

IMPROVING TRANSPORTATION SYSTEMS MANAGEMENT AND OPERATIONS (TSM&O)

Capability Maturity Model Workshop White Paper

Performance Measurement



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Executive Summary

Background

Research done through the Second Strategic Highway Research Program (SHRP 2) determined that agencies with the most effective transportation systems management and operations (TSM&O) activities were differentiated not by budgets or technical skills alone, but by the existence of critical processes and institutional arrangements tailored to the unique features of TSM&O applications. The significance of this finding has been validated in 40 State and regional self-assessment workshops using the Capability Maturity Model (CMM) and its six dimensions of organizational capabilities. This White Paper focuses on Performance Measurement as one of the central dimensions of capability needed to support effective transportation systems management and operations (TSM&O) – including collaboration with public safety agencies, MPOs, local government, and public-private partnerships. The Paper summarizes the TSM&O state-of-the-practice based on the Workshops and subsequent implementation plans developed at 23 sites selected by FHWA and the American Association of State Highway and Transportation Officials (AASHTO) as part of SHRP 2 Implementation.

Scope

The paper includes the following material:

- A description of the SHRP 2 research and Workshop process related to the institutional and process aspects of TSM&O including a description of the CMM Self-Assessment Framework and its application to the Performance Measurement dimension.
- A discussion of the state-of-the-practice regarding Performance Measurement in terms of their key elements including self-assessed capability level.
- A description of key synergies between Performance Measurement and the other dimensions of capability – and managers span of control to affect improvement.
- Best practice examples and references.
- Suggested actions to address Performance Measurement needs on a national level.
- An Appendix presenting the Common Implementation Plan Priority Actions for the Performance Measurement dimension.

State of the Practice Findings for Performance Measurement

Key findings from the workshops included:

Measures Definition

- **Policy visibility of performance.** Most states/regions are conscious of the impending requirements of MAP-21, and performance measures are much discussed in professional circles. All locations were at least in the stage of developing operations performance measures and most had started to compile them. Several agencies cited the need for guidance and standardization in performance measure development.
- **Performance measure definition.** Lack of performance measure definitions for weather, work zones, and signalized arterials was frequently mentioned as a problem. Performance measures for programs where multiple agencies are involved – such as incident management – is sometimes problematic.
- **Input, output, and outcome measures.** The agencies that defined outcome measures reported having reviewed the literature and observed what other agencies were doing, but a single reference for guidance was not used. As with output measures, the need for guidance and standardization of outcome was cited by several agencies.
- **Resources for Performance Measurement.** Obtaining funding for Performance Measurement is a challenge for some agencies. In some cases, upper management is not convinced of the need for it, and the funding must come from existing budgets. One promising trend observed in several State DOTs (and discussed in others) involved active use of an existing agencywide Performance Measurement office/unit or an intention to establish such a unit in response to the Performance Measurement requirements of MAP-21.

Data Acquisition

- **Existing data availability.** The availability of data for incident management activities varies among agencies. Some TSM&O units collect and “own” TIM data. In other agencies, TSM&O units are dependent on emergency responder CAD systems for TIM data. Freeway detector data also are widely available but not all agencies use them to develop congestion statistics (outcome measures). Work zone data are difficult to obtain. Work zones are usually overseen by other units within the agency (e.g., construction, capital projects) and might not be connected to other operations activities, even during implementation. As a result, they have their own processes.
- **Outsourcing.** Several agencies mentioned MAP-21 as a driving force behind travel-time/speed data acquisition. Private vendor vehicle probe data are becoming more widely available. Many suggested that they were looking into probe data not only to meet MAP-21 requirements but also to fill in gaps where detectors do not exist. Several agencies have existing contracts with traffic information providers, while others are investigating it, especially in response to meeting MAP-21 requirements.

Measures Utilization

- **Internal utilization.** Incident management and snow and ice control are the two areas where performance data are used for operational management. The high public visibility of road clearance conditions and operations has led many snow belt states to track and report clearance in real time. Some agencies conduct after-action review of incidents that are supported by the data, although the reviews drill down deeper into what caused problems and what worked well with the management of the incident. Traveler information program performance (e.g., web site hits and VMS messages) also was noted by several areas: usage statistics and trends were monitored, and in some cases influenced operational decisions in terms of system enhancements or upgrades.
- **External reporting.** Production of periodic performance reports was the most common use of performance measures, although not all agencies produced them. A few States included TSM&O-related activity measures – largely output data on external (web site) dashboards. Because of data availability and the ease of summarizing them, incident characteristics were by far the most frequent subject of performance reports. Travel time (congestion) based reports based on measured data were far more rare.
- **Management accountability.** Accountability for TSM&O program performance is in the early stages. Several States have incident clearance targets but conduct reviews only when the target (often 90 minutes) is exceeded. There were no instances described in workshops where DOT units were subject to performance reviews in this regard.
- **Comprehensive performance management program.** No agency has achieved a fully integrated Performance Measurement system that links inputs, outputs, outcomes, and targets into a formal TSM&O performance management process. Agency staff are aware of the importance of outcome measures to making the business case for TSM&O to decision makers and the public, but they have made very limited progress in considering the data and analytics related to outcome measures such as travel time, reliability, and safety.
- **Outsourcing of outcome measures.** Private sector probe data is seen by many States as a way of obtaining useful performance analyses. Several States are in the early stages of identifying outcome measures and acquiring probe data to support them. DOTs with extensive toll operations are capitalizing on tags as probes. A number of States and regions recognize the need to focus on Performance Measurement for arterial operations, although data availability is an obstacle.
- **Use of performance measures in business case materials.** Only a few agencies have prepared a TSM&O strategic plan that identifies TSM&O goals and objectives and develops performance measures that track progress towards them. Few agencies had any guiding documents of any kind (e.g., operations data business plan, Performance Measurement plan) to guide the development of the Performance Measurement that

was in place; most were done with minimal advance planning. Several agencies cited a need for guidance on conducting before/after evaluations of operations projects.

Synergism

Performance Measurement is especially interactive with the Business Processes and Collaboration dimensions. The Business Processes dimension should be used to define the Performance Measurement framework. This should be an ongoing process, not a single undertaking or a one-way link. Performance Measurement itself should evolve along with the other dimensions as more is learned about what types of measurement are needed. The Collaboration dimension is significant in that Performance Measurement needs to be consistent across departments and agencies. Collaboration is important to Performance Measurement in that it can “break down silos” of related but uncoordinated activities.

State and Regional DOT Implementation Plan Priorities

The leading participant-suggested actions for Performance Measurement include:

- Creating a comprehensive performance measurement system. This includes: linking performance measures to TSM&O goals; establishing common performance measure definitions; defining performance measures for all aspects of operations; linking output measures to outcome measures for system performance; specifying target setting procedures; identifying data sources to support performance measures; and software specifications for a formal monitoring system.
- Promoting operations in traditional planning and programming processes. This includes: integrating operations into planning documents; applying a common set of performance measures for all phases of the project development process; developing a modeling plan and tools for supporting TSM&O analysis; and specifying evaluation procedures for completed TSM&O projects.
- Developing a communication strategy for describing the benefits of TSM&O to upper management and the public.

