Operations Performance Management Primer

From Performance Measures to Performance Management

April 2024

U.S. Department of Transportation
Federal Highway Administration

FOREWORD

The purpose of this Primer is to orient transportation practitioners to the principles and practices of Operations Performance Measures and Management (OPMM). OPMM aims to support continuous improvement in the practice of Transportation Systems Management and Operations (TSMO), a set of strategies that focus on operational strategies that improve the transportation system. Simply put, OPMM includes traditional operations performance measurement practices while incorporating the Transportation Performance Management (TPM) principles for TSMO programs. OPMM is a strategic and data-driven approach to making investment and policy decisions to achieve operations goals.

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16. Abstract

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: volumes greater than 1,000 L shall be shown in m^3			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2,000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2,000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	2.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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LIST OF ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
CDOT	Colorado Department of Transportation
CMF	Capability Maturity Frameworks
CMP	Congestion Management Plans
DOT	Department of Transportation
DSS	Decision Support Systems
FHWA	Federal Highway Administration
IT	Information Technology
ITS	Intelligent Transportation Systems
LHL	Lane-Hours Lost
LRTP	Long-Range Transportation Plan
MAP-21	Moving Ahead for Progress in the 21st Century Act
MPO	Metropolitan Planning Organization
MRCC	Metro Regional Centerline Collaborative
OPMM	Operations Performance Measures and Management
PBPD	Performance-Based Practical Design
PBPP	Performance-Based Planning and Programming
PennDOT	Pennsylvania Department of Transportation
PM3	Third Performance Management Rulemaking
SHRP 2	Strategic Highway Research Program 2
STIP	Statewide Transportation Improvement Programs
TPM	Transportation Performance Management
TSMO	Transportation Systems Management and Operations
VMT	vehicle-miles traveled

EXECUTIVE SUMMARY

This Primer describes the principles of Operations Performance Measures and Management (OPMM) in the context of transportation investment decisionmaking and other performance management activities. OPMM is a data-driven process that develops investments based on the actual performance of the transportation system. Its features are shared with the broader contexts of Transportation Performance Management and Performance-Based Planning and Programming, but is tied specifically to mobility performance and the application of transportation systems management and operations (TSMO) strategies. OPMM enables consideration of TSMO projects in these broader contexts and supplies valuable mobility performance information for multimodal decisionmaking.

CHAPTER 1. INTRODUCTION

PURPOSE OF THIS PRIMER

The purpose of this Primer is to orient transportation practitioners in State Departments of Transportation (DOT), Metropolitan Planning Organizations (MPO), and other transportation agencies to the principles and practices of Operations Performance Measures and Management (OPMM). OPMM aims to support continuous improvement in the practice of Transportation Systems Management and Operations (TSMO), a set of strategies that focus on operational strategies that improve the transportation system. OPMM includes traditional operations performance measurement practices while incorporating the Transportation Performance Management (TPM) principles for TSMO programs. OPMM is a strategic and data-driven approach to making investment and policy decisions to achieve operations goals. OPMM provides a basis for making sound TSMO investment decisions by state DOTs and MPOs.

WHAT IS OPERATION PERFORMANCE MEASURES AND MANAGEMENT?

OPMM is the basis for making continuous improvements in TSMO practice. At its most basic form, OPMM addresses four fundamental questions:

1. What are congestion and related conditions like on the system (base-level performance)?
2. How does a region's or a State's congestion, reliability and related performance levels compare to those of our peers?
3. Are things better or worse (trends)?
4. Did my program have anything to do with trends we are seeing (investment analysis)?

Developing, reporting, and making investment decisions based on OPMM activities have many advantages for TSMO personnel. Specifically, OPMM:

- Provides transparency to the public and accountability to public officials.
- Documents where the problems are.
- Allows tailoring of solutions to specific problems.
- Evaluates how well past investments worked.
- Provides consistency with other agency TPM activities.
- Puts TSMO on equal footing with other program areas with a longer history of TPM and asset management.

This primer will define OPMM by first showing its context in the overall transportation investment decisionmaking process in chapter 2.

CHAPTER 2. RELATIONSHIP OF OPERATIONS PERFORMANCE MEASURES AND MANAGEMENT TO TRANSPORTATION PERFORMANCE MANAGEMENT AND PERFORMANCE BASED PLANNING AND PROGRAMMING

INTRODUCTION

Before further defining what OPMM is, it is important to relate OPMM to the related principles of TPM and Performance-Based Planning and Programming (PBPP), and Planning for Operations, both of which provide a broad framework for developing and using performance measures as the basis for transportation investment decisions. While the general principles are the same, OPMM is specifically focused on providing improved mobility and trip reliability by applying TSMO strategies. This chapter explains the principles of transportation performance management and provides examples of the application of these principles.

WHY UNDERTAKE TRANSPORTATION PERFORMANCE MANAGEMENT?

TPM is a strategic approach that uses system information to make investment and policy decisions to achieve performance goals.[1] The reason TPM is a worthwhile practice is because, when implemented, it can lead to improved transportation system performance. TPM achieves this by helping transportation agencies determine what results (strategic goals) are to be pursued, then guiding investments to achieve those results using information from past performance levels and forecasted conditions to select the best investments, routinely measuring progress toward those strategic goals, and then using those progress reports to make adjustments in planned expenditures to more effectively allocate available resources to meet the adopted performance goals. TPM is grounded in sound data management, usability, and analysis as well as in effective communication and collaboration with internal and external stakeholders.

The TPM Guidebook articulates some benefits of implementing TPM practices:

- Creation of Unifying Focus for Agency: TPM creates a unified focus for an agency by clearly communicating "where do we want to go." TPM achieves this through connected goals and objectives that reflect what the public and stakeholders expect from the agency, which in turn helps agency staff to link transportation investments to what the public cares about.
- Prioritization of Investments Based on Performance Needs: Focusing transportation investments on performance, both past and predicted future performance, allows agencies to effectively use limited resources. TPM practices are rooted in data-driven decisionmaking which enables agencies to prioritize investments based on observed performance needs.
- Linking Funding Requests to System Performance: Data on system performance can be used to articulate to decisionmakers the impact of increasing or decreasing funding levels.
- Communication of the Benefits from Transportation Performance: Performance data enables agencies to communicate the outcomes of investment decisions to external stakeholders. In turn, this helps agencies and external stakeholders engage in a more productive dialogue on

[1] Federal Highway Administration. (no date). "TPM Guidebook." (website) Washington, D.C. Available online: https://www.tpmtools.org/guidebook/, last accessed April 7, 2022.

what performance outcomes are desired and the necessary strategies to achieve those outcomes.

- Fulfillment of Legislative Requirements: Employing TPM practices will assist agencies in implementing TPM-related regulatory requirements as mandated in the Fixing America's Surface Transportation Act.

Transportation Performance Management Principles

OPMM is strongly related to the principles of TPM, which has been broadly applied to many transportation agency functions, such as the management of physical infrastructure and assets. In recent years, State DOTs have begun to recognize the need to support decisions—both large decisions about major projects or initiatives and smaller everyday decisions—with improved data and analysis. The combination of flat or declining revenues with equal or greater demand from customers for quality service has caused agencies to turn to new methods to improve efficiency. TPM provides a framework that can help transportation agencies set realistic goals, focus on the most important challenges, and improve efficiency.

All State DOTs collect substantial amounts of data, and many State DOTs also already calculate performance measures. In the last several years, however, there has been a shift from *performance measurement to performance management.* Performance measurement is simply reporting how the transportation system is functioning. Performance management uses measurement as a foundation, but extends it by carefully and strategically selecting measures, setting targets, reporting measures, evaluating past investments, and most importantly, using this information to shape decisions. Figure 1 provides a broad outline of the functions in the OPMM process.

Reflecting the importance of TPM, the Moving Ahead for Progress in the 21st Century Act (MAP-21) includes a series of requirements for States to report performance in areas, including safety, pavements, bridges, freight, mobile source emissions, and congestion.[2] MAP-21 is a fundamental shift in Federal transportation funding by requiring State DOTs to set targets and to report on the performance progress toward the targets. MAP-21 is a significant step toward conducting TPM, but many other functions should be fulfilled before a complete TPM process is in-place at transportation agencies.

[2] 23 U.S.C. 150(d)(1), https://www.govinfo.gov/content/pkg/USCODE-2019-title23/html/USCODE-2019-title23-chap1-sec150.htm. http://www.gpo.gov/fdsys/pkg/PLAW-112publ141/html/PLAW-112publ141.htm; last accessed April 7, 2022.

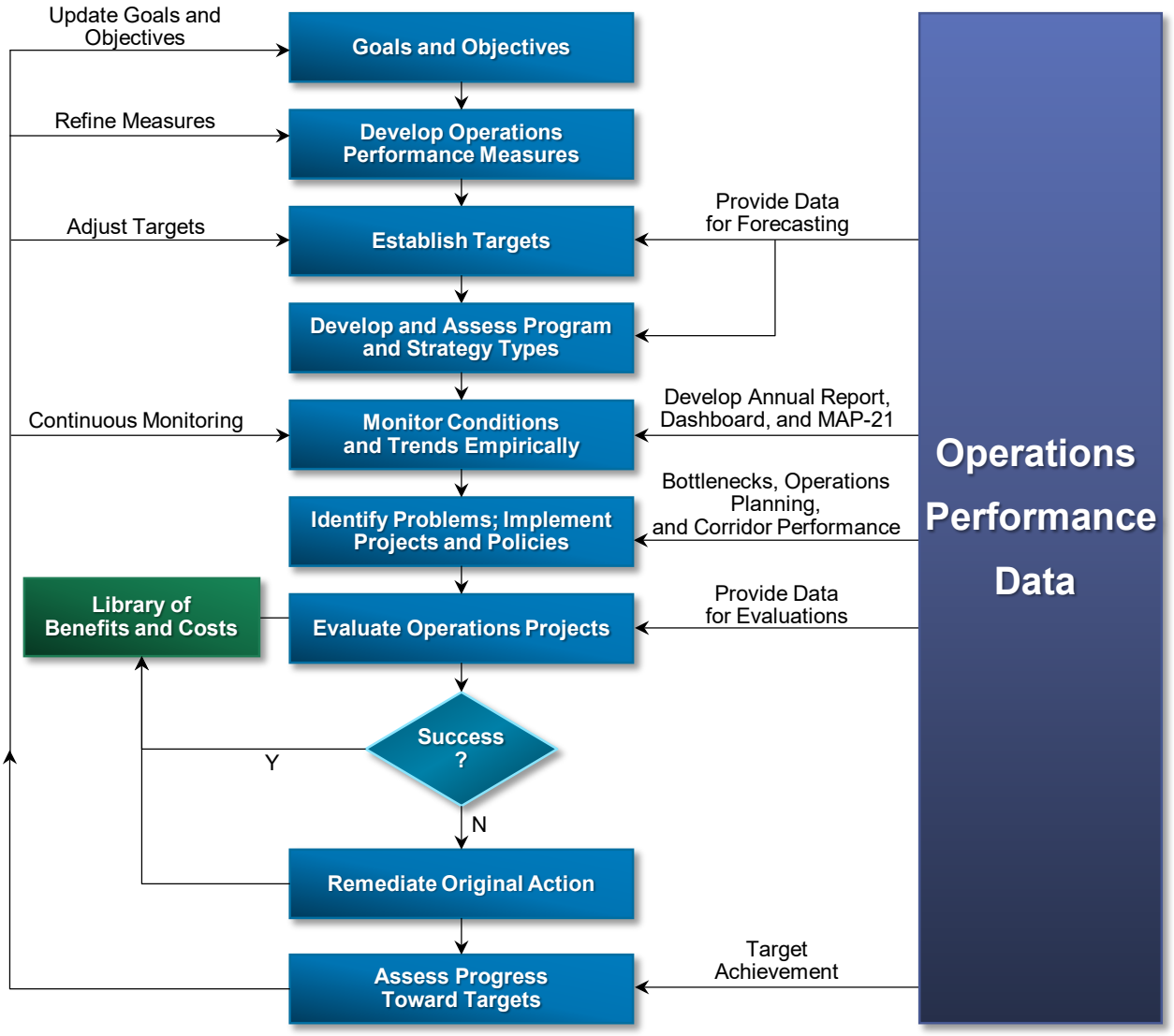

Figure 1. Flow chart. General features of operations performance measures and management.
(Source: Federal Highway Administration)

The principles of TPM are reflected in its 10 distinct components. These include the following:

1. Strategic Direction.
2. Target Setting.
3. Performance-Based Planning.
4. Performance-Based Programming.
5. Monitoring and Adjustment.
6. Reporting and Communication.
7. Organization and Culture.

8. External Collaboration and Coordination.
9. Data Management.
10. Data Usability and Analysis.
11. Strategic Direction.
12. Target Setting.
13. Performance-Based Planning.
14. Performance-Based Programming.
15. Monitoring and Adjustment.
16. Reporting and Communication.
17. Organization and Culture.
18. External Collaboration and Coordination.
19. Data Management.
20. Data Usability and Analysis.

Strategic Direction (Component 1) establishes an agency's direction through well-defined goals and objectives, and enables assessment of the agency's progress towards meeting goals by defining a set of aligned performance measures. It is the critical first step in the TPM process and the foundation upon which all performance management rests. To be effective, the Strategic Direction should be integrated into a transportation agency's long-range transportation plan (LRTP) and related documents.

Target setting (Component 2) is the use of baseline data, information on possible strategies, resource constraints, and forecasting tools to collaboratively establish a quantifiable level of performance the agency wants to achieve within a specific timeframe. Importantly, target setting should be evidence based and data driven. Targets make the link between investment decisions and performance expectations as established in the Strategic Direction. In addition, targets help bring transparency to the transportation decisionmaking process.

Performance-Based Planning (Component 3) is the use of agency goals and objectives and performance trends to drive development of strategies and priorities in the LRTP and other performance-based plans and processes. The resulting planning documents become the blueprint for how an agency intends to achieve its desired performance outcomes.

Performance-Based Programming (Component 4) is the use of strategies and priorities to guide the allocation of resources to projects that are selected to achieve goals, objectives, and targets. Performance-Based Programming establishes clear linkages between investments made and expected outputs and outcomes.

Monitoring and Adjustment (Component 5) emphasizes that what agencies do with performance information distinguishes TPM from performance measurement. Management is distinguished from measurement in that upon measuring performance, a management framework insists that this information be fed back into the framework in order to adjust programming decisions. In

other words, performance management encourages agencies to actively use information gained from monitoring performance data to obtain key insights into the effectiveness of decisions and identify where adjustments in programming need to be made.

