or how data should be used in the decision-making process? – Also unclear is when are data good enough for use in decision making? 	<ul style="list-style-type: none"> – Identify a range of decisions that would benefit from performance information – Make the case for “why” performance info would be beneficial (what are we trying to fix/solve?) – Next, what are the performance data needs for those specific decisions? What varies by decision scope (e.g., regional vs. project) – Provide guidance on what data investment necessary for decision (e.g., don’t want to invest \$1M for a \$15 decision) – Include best practices and case studies

Topic #5: Creating Context for Performance Results (5 votes)

Problem	Elements
<ul style="list-style-type: none"> – National comparison made incorrectly – We can actually learn from benchmarking—IF we know how to effectively compare – Lack of context to performance info results in damaging conclusions 	<ul style="list-style-type: none"> – What characteristics are the most important when comparing performance? (e.g., age, asphalt vs. concrete, weather, population density)? – Does the ability to compare across agencies vary by measure? – How to identify peer(s) for benchmarking? – How can results be normalized? – How respond to misleading and inappropriate national comparisons

V. Keynote Address: Carolyn Flowers, CEO- Charlotte Area Transit System (CATS)

- Performance management something we all should do (not b/c of MAP-21). Why?
 - Communicate to public how using public \$ (this especially true for CATS because of ballot based sales tax= tenuous situation)
 - Demonstrate can deliver large capital projects: CATS building a LR system so a lot of attention on agency (and last extension was over budget and late destroying public confidence)
 - Provides the means to tell YOUR side of the story
 - Articulate the impact agency decisions have on lives of individuals (personalize it) and on public officials (catering to them is important)
 - Create mode-neutral talking point for region. This is about transportation Not transit or highway. Charlotte has goals for both highway and transit
- CATS tried many means of communicating results (outcomes)
 - Before/after photos to show station area development (TOD) results
 - Infographics provide visual summary of project impacts
 - Catchy phrases e.g., “the truth about transit”
 - Calculate value capture- people listen to this number
 - Social media including twitter and facebook
- Performance management is all about telling a story

VI. Communicating and PM Resources and Practice Panel

- Nine agencies (listed below) with notable performance communication approaches gave a brief overview of recent activities. Note: Presentation slides can be found in the appendix

Scott Omer, Arizona DOT
John Selmer, Iowa DOT
Jason Firman, Michigan DOT
Mark Gieseke, Minnesota DOT
Machelle Watkins, Missouri DOT
Tamara Haas, New Mexico DOT
Erik Filhorn, Vermont AOT
Daniela Bremmer, Washington State DOT
Lori Richter, Wisconsin DOT

- Issues raised during presentation discussions:
 - Set up regular meetings between State DOTs and MPO/COG planners to establishing open lines of communication
 - Important to identify “who is the audience” I am trying to reach?
 - Through partnership can identify new resources (e.g., Maricopa Association of Governments is full of big-data Ph.D. folks—amazing source of data analysis)

- When reaching out to “non-DOT folks” need to figure out what is important to them and use their language. Ex: Time (everyone understands that)
- Maps an effective means of communicate a lot of information (e.g., snow plow operations impact, pavement condition)
- Infographics: more and more commonly used
- “help reveal the story by using data”
- Don’t restrict data access, instead make it visible to all and review it regularly = data will impact behavior
- Present data in a format that staff can act on (e.g., breaking down by time of data and location)
- You may be surprised who is using performance reports (e.g., MnDOT senior officials balked at the shift of an annual PM report to biannual because “it was the one place where could find results, explanation for results and list of what doing to improve)
- A shift is occurring from printed performance reports to web-based reports
- Next frontier: how to include transit performance in regional reports? WSDOT surprised how inclusion of transit changed the reception of their performance report
- Challenge we face: how to get the public to care about something they are not interested in?
- Think about where the public is interacting with your agency the most and put messages there (e.g., variable message sign on roads, banners on website, weave into media releases)
- Audit findings or external reports (e.g., GAO) can drive the adoption of performance
- Having different performance data published in different report is a sure fire way to erode public support. Get to ONE number for each measure.
- Publishing data will lead to it being cleaned (e.g., VTDOT database had a park-and-ride in the ocean- once published, this mistake quickly fixed) but don’t wait for perfect data or you will be waiting for a long, long time

VII. Development of Research Project Topics: Communication Focus

- Continuing the effort from earlier in the workshop, participants identified X additional research project topics that had a focus on communication. (Note: highlighted topics indicate a high level of participant interest)

Topic #6: Does It Pay to Communicate? (18 votes)

Problem	Elements
<ul style="list-style-type: none"> – Does communications have a return on investment – Does communication really make a difference or do other influences really “turn the rudder”? 	<ul style="list-style-type: none"> – Develop evaluation methods and techniques to estimate value of communications investment – How does this investment vary by audience? Which audience results in the highest return? – How will communication ROI vary by agency? One