Best Practices and National needs

This white paper describes example best practices and reference material regarding the implementation plan priority needs noted above. The paper also suggests supportive national actions to improve TSM&O Performance Measurement including: developing standard definitions and procedures for plan development, measures, data processing, target setting, and reporting; syntheses of best practices in performance measurement and management; a field test of a comprehensive operations performance management system. Important roles were seen for FHWA, AASHTO and the National Operations Center of Excellence in supporting these efforts.

1.0 TSM&O Capability Maturity Self-Assessment Program: General Background

Many State DOTs and regions have recognized the importance of more effective TSM&O to improving customer service and system performance. Best practice TSM&O is being developed as an integrated program to optimize the performance of existing multimodal infrastructure through implementation of systems, services, and projects to optimize capacity and improve the security, safety, and reliability of the transportation system.

1.1 TSM&O and the Capability Maturity Model

The Second Strategic Highway Research Program (SHRP 2) included a Reliability Focus Area that produced research and products on many important data, analytic, and design issues, as well as process and applications improvements. One project identified the institutional characteristics of the agencies with the more effective TSM&O activities.¹ This research determined that agencies with the most effective TSM&O activities were differentiated not by budgets or technical skills alone, but by the existence of critical processes and institutional arrangements tailored to the unique features of TSM&O applications. These processes and institutional arrangements are defined by six critical dimensions: business processes; systems and technology; performance measurement; agency culture; organization and staffing; and collaboration.

Using these critical dimensions, the research project adapted concepts from the Capability Maturity Model (CMM) – widely used in the Information Technology industry – to develop a self-assessment framework designed to help transportation agencies identify their current strengths and weaknesses and related actions needed to improve their capabilities for effective TSM&O – in effect, a roadmap for “getting better at getting better.”

1.2 CMM Self-Assessment Workshops

The TSM&O CMM framework has been used as the basis for the development of a facilitated one-day self-assessment workshop process for State DOTs and regions. The CMM workshops are intended to improve the effectiveness of TSM&O applications and activities by assisting the unit managers and key technical staff with day-to-day oversight of TSM&O-related activities, as well as DOT partners, including public safety agencies, MPOs, local governments, and the private sector.

The workshop framework provides a structured focus on the six dimensions of capability, together with a facilitated self-assessment process in which participants evaluate their current activities and arrangements according to criteria from the CMM framework defining levels of

¹ *Institutional Architectures to Improve Systems Operations and Management*, SHRP 2 L06, 2012.

capability. The current challenges and problems identified by workshop participants are used to identify actions needed to improve capability, which are subsequently embodied in an implementation plan to improve the effectiveness of TSM&O.

Senior agency leadership is involved in a pre-workshop briefing and their approval of the implementation plan is required as a precondition of Federal financial assistance for the SHRP2 Implementation Assistance program sites.

1.3 The Capability Maturity Self-Assessment Framework

The CMM self-assessment framework is structured in terms of six dimensions of capability. Three dimensions are process oriented:

- **Business Processes**, including planning, programming, and budgeting (resources);
- **Systems and Technology**, including use of systems engineering, systems architecture standards, interoperability, and standardization; and
- **Performance Measurement**, including measures definition, data acquisition, and utilization.

Three dimensions are institutional:

- **Culture**, including technical understanding, leadership, outreach, and program legal authority;
- **Organization and Staffing**, including programmatic status, organizational structure, staff development, and recruitment and retention; and
- **Collaboration**, including relationships with public safety agencies, local governments, MPOs, and the private sector.

For each of these six dimensions, the self-assessment utilizes four criteria-based “levels” of capability maturity that indicate the direction of managed changes required to improve TSM&O effectiveness:

- **Level 1 – “Performed.”** Activities and relationships largely ad hoc, informal, and champion driven, substantially outside the mainstream of other DOT activities.
- **Level 2 – “Managed.”** Basic strategy applications understood; key processes’ support requirements identified and key technology and core capacities under development, but limited internal accountability and uneven alignment with external partners.
- **Level 3 – “Integrated.”** Standardized strategy applications implemented in priority contexts and managed for performance; TSM&O technical and business processes developed, documented, and integrated into DOT; partnerships aligned.

- **Level 4 – “Optimizing.”** TSM&O as full, sustainable core DOT program priority, established on the basis of continuous improvement with top-level management status and formal partnerships.

This structure of critical key dimensions of capabilities and their levels as self-assessed was used as the basis for the determination of the current state of the practice in the Performance Measurement dimension as discussed in the sections that follow.

1.4 CMM Self-Assessment Workshops Analyzed

This white paper synthesizes findings, as of December 2014, from 23 of 27 sites selected by FHWA and AASHTO in 2013 as part of the SHRP 2 Implementation Assistance Program. These 23, listed in Table 1.1, include 19 State DOTs (statewide or district focus) and four regional entities (including two MPOs).²

Table 1.1 Self-Assessment CMM Workshop Locations Analyzed in this White Paper

Arizona	NOACA (Cleveland, OH)
California	Ohio
Colorado	Oregon
Florida District 5 (Orlando)	Pennsylvania
Georgia	Rhode Island
Iowa	South Dakota
Kansas District 5 (Wichita)	Tennessee
Maryland	Utah
New Jersey	Washington, D.C.
Michigan	Washington State
Missouri	Whatcom (Whatcom County, Washington)
NITTEC (Buffalo, NY)	

² For a detailed discussion of prior workshops and those selected for the SHRP 2 Implementation Assistance Program, see the Organizing for Reliability – Assessment and Implementation Plan Development Final Report.

2.0 Summary of All Capability Dimensions

As background to this discussion of the Performance Measurement dimension in this white paper, it is useful to understand all the CMM dimensions in terms of the comparative capability levels and related initiatives. Table 2.1 presents the range of self-assessment levels by CMM dimension and capability level for the 23 workshop locations analyzed in this white paper.

Table 2.1 Workshop Self-Assessment Levels Distribution by Dimension (23 Workshops)

Dimension	Capability Self-Assessment			
	Level 1 Performed	Level 2 Managed	Level 3 Integrated	Level 4 Optimizing
Business Processes	11	10	2	0
Systems and Technology	7	12	3	1
Performance Measurement	9	11	3	0
Culture	8	11	4	0
Organization and Staffing	8	9	6	0
Collaboration	4	12	6	1

Note: Workshop self-assessment scores were often augmented with a “plus” or “minus” or given as a fraction (e.g., 1.5). For the purpose of the exhibit, “pluses” and “minuses” were ignored and all fractions were rounded to a whole number (with one-halves rounded down).

Self-assessment “scoring” is subjective, is specific to each state/region, and represents the consensus of workshop participants. The scores cannot be used for cross-site comparison, as some states/regions were tougher self-graders than others were. Nevertheless, within a given state/region, the scores for each dimension appear to reflect the relative level of capability among the dimensions. However, certain general conclusions can be drawn:

- Most locations assessed themselves at the “performed” or “managed” level (often somewhere in between) for most dimensions.
- Only two locations rated themselves as Level 4 in specific dimensions.
- Only a few agencies indicated reaching the level of “integrated” on more than two dimensions.
- While the aggregate distributions among several dimensions were similar (see Figure 2.1), this result masks very different distributions within individual agencies; that is, strengths and weakness differed among agencies responding to varying conditions.

- Collaboration and Systems and Technology are the strongest dimensions; for Collaboration, this reflects in part the impact of recent FHWA incident management training and other collaboration outreach; for Systems and Technology, this reflects an advancement in technology deployment over the past 10–15 years.