Reporting and Communication (Component 6) is the use of products, techniques, and processes to communicate performance information to different audiences for maximum impact. Reporting increases accountability and transparency to external stakeholders and helps explain to both agency staff and external stakeholders how TPM is driving a data-driven approach to decisionmaking, and why changes to previously developed plans need to occur in order to meet the strategic goals adopted by the agency.

Organization and Culture (Component 7) refers to the institutionalization of a TPM culture within the agency, as evidenced by leadership support, employee buy-in, and embedded organizational structures and processes that support TPM.

External Collaboration and Coordination (Component 8) refers to the established processes to collaborate and coordinate with agency partners and stakeholders on planning/visioning, target setting, programming, data sharing, and reporting. External collaboration allows agencies to leverage partner resources and capabilities, as well as increase understanding of how activities impact and are impacted by external factors.

Data Management (Component 9) encompasses a set of coordinated activities for maximizing the value of data to an organization. It includes data collection, creation, processing, storage, backup, organization, documentation, protection, integration, dissemination, archiving, and disposal. The data management effort creates, organizes, and makes available the data resources needed for the final component.

Data Usability and Analysis (Component 10) takes the valuable data sets from the previous component and ensures those data are accessible and usable by the staff and stakeholders that need them. It also ensures individuals have the necessary analysis capabilities available to support both the production of the performance reports identified in Component 6 and the analytical tools needed to describe the value of alternative projects, plans, and strategies that are under consideration for achieving the desired strategic goals. While many agencies have a wealth of data, those data are often disorganized or cannot be analyzed effectively to produce useful information to support target setting, monitoring, project selection, decisionmaking, or other TPM practices.[3]

Transportation Performance Management Examples

There are numerous examples of agencies that implemented TPM strategies aimed at improving results in one or more performance areas. This section of the report highlights a few examples from around the country. Examples include the Metro Regional Centerline Collaborative (MRCC) in the Minneapolis-St. Paul region, the Pennsylvania DOT's (PennDOT) bridge report card, and the Colorado Department of Transportation's (CDOT) I-70 West Traffic Management Program.

[3] Federal Highway Administration. (no date). "TPM Guidebook." (website) Washington, D.C. Available online: https://www.tpmtools.org/guidebook/, last accessed April 7, 2022.

The MRCC is a joint collaborative project among the seven counties that comprise the Metropolitan Council MPO region to develop a road centerline data model and dataset to meet the core business needs of local governments and regional interests.[4] The goal of the MRCC is to create and maintain a locally sourced road centerline dataset that can be used to meet the needs of local, regional, and State partner agencies. The core uses of the data include vehicular routing, emergency response, and the cartographic representation of road features, including pavement conditions, among others. The MRCC is a good example of the External Collaboration component of TPM as well as the pavement and system performance TPM areas.

The PennDOT publishes an annual report card on the condition of bridges throughout the Commonwealth of Pennsylvania.[5] The report documents the number of bridges classified as structurally deficient and/or functionally obsolete, the average age of bridges, and weight restrictions, among others. In addition, the report examines the resilience of the Commonwealth's bridges by accounting for the number of fracture critical bridges (i.e., bridges with at least one member whose failure would cause a significant portion of the bridge or the entire bridge to collapse). The bridge report card concludes with recommendations for improving bridge conditions. Overall, the PennDOT bridge report card provides an illustrative example of the performance-based planning and the reporting and communication components of TPM.

CDOT deploys a number of management strategies for improving the safety and reliability of travel on the I-70 West corridor that are exemplary of the monitoring and adjustment component of traffic management. During the winter months, adverse weather and incidents caused by weather conditions cause travelers on this corridor to experience significant delays. To improve operations, CDOT uses a number of traffic control measures such as ramp management, snowplow escorts, quick clearance of traffic incidents, real-time traveler information, and commercial vehicle staging to maintain traffic flows through the Eisenhower Tunnel. Snowplow escorts involve short holds of traffic to allow CDOT snowplows to lead an escort of traffic with the Colorado State Patrol up steep mountain passes in adverse conditions. This allows for traffic to travel on freshly treated roads at a safe, controlled speed that helps reduce the occurrence of weather-related crashes. Commercial vehicle staging activities include, when conditions are appropriate, closing I-70 to commercial vehicles when road conditions and traffic volumes are such that a public safety emergency is likely and imminent.

RELATIONSHIP TO PERFORMANCE-BASED PLANNING AND PROGRAMMING

PBPP refers to the application of performance management within the planning and programming processes of transportation agencies to achieve desired performance outcomes for the multimodal transportation system. This includes a range of activities and products undertaken by a transportation agency together with other agencies and stakeholders.[6]

[4] MetroGIS. (2022). "Centerline Collaborative."(website) St. Paul, MN. Available online: https://metrogis.org/projects/centerlines-initiative.aspx, last accessed April 7, 2022.

[5] Pennsylvania Department of Transportation. (no date). "Report Card for Pennsylvania's Infrastructure, Bridges." (website) Harrisburg, PA. Available online:http://www.pareportcard.org/PARC2014/downloads/PA_2014_RC_Bridges.pdf, last accessed April 7, 2022.

[6] Grant, M., D'Ignazio J., Bond, A., McKeeman, A. (2013). *Performance-Based Planning and Programming Guidebook,* Report No. FHWA-HEP-13-041, Federal Highway Administration, Washington D.C. Available online: https://www.fhwa.dot.gov/planning/performance_based_planning/pbpp_guidebook/, last accessed April 7, 2022.

The functions of OPMM shown back in figure 1 are hallmarks of PBPP. The *Performance-Based Planning and Programming Guidebook* identifies the functions listed below.[7]

Strategic Direction (What is the agency's vision for meeting its mission?)—In the transportation planning process, strategic direction is based upon a vision for the future, as articulated by the public and stakeholders. PBPP includes:

- Goals and Objectives—Stemming from a State's or region's vision, goals address key desired outcomes, and supporting objectives (specific, measurable statements that support achievement of goals) play a key role in shaping planning priorities.
- Performance Measures—Performance measures support objectives and serve as a basis for comparing alternative improvement strategies (investment and policy approaches) and for tracking results over time.
- **Planning Analysis (How are we going to get there?)—**Driven by data on performance, along with public involvement and policy considerations, agencies conduct analysis in order to develop investment and policy priorities.
    - Identify Trends and Targets—Preferred trends (direction of results) or targets (specific levels of performance desired to be achieved within a certain timeframe) are established for each measure to provide a basis for comparing alternative packages of strategies. This step relies upon baseline data on past trends, tools to forecast future performance, and information on possible strategies, available funding, and other constraints.
    - Identify Strategies and Analyze Alternatives—Performance measures are used to assess strategies and to prioritize options. Scenario analysis may be used to compare alternative packages of strategies, to consider alternative funding levels, or to explore what level of funding would be required to achieve a certain level of performance.
    - Develop Investment Priorities—Packages of strategies for the LRTP are selected that support attainment of targets, considering tradeoffs between different goal areas, as well as policy priorities.
- **Programming (What improvement projects will help to achieve the stated goals and objectives?)—**Programming involves selecting specific investments to include in an agency capital plan and/or in a Transportation Improvement Program or Statewide Transportation Improvement Programs (STIP). In a PBPP approach, programming decisions are made based on their ability to support attainment of performance targets or contribute to desired trends, and account for a range of factors.
- **Implementation and Evaluation (How well did the completed projects perform?)—** These activities occur throughout implementation on an ongoing basis, and include:
    - Monitoring—Gathering information on actual conditions.
    - Evaluation—Conducting analysis to understand to what extent implemented strategies have been effective.

[7] *Performance-Based Planning and Programming Guidebook*, FHWA-HEP-13-041.

  - Reporting—Communicating information about system performance and the effectiveness of plans and programs to policy-makers, stakeholders, and the public.

- Performance measurement is at the core of PBPP and it is also a crucial feature of OPMM. TSMO improvements' impacts on the transportation system can be captured through assessing roadways performance, especially in terms of travel time reliability. To assess the performance of the transportation system, agencies should select measures and identify operational data that need to be acquired to undertake a comparable evaluation. Performance measures helps to clarify the definition of goals, monitor or track performance over time, and assess the effectiveness of projects and strategies.

The *Performance-Based Planning and Programming Guidebook* recommends following factors to consider in selecting measures:[8]

- Does it represent a key concern?
- Is it clear?
- Are data available?
- Can it be forecasted?
- Is the measure something the agency and its investments can influence?
- Is the measure meaningful for the types of services or area?
- Is improvement direction clear?

For instance, the City of Baltimore, MD, optimized near 200 traffic signals along 9 arterials to reduce delay and improve travel time for motorists commuting to and from downtown Baltimore City. They defined following performance measures to evaluate project performance results:

- Vehicle Delay.
- Number of Stops.
- Fuel Consumption.
- Carbon Monoxide Emissions.
- Nitrous Oxide Emissions.

The Michigan DOT uses the dynamic late lane merge system, often called a "zipper merge," to help reduce delays in high-traffic work zones. In order to evaluate their progress, they used the following performance measures:

- Average Travel Time.
- Average Travel Speed.
- Average Delay.

[8] Federal Highway Administration. (2013). *Performance-Based Planning and Programming Guidebook,* FHWA-HEP-13-041, https://www.fhwa.dot.gov/planning/performance_based_planning/pbpp_guidebook/.

CORRELATION TO PLANNING FOR OPERATIONS

Planning for operations is a joint effort between planners and operators to support improved regional transportation system management and operations. Planning for operations in the metropolitan transportation planning process means developing operations objectives to direct the consideration of operational performance during the planning process and incorporating operations solutions into investment decisions that support the operations objectives. This approach ensures that operations needs are addressed in regional planning and investment decisions.[9]

Planning for Operations is an objectives-driven, performance-based process, and thus embodies the major attributes of TPM generally and OPMM specifically. It strives to integrate consideration of operations strategies into each step of the transportation planning process, including long-range studies and short-range plans. Practically speaking, the success of Planning for Operations is indicted by the inclusion—or at least the consideration of—operations strategies in planning documents and processes.

Traditionally, transportation planning and transportation system operations have been largely independent activities. While planners focus on long-range transportation investments, operators are typically more concerned with addressing immediate system needs such as incident response, traffic control, and work zone management. Planning for Operations connects these two vital components of transportation and integrates operations considerations into the planning process. It needs collaboration among and within various transportation agencies (e.g., transit agencies, State DOTs, toll authorities) as well as local governments.[10]

More specifically, planning for operations integrates TSMO into the transportation planning process for the purpose of improving regional transportation system efficiency, reliability, and options. TSMO strategies are programs, projects, or services designed to get the safest and most efficient use out of existing and planned infrastructure.[11,12] Often, TSMO strategies allow transportation agencies to improve and/or maintain performance levels without the high cost and time needed to expand capacity.

OPMM is related to the Planning for Operations approach because both represent "performance-based" strategies for transportation decisionmaking. Rather than focusing on projects and investment plans first and then gauging their impacts on performance later, the planning for operations approach first develops objectives for transportation system performance and then uses performance measures and targets as a basis for identifying solutions and developing investment strategies. In this manner, OPMM and Planning for Operations are linked by their focus on performance and outcomes.

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[9] Grant, M., Bauer, J., Plaskon, T., and Mason, J. (2010). *Advancing Metropolitan Planning for Operations: An Objectives-Driven, Performance-Based Approach: A Guidebook* Report No. DTFH61-06-D-00005, Federal Highway Administration, Washington, D.C. Available online: https://ops.fhwa.dot.gov/publications/fhwahop10026/fhwa_hop_10_026.pdf, last accessed April 7, 2022.

[10] Federal Highway Administration. (no date). "About Organizing and Planning for Operations." (website) Washington, D.C., Available online: https://ops.fhwa.dot.gov/plan4ops/about.htm, last accessed April 7, 2022.

[11] Federal Highway Administration. (no date). "Transportation Systems Management and Operations (TSMO) Strategies.) (website) Washington, D.C. Available online: https://ops.fhwa.dot.gov/plan4ops/focus_areas/integrating/operations_strategies.htm, last accessed April 7, 2022.

[12] Grant, M., Noyes, P., Oluyede, L., Bauer, J. (2017)., *Developing and Sustaining a Transportation Systems Management and Operations Mission for Your Organization, A Primer for Program Planning,* Report No. FHWA-HOP-17-017, Federal Highway Administration, Washington, D.C. Available online: https://ops.fhwa.dot.gov/publications/fhwahop17017/fhwahop17017.pdf, last accessed April 7, 2022.

OPMM fits seamlessly into the Planning for Operations process. As part of the strategic planning process, planning goals and objectives should coincide with those of OPMM. For example, if a planning goal is to reduce highway congestion, then operations goals and objectives should be formulated around that goal. Further, the data used for OPMM can also be used for Planning for Operations. Figure 2 shows an example of how general planning goals filter down to specific objectives for operations.

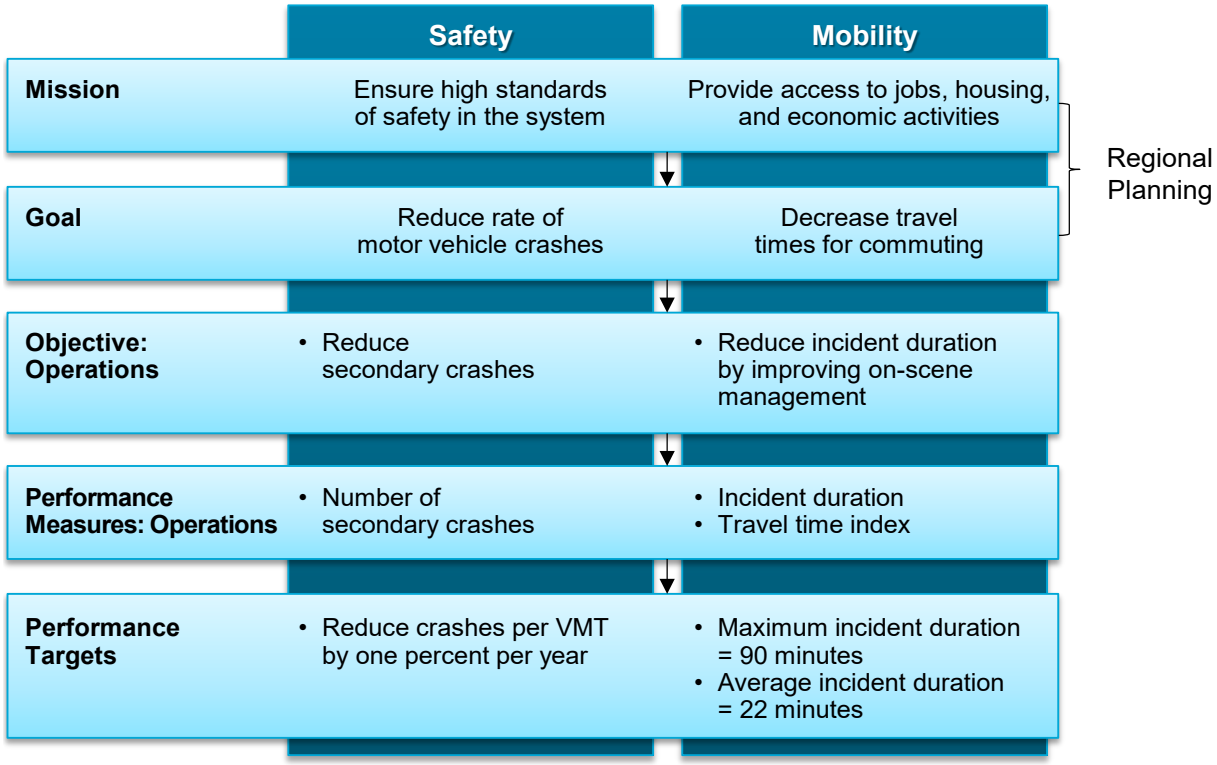

Figure 2. Diagram. Operations performance measures and management and the strategic planning process.
(Source: Federal Highway Administration.)