	<p>size likely does not fit all</p> <ul style="list-style-type: none"> – Take real world examples to estimate how much agencies spent on communication efforts and what were the benefits (if they existed) – Build on existing communications research
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Topic #7: Communicating the Importance of Establishing Targets (10 votes)

Note: this could be combined with Topic # 5

Problem	Elements
– Publishing targets will become more common forcing agencies to deal with challenging situations (e.g., declining targets)	<ul style="list-style-type: none"> – Tips on how to explain declining targets, why targets will vary by state – Effective ways to engage stakeholder in the setting of targets – Explaining the impact of tradeoffs on target values – Evaluate using targets to manage expectations

Topic #8: Communicating Real Time Performance Data to Impact Customer Decisions (9 Votes)

Problem	Elements
– With the increased availability of real time data, research is needed to understand how this performance information can be presented to customers to impact decisions (e.g., changing departure time or route based on travel time reliability)	<ul style="list-style-type: none"> – Use market segmentation to identify different markets that we serve – What information do the different markets (people) really want and in what format? What level of personalization/interactivity is necessary? Does the format change by type of information? – Document DOT best practices – How address ADA? – Can this research inform conversations about operations costs/levels of service? – Build off of SHRP2: Effectiveness of different approaches to disseminating traveler information on travel time reliability (Project L14)

Appendix B. Workshop 2

TRB Annual Meeting (Washington, DC): TPM Research Roadmap Workshop, January 15, 2015 Meeting Notes

TPM Research Roadmap Workshop TRB Annual Meeting January 14, 2015

Workshop Agenda: Introduction (Hyun-A Park)

- Overview of the workshop
- Overview of the AASHTO SCOPM Research Roadmap project and status

AASHTO SCOPM Research Task Force Update (Coco Briseno)

- Overview of the AASHTO SCOPM Research Task Force activities

TRB Performance Measures Committee Research Update (Mara Campbell)

- Overview of the TRB Performance Measures Committee research-related activities

FHWA Transportation Performance Management Research Update (Mark Swanlund)

- Overview of the FHWA TPM research pipeline

Transportation Roundtable Research Session Update (Matt Hardy)

- Summary of TPM Roundtable research roadmaps sessions

AASHTO Annual Meeting SCOPM Research Workshop Update (Trish Hendren)

- Summary of the research roadmap workshop results

Break

Breakout Group A: Research Roadmap Mechanics (Christos Xenophontos)

- Review current set of research needs.
 - Review the current set of categories with identified set of research needs
 - Suggest improvements to the categories that will be used for the roadmap
 - Suggest improvements (add/delete sections, highlight priorities)

Breakout Group B: Research Needs Review and Research Statement Development (Mark Swanlund)

- Review the draft research needs identified to date
- Draft new research statements

Workshop Attendees:

The following are attendees who participated in the group exercises. There were additional attendees at the workshop who left after the presentation portion of the agenda.

Name	Organization
Susan Barker	Kansas DOT
Chad Baker	California DOT
Coco Brisano	California DOT
Mara Campbell	HERE
Tasha Clemons	FHWA
Pete Costello	INRIX
Jim Davis	NYSDOT
Gerardo Flintsch	Virginia Tech
Wayne Francisco	GHD
Matt Hardy	AASHTO
Anne Hartell	Vienna University of Economics and Business
Mike Harvey	Iowa DOT
Darryl Heid	Road Commission for Oakland County
Trish Hendren	Spy Pond Partners
Bill Hyman	TRB/SHRP2
Alex Jendzejec	Booz Allen Hamilton
William Johnson	Colorado DOT
Randy Lee	Oklahoma DOT
Lois Mandell	US GSA
John Moore	KYTC
Linda Narigon	Iowa DOT
David Ooten	Oklahoma DOT
Michael Pack	University of MD, CATT Lab
Hyun-A Park	Spy Pond Partners
Lori Richter	WisDOT
Alan Roland	DOT - Abu Dhabi, United Arab Emirates
Hamid Sadraie	Caltrans
Omar Smadi	Iowa State University
Mark Swanlund	FHWA
Matthew Swift	Oklahoma DOT
Nadarajah Swaneswara	FHWA
Muramatsu Tadahisa	Express Highway Research Foundation of Japan
Andrew Warren	Arkansas HTD
Robert Winick	Motion Maps

Brad Winkler	Michigan DOT
Christos Xenophontos	RIDOT
Connie Yew	FHWA

The workshop results are the collected and condensed items from the products of four workshop sessions addressing transportation performance management research needs:

- TPM Roundtable. November, 2013
- AASHTO Summer Meeting SCOPM/SCOP Roadmap Session. June, 2014
- TPM Roundtable. November, 2014
- TRB Roadmap Session. January, 2015

Results are organized into six categories:

- Measures;
- Data, Methods, and Analysis;
- Organizational and Institutional Issues;
- Implementation (including decision-making);
- Communication;
- Other

An alternative option for categories was suggested:

- Operations
- Tools/System Performance/Gap Competency/Ethics
- PM Decisions
- Stakeholder Wants/Need
- Regional Context

Appendix C. User Guide

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