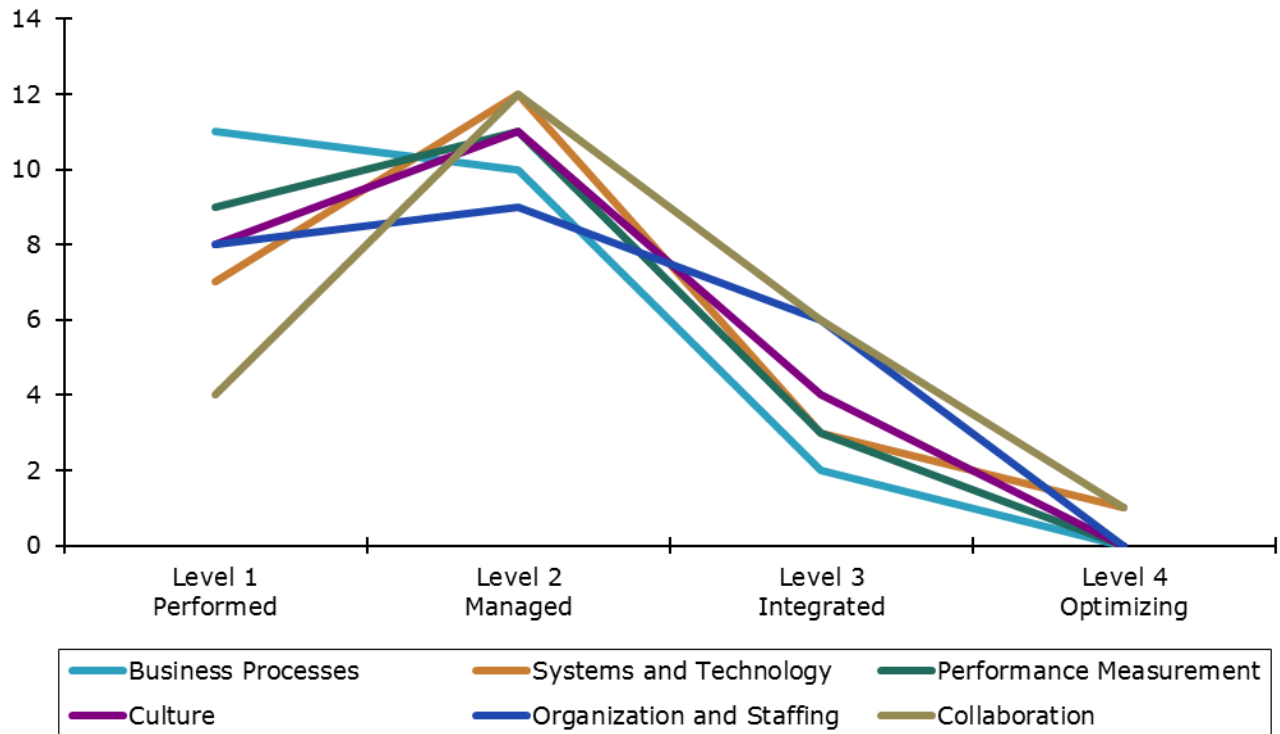


Figure 2.1 Graph. Distribution of Self-Assessments (23 Workshops)

(Source: Cambridge Systematics, Inc. and Parsons Brinckerhoff.)

Within a given dimension, there is often a significant gap between best practice and average practice among states/regions. Even within individual states/regions, progress in improving capabilities across the six dimensions is uneven. In many cases, however, there is visible change and strong staff leaders that are fully aware of what best practice is and are working within their institutions to develop essential capabilities.

2.1 Synergies among Dimensions of Capability

One of the most important findings of the SHRP 2 research, clearly validated in the workshops, was the apparent synergy among technical and institutional dimensions, as suggested in Figure 2.2. The dimensions of capability appear to be highly interdependent, such that it is difficult to improve a current level of capability in one dimension without simultaneously improving other dimensions that support it. This is reflected by the narrow spread in capabilities found among all workshops. As examples, workshop participants noted that

strategic planning is hampered by lack of performance data; business processes were hampered by lack of staff capabilities; and reorganization was impossible without top management buy-in (Culture).

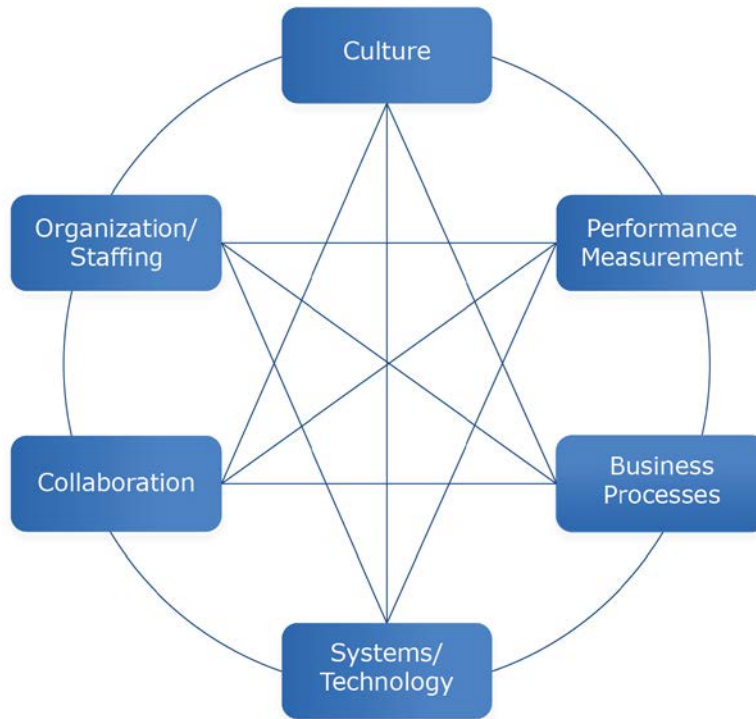


Figure 2.2 Graph. Synergy among Dimensions of Capability

(Source: Cambridge Systematics, Inc. and Parsons Brinckerhoff.)

2.2 General Implementation Plan Priorities for All Six Dimensions

Essential actions and products identified through the workshop and implementation plan process are presented below to establish some context regarding consideration of implementation plan recommendations for all six dimensions from the 23 workshops. A wide variety of actions are recommended across the six dimensions, including plans, processes, agreements, business cases, and organizational and staffing recommendations, each of which has a mutually reinforcing effect on overall capability.

Business Processes

- Develop a statewide/regional TSM&O program plan
- Integrate TSM&O into the conventional State and metropolitan planning process

Systems and Technology

- Update both regional and statewide system architectures for new/emerging TSM&O applications
- Improve ITS systems procurement process and/or relationships with agency IT unit

Performance Measurement

- Develop a plan for performance measures, data, and analytics
- Secure agreement from the public safety community on measures for incident management

Culture

- Develop a persuasive business case for TSM&O
- Develop a communications/outreach plan/branding for stakeholders

Organization and Staffing

- Define an appropriate organizational structure for the TSM&O program
- Identify core capabilities needed and develop related staffing and training plan

Collaboration

- Improve collaboration related to TIM including participating in TIM training and establishing a forum for building interagency relationships

Align partners' TSM&O objectives and interact on a regular basis

3.0 State of the Practice for the Performance Measurement Dimension

3.1 The Performance Measurement Dimension

Performance Measurement is the means of determining the effectiveness of organizational activity using tools such as measures definition, data acquisition, and measure utilization. It both establishes the framework for conducting performance measurement and applies those tools. Performance Measurement is fundamental to all other capability dimensions in that it identifies how well an organization is delivering operations services and identifies areas that need improvement. Performance measurement for operations encompasses several aspects of mobility, including congestion level and travel time reliability. The capability-level criteria used in the self-assessments for this dimension are shown in Table 3.1.