CHAPTER 3. OPERATIONS PERFORMANCE MANAGEMENT: MAJOR FUNCTIONS

OVERVIEW

The major functions of an OPMM program are discussed in this chapter. OPMM's major functions are as follows.

- **Performance Measurement.** OPMM measures are clearly defined and are easy to understand and visualize by technical and nontechnical audiences. They provide decision support for the operation of specific TSMO activities (e.g., the need for signal timing plan changes), describe multimodal performance, and are directly applicable for making decisions. At least some measures focus on performance from the customer's/traveler's point of view; measures are continuously reviewed and modified. High-quality data are available and data sources are standardized and integrated across all department/agencies; long-term budget commitments for the purchase of private data are established.
- **Performance Monitoring.** A single data system houses all operations data, which are seamlessly integrated; the system is routinely updated and modified using sound Information Technology (IT) principles; agency personnel receive ongoing training on the use of the system; hardware architectures and technology routinely upgraded to improve performance; systems and data integration/interoperability maintained on a continuing basis across multiple agencies in the region, and real-time multimodal situational awareness actively used to support adaptive multi-agency operational plans.
- **Reporting.** OPMM performance measures are reported internally for utilization and externally for accountability and program justification. Reporting systems automatically flag areas where performance does not meet targets or expectations; operations performance measures are used in general agency planning and programming activities.
- **Project/Strategy Evaluation.** A routine and ongoing evaluation of TSMO projects is established and uses data from the single data system with little or no need for additional data collection. Before/after analysis of completed projects is done with controls to ensure that background factors are not affecting treatment outcomes. When projects produce positive results, they are highlighted in communication and public relations instruments for decisionmakers and the public. When projects do not produce the desired outcomes, after-action analysis is conducted to determine why.
- **Operate.** OPMM is fully integrated into all related agency functions and used to create planning and programming documents on equal footing with all other functional areas. OPMM strategic, tactical, and program plans are integrated with jurisdictions' multisectoral plans and programs (e.g., Performance-Based Practical Design, long-range transportation programs, and the Congestion Management Process) based on formal continuing planning processes. OPMM goals and objectives are included in general planning documents. The OPMM program leads to TSMO strategies being considered simultaneously with capacity and demand management strategies at all stages of project development (planning, preliminary engineering, design). Operations data is used to diagnose congestion problems and assess impacts of all types of strategies.

- **Input for Investment Decisionmaking.** In addition to routine reporting of performance, decisions on TSMO investments should be informed by performance measures. Performance measures are used to describe the size and nature of mobility problems in such a way that TSMO strategies can be tailored to address them.

PERFORMANCE/MEASUREMENT

System monitoring and performance measurement are important components of OPMM.[13] These components are interrelated components as performance measures indicate how well the transportation system is performing while monitoring refers to tracking performance over time. In addition to providing a means of monitoring progress towards operations objectives, performance measures also allow an agency to:

- Identify needs and system performance deficiencies.
- Assess potential impacts of TSMO strategies.
- Evaluate effects of implemented projects.
- Communicate progress to stakeholders.

Monitoring helps transportation agencies to reach better decisions about how to operate the system and the investments needed to support operations. With the information gathered from performance measurement and monitoring tasks, an agency can gain a better understanding of system performance needs and deficiencies, measure progress towards operational objectives, and ultimately refine project and program implementation and operation. That same data generated from the OPMM approach can even be fed back into the planning process for a fully integrated approach to transportation decisionmaking. However, without a mechanism to measure and monitor performance, an agency will not realize the full value of developing operational objectives.

To get started, agencies should follow these steps to develop the performance monitoring function of OPMM:

- **Where should monitoring take place?** Should we monitor facilities, entire trips, or both? How should facilities and trips be defined (what is their extent)? Do we only monitor facilities and trips we know are already congested or do we include the entire system under our purview?
- **What should be monitored?** What aspects of congestion and safety should we monitor: do we monitor not only congestion level but also its determinants like demand and disruptions? What performance measures should we use for each of these categories?
- **When should monitoring occur?** What time periods should be monitored: weekday peak periods, off-peak periods, and/or weekends?

[13] Grant, M., Bauer, J., Plaskon, T., and Mason, J. (2010). *Advancing Metropolitan Planning for Operations: An Objectives-Driven, Performance-Based Approach,* Report No. FHWA-HOP-10-026, Federal Highway Administration, Washington, D.C. Available online: https://ops.fhwa.dot.gov/publications/fhwahop10026/fhwa_hop_10_026.pdf, last accessed April 7, 2022.

- **How** will monitoring be achieved? What data are available for supporting the desired monitoring activity? Will new data collection have to be performed? What analytic tool will be used to perform the monitoring? Can the analytics be performed in-house, by a commercial tool, by a custom-built system, or by a service contract?
- **Who** will be responsible for managing the monitoring portion of OPMM activities? What staff will be involved?

Operations Performance Measures

Overview

TSMO covers a wide range of activities including the management of incidents, weather, work zones, traffic control devices, traveler information, and traffic flow (e.g., Active Traffic Management). Operations performance measures should be constructed for each of these program areas. The Federal Highway Administration (FHWA) and transportation agencies have constructed a broad list of performance measures that can be applied for OPMM.[14]

Conceptually, performance measures for OPMM are organized around the factors that influence congestion and safety as shown in figure 3. For example, consider traffic incident factors. The "first order" cause of incident-related congestion is the amount of time that lanes and shoulders are blocked, which in turn are influenced by several factors. Continuing down the chain, one of the factors, incident duration, is a function of many subfactors including the effectiveness with which incidents are managed. This framework is considered when constructing OPMM performance measures. These measures have the following general features.

Mobility Measures

For the purpose of OPMM, mobility measures are those that relate to the travel time experience of transportation system users. This experience can be demonstrated for individual highway facilities and trips made by any mode. Users' travel time experience can also be summarized by region and State.

Mobility measures have a long history in the profession, but only within the past decade has data been available to permit measuring systemwide performance.[15] Data availability played a key role in the recent creation of Federal mobility performance measures. Based on the MAP-21 legislation, FHWA promulgated rules regarding mobility, and developed the "Performance Measure 3 (PM3)" that must be reported by State DOTs and MPOs.[16] Three measures were developed:[17]

- National Highway Performance Program Reliability: The percent of the National Highway System that is deemed to be reliable.[18]

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[14] Federal Highway Administration. (no date). "Operations Performance Measurement." (website) Washington, D.C. Available online: https://ops.fhwa.dot.gov/perf_measurement/index.htm, last accessed April 7, 2022.

[15] Texas A&M Transportation Institute. (2022). "Urban Mobility Information." (website) College Station, TX. Available online: https://mobility.tamu.edu/, last accessed April 7, 2022.

[16] 23 CFR 490.101 and 23 CFR 490.105

[17] https://www.fhwa.dot.gov/tpm/guidance/hif18040.pdf

[18] 23 CFR Part 490 Subpart E

- Freight Reliability: Truck travel time reliability index for the Interstate system.[19]
- Annual Hours of Peak Hour Excessive Delay per Capita: For selected urbanized areas, the total amount of person delay per person. (National Performance Measures for Congestion Mitigation and Air Quality Improvement Program—Traffic Congestion)[20]

To support agencies' reporting requirements, FHWA also made available a data set, the National Performance Management Research Data Set that is to be used not only for Federal reporting requirements but for other OPMM activities as well.[21]

[19] 23 CFR Part 490 Subpart F

[20] 23 CFR Part 490 Subpart G

[21] Federal Highway Administration. (no date). "Operations Performance Measurement." (website) Washington, D.C. Available online: https://ops.fhwa.dot.gov/perf_measurement/index.htm, last accessed April 7, 2022.

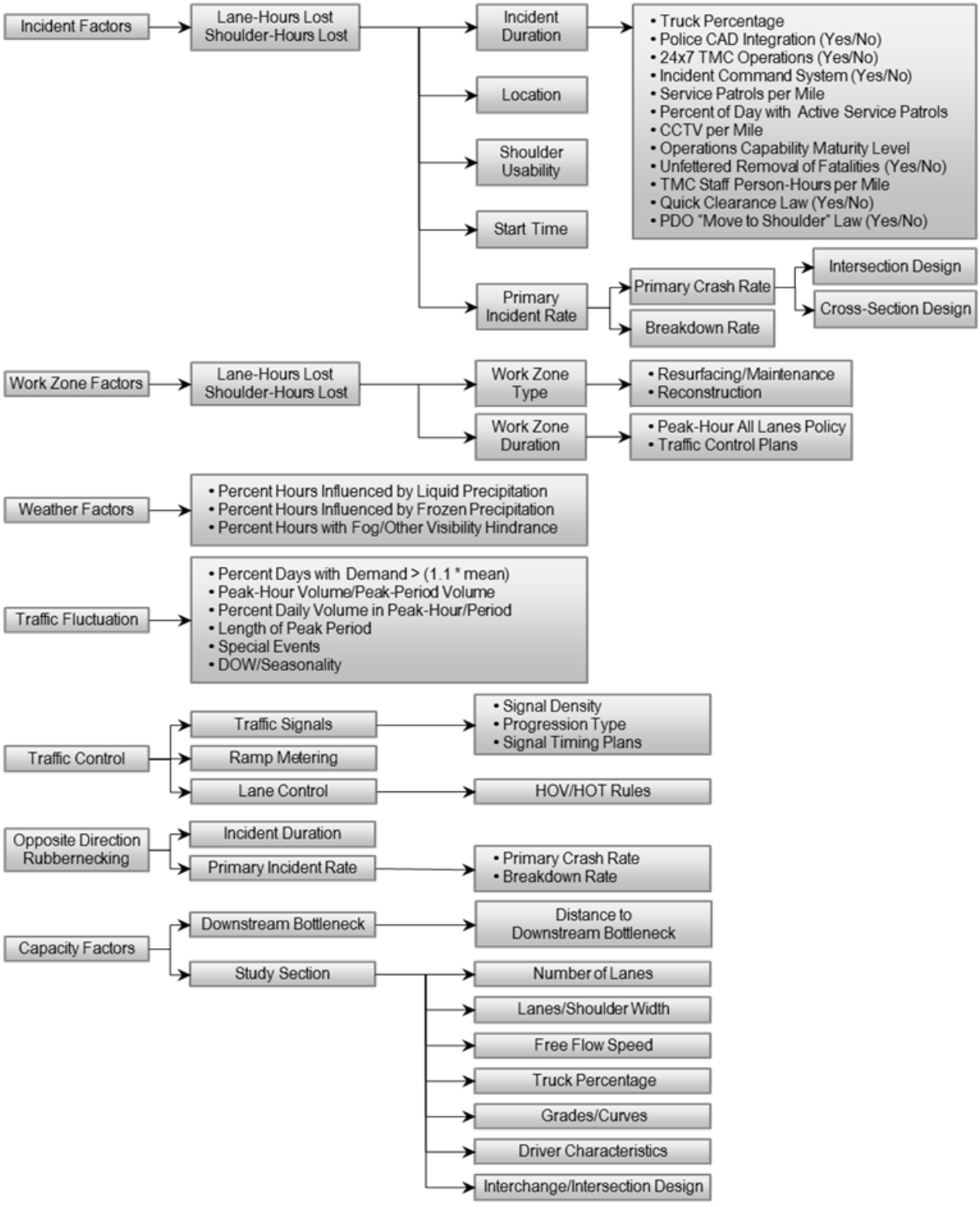

Figure 3. Flow chart. Influencing factors for congestion.
(Source: Federal Highway Administration.)

The PM3 are constructed to gauge systemwide mobility performance. Many other measures have been developed that are better suited for measuring the performance of individual facilities, trips, and bottlenecks. For example, FHWA has fostered the use of reliability measures by practitioners even before the PM3 were developed.[22] Travel time reliability is how mobility performance of a facility, trip, or system varies from day-to-day. It is influenced by the variability in system conditions: incidents, inclement weather, work zones, and demand that change over time. Reliability is, therefore, extremely important for OPMM. Other examples of operations performance measures follow:

The FHWA has recommended performance measures for monitoring freight bottlenecks:[23,24]

- Total Delay (vehicle-hours and person-hours)—Actual vehicle-hours (or person-hours) experienced in the highway section minus the vehicle-hours (or person-hours) that would be experienced at the reference speed. Delay can be compared across the system when normalized by segment length to get total delay per mile.
- Hours of delay per truck-Vehicle-hours of delay normalized by number of trucks.
- Mean Travel Time Index—The mean travel time over the highway section divided by the travel time that would occur at the reference speed.
- Planning Time Index—The 95th percentile Travel Time Index computed as the 95th percentile travel time divided by the travel time that would occur at the reference speed.
- 80th Percentile Travel Time Index—The 80th percentile Travel Time Index computed as the 80th percentile travel time divided by the travel time that would occur at the reference speed.
- Hours of Congestion per Year—Number of hours where vehicle speeds are below predetermined thresholds.
- Average and 95th Percentile Queue Length—Developed from a distribution of queue lengths, the highway distance where the speeds of contiguous segments upstream of an identified bottleneck location are less than a threshold.
- Value of wasted time and fuel due to congestion for each segment—Calculated as congestion delay multiplied by the value of time and the value of excess fuel consumption.

External Factors Affecting Mobility

Traffic demand (volumes) is a highly significant form of data for OPMM. Demand not only drives the congestion produced by physical bottlenecks, but determines the severity of disruptions such as traffic incidents and work zones; under light traffic conditions, an incident or work zone may have no appreciable impact on traffic flow. Previous work showed how small changes in vehicle-miles traveled (VMT) (a common measure of demand) can have large

[22] Texas Transportation Institute andCambridge Systematics, Inc. (2006). "Travel Time Reliability: Making It There On Time, All The Time." (website) Federal Highway Administration, Washington, D.C. Available online: https://ops.fhwa.dot.gov/publications/tt_reliability/, last accessed April 7, 2022.