Table 3.1 Self-Assessment Workshop Levels of Capability Maturity for Performance Measurement

Performance Measurement Criteria for Level Achievement	
Capability Level 1	Some output-level performance is measured and reported by some jurisdictions
Capability Level 2	Output-level performance measures are used directly for after-action debriefings and improvements; data easily available and “dashboarded”
Capability Level 3	Outcome-level measures identified (networks, modes, impacts) and routinely utilized for objective-based program improvements
Capability Level 4	Output and outcome performance measures reported internally for utilization and externally for accountability and program justification

Among the 23 workshops, the average self-assessed capability for Performance Measures is 1.92, with nine sites at Level 1, 11 sites at Level 2, and three sites at Level 3. Figure 3.1 indicates Performance Measurement assessment relative to the other dimensions.

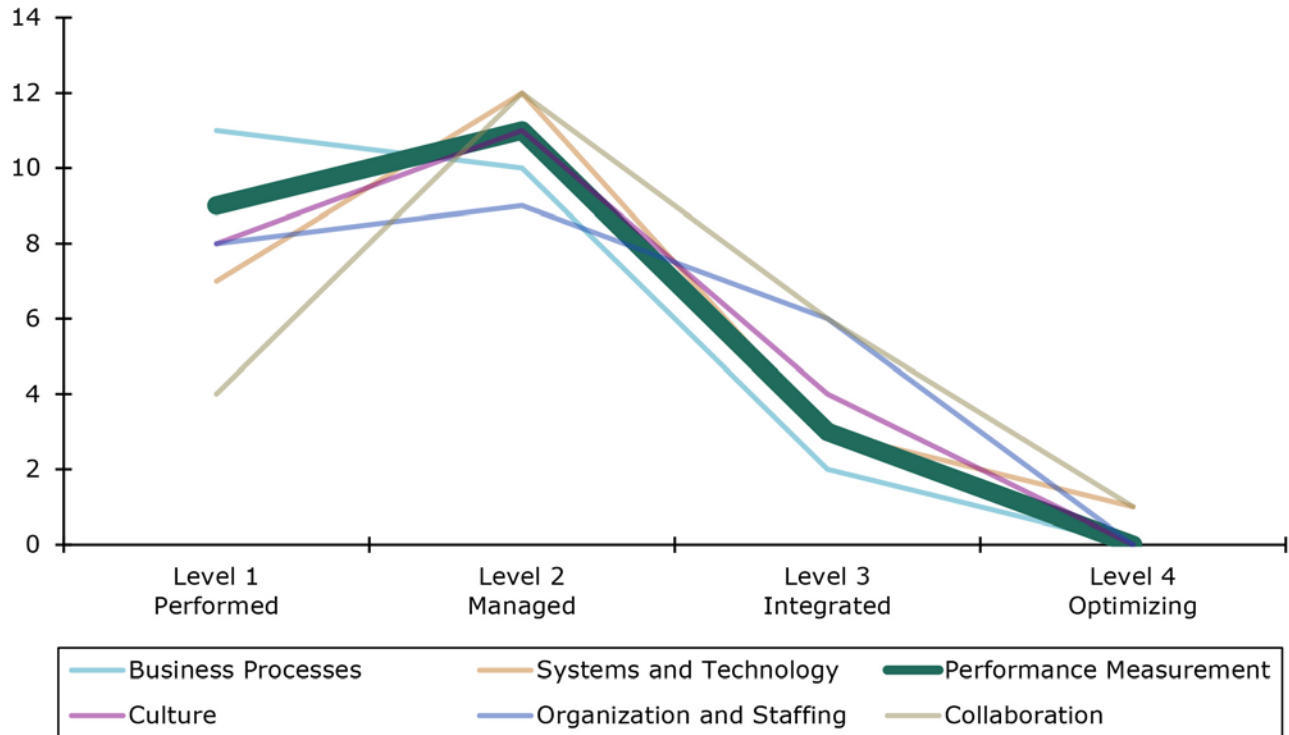


Figure 3.1 Graph. Performance Measurement Compared to Other Dimensions of Capability

(Source: Cambridge Systematics, Inc. and Parsons Brinckerhoff.)

The discussion of the state of the practice regarding the Performance Measurement Dimension below is divided into key elements, based on the approach used in the *AASHTO Guide to Systems Operations and Management*:

- Measures definition;
- Data acquisition; and
- Measures utilization.

The material that follows discusses important observations regarding the current state of play in each key element.

3.2 Measures Definition

- **Policy visibility of performance.** Most states/regions are conscious of the impending requirements of MAP-21, and performance measures are much discussed in professional circles. All locations were at least in the stage of developing operations performance measures and most had started to compile them. With a few exceptions, the measures were limited to output measures, with the vast majority being related to TIM, probably

because of the availability of data from incident management logs and the focus on TIM programs and strategies that is emerging across the country. The TIM output measures were relatively consistent in their definitions as they mostly relate to the “incident timeline,” but subtle differences in defining when a specific TIM activity starts and stops were present (e.g., what signifies the end of an incident: all lanes open, all emergency vehicles absent, or return to normal traffic?). Several agencies cited the need for guidance and standardization in performance measure development.

- **Performance measure definition.** Lack of performance measure definitions for weather, work zones, and signalized arterials was frequently mentioned as a problem. The most easily accessible performance measures identified in the workshops relate to freeways, probably due to data availability, a longer history of freeway measurement nationwide, and the fact that State DOTs (a key target audience for the workshops) are largely focused on freeway operations. Even with consistent definitions, obtaining data for performance measures in these areas will be a challenge. Performance measures for programs where multiple agencies are involved – such as incident management – is sometimes problematic. DOTs and public safety agencies may hold themselves to different standards regarding the stages in incident management (i.e., how the incident “timeline” is defined), and sometimes how the stages are defined may differ. Ownership of measures also can be a challenge in getting consensus on measure definition, especially when multiple agencies are involved and one agency decides to define specific measures for processes that they do not necessarily “own.” This can be a special problem for State DOTs that are dependent on law enforcement CAD data.
- **Input, output, and outcome measures.** The agencies that defined outcome measures reported having reviewed the literature and observed what other agencies were doing, but a single reference for guidance was not used. As with output measures, the need for guidance and standardization of outcome measures was cited by several agencies. A few agencies noted a disconnect between operations units and planning units in terms of performance measures, i.e., different measures are used. At least two agencies identified the need to track assets (“input” performance measures in the literature) in addition to outputs and outcomes. They view the hard assets as critical to providing operations services and need better data to support maintenance and replacement budgeting decisions.
- **Resources for Performance Measurement.** Obtaining funding for Performance Measurement is a challenge for some agencies. In some cases, upper management is not convinced of the need for it, and the funding must come from existing budgets. One promising trend observed in several State DOTs (and discussed in others) involved active use of an existing agencywide Performance Measurement office/unit or an intention to establish such a unit in response to the Performance Measurement requirements of MAP-21. Responsibility for various measures and measure reporting was often allocated to multiple units within an agency, and a unit not connected with TSM&O is often responsible for reporting performance agencywide.

3.3 Data Acquisition

- **Existing data availability.** The availability of data for incident management activities varies among agencies. Some TSM&O units collect and “own” TIM data. In other agencies, TSM&O units are dependent on emergency responder CAD systems for TIM data. Freeway detector data also are widely available but not all agencies use them to develop congestion statistics (outcome measures). Work zone data are difficult to obtain. Work zones are usually overseen by other units within the agency (e.g., construction, capital projects) and might not be connected to other operations activities, even during implementation. As a result, they have their own processes. Another issue is that the nature of a work zone is constantly changing (e.g., number of lanes closed) and it is difficult to obtain information about when these changes occur so that they can be correlated with changes in travel-time performance. Even if a documentation process exists, contractors might not report the changes that allow for accurate tracking.
- **Outsourcing.** Performance data (e.g., volumes and speeds) from agency owned field equipment is widely available and can be used for developing outcome measures. Maintenance and replacement of the field equipment is expensive, leading some agencies to investigate the use of private vendor travel time data for use in both operations strategies and performance measurement. Several agencies mentioned MAP-21 as a driving force behind travel-time/speed data acquisition. Private vendor vehicle probe data are becoming more widely available. Many suggested that they were looking into probe data not only to meet MAP-21 requirements but also to fill in gaps where detectors do not exist. Several agencies have existing contracts with traffic information providers, while others are investigating it, especially in response to meeting MAP-21 requirements.

3.4 Measures Utilization

- **Internal utilization.** Incident management and snow and ice control are the two areas where performance data are used for operational management. The high public visibility of road clearance conditions and operations has led many snow belt States to track and report clearance in real time. Regarding incident management, while many States collect basic incident data (number, type, location, type) and several report clearance times, including externally, only a few make routine use of the data to modify incident management programs. Some agencies conduct after-action review of incidents that are supported by the data, although the reviews drill down deeper into what caused problems and what worked well with the management of the incident. One agency noted there is reluctance to conduct these reviews because of fear that blame will be assigned. Traveler information program performance (e.g., web site hits and VMS messages) also was noted by several areas: usage statistics and trends were monitored, and in some cases influenced operational decisions in terms of system enhancements or upgrades. The development of outcome measures is impeded by limitations on the availability and integration of multisource data. While there are some good examples (RITIS from University of Maryland or RADS from Arizona), many areas struggle to efficiently acquire, integrate, and use multisource data for performance measures.

Agencies are struggling to decipher how to use performance measures in the decisionmaking process. A common theme among all workshops was that performance measures are not substantially integrated into the decisionmaking process, and that this is likely the most difficult barrier to overcome. Sometimes minor changes in practice are made based on performance measure information – such as increasing service patrols or identifying congested locations for ramp meters – but performance measures are not used at the program level to determine funding levels or emphasis areas. Along the same lines, no agencies have used performance measures to develop a composite picture of congestion – such as the “congestion pie” – that could help guide program and project investment levels holistically. When agencies move beyond TIM performance measures, the requisite data management and analysis tools become more complex to develop and maintain.

- **External reporting.** Production of periodic performance reports was the most common use of performance measures, although not all agencies produced them. A few states included TSM&O-related activity measures – largely output data on external (web site) dashboards. Because of data availability and the ease of summarizing them, incident characteristics were by far the most frequent subject of performance reports. Travel time (congestion) reports based on measured data were far more rare, but many states are in the process of developing them. In a few cases, the operations agencies developed congestion reports based on field data from detectors (limited to freeways). In other cases, other units or agencies develop the congestion report, in which case, the uses of the products were not integrated. There was general agreement that the use of private vendor data offers great potential for future congestion reports, as it is not limited to freeways with roadway detectors. Agencies that have produced performance reports are frustrated that the public doesn’t seem to understand them or appreciate how they relate to their experiences, highlighting the need to find more effective ways of communicating performance measures. One possibility may be because performance reporting currently is done from the facility perspective, while travelers experience the system through complete trips. Conducting customer surveys related to the delivery of operations services is rare, and when it is done, it is not done periodically but as a one-time study, or operations services are included as a small part of a broader agency customer relations survey. At least one agency collects customer feedback from service patrol assists.
- **Management accountability.** Accountability for TSM&O program performance is in the early stages. Several states have incident clearance targets but conduct reviews only when the target (often 90 minutes) is exceeded. There were no instances described in workshops where DOT units were subject to performance reviews in this regard. A few states report using Performance Measurement on specific major projects such as corridor improvements. These instances can present opportunities, such as to expand a successful work zone performance measurement and reporting initiative (e.g., travel times, safety), in part by leveraging the demonstrated success of the initiative to secure required resources and technical support.

- **Comprehensive performance management program.** No agency has achieved a fully integrated Performance Measurement system that links inputs, outputs, outcomes, and targets into a formal TSM&O performance management process. Agency staff are aware of the importance of outcome measures to making the business case for TSM&O to decision makers and the public, but they have made very limited progress in considering the data and analytics related to outcome measures such as travel time, reliability, and safety. Part of the reason is that these outcomes also are affected by other programs, such as capacity expansion, demand management, alternative mode use, and safety countermeasures. It is clear that outcomes must be managed on an cross-jurisdictional basis, but this has not occurred.
- **Outsourcing of outcome measures.** Private sector probe data is seen by many states/regions as a way of obtaining useful performance analyses. It appears that the need for progress in this area has inhibited staff from making the business case for TSM&O benefits on either a stand-alone or alternative investment basis. Several states are in the early stages of identifying outcome measures and acquiring probe data to support them. DOTs with extensive toll operations are capitalizing on tags as probes. A number of states and regions recognize the need to focus on Performance Measurement for arterial operations, although data availability is an obstacle.
- **Use of performance measures in business case materials.** Only a few agencies have prepared a TSM&O strategic plan that identifies TSM&O goals and objectives and develops performance measures that track progress towards them. Few agencies had any guiding documents of any kind (e.g., operations data business plan, Performance Measurement plan) to guide the development of the Performance Measurement that was in place; most were done with minimal advance planning. Several agencies cited a need for guidance on conducting before/after evaluations of operations projects. Such guidance ideally would include information regarding how to package the results to highlight the benefits of operations to management and the public. Demonstrating benefits of operations seemed to be a motivation for several agencies to undertake Performance Measurement in the first place. There is a desire to use consistent measures across all agency functions.

4.0 Relationships to Other Capability Dimensions

4.1 Synergy

All of the TSM&O dimensions are synergistic and therefore each one is an essential focus of improving capability. It was apparent from the workshops that Performance Measurement is integrated with the other CMM dimensions. As shown in Figure 4.1, Performance Measurement informs the other dimensions about how well their actions are succeeding or failing.