[23] Margiotta, R., Eisele, B., and Short, J. (2015). *Freight Performance Measure Approaches for Bottlenecks, Arterials, and Linking Volumes to Congestion,* Report No. FHWA-HOP-15-033, Federal Highway Administration, Washington, D.C.

[24] Federal Highway Administration (2018). *Truck Freight Bottleneck Reporting Guidebook*, Report No. FHWA-HOP-18-070, Washington, D.C. Available online: https://www.fhwa.dot.gov/tpm/guidance/hop18070.pdf, last accessed April 7, 2022.

impacts of performance measures.[25] Table 1 shows how performance degraded slightly between 2006 and 2007 with only a marginal increase in VMT. However, performance improved significantly between 2007 and 2008 when VMT dropped due to the onset of the economic recession. In this case, a 3.1 percent drop in VMT led to a 12 percent decrease in average travel times and a 10 percent decrease in the 95th percentile travel time.

Table 1. Changes in performance on selected Atlanta, Georgia freeways, 2006 to 2008.

	Year		
Metrics	**2006**	**2007**	**2008**
Travel Time Index	1.720	1.800	1.585
Average Travel Time	10.033	10.492	9.220
95th Percentile Travel Time	14.266	15.151	13.597
80th Percentile Travel Time	11.874	12.400	10.989
Skew Statistic	1.186	1.196	1.308
Daily Vehicle Miles Traveled	1,789,122	1,790,030	1,734,742

(Source: Cambridge Systematics et al. (2013)., *Analytical Procedures for Determining the Impacts of Reliability Mitigation Strategies,* Strategic Highway Research Program 2 Report S2-L03-RR-1, Transportation Research Board, Washington, D.C.)

Demand data that is continuously collected is the richest type of data not only for real-time TSMO applications, but for OPMM; continuous demand data allows for the creation of demand profiles that can be used in modeling. Further, demand should be used in creating certain OPMM performance measures (e.g., delay) and in weighting facility- and trip-based statistics for aggregation to areawide statistics. Demand data is collected continuously from freeway detectors as well as some from signalized highway detectors as discussed earlier in this chapter. FHWA has produced material useful for understanding and assessing external influences on OPMM performance measures.[26]

Additionally, traffic volume data are most often included in the statewide roadway inventory maintained by each State DOT. The most common traffic volume attribute in a statewide roadway inventory is annual average daily traffic, which is a single average count value for each calendar year. More detailed traffic count data are available from permanent continuous count stations, but these detailed counts are not available for the entire roadway network, only a limited number of locations.

At the program level, understanding trends in demand—as well as in traffic disruptions—helps to explain trends in outcome measures. As part of transparency and accountability reporting, simply reporting trends in outcomes measures (e.g., delay and reliability) is insufficient. Displaying how outcome measures change over time tells us whether conditions are better or worse, but they do not tell us why they are better or worse. Understanding the factors that led to outcome trends is significant for a number of reasons:

[25] Cambridge Systematics et al. (2013)., *Analytical Procedures for Determining the Impacts of Reliability Mitigation Strategies,* Strategic Highway Research Program 2 Report S2-L03-RR-1, Transportation Research Board, Washington, D.C.

[26] Dadashova, B., Lasley, P., Koeneman, P., and Turner, S. (2018)., *Approaches to Presenting External Factors with Operations Performance Measures,* Report No. FHWA-HOP-18-002, Federal Highway Administration, Washington, D.C. Available online: https://ops.fhwa.dot.gov/publications/fhwahop18002/index.htm, last accessed April 7, 2022.

1. Knowledge of the relative contribution of the factors will lead to better investment selection at the project level ("targeted investments") and better definition of programs at the statewide level (e.g., more emphasis on one of the factors).
2. Understanding how external factors affect performance is extremely useful for setting performance targets. For example, forecasts of areawide economic factors are widely available, and understanding how these factors affect performance will aid agencies in determining the most appropriate targets.
3. Understanding the effects of external factors on performance outcomes allows agencies to identify the causes of dips or spikes in performance that may be surprising, to "adjust" trends (i.e., to produce a more normalized time series) based on what-if assumptions, and to facilitate cross-sectional comparison of performance outcomes among locales and corridors over a given period of time.
4. Communicating mobility performance to management and the public is enhanced with a deeper understanding of why trends occurred. Being able to explain how external factors, especially ones that are largely outside of the control of transportation agencies, influence trends demonstrates transparency and can also be used to help justify program investments. It also provides professionals with hard information rather than relying on anecdotes and guesses when communicating mobility in a journalistic sense.

Two Strategic Highway Research Program 2 (SHRP 2) projects can help practitioners understand the influence that external factors have on mobility in general and reliability specifically. SHRP 2 Project L11, *Evaluating Alternative Operations Strategies to Improve Travel Time Reliability*, explored the influence of several factors:[27]

- Demographics, land use, and urbanization.
- Environment and climate change.
- Energy costs and availability.
- Technological innovation.
- Freight trends.
- Finance, road pricing, and privatization.

SHRP 2 project L04 examined how external factors influencing reliability can be included in forecasting models.[28]

Figure 4 demonstrates the concept of how external factors affect demand and the other contributing factors to congestion, the "first order" determinants of mobility: incidents, weather, work zones, capacity, and demand.

[27] https://nap.nationalacademies.org/catalog/22687/evaluating-alternative-operations-strategies-to-improve-travel-time-reliability, last accessed December 8, 2022.

[28] *Stogios, Y., Brijmohan, A., Mahmassani, H., Kim, J., Chen, Y., and Vovsha, P. https://nap.nationalacademies.org/login.php?action=guest&record_id=22387*Transportation Research Board, Washington, D.C. Available online: https://www.nap.edu/login.php?action=guest&record_id=22388, last accessed December 8, 2022.

It is clear that demand has the greatest number of external influencing factors and the effect of demand on OPMM performance measures cannot be overstated. Demand can be changed in a number of ways: the total number of trips made, trip length, or temporal distribution of trips (e.g., peak versus off peak). Accounting for how external factors affect each of these aspects of demand is a critical component of any relationships that are developed.

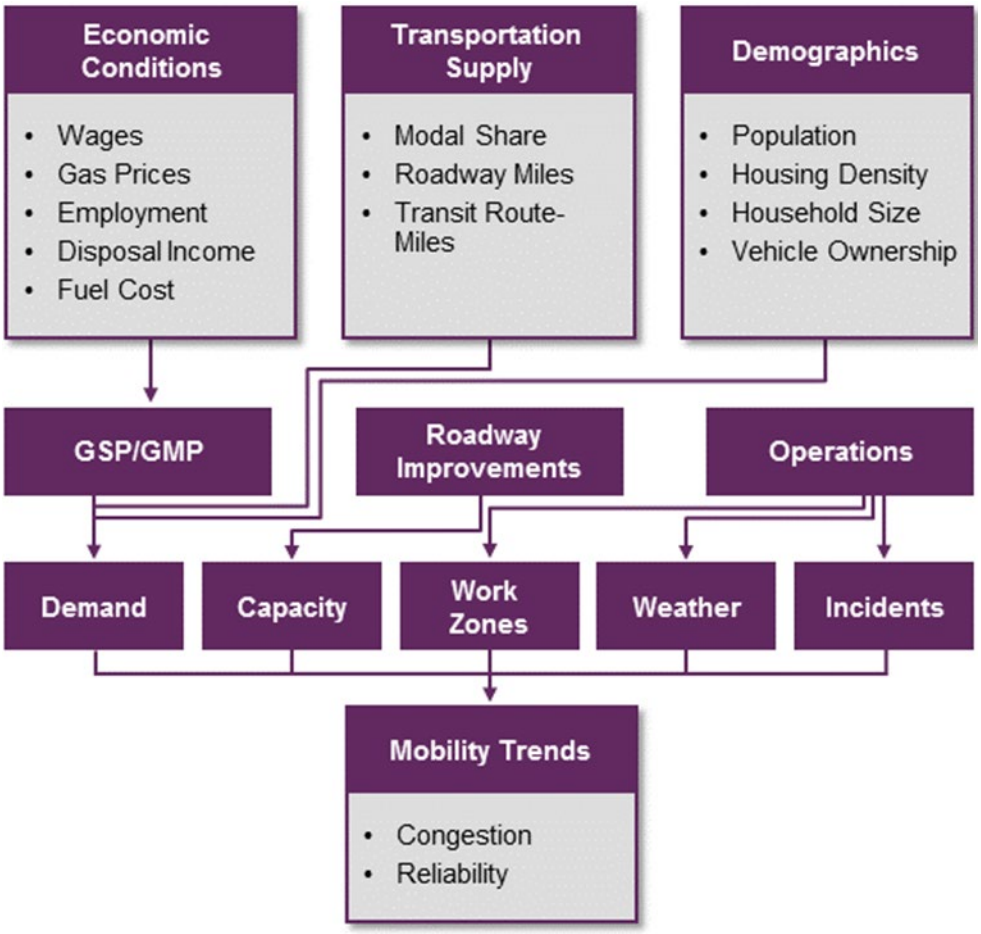

Figure 4. Flow chart. Relationship between external factors and operations performance measures and management.
(Source: Federal Highway Administration.)

PERFORMANCE MONITORING

Collecting data on actual system performance allows a region to monitor performance trends and determine if indicators are moving in the right direction. Performance measures and trends can then be communicated internally and externally through periodic performance reports. Periodic performance reports are an effective tool for communicating how the OPMM approach is used to improve performance and the quality of life for the traveling public. A number of agencies already use performance reports to inform decisionmakers about system performance and the effectiveness of OPMM strategies.

REPORTING

Periodic performance reports support the OPMM approach in a number of ways including:

- Providing a realistic view of system performance improvements that can be attained through management and operational investments.
- Providing operations managers with up-to-date benchmarks on how, or if, operations programs are contributing to performance objectives.
- Supporting realistic policies that recognize system constraints to performance improvement and also the role of system management and operations to maintaining a desired level of performance.

Related to the discussion in the Planning for Operations section, periodic performance reporting is best supported through sustained communication between planning and operations staffs. Sustained communication encourages routine coordination between staffs and allows operational tools to be more effectively leveraged during the planning process. Thus, in addition to being a core component of OPMM, periodic performance reporting supports the fundamental concept of planning for operations on which OPMM relies.

The FHWA has compiled numerous examples on reporting congestion and safety performance.[29] Beyond these, several other reporting mechanisms offer insight into how to conduct performance reporting:

- Figure 5 is an example of statewide reporting of travel time reliability, showing the trends over time. Trend analysis is highly useful for gauging the top-level effects of OPMM and other congestion mitigation programs. Increasing unreliable travel is an indicator that TSMO strategies could be beneficial.
- Figure 6 shows how congestion on a facility grows and dissipates over time and space. This chart may be produced in real time or may use monthly or annual averages. This visual analysis communicates the nature and extent of congestion on a facility.
- Figure 7a is a facility-level diagram showing the reliability of the facility with several causal factors of reliability shown. One can see the high variability in travel times on this facility through the travel time distribution, which is the basis for developing reliability performance measures. This type of diagnostic "drills down" into the root causes of congestion and can be used to target TSMO strategies.
- Figure 7b is another example of presenting facility-level performance in times of several performance measures.

[29] Federal Highway Administration. (no date). "Examples of Performance Measurement Programs." (website) Washington, D.C. Available online: https://ops.fhwa.dot.gov/perf_measurement/example_programs.htm, last accessed April 7, 2022.

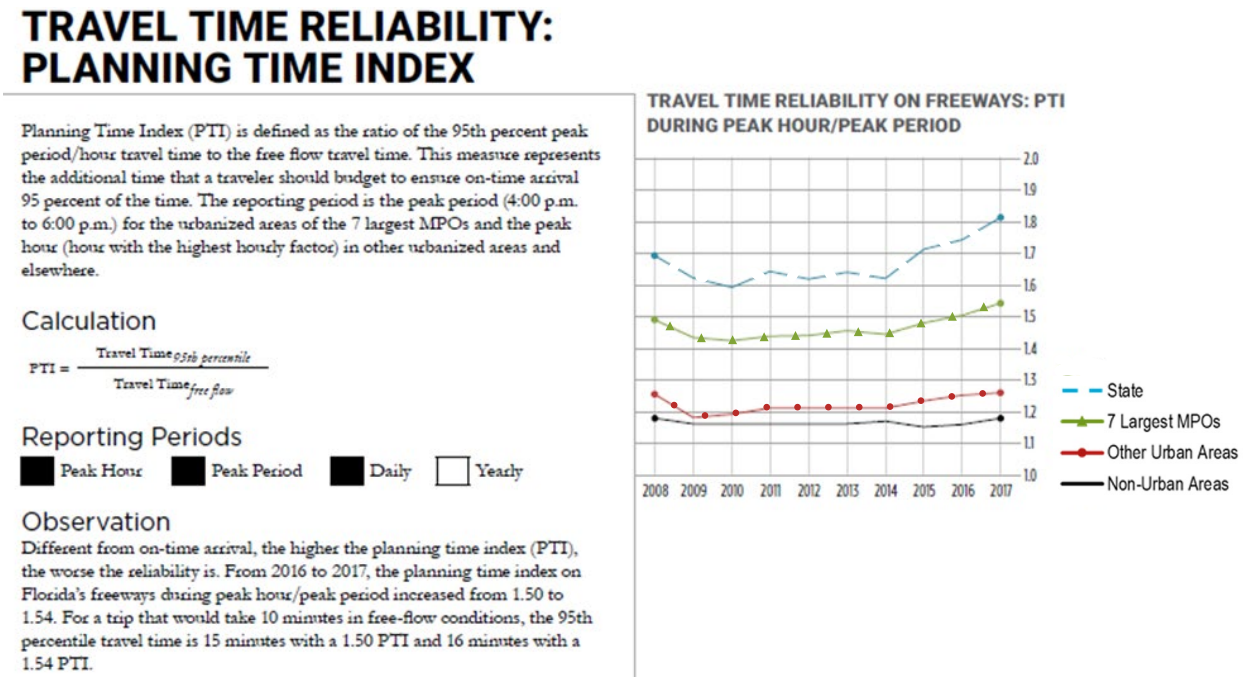

Figure 5. Chart. Travel time reliability trends on Florida freeways.
(Source: Florida Department of Transportation, 2020.)