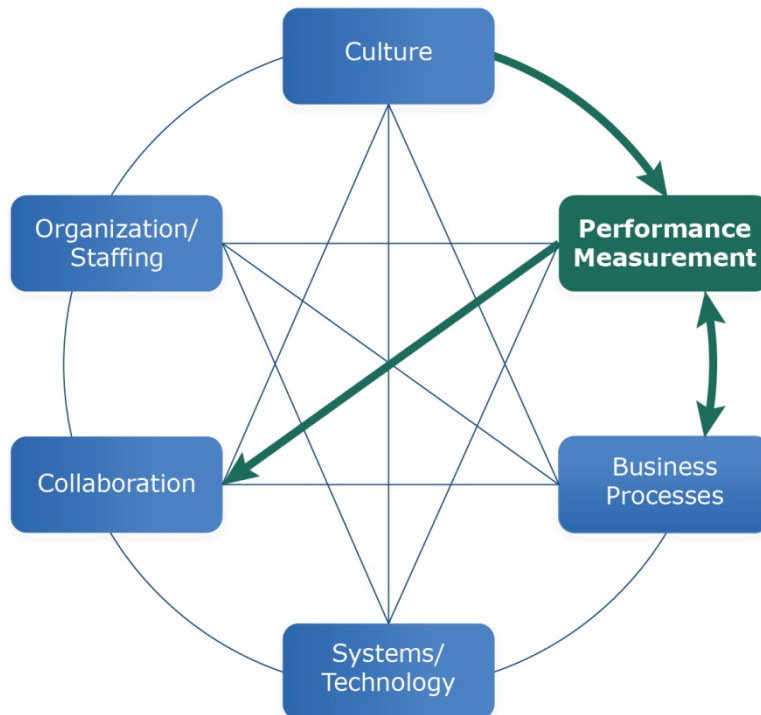


Figure 4.1 Graph. Key Synergisms between Performance Measurement and Other Dimensions

(Source: Cambridge Systematics, Inc. and Parsons Brinckerhoff.)

At the top level, outcome measures indicate the general health of agencies' actions. Output measures identify specific actions that need to be modified. While this performance information is common to all dimensions, certain relationships have special characteristics:

- The Business Processes dimension is unique in that it should be used to define the Performance Measurement framework. This should be an ongoing process, not a single undertaking or a one-way link. Performance Measurement itself should evolve along with the other dimensions as more is learned about what types of measurement are needed.

- The Collaboration dimension is significant in that Performance Measurement needs to be consistent across departments and agencies. Collaboration is important to Performance Measurement in that it can “break down silos” of related but uncoordinated activities. Nowhere was this more important than in the State DOT/MPO relationship, where measures that support operations planning would benefit from close collaboration. Collaboration with emergency responders also is required to develop common performance measures in order to share data.

4.2 Span of Control

The workshops focused on middle management involved with TSM&O. This kind of staff is typically at the third or fourth level within a State DOT headquarters, second or third level in DOT districts/regions, and specialized staff in MPOs. These individuals have responsibility for visible functions such as TMC operations, incident management, or snow and ice control. Often because of their lack of formal authority, some of the more effective individuals are seen by their peers as “champions” whose influence is exerted through energy, experience, agency knowledge, and long-standing relationships.

Performance Measurement is an area that, in concept, is substantially within the span of control of middle management, with some resource support from upper management and in some cases, explicit encouragement. Output (activity) measures directly monitor the day-to-day activities of operations personnel, and thus can indicate where changes need to be made. An important challenge remains the coordination of outcome measures for organizations that have a stake in improving mobility performance, including planning and capital programs.

5.0 Implementation Plan Capability Improvement Actions

All agencies included some aspect of Performance Measurement in their implementation plans to improve agency capability, including the need to match performance measures with TSM&O goals and objectives. Those agencies that had developed some form of Performance Measurement did so on an ad hoc basis with no linkage to the overall vision of their TSM&O program. Specifically, the mechanism for incorporating performance measures was their inclusion in the TSM&O Strategic Plan. Because the strategic plan is a high level document, additional types of supporting documents also were cited as necessary for implementation of a Performance Measurement program; these include a TSM&O data business plan and TSM&O Performance Measurement plan (or similar name). Topics that would be covered in these documents include the following:

- Linking performance measures to TSM&O goals and objectives (performance measures should be used to track progress toward meeting goals, objectives, and targets).
- Establishing common performance measure definitions for internal partners (planning and construction) and external partners (emergency responders).
- Defining performance measures for all aspects of operations, including TIM, weather, work zones, and signal operations.
- Linking output measures to outcome measures for system performance, that is, understanding how changes in operations-related output measures affect system performance.
- Promoting operations in traditional planning and programming processes, especially integrating them into formal documents (e.g., long-range transportation plan, transportation improvement program).
- Applying a common set of performance measures for all phases of the project development process, from initial planning to final evaluation.
- Reporting formats, including dashboards.
- Strategy for integrating and using TSM&O performance measures in agency decisionmaking processes
- Data collection, management, and system development, including identification of data sources and the filling of data gaps in the data; as software is required for a Performance Measurement system, additional documents would be required to identify architecture, system design, and functional requirements. Data management also includes validation, quality control, aggregation, and accessibility to a wide range of users.

- Developing a modeling plan and tools for supporting TSM&O analysis
- Specifying evaluation procedures for completed TSM&O projects so that analyses are done consistently and results are transferrable
- Communication strategy for describing the benefits of TSM&O to upper management and the public
- Specifying target setting procedures.

5.1 Integration of Performance Measures into Decisionmaking

A major area with which agencies seem to struggle was the integration of TSM&O performance measures into investment decisionmaking at all levels. Agencies know they need to do this but are unsure how to proceed. Several agencies noted that the MAP-21 requirements are spurring interest in Performance Measurement in general, and that this interest should be leveraged for implementing TSM&O Performance Measurement. As a result of the MAP-21 requirements, many are investigating the purchase and use of private vendor probe data for the development of outcome measures. The question of how to use outcome and output measures in decisionmaking is problematic to agencies, however. There is little precedent, and the best approach depends on the institutional structure of the agency and the degree to which other units support TSM&O. As a starting point, performance measures were identified for use in project selection, prioritization, and resource allocation. TSM&O performance measures also should be used as a basis for identifying investments in several related functions:

- Long-range planning in coordination with MPOs
- TSM&O deployment planning
- Annual program plans.

5.2 Performance Information to Support the TSM&O Business Case

A commonly expressed motivation for undertaking Performance Measurement in the first place was to justify TSM&O programs. Agencies felt that their programs have positive benefits but it was difficult to explain them because TSM&O projects “don’t have ribbon-cutting” and the public doesn’t associate largely invisible TSM&O actions with congestion improvements. In the absence of the visibility and higher impact of capacity expansion projects, performance measures are seen as a way to get the TSM&O “story” across. Even in cases where agencies had published performance measures showing the positive effect of TSM&O, the message was difficult to convey. Improved communication procedures would be a big help. In the few cases where customer surveys exist, they are not focused on TSM&O activities but rather agencywide performance; questions about the details of TSM&O activities are rare in these surveys. It was recognized that customer surveys can be a significant way to communicate the effectiveness of TSM&O; however, little guidance exists on how to design and conduct customer surveys specifically targeted to the topic of TSM&O.

5.3 Alignment of Measures with Partners

Coordination of Performance Measurement activities with internal (and especially external) partners was another common theme in the Implementation Plans. It was recognized that TSM&O performance programs were developed largely in a vacuum and that many other departments and agencies are involved in tracking various aspects of transportation system performance. It also was recognized that data from outside groups could be leveraged for TSM&O needs, highlighting the need to disseminate performance data and measures to partners.

Internally, examples of units requiring coordination for Performance Measurement are planning and programming, those responsible for work zones (construction and maintenance), and signal operations (if a different group does this). Externally, emergency responders (police and fire) and MPOs have a stake in coordinating Performance Measurement activities. For example, police CAD systems generate data usable for TSM&O purposes. Many MPOs routinely develop congestion reports (outcome related); many have purchased their own data.

5.4 “Learning as You Go”

A strong desire existed to observe and learn what TSM&O departments in other agencies were doing. Clearly, the profession is at the beginning of the Performance Measurement era and there is little precedent for how to structure a program. Also, some degree of experimentation is needed. As a result, many implementation plans suggested that peer-to-peer exchanges be undertaken.

Likewise, because comprehensive performance management has not been undertaken (the highest scores of “3” were achieved by only three agencies), several agencies identified the need “to start small.” Several suggested developing a pilot program in a region or selected priority corridors. Others wanted to do a staged approach to full implementation, building that approach into their Performance Measurement planning documents.

6.0 Best Practice Examples

As noted above, most CMM workshop sites have undertaken some degree of TSM&O Performance Measurement. Most of the activities are rudimentary, however, focusing on producing, but not fully utilizing, performance measures. Most of the TSM&O Performance Measurement production focused on incident data, primarily because these data are simple, not too voluminous, and collected directly by TSM&O units or easily obtained through emergency responder CAD systems. That said, several states had advanced beyond their peers and serve as guideposts for others.

Georgia DOT (GDOT). GDOT has a relatively comprehensive program that encompassed several (but not all) Performance Measurement functions. GDOT has a long history of publishing weekly and monthly reports on TSM&O activities. The focus of the reporting is TIM characteristics but other aspects also are covered, including 511 calls, GDOT traveler information web site “hits,” and device health. They have used the incident performance data to adjust service patrol intensity and duration in corridors. GDOT has not yet integrated these output-related measures with outcome (travel time-based) measures, but they have used travel time data from their detectors to identify bottlenecks and to locate potential locations for ramp metering. They also are using commercially provided travel time data to fill in gaps and as a basis for their Regional Traffic Operations Program (RTOP), which is heavily oriented to signalized arterials. Perhaps the Performance Measurement area where GDOT is the strongest is evaluations. Whenever GDOT implements a new TSM&O strategy, the agency evaluates its effectiveness. These evaluations include benefits assessments for use in justifying TSM&O programs. GDOT’s extensive and highly maintained detector network enables these evaluations to take place. GDOT has also developed an agencywide performance dashboard. It includes a TSM&O measure (service patrol response time) and summary outcome measures for congestion. The front page of the dashboard allows users to drill down to obtain details regarding each top-level measure.

Maryland SHA (MSHA). MSHA has a long-standing TSM&O Performance Measurement program (currently limited to freeways). The program has overcome many of the obstacles faced by agencies, but the major limitation was incorporating performance measures into investment decisions at multiple levels, which, as pointed out above, is a particularly difficult problem to rectify both technically and institutionally. MSHA historically had a very strong output-level Performance Measurement program in the form of its CHART program, which has published annual performance reports for over a decade. The CHART reports included an assessment of the benefits of CHART activities, but this assessment was based on modeling rather than measurement. MSHA now includes outcome measures in its reporting, primarily based on vehicle probe data obtained through the I-95 Corridor Coalition. The Annual Mobility Report includes both outcome congestion measures and a separate section on TIM performance. Congestion performance reporting had been limited to freeways but is being expanded to include signalized arterials. The same data are used to inform discussions with the State legislature on funding, a good example of a data-driven process.

Washington State DOT (WSDOT). From an agencywide perspective, WSDOT has been a national leader in Performance Measurement for many years. Its *Gray Notebook* is often cited as the best example of performance reporting done by State DOTs. In general, Performance Measurement data are effectively utilized in programming and long-term planning at WSDOT. The TSM&O program has successfully used operational outcome data to secure more funding for additional TSM&O projects. WSDOT also has started to set performance targets for many activities, such as incident clearance.

Despite the presence of the exemplary *Gray Notebook* and other positive aspects of the Performance Measurement program, however, the TSM&O Performance Measurement program faces challenges. Workshop participants' assessment of the program was better than the average of other workshops, but some noted that performance measures were not substantially integrated into the decisionmaking process (a common theme among all workshops and the most difficult barrier to overcome). No set of common performance measures exists for characterizing TSM&O outcomes. Tactical decisions use some Performance Measurement data, but some systems and processes could more effectively utilize the available data. The linkage between the performance information in the *Gray Notebook* and decisions about specific investments is tenuous, reflecting a need to go beyond performance reporting to a fully integrated Performance Measurement program.

7.0 Addressing Needs on the National Level

The workshop assessments of agency weaknesses and the resulting Implementation Plan actions provide a basis for recommending an agenda of needs for research, guidance and training. A variety of mechanisms can be used to implement the agenda, including FHWA, NCHRP, and pooled fund studies. Suggestions are presented below in Table 7.1. Many of the suggestions coincide with projects identified in FHWA’s Operations Performance Measures and Management (OPMM) Program Road Map;³ these are noted by OPMM project number. As most of the OPMM projects are still in the development phase, these suggestions, as well as the findings elsewhere in this document, should be used when the scopes of OPMM projects are finalized. FHWA may want to consider revising the OPMM scopes as they currently exist using the insights gleaned from the workshops.

Table 7.1 Suggested National Activities to Support Improvements in Performance Measurement

Activity	Performance Measurement Element	Sponsor(s)	Comments
Develop checklist for developing a TSM&O Performance Management Plan	Measure definition	FHWA	Assimilate current best examples; produced a template/ prototype document
Develop standardized definitions for a wide range of TSM&O performance measures covering TIM, work zones, weather, and signalized arterials	Measure definition	FHWA OPMM #12 and #17; possible AASHTO or ASTM if formal standards are to be produced	Some efforts currently underway (e.g., NUG) but do not cover all relevant measures, just a common core; more guidance is needed especially in coordination of both outcome measures (e.g., MPOs, MAP-21 measures) and output measures (e.g., emergency responders)
Develop standardized procedures for conducting TSM&O evaluations	Measure utilization	FHWA OPMM #14	Some guidance developed in SHRP 2 L17 but needs further methodology work and case studies

³ <http://www.ops.fhwa.dot.gov/publications/fhwahop14012/index.htm>

Activity	Performance Measurement Element	Sponsor(s)	Comments
Develop guidance on TSM&O performance target setting	Measure utilization	FHWA OPMM #4	Coordinate with target setting procedures in other functional areas; explore analytical methods available and how to conduct consensus exercises
Document best practices for communicating TSM&O performance	Measure utilization	FHWA OPMM #13	Needs to move beyond what “best” agencies are doing and adapt methods from other sectors
Develop guide to TSM&O data acquisition, management, and analysis methods	Data acquisition	NCHRP or FHWA	Include requirements for a prototype system; incorporate standardized procedures noted above; identify alternative strategies for data acquisition especially from other agencies or units, including best practice case studies
Conduct Peer-to-Peer Exchange on TSM&O Performance Measurement	Measure definition, data acquisition, and measure utilization	FHWA	Formal program with a set number of annual exchanges
Document best practices in using TSM&O performance measures in investment decisionmaking	Measure utilization	NCHRP or Pooled Fund	Conduct scan for best practices and enhance as necessary; feed results into field test
Conduct field test of TSM&O performance measures in decisionmaking	Measure utilization	FHWA	Follow-on to above study; fund an agency to design and implement a model procedure for fully utilizing TSM&O performance measures for decisionmaking; include both long-range and short-range activities; include development of a comprehensive and linked PM program: inputs, outputs, outcomes, and targets

8.0 References

AASHTO TSM&O Guidance: Performance Measurement Dimension. AASHTO's web-based TSM&O Guidance follows the six dimensions of TSM&O capability described in this white paper, including Performance Measurement. It is designed for transportation agency managers whose span of control relates to the operations and management of the roadway system, including policy makers and program managers for ITS and TSM&O at both the State and regional level. It incorporates insights from a review of the state of the practice in TSM&O among transportation agencies into a well-accepted change management framework that identifies doable steps toward mainstreaming TSM&O on a continuously improving basis. Specific guidance for performance measurement is cited here for advancing an agency currently at Level 1 to Level 2 within the CMM framework. Other level changes within the framework can be found on the [AASHTO TSM&O Guidance web site](http://www.aashtotsmoguidance.org/guides/PM_L2.pdf).

http://www.aashtotsmoguidance.org/guides/PM_L2.pdf

Establishing Monitoring Programs for Mobility and Travel-Time Reliability, SHRP 2 Project L02. Presents procedures for managing and processing data for performance measures as well as some technical ways of presenting performance information.