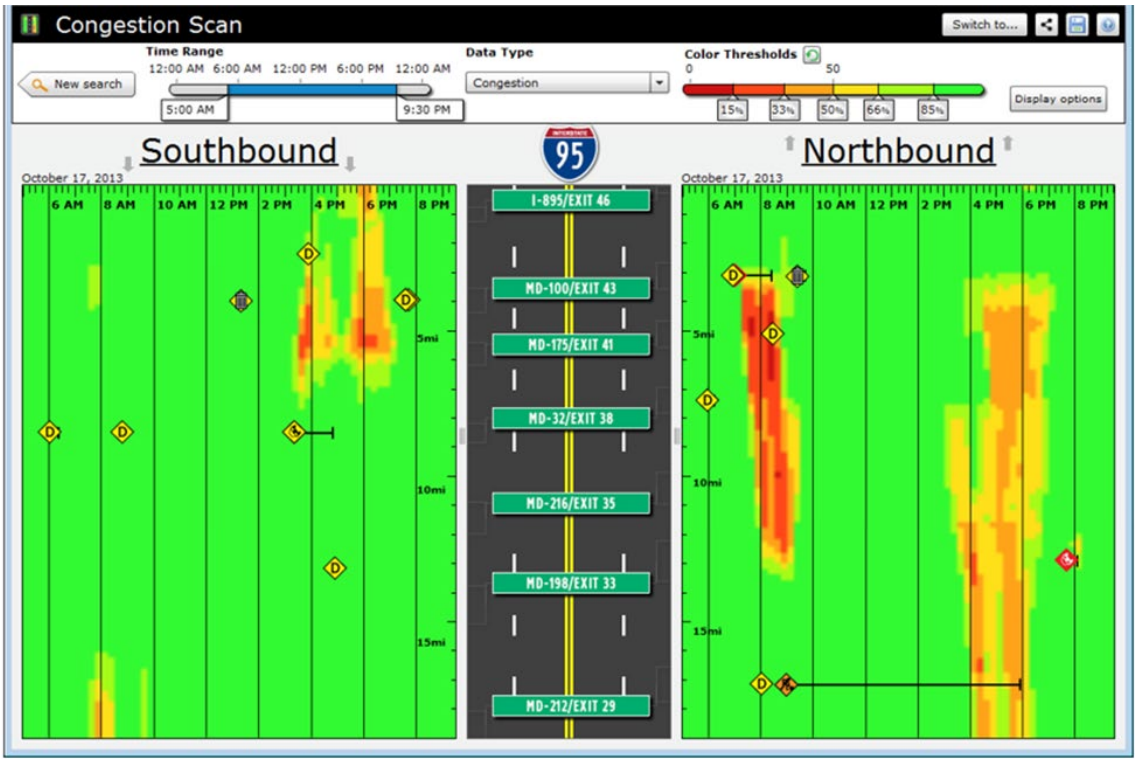

Figure 6. Screenshot. Depiction of congestion in time and space.
(Source: University of Maryland Center for Advanced Transportation Technology Lab, 2018.)

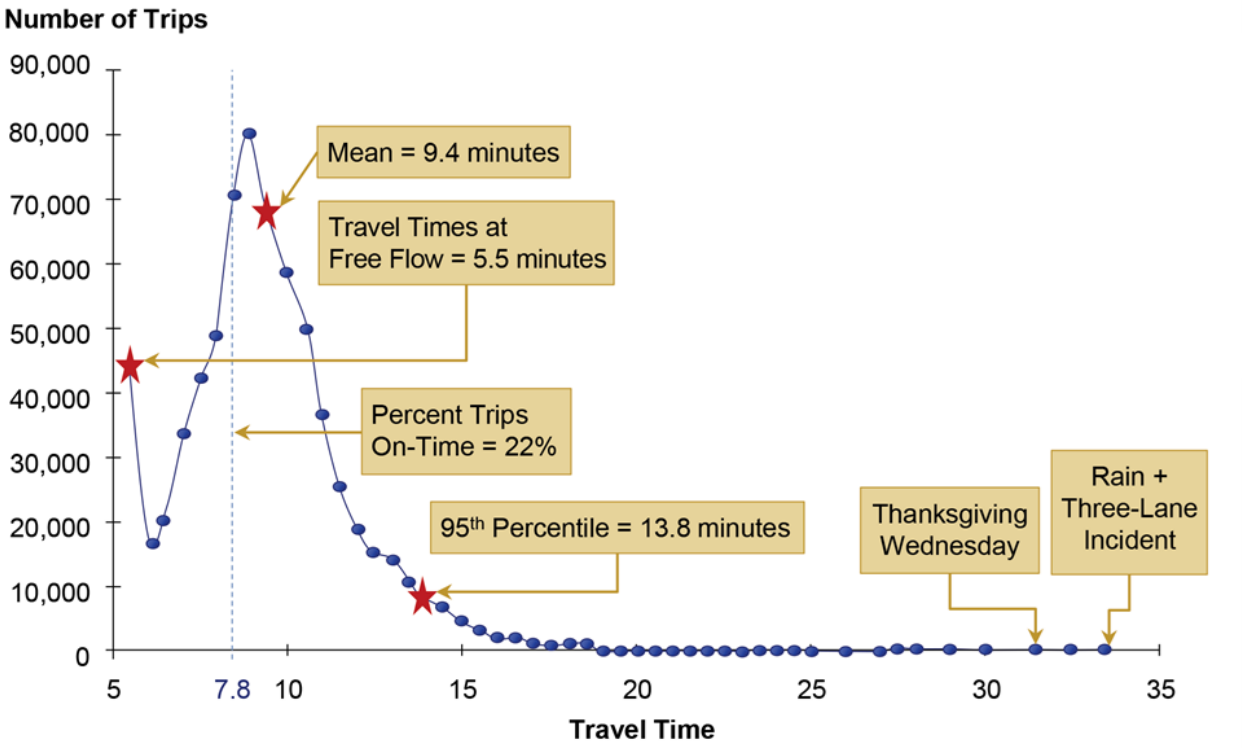

Figure 7a. Chart. Reliability characteristics: I-75 Northbound I-85 Roswell Road, Atlanta.
(Source: Federal Highway Administration, 2021.)

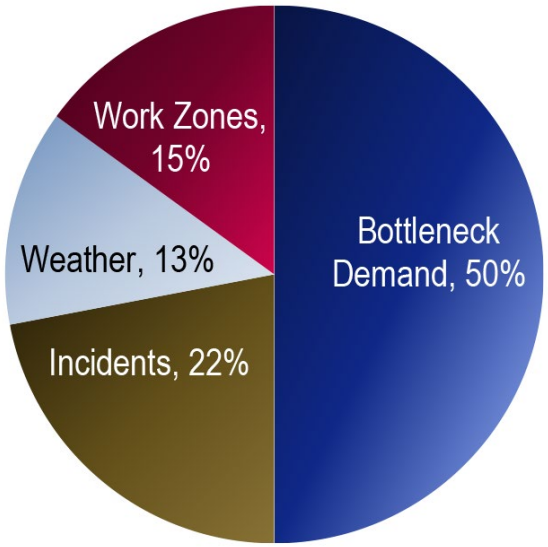

Figure 7b. Chart. Sources of Congestion: I-75 Northbound I-85 Roswell Road, Atlanta.
(Source: Federal Highway Administration, 2021.)

Table 2a. Time slice—PM peak period (4:30 p.m. to 6:30 p.m.).

Disruption	
Type	**Indicator**
Incident	13.9 Lane-Hours Lost (LHL)
Work Zone	8.8 LHL
Percent Days Weather Influenced	11%
Percent Days with Demand >110% off Normal	18%

Table 2b. Incident analysis.

Category	Number	Duration (Minutes)	
		Mean	**95th Percentile**
All	94	32.1	75.5
Lane-Blocking	90	32.4	75.5
Large Truck	2	20.3	38.6

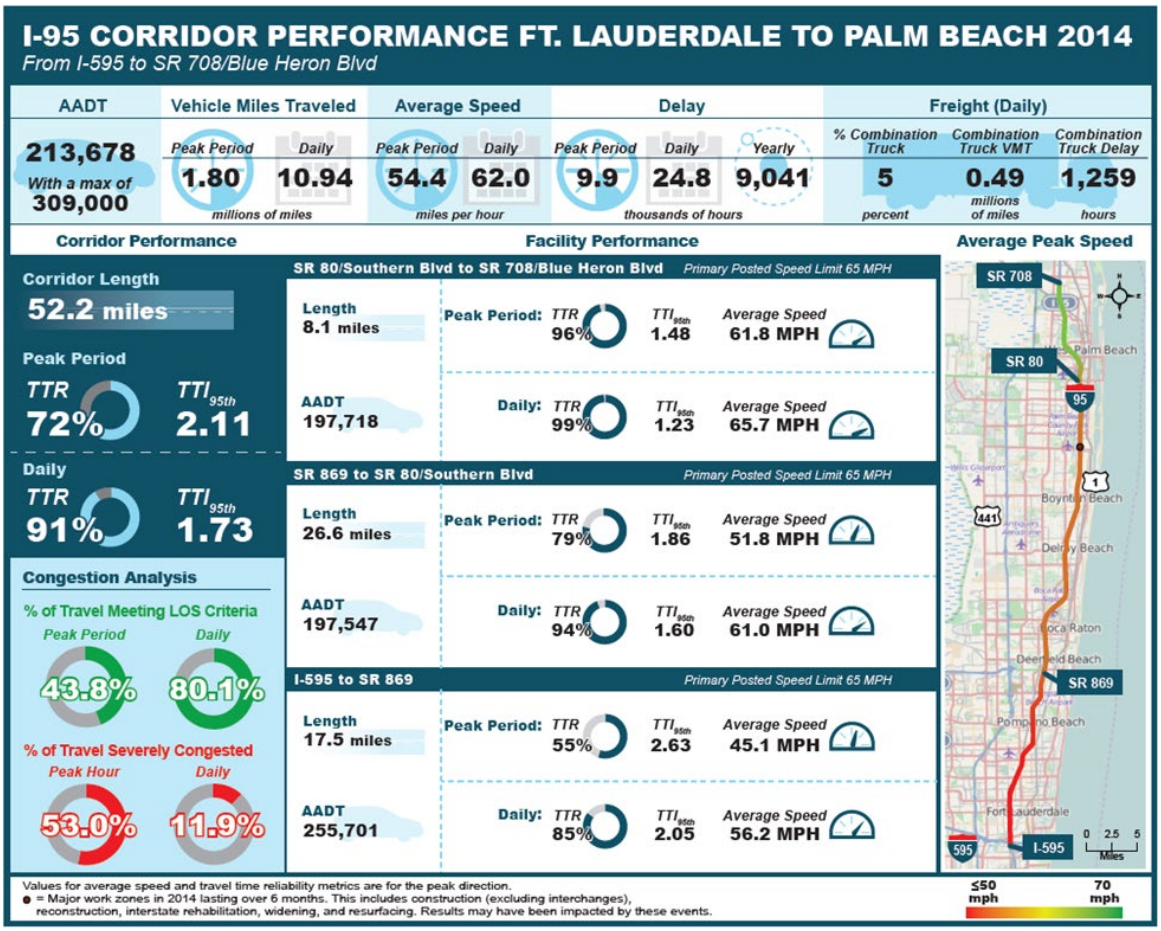

Figure 8. Screenshot. Presentation of travel time measures in on a facility.
(Source: Florida Department of Transportation.)

PROJECT/STRATEGY EVALUATION

Overview

Evaluation is an important step in a management-based approach to operations that is closely tied to monitoring/measurement activities. Evaluation refers to the practice of assessing the effectiveness of an operational strategy or practice towards achieving a desired performance objective. It is closely tied to monitoring/measurement activities because without the measurement of performance and monitoring performance indicators over time, evaluation is not possible.

Assessing the effectiveness of strategies and investment through evaluation studies is necessary if an agency is to realize the full benefits of OPMM. Having a better understanding of the effectiveness of strategies and investments allows transportation planners and operators to work together to devise more effective investment strategies to meet performance objectives. Strategies that are already working can be fine-tuned to perform even better while those that are not working can be fixed or abandoned.

Evaluation is closely tied to monitoring/measurement through three interrelated elements as part of an iterative process:

1. Assessing the effectiveness of strategies.
2. Tracking system performance.
3. Refining operations objectives.

As discussed at the beginning of this chapter, assessing the effectiveness of strategies provides agencies the opportunity to further refine those strategies or to devise new ones. It also provides the necessary input to the Reporting element of OPMM so that agencies may be able to communicate the value of various operational strategies to decisionmakers and the public. Importantly, to be able to assess the effectiveness of various strategies, agencies will need to have data on before-and-after conditions. Otherwise, there is no baseline by which to measure whether performance has improved or worsened.

A key component of OPMM is the ability to conduct evaluations of completed projects and to use the results to make better-informed investment decisions in the future. Historically, evaluation of congestion mitigation projects, including TSMO, were limited in number and scope because of data scarcity. Conversely, transportation agencies routinely invest great effort in forecasting the impact of transportation improvements, but practitioners have seldom had the opportunity to evaluate the outcomes of these investments, except in isolated cases where special studies are conducted. The large amount of data that is now available allows evaluations to become routine with little or no additional data collection needed.

Although a rich history of evaluations has been accumulated, the vast majority of studies lack a consistent method; common performance measures; and, most problematic, controls for dealing with factors that can influence the observed performance other than the project treatment.[30] A

[30] U.S. Department of Transportation, Office of the Assistant Secretary for Research and Technology, Intelligent Transportation Systems. (no date). "Benefits Database Overview." (website) Washington, D.C. Available online: http://www.itsbenefits.its.dot.gov/, last accessed April 7, 2022.

thorough treatment of an evaluation methodology is beyond the scope of this primer. Regardless of what a comprehensive methodology entails, at its core, it will be examining travel time and demand data. The remainder of this section focuses on the use of these data types.

Relevant Data

A comprehensive and statistically valid evaluation methodology will have to draw on a variety of data types to establish controls. Observational studies usually make use of experimental controls to account for the effect of variation in the measurement of interest and for the effect of exogenous factors. In classic observational before and after studies, controls are sites that have not received the improvement (treatment), but have underlying characteristics similar to the test sites before the improvement. Figure 9 shows an example of tracking congestion via the Travel Time Index over time for a control and test (treatment) site.

Because the primary impact of interest is congestion, another method of establishing experimental controls can also be used. This approach is based on examining the underlying causal factors to congestion in the before and after periods. Travel time-based impacts are the primary factor of interest, but many factors can influence travel time besides an improvement project, including incidents, demand (e.g., day-to-day and seasonal variations and special events), weather, work zones, traffic controls, and general operations policies. Ideally, the influence of these factors is stable (or nearly so) in the before and after periods of project implementation, which allows for observed changes in travel times to be untainted. In theory, all of these data types can be obtained from archived operations data, although in practice, some operations may choose not to archive certain types of data.