<http://www.trb.org/Main/Blurbs/168764.aspx>

Incorporation of Travel Time Reliability into the Highway Capacity Manual, SHRP 2 Project L08. Defines a family of performance measures and provides a method for predicting travel time reliability.

<http://www.trb.org/Main/Blurbs/169594.aspx>

Washington State DOT Gray Notebook. Agencywide performance report with advanced graphics and explanations. Very good trend presentations.

<http://www.wsdot.wa.gov/accountability/>

NCHRP Web-Only Document 97: Guide to Effective Freeway Performance Measurement: Final Report and Guidebook. Background on the data and measures that need to be developed. An early reference that is a bit dated but still has the fundamentals.

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_w97.pdf

A Guidebook for Standard Reporting and Evaluation Procedures for TSM&O Strategies, prepared for SHRP 2 Project L17. Presents evaluation procedures, but methodology is incomplete (needs to cover experimental controls more expansively and needs an example).

http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_L17_Gap-Filling_Project_4_GuidebookForStandardReportingAndEvaluationProceduresFor_TSM&O_Strategies.pdf

NCHRP Report 666, *Target-Setting Methods and Data Management to Support Performance-Based Resource Allocation by Transportation Agencies, 2010.* Describes how agencies currently do target setting and how they can improve.

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_666.pdf

NCHRP 8-70 – Target-Setting Methods and Data Management To Support Performance – Based Management Resource Allocation by Transportation Agencies. Additional description of target setting procedures, focusing more heavily on data.

<http://www.trb.org/Publications/Blurbs/164178.aspx>

Traffic Incident Management Performance Measures Final Report, FHWA. Provides a set of standard measures and procedures for TIM Performance Measurement.

<http://ops.fhwa.dot.gov/publications/fhwahop10010/index.htm#toc>

Performance Measures for Traffic Signal Systems: An Outcome-Oriented Approach. In-depth look at the full array of performance measures needed to manage, improve, and document signal and signalized arterial performance.

<http://docs.lib.purdue.edu/jtrpaffdocs/3/>

Performance Measures Course. Provided by the University of Maryland’s Consortium for ITS Training and Education (CITE). Covers the essentials of TSM&O Performance Measurement.

<http://www.citeconsortium.org/courses/performanceasures.html>

Operations Performance Measures: The Foundation for Performance-Based Management of Transportation Operations Programs. An extended brochure providing an overview of TSM&O Performance Measurement; could be used to communicate need for Performance Measurement.

<http://www.ops.fhwa.dot.gov/publications/fhwahop12018/fhwahop12018.pdf>

FHWA Office of Operations/Operations Performance Measurement Website. Provides guidance on several relevant topics including: Performance Measurement Fundamentals, Examples of Performance Measurement Programs, and Operations Performance Measurement Research.

http://ops.fhwa.dot.gov/perf_measurement/index.htm

FHWA Office of Operations, Operations Performance Measures and Management Roadmap. Provides a list of activities to be undertaken by FHWA and others to promote operations performance management.

<http://ops.fhwa.dot.gov/publications/fhwahop14012/fhwahop14012.pdf>

GDOT Performance Dashboard. Many States have dashboards but GDOT's allows drilling down.

<http://www.dot.ga.gov/BS/Performance>

Maryland Mobility Report. Excellent use of data to develop both outcome and output measures.

http://sha.maryland.gov/OPPEN/2013_Maryland_Mobility.pdf

Appendix: Steps to Implement Common Implementation Plan Priority Actions for Performance Measurement Dimension

The steps listed below implement the most common priority actions identified by workshop participants when developing their implementation plans. Although the actions themselves are not stated, they generally address improvement in each of the business process elements. The steps for each action were developed by the workshop site core team, assisted by a template of facilitator-supplied suggested steps based on workshop outputs, and structured consistent with the basic CMM guidance presented in the AASHTO TSM&O Guidance.

Performance Measurement program development

1. Coordinate TSM&O Performance Measurement with TSM&O Strategic Plan
 - a. Establish performance-related goals and objective for TSM&O, both for Federal (MAP-21) and agency reporting and for use in managing (improving) specific strategy applications
2. Develop Performance Measurement Plan and/or Data Business Plan that includes
 - a. Measures (outputs and outcomes)
 - b. Targets (including variations across districts/regions)
 - c. Data availability and acquisition (identify current data to support performance measures and identify data gaps and needs)
 - d. Analytical methods
 - e. Use of measures for project selection/prioritization and resource allocation
 - f. Internal and external reporting – audiences/needs/methods
 - g. Evaluations of completed projects.
3. Define a work program for a staged approach to implementation building on current processes and capabilities; identify staff resources (or external resources) needed to support this effort
4. Identify ongoing collaboration with external partners:
 - a. Measure definition
 - b. Shared data

- c. Coordinated/integrated planning and programming (e.g., with MPOs).
5. Standardize TSM&O Performance Measurement related to both recurring and nonrecurring congestion on both freeways and arterials
6. Identify and coordinate with internal users and customers of performance data
7. Develop a TSM&O Performance Measurement pilot program or staged approach to implementation

Measure utilization

1. Develop a strategy for how performance data will be integrated into agency processes, including freeway management (real-time and longer-term freeway operations program planning), project planning, and maintenance, as well as arterial operations improvements as appropriate
2. Establish a format and overall approach for how measures will be displayed and reported for both internal and external use. Consider abbreviated dashboard formats, graphical/map formats, and other ways of displaying performance information. Tailor performance report formats for specific external and internal audiences
3. Review experience and activities of peer agencies especially regarding relationship between key performance measures and goals, strategy applications and data availability (short and medium term), and related analytical requirements
4. Formalize process for post-incident management assessment, including definitions, performance-related criteria follow-up, and data assembled

Measure development

1. Review MAP-21 requirements (and 2014 deadline) being implemented at the agency level, including targets and timeframes, and ensure common terminology and objectives between TSM&O and other agency activities
2. Identify specific responsibilities for collection, analysis, and reporting/communicating, including liaison with agency performance groups and support of Public Information Office staff in communications
3. Identify applicable performance measures at the regional and corridor levels that will help make the business case and improve investment decisionmaking.

U.S. Department of Transportation
Federal Highway Administration
Office of Operations
1200 New Jersey Avenue, SE
Washington, DC 20590

www.ops.fhwa.dot.gov

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