Analytical Procedures

Figure 10 outlines an approach for evaluation TSMO (or any congestion mitigation) projects. The concept is to quantify the factors that can influence travel times in the before and after periods, decide if they are roughly equivalent, and if not, make adjustments to the travel time measures based on applying models. Using models to adjust the controls has not been examined deeply yet, but it is similar to the Empirical Bayes method used in highway safety analysis, where observed data is adjusted for external influences using a model.[31]

[31] Hauer, E., Harwood, D. W., Council, F. M., and Griffith, M. S. (2002) *Estimating Safety by the Empirical Bayes Method: A Tutorial,* Transportation Research Record 1784, Transportation Research Board, Washington, D.C.

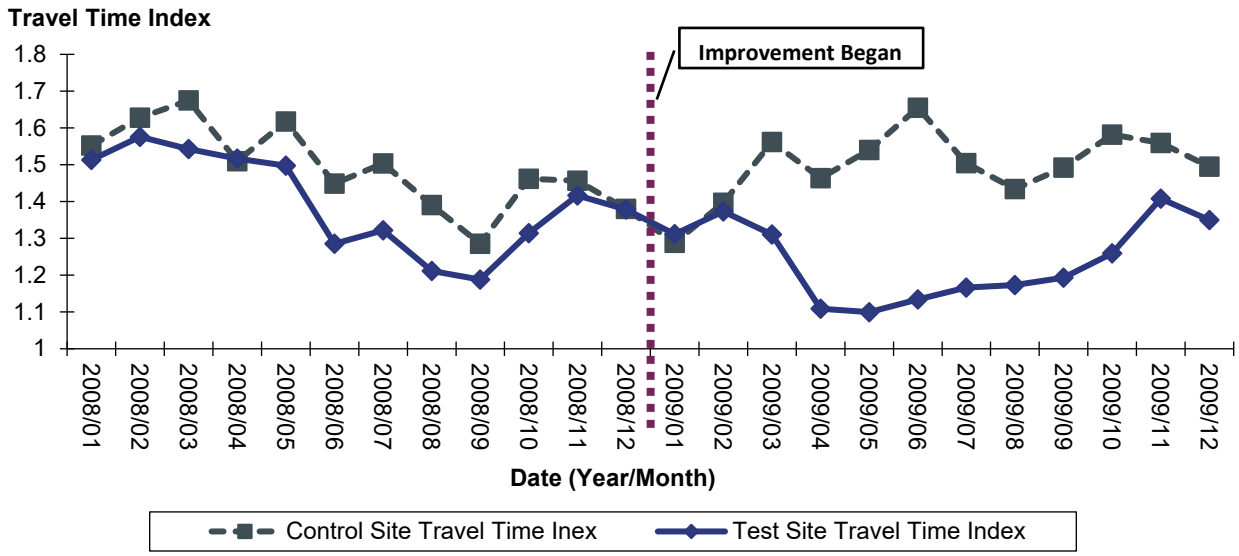

Figure 9. Line graph. Example time plot of travel time index on test and control sites.
(Source: Federal Highway Administration.)

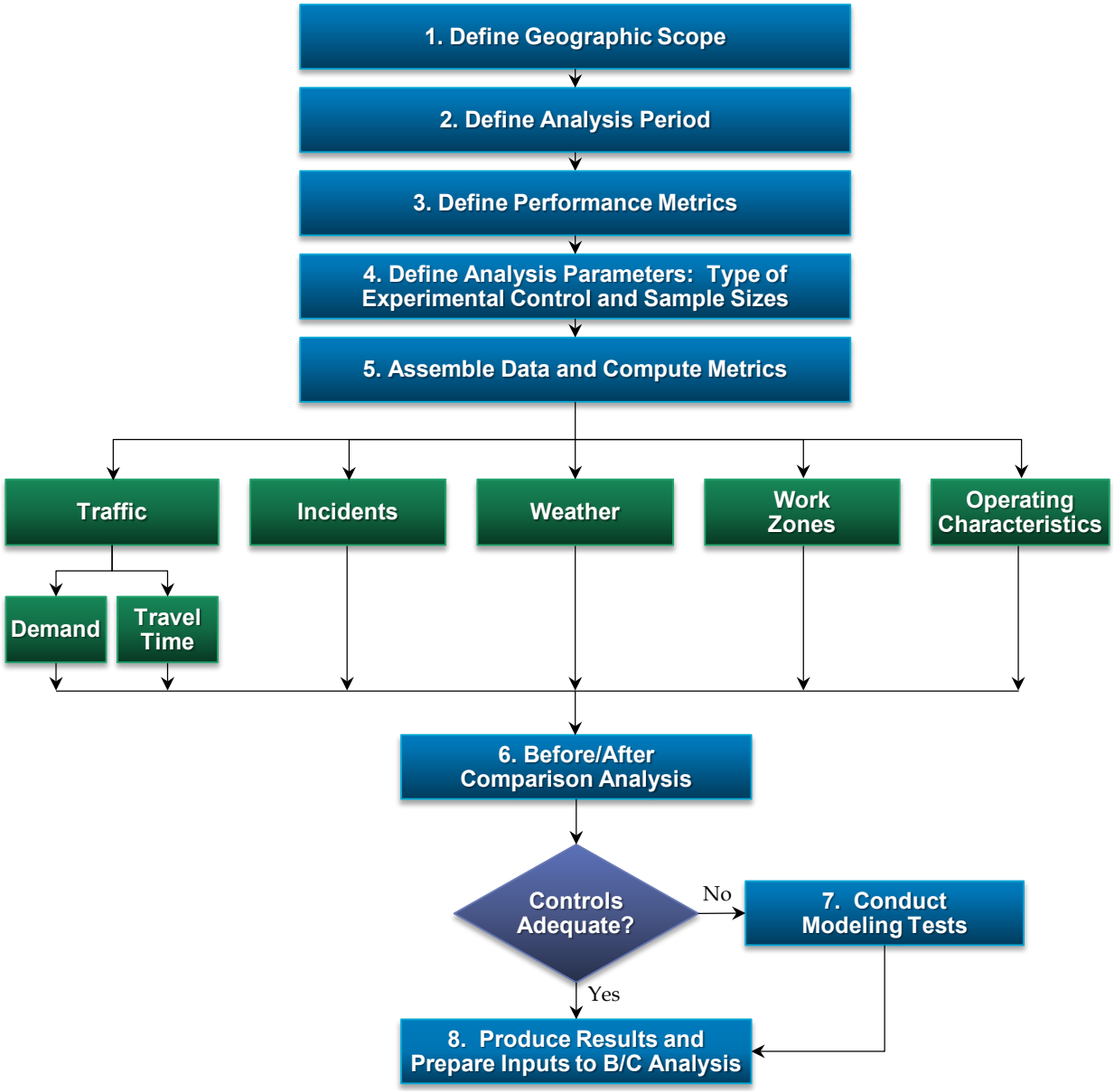

Figure 10. Flow chart. Before/after evaluation methodology using controls for exogenous factors.
(Source: Federal Highway Administration.)

OPERATE

Up to this point, the OPMM discussion in this Primer has been on monitoring and understanding past trends in mobility, the effectiveness of TSMO strategies to address them, and using this information so that state and local transportation agencies can invest more effectively. Most TSMO strategies are dynamic in that they adapt to current conditions, so OPMM has a real-time as well as a historical context. Decision support systems (DSS) are a key tool in implementing dynamic control of TSMO strategies. DSS use a variety of data sources in an automated, computer-based environment to support business and operational decisionmaking. Applications

of DSS include Integrated Corridor Management where a key aim is to balance demand with available capacity, including the consideration of multiple modes.

As with historical OPMM activities, DSS rely on performance measurement of the transportation system, but in a real-time situation. Emerging nontraditional sources of data enable new insights into system performance, and can lead to identifying previously undetected trends and relationships.

CHAPTER 4. OPERATIONS PERFORMANCE MEASURES AND MANAGEMENT IN DECISIONMAKING

HOW OPERATIONS PERFORMANCE MEASURES AND MANAGEMENT ENHANCES TRANSPORTATION SYSTEMS MANAGEMENT AND OPERATIONS PLANNING AND PROGRAMMING DECISIONS

Performance management provides a means to efficient investment of Federal transportation funds by increasing accountability and transparency, and improving project decisionmaking through performance-based planning and programming. States have been developing performance measures and implementing performance management for several years, often prior to Federal TPM requirements. Consequently, consistency at the national level is essential as a subsequent step.

The intent of TSMO is effective and cost-efficient solutions in lieu of major capital investments. TSMO strategies aim to better leverage capacity limitations due to congestion, incidents, construction, weather, poor signalization, and other factors. TSMO improvements are based on measuring performance on a regular basis, tracking performance changes over time, and managing the transportation system to achieve desired results.

OPMM can enhance TSMO though improving communications between decisionmakers, stakeholders and the traveling public. Following steps can be used as a part of OPMM to advance TSMO:[32]

- Using a performance-based approach to provide users with a high quality and reliable highway system.
- Helping to extend the performance life of new facilities and support the agency's overall mission to manage and operate the transportation system.
- Implementing a comprehensive system level performance measurement program to monitor progress toward mobility and reliability targets.
- Developing a data supported system for resources in need of performance reporting.

FHWA and the Federal Transit Administration promote planning for TSMO among MPOs, State and local State DOTs, transit agencies, and other stakeholder organizations through guidebooks, case studies, workshops, courses, and webinars. A few of their previous works are listed below:

- Planning for TSMO within Corridors—A Desk Reference.[33]

[32] Maryland Department of Transportation (2016). *TSM&O Strategic Transportation Plan,* Annapolis, MD. Available online: https://www.roads.maryland.gov/OPPEN/MD_TSMO_Strategic%20Implementation%20Plan_Aug%202016.pdf, last accessed April 7, 2022.

[33] Bauer, J.,Platman, Deena, Grant, Michael, and Smith, Michael, Jocelyn Bauer, Deena Platman, Michael Grant, Michael Smith, *Planning for Transportation Systems Management and Operations within Corridors – A Desk Reference*, Report No, FHWA-HOP-16-037, Federal Highway Administration, Washington, D.C. Available online: https://ops.fhwa.dot.gov/publications/fhwahop16037/fhwahop16037.pdf, last accessed December 8, 2022,

- Advancing TSMO through Scenario Planning.[34]
- TSMO in Action.[35]
- Maryland TSMO Strategic Implementation Plan.[36]
- Developing and Sustaining a TSMO Mission for Your Organization—A Primer For Program Planning.[37]

TSMO program planning is a living process which should reflect all undertaking agencies plans. TSMO primer for program planning articulated that there is no single method for agencies to advance TSMO, and recommended several key elements and principles that should be undertaken by agencies in order to develop a comprehensive plan.[38] TSMO program planning three key elements are:

1. Strategic elements: The main focus of this step is to develop the business case for TSMO vision and program mission. Identify performance measures that link to TSMO goals.
2. Programmatic elements: This step addresses issues such as leadership support, organizational structure, career development plans for TSMO staff, and strategies to promote TSMO culture within the agency and among partners.
3. Tactical elements: Identifying prioritized services, activities, and projects. [39]

INTEGRATING OPERATIONS PERFORMANCE MEASURES AND MANAGEMENT INTO AGENCY PROCESSES

Agencywide Performance Reporting

Performance measures can be defined at several different levels for TSMO program management. These include:

- Inputs: resources put into an activity (e.g., staff-hours associated with incident management, number of ramp meters).
- Activities or Outputs (e.g., number of signal controllers upgraded).
- Outcomes (e.g., travel time, congestion level). Outcome measures are used to monitor progress toward goals and objectives.

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[34] Bauer, J., Ange, K., Twaddell, H. (2015). *Advancing Transportation Systems Management and Operations through Scenario Planning,* Report No. FHWA-HOP-16-016, Federal Highway Administration, Washington, D.C. Available online: https://ops.fhwa.dot.gov/publications/fhwahop16016/fhwahop16016.pdf, last accessed April 7, 2022.

[35] Clark, J., et al. (2017). *Transportation Systems Management and Operations in Action,* Report No. FHWA-HOP-17-025, Federal Highway Administration, Washington, D.C. Available online: https://ops.fhwa.dot.gov/publications/fhwahop17025/fhwahop17025.pdf, last accessed April 7, 2022.

[36] Maryland Department of Transportation. (2016). *Strategic Implementation Plan.* Annapolis, MD. Available online: https://www.roads.maryland.gov/OPPEN/MD_TSMO_Strategic%20Implementation%20Plan_Aug%202016.pdf, last accessed April 7, 2022.

[37] Grant, M. Noyes, P., Oluyede, Bauer, J., and Edelman, M. (2017). *Developing and Sustaining a Transportation Systems Management and Operations Mission for Your Organization—A Primer for Program Planning,* Report No. FHWA-HOP-17-017, Federal Highway Administration, Washington, D.C. Available online: https://ops.fhwa.dot.gov/publications/fhwahop17017/fhwahop17017.pdf, last accessed April 7, 2022.

[38] Ibid.

[39] Ibid.

- Efficiencies (e.g., money spent per reduction in incident duration). Efficiency measures are used to evaluate the effectiveness of overall transportation programs.

Performance measures for OPMM should be developed for the input, output, and outcome levels. Further, they should be vertically integrated. That is, a fully integrated set of performance measures should be constructed, where higher-level performance measures (outcomes) are directly influenced by changes in lower-level measures. In the general literature on performance measurement, this is described as a program logic model.[40]

Program logic models visually map the cause-effect relationships that exist between the inputs, activities, outputs, and outcomes produced by their programs or projects, for specific stakeholders. Program logic models also provide a framework for assessing the impact achieved by the organization's application of resources to its programs. These models are intended for organizations whose impact is social change, such as reducing health problems from smoking, reducing water consumption in times of drought, increasing use of sunscreen to minimize skin cancer incidence, or reducing homelessness.

Figure 11 shows how this model can be adapted for traffic incident management. The distinction between "outputs" and "outcomes" is that outcomes are experienced directly by the user of the highway, while outputs are related to how incident management activities perform (which in turn influence outcomes). Note that measures related to daily operations activities feed into a broader context, and are indicated by broader planning vision, goals, and objectives. In addition, as one goes higher in the structure, the influence of other factors outside of incident management affect congestion and travel time reliability.

[40] Besharov, Douglas J., Baehler, Karen J., and Klerman, Jacob Alex. (2017). *Improving Public Services: International Experiences in Using Evaluation Tools to Measure Program Performance,* ISBN-13: 9780190646059.

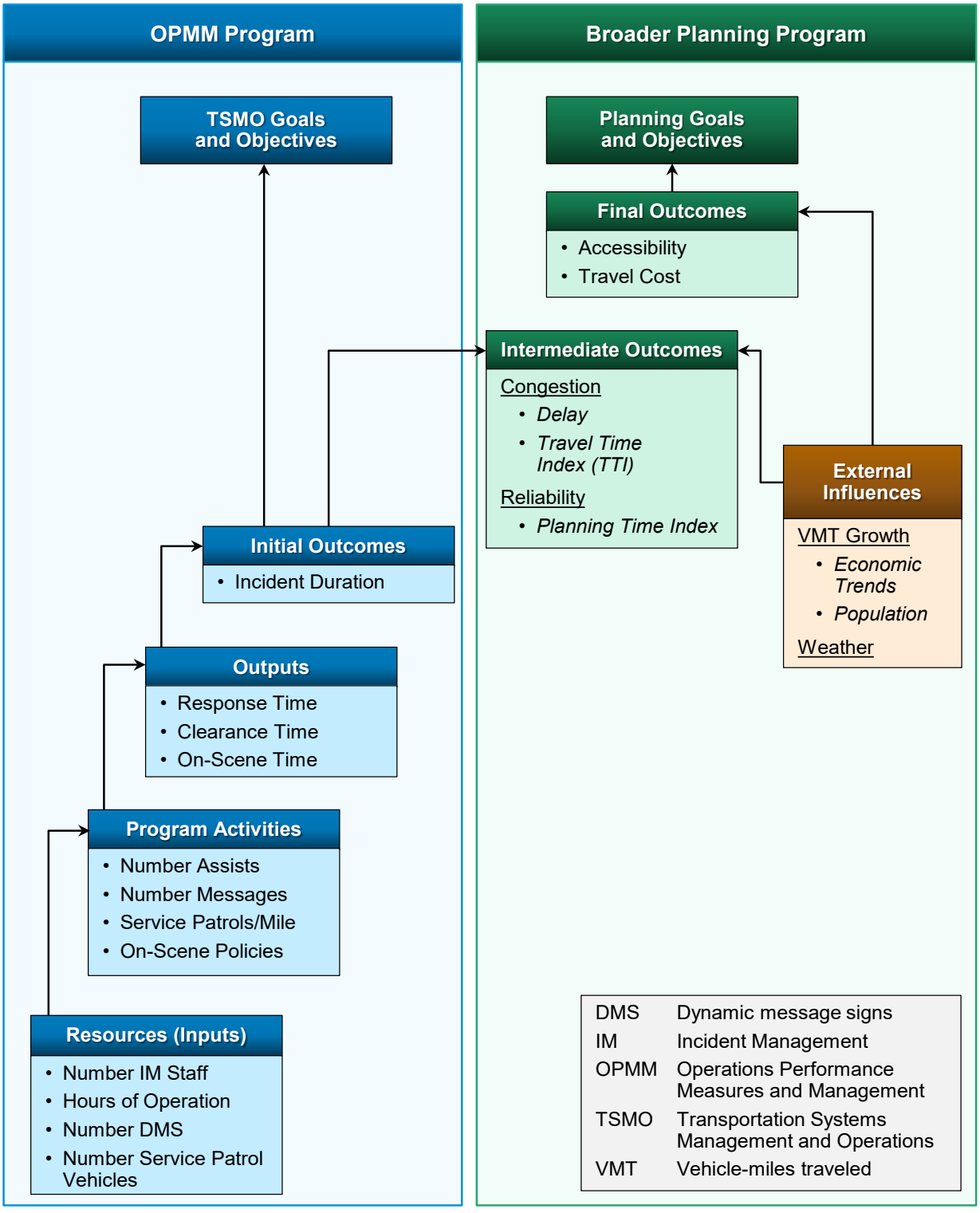

Figure 11. Diagram. Program logic model applied to traffic incident management.
(Source: Federal Highway Administration.)

Performance-Based Planning and Programming

PBPP refers to the application of performance management principles within the planning and programming processes of transportation agencies to achieve desired performance outcomes. PBPP is based on establishing performance goals and continuously measuring progress toward those goals with performance measures. PBPP is data-driven and uses data to support long-range and short-range investment decisionmaking.

OPMM uses a variety of performance measures for many purposes. While some measures may be dictated by legislative or regulatory mandates, it is useful to also select measures that provide internal or detailed operational and planning data beyond that normally needed for reporting purposes. Understanding the range of needs and uses is important in the process of identifying the measures. For example, already deployed TSMO strategies can be "tweaked" in the short term to address measured changes in performance. In the long term, different TSMO strategies can be applied in response to changing performance levels.

PBPP is meant to affect a range of activities and products related to planning and programming, among them are:

- LRTPs.
- Federally required plans and processes such as Strategic Highway Safety Plans, Congestion Management Plans (CMP), and Transportation Asset Management Plans.
- Transportation Improvement Programs.
- STIPs.

OPMM has important roles to play in the production of most of these planning and programming products. OPMM performance measures on mobility inform the development of a broad range of strategies that go into these products. Additionally, the identification of TSMO strategies and their potential impact need to be included in these broader scope documents to ensure that TSMO is viewed on equal footing with other forms of improvements.

For example, CMPs are "…systematic and regionally accepted approach for managing congestion that provides accurate, up-to-date information on transportation system performance and assesses alternative strategies for congestion management that meet State and local needs."[41] OPMM performance measures are primarily related to congestion and are thus the starting point for CMP development. Moreover, the CMP is an ideal place to plan for TSMO deployment along with other congestion mitigation strategies.

Performance-Based Practical Design

Performance-Based Practical Design (PBPD) is based on modifying a traditional design approach to tailor the design of an improvement so that its performance meets both project and system objectives. PBPD uses data to understand current performance and deficiencies and

[41] Federal Highway Administration. (no date). "Organizing and Planning for Operations." (website) Washington, D.C. Available online: https://ops.fhwa.dot.gov/plan4ops/focus_areas/cmp.htm, last accessed April 7, 2022.

performance analysis tools to predict the impact of proposed improvements. It considers both short- and long-term project and system goals.

Whereas Planning for Operations is performed at the beginning of the project development process, PBPD is done as part of the design process. Just as with Planning for Operations, OPMM can supply both the data and performance analysis tools to assess the impacts of operations strategies during the design process. Ideally, operations strategies have been previously identified during planning steps, but even if they are not, they can still be considered at the design stage.

For example, the data used to develop OPMM performance measures—especially travel time, weather, and incident data—can be used to document current performance and to influence design decisions. These data may indicate problems that would otherwise go undetected using only the demand and geometric data that are typically used for design. A further example of how the operations strategy of Active Traffic Management can be considered during the PBPD process has been prepared by the FHWA.[42] More detail on the OPMM data sources and performance analysis tools appear later in this Primer.

Operations Performance Measures and Management Support of Freight Performance Management and Planning

Just as OPMM is the enabling mechanism for TSMO Planning and plays a role in the larger planning environment, it also supports freight performance management and planning. One of the key areas of support is in the required reporting of freight bottlenecks. As part of the Federally mandated reporting, State DOTs must identify and describe the ways in which they are addressing congestion at freight bottlenecks[43]. The FHWA Truck Freight Bottleneck Reporting Guidebook recommends the following process for identifying bottlenecks, which is the starting point for addressing freight issues in TPM:[44]

- Gather data for bottleneck identification and analysis, including travel times, truck volumes, traffic management center operational data, and truck restriction information from roadway inventories.
- Screen for truck freight bottlenecks using a data-driven process for more detailed site-specific analysis and verification.
- Validate truck freight bottleneck list using of comparable data, expert validation, stakeholder input, or additional research.
- Evaluate the causes of bottlenecks based upon analysis of roadway characteristics, field assessment, and discussions with affected road users.
- Prioritize the list of freight truck bottlenecks to focus freight planning efforts on the highest and best use of limited resources.

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[42] Federal Highway Administration. (2022). "Demonstrating Performance-Based Practical Design through Analysis of Active Traffic Management." Washington, D.C. Available online: https://ops.fhwa.dot.gov/publications/fhwahop16087/fhwahop16087.pdf, last accessed April 7, 2022.

[43] 23 CFR 490.609

[44] Federal Highway Administration. (2018). *Truck Freight Bottleneck Reporting Guidebook*, Report No. FHWA-HOP-18-070, Washington, D.C. Available online: https://www.fhwa.dot.gov/tpm/guidance/hop18070.pdf, last accessed April 7, 2022.

Bottleneck identification is part of the OPMM process of monitoring current mobility conditions. In urban areas, the worst bottlenecks are typically related to geometric and capacity deficiencies apparent during peak periods. However, while trucks must also navigate these types of bottlenecks, trucks also are subject to bottlenecks created by policy restrictions, such as time of day and routing restrictions. Freight bottlenecks are generally categorized as follows:

- Congestion Bottlenecks—Bottlenecks characterized by significant reductions in average truck speeds can be either recurrent or nonrecurrent.
    - Recurrent congestion bottlenecks—Recurrent congestion occurs when traffic over-demand at peak periods routinely exceeds a road's capacity, defined primarily by the number of lanes and the travel speed for which they were designed.
    - Nonrecurrent congestion bottlenecks—These bottlenecks occur sporadically when out-of-the-ordinary incidents impede road capacity, add travel demand or, in extreme cases, force re-routing or a complete halt to all travel, such as, crashes, special events, work zones, or severe weather.
- Truck Restriction Bottlenecks—Truck-specific bottlenecks attributed to infrastructure restrictions that uniquely impact trucks and may require trucks to take longer routes, carry smaller loads or move at different times of day, such as substandard vertical or horizontal bridge clearance, weight restrictions, steep grades, hazardous materials restrictions, or delays at port gates, intermodal rail yards, border crossings, and weight stations.

OPMM has a direct effect on freight bottleneck planning and management. The same data that is used to monitor congestion-based performance for general traffic can be used for truck-specific bottleneck performance, with the inclusion of truck volumes. Moreover, solutions to freight bottlenecks can be integrated into TSMO solutions. Such a framework will lead to a coordinated and comprehensive State freight plan.

CHAPTER 5. ASSESSING YOUR PROGRESS IN CONDUCTING OPERATIONS PERFORMANCE MANAGEMENT

PRIMER SUMMARY

This Primer has described the principles of OPMM in the context of transportation investment decisionmaking and other performance management activities. OPMM is a data-driven process that develops investments based on the actual performance of the transportation system. Its features are shared with the broader contexts of Transportation Performance Management and Performance-Bases Planning and Programming, but is tied specifically to mobility performance and the application of TSMO strategies. OPMM enables TSMO projects to be considered in these broader contexts and also supplies valuable mobility performance information for multimodal decisionmaking.

OPMM is also an iterative process based on the major functions of:

- Monitor and measure performance.
- Report performance.
- Evaluate improvements.
- Operate the system.
- Make investment decisions based on performance.
- Repeat and revise the process over time.

Each of these functions is described in detail in earlier sections of this Primer. The next section describes a process for evaluating agencies' stage of OPMM development and for improving their level of development.

OPERATIONS PERFORMANCE MEASURES AND MANAGEMENT CAPABILITY MATURITY FRAMEWORK

Overview

A Capability Maturity Framework (CMF) is a formal process that can be used by agencies to understand how fully they have adopted specific concepts into their business practices and procedures. The CMF recognizes that improvements in capability should be implemented in incremental and "doable" steps that can be taken as resources and conditions permit. Those steps include clearly identified criteria that build upon previous activities to reduce the risk of failure. The CMF is designed to help agencies better understand how their business practices currently function relative to specific functional goals, and once they understand their current status relative to those goals, help them adopt new business practices and procedures by providing a path that guides the agency and its staff from ad hoc application of the desired business principals to formal application of them within the agency's routine business processes.

CMFs have been developed for many functional areas including TSMO. CMFs are an enhanced form of self-assessment based on a matrix analysis of the level of sophisticated achieved by an

agency for a given program. CMFs promote a process-driven approach to continually improve agency actions. The matrix is defined by two factors:

1. **Process Improvement Areas.** These are broad categories, sometimes called "dimensions," that relate to how well an agency functions. There are typically six process improvement areas for the TSMO CMF, these are business processes, systems and technology, performance measurement, organization and workforce, culture, and collaboration. Each of these areas may be broken down into supporting categories.
2. **Levels.** For each process improvement area, four levels are defined, with each level representing higher forms of achievement and greater sophistication in agency actions.
    a. Level 1: Ad hoc. Activities and relationships are informal and champion-driven, substantially outside the mainstream of other agency (State DOT or MPO) activities.
    b. 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.
    c. Level 3: Integrated. Standardized strategy applications implemented in priority contexts and managed for performance; technical and business processes developed, documented, and integrated into agency; partnerships aligned.
    d. Level 4: Optimized. Full, sustainable core agency program priority, established on the basis of continuous improvement with top-level management status and formal partnerships.[45]

Agencies assess what level they have achieved for each process improvement area. The CMF offers guidance for how to move to the next level for each cell in the matrix. Agencies then prepare an Action Plan to follow through on the guidance needed to improve their process (i.e., "advance to the next level").

Implementing an Operations Performance Measures and Management Capability Maturity Framework

Table 3 shows the OPMM CMF. The goal of the OPMM CMF is to help transportation agencies operate the surface transportation system using data-driven decisions and data-driven investments. It addresses the stages that agencies, jurisdictions and regions advance through as they move from ad hoc consideration of transportation system operations to fully embracing OPMM as a key aspect of their routine work. In the context of the CMF, "fully embracing OPMM" means using both operational activities and performance measures to manage and optimize transportation outcomes.

A CMF consists of six primary dimensions (areas which need to be examined/considered by the agency.) Table 3 is divided into these six dimensions, and one or two simple examples are given of detailed ways the OPMM CMF can be applied to each of the six TSMO operational topics (Traffic Management, Traffic Incident Management, Work Zone Management, Weather

[45] Federal Highway Administration. (2022). "Business Process Frameworks for Transportation Operations." (website) Washington, D.C. Available online: https://ops.fhwa.dot.gov/tsmoframeworktool/cmf_overview.htm, last accessed April 7, 2022.

Management, Special Events, and Traffic Signal Systems Management). The six primary dimensions of the OPMM CMF are:

- Business Processes.
- Systems and Technology.
- Performance Measurement.
- Culture.
- Organization and Workforce.
- Collaboration.

The **business process** dimension examines the status of OPMM within the agency's overall planning, project scoping, project selection, project programming, and budgeting business processes. It examines whether operational improvements are being considered on an equal basis with other types of system improvements. The **systems and technology** dimension examines how effectively OPMM is incorporated in the agency's systems engineering, systems architecture and standards efforts. The better OPMM is incorporated into these areas, the more effectively it can ensure or encourage interoperability between the technologies being adopted, expanded or implemented, thus providing better traffic flow through more integrated operations. The **performance measurement** dimension examines the degree to which OPMM performance measures have been incorporated in the agencies processes. It includes whether formal OPMM performance metrics definitions have been adopted and used, whether the data needed to inform those metrics has been identified and collected, and the degree to which those metrics are being used.

The **culture** dimension addresses the degree to which OPMM has been supported within the overall direction the agency is taking. This includes areas such as whether agency leadership is actively promoting the use of OPMM, the degree to which OPMM is being included in outreach to stakeholders, the degree of technical understanding of OPMM which exists within the agency, and the extent to which legal authority to perform OPMM tasks is available. The **organization and workforce** dimension continues to look at this human development side of adopting the OPMM process within the agency. It examines whether the agency's organizational structure supports OPMM, whether there are staff development resources available for teaching OPMM, whether the agency works to recruit and retain staff in the area of OPMM, and the overall programmatic status of OPMM within the agency.

The final dimension is **collaboration.** This dimension addresses the extent to which the agency routinely includes OPMM in its interactions with other agencies, jurisdictions, and organizations it works with. Coordination is often vital for the effective use of OPMM. Agencies that are often important collaborators in the delivery of effective OPMM include other transportation agencies, public safety agencies, local governments, metropolitan planning organizations, and the private sector.

Within each of these six dimensions the CMF describes four different levels of adoption relative to the activities in those dimensions. These four levels describe how a given activity associated with transportation system operations is performed within the agency and the degree to which the

activity is a formal and integral part of how the agency routinely performs the transportation project identification, selection, and prioritization system.

These levels of adoption also provide the agency with insight into what changes can be adopted which can help an agency move gradually to a more systematic adoption and use of OPMM.

The four different levels of adoption incorporated in the CMF are:

- Performed or Ad-Hoc (Level 1).
- Managed (Level 2).
- Integrated (Level 3).
- Optimized (Level 4).

When an agency is in the Performed stage of adoption of OPMM, the OPMM activities being performed are generally outside the mainstream of other agency activities. They are typically performed by someone championing their adoption, with their relationship to other agency activities being informal or ad-hoc relative to the agency's typical business practices.

When an agency's adoption of OPMM progresses to the next level, Managed, OPMM activities have progressed to the point where core OPMM capacities are under development, but there is little internal accountability or direction for the outcome from those activities, and as a result, the outcomes from those efforts are uneven and not always connected to external agency partners.

The third level of OPMM adoption, Integrated, is reached when priority areas within the agency are being managed for performance. At this level, the technical and business processes that support OPMM are being developed within the agency, documented, and integrated into agency training and external partnerships.

The final level of OPMM adoption, Optimized, is reached when OPMM has become a core agency program priority. At this point, agencies have full adopted the use of data driven decisionmaking, and the goal of continuous improvement. These business approaches receive full support of high-level management and for agency partnerships.

The current version of FHWA's OPMM CMF is shown on the following pages. It addresses the tasks that reflect the performance of operations performance management (monitoring/measuring—reporting—evaluating—operating), across examples of the various work areas of TSMO (traffic management, traffic signal systems management, traffic incident management, work zone management, weather management, and special event management).

Moving to full implementation of the OPMM entails first understanding where an agency currently sits within the CMF, determining activities that allow the agency to move to more formal and comprehensive adoption of the OPMM concepts within the agency's business processes, implementing those activities, and monitoring the changes in the organization that take place, and then continuing to review and refine agency processes, systems, culture and organization.

Table 3. Operations Performance Measures and Management capability maturity framework.

DIMENSIONS	LEVEL 1 PERFORMED, Low Level	LEVEL 2 MANAGED, Medium Level	LEVEL 3 INTEGRATED, High Level	LEVEL 4 OPTIMIZED, Highest Level
Business Processes (Planning, Programming, Budgeting)	Each jurisdiction managing its own issues as it's needed according to individual priorities and capabilities; travel time monitoring only performed to fulfill Federal reporting requirements.	Consensus regional approach developed regarding Operations Performance Measures and Management goals, deficiencies, benefit/cost, networks, strategies and common priorities; operations data used as input to forecasting models and their calibration; TSMO planning and documents not used in broader planning and design processes and documents. Performance measures are reported but not directly incorporated into the planning process.	Regional program integrated into jurisdictions' overall multimodal transportation plans with related staged program and are integrated within agency plans, programs, and budgets, formation of multimodal, multi-agency corridor management teams/programs; TSMO plans are used as input to broader planning and programming plans. System performance relative to adopted targets are used to guide plan development and project selection.	TSMO integrated into jurisdictions' multisectoral plans and programs, based on formal continuing planning processes; TSMO strategies considered simultaneously with capacity and demand management strategies at all stages of project development (planning, preliminary engineering, design); operations data used to diagnose congestion problems and assess impacts of all types of strategies as well as for program budget decisions. Agencies work jointly to develop multimodal solutions for meeting performance targets.

Table 3. Operations Performance Measures and Management capability maturity framework (continuation).

DIMENSIONS	LEVEL 1 PERFORMED, Low Level	LEVEL 2 MANAGED, Medium Level	LEVEL 3 INTEGRATED, High Level	LEVEL 4 OPTIMIZED, Highest Level
Business Processes (Planning, Programming, Budgeting)	**Actions to Advance to Level 2:** Revise planning documents (e.g., long-range transportation plans, transportation improvement programs, corridor studies) to include regional coordination of TSMO strategies with other improvement types.	**Actions to Advance to Level 3:** Revise planning documents to list TSMO projects. Adopt regional performance targets for adopted performance metrics. Update existing TSMO Strategic Plan to include Operations Performance Measures and Management principles.	**Actions to Advance to Level 4:** Revise internal needs assessment procedures to allow consideration of TSMO strategies as viable alternatives at all stages of project development. Use travel time performance trends in the creation of transportation plans. Integrate TSMO into Performance Based Practical Design practices. Update transportation plans to consider the effectiveness of previous activities, and adjust plans based on those successes/failures. Create TSMO business case materials based on local performance measures: trends and successes.	

Table 3. Operations Performance Measures and Management capability maturity framework (continuation).

DIMENSIONS	LEVEL 1 PERFORMED, Low Level	LEVEL 2 MANAGED, Medium Level	LEVEL 3 INTEGRATED, High Level	LEVEL 4 OPTIMIZED, Highest Level
Systems and Technology	Ad hoc approaches to operations data system implementation without consideration of systems engineering and appropriate procurement processes; operations data systems exist only in a few functional areas (e.g., incident management).	Individual data systems exist for operations data but the data cannot be easily integrated and only rudimentary reporting functions exist; data analysis is performed with separate tools; System development is not coordinated and do not follow sound information technology principles. Data systems within the region routinely report performance measures.	Individual systems for all forms of operations data are developed and data can easily be integrated when being analyzed, but users perform this integration for every analysis; separate analysis tools are used but a set of standardized analyses exist; a process has been established for updating data systems and analysis programs; data systems are used for real-time multimodal situational awareness present in the region.	A single data system houses all operations data which are seamlessly integrated. The system is routinely updated and modified using sound information technology principles; agency personnel receive ongoing training on the use of the system. Hardware architectures and technology are routinely upgraded to improve performance; systems and data integration/ interoperability is maintained on a continuing basis across multiple agencies in the region, real-time multimodal situational awareness is actively used to support adaptive multi-agency operational plans.

Table 3. Operations Performance Measures and Management capability maturity framework (continuation).

DIMENSIONS	LEVEL 1 PERFORMED, Low Level	LEVEL 2 MANAGED, Medium Level	LEVEL 3 INTEGRATED, High Level	LEVEL 4 OPTIMIZED, Highest Level
Systems and Technology	**Actions to Advance to Level 2:** Update the regional intelligent transportation systems architecture to include data archiving and analysis.	**Actions to Advance to Level 3:** Develop a Data Business Plan.	**Actions to Advance to Level 4:** Define and implement an Operations Performance Measures and Management monitoring program. Develop a Data System Requirements Plan, including the use of advanced analytics. Use the Requirements Plan to guide the development of an integrated regional data system. Update the Data Business Plan to include emerging/nontraditional sources of data.	

Table 3. Operations Performance Measures and Management capability maturity framework (continuation).

DIMENSIONS	LEVEL 1 PERFORMED, Low Level	LEVEL 2 MANAGED, Medium Level	LEVEL 3 INTEGRATED, High Level	LEVEL 4 OPTIMIZED, Highest Level
Performance Measurement: Measures Definition	Measures are typically poorly defined and not straightforward to understand by technicians; only simplistic output measures exist. Limited data acquisition is in place. Data quality is questionable and usually not shared across agencies. Some outputs are measured and reported by some jurisdictions but they are usually not used for meaningful decisionmaking.	Measures are clearly defined but are agency-specific and might be highly technical and not easy to understand and visualize by technicians; outcome measures are defined but are not used by all agency functional areas. Data usually are available but are not integrated across different department/agencies. Some data quality issues may exist. Output data are easily available and reported via dashboards and used directly for after-action debriefings and improvements.	Measures are clearly defined and are easy to understand by technicians/nontechnicians, measures address multiple modes and multiple desired public outcomes, and apply to both the regional planning objectives and effectiveness of the adopted operations activities; input, output, and outcome measures are defined. High-quality data are available, integrated across different department/ agencies, and collected across modes, with specific emphasis on the interaction between modes. A formal data quality control process is defined and used. Outcome measures are identified and routinely used for decisionmaking and objective-based program improvements. A formal project evaluation program is established; routine reporting mechanisms are created (e.g., annual scorecards); operations performance measures used routinely in TSMO planning.	Measures are clearly defined/easy to understand/visualize by technicians/nontechnicians; provide decision support for TSMO activities (e.g., needed signal timing plan changes), describe multimodal performance, and are directly usable for decisionmaking. Some measures focus on the traveler's perspective. Standardized high-quality data are available and integrated across all agencies; long term budget commitments are made for required data collection. Performance measures are used internally for system management and reported externally for accountability. Reporting systems automatically flag areas where performance does not meet targets or expectations; operations performance measures are used in general

				agency planning and programming activities.

Table 3. Operations Performance Measures and Management capability maturity framework (continuation).

DIMENSIONS	LEVEL 1 PERFORMED, Low Level	LEVEL 2 MANAGED, Medium Level	LEVEL 3 INTEGRATED, High Level	LEVEL 4 OPTIMIZED, Highest Level
Performance Measurement: Measures Definition	**Actions to Advance to Level 2:** Update TSMO Performance Measurement Plan or Strategic Plan to include Operations Performance Measures and Management. Include in planning documents discussion and presentation of outcome travel time-based performance measures and external factors.	**Actions to Advance to Level 3:** Synchronize performance measures between forecasting models and monitoring (same measures are used).	**Actions to Advance to Level 4:** Define a full suite of outcome and output measures for use by all involved agencies.	

Table 3. Operations Performance Measures and Management capability maturity framework (continuation).

DIMENSIONS	LEVEL 1 PERFORMED, Low Level	LEVEL 2 MANAGED, Medium Level	LEVEL 3 INTEGRATED, High Level	LEVEL 4 OPTIMIZED, Highest Level
Performance Measurement: Data Acquisition	Data collection and reporting is based on available reporting capabilities of legacy management systems. Data quality is questionable, only a limited set of metrics can be computed. Performance reporting is not typically used for meaningful decisions.	Performance metrics are adopted, and include multijurisdiction trips. Performance reporting is multimodal. Data systems within the region routinely report those measures, but are not linked, do not include all jurisdictions (e.g., city arterials), and may have periodic data quality issues.	Performance reporting is routinely performed by all jurisdictions. Regional performance targets are set for adopted performance metrics. High quality data are available to all jurisdictions and across all modes.	Regional operational decisions are directly influenced by outcomes from routine performance reports relative to adopted targets. Performance reports are routinely used to examine and adjust traffic management activities. The public and public decisionmakers can easily understand why specific decisions are being made, and track performance relative to adopted targets.
Performance Measurement: Data Acquisition	**Action to Advance to All Higher Levels:** A Data Acquisition Plan is prepared that specifies: the internal and external data sources to be used; data purchases; funding stream; and data stewardship.			

Table 3. Operations Performance Measures and Management capability maturity framework (continuation).

DIMENSIONS	LEVEL 1 PERFORMED, Low Level	LEVEL 2 MANAGED, Medium Level	LEVEL 3 INTEGRATED, High Level	LEVEL 4 OPTIMIZED, Highest Level
Performance Measurement: Measures Utilization	Data collection and reporting is based on available reporting capabilities of legacy management systems. Data quality is questionable, only a limited set of metrics can be computed. Performance reporting is not typically used for meaningful decisions.	Performance metrics are adopted, and include multijurisdiction trips. Performance reporting is multimodal. Data systems within the region routinely report those measures, but are not linked, do not include all jurisdictions (e.g., city arterials), and may have periodic data quality issues.	Performance reporting is routinely performed by all jurisdictions. Regional performance targets are set for adopted performance metrics. High-quality data are available to all jurisdictions and across all modes.	Regional operational decisions are directly influenced by outcomes from routine performance reports relative to adopted targets. Performance reports are routinely used to examine and adjust traffic management activities. The public and public decisionmakers can easily understand why specific decisions are being made, and track performance relative to adopted targets.

Table 3. Operations Performance Measures and Management capability maturity framework (continuation).

DIMENSIONS	LEVEL 1 PERFORMED, Low Level	LEVEL 2 MANAGED, Medium Level	LEVEL 3 INTEGRATED, High Level	LEVEL 4 OPTIMIZED, Highest Level
Performance Measurement: Measures Utilization	**Actions to Advance to Level 2:** Produce an Annual Mobility Report or Scorecard.	**Actions to Advance to Level 3:** Mandate that all planning and preliminary engineering analyses and products use the regionally defined performance measures. Establish targets based on the performance measures; use the targets to support regional vision, goals, and objectives Add targets to short- and long-term planning documents. Extend the Annual Mobility Report to include bottleneck and high priority facilities in its analysis; progress toward short- and long-term targets; outcome measures for TSMO, capacity, demand, and alternate mode strategies.	**Actions to Advance to Level 4:** Establish an ongoing Evaluation Program for completed congestion mitigation projects. Review performance measures every 2–3 years and revise if necessary; revisions are included in all documents that use the performance measures. Modify forecasting procedures to produce all target-based performance measures. Extend the Annual Mobility Report to include mapping of external factors to performance trends.	

Table 3. Operations Performance Measures and Management capability maturity framework (continuation).

DIMENSIONS	LEVEL 1 PERFORMED, Low Level	LEVEL 2 MANAGED, Medium Level	LEVEL 3 INTEGRATED, High Level	LEVEL 4 OPTIMIZED, Highest Level
Culture (Changing Culture and Building Champions)	Individual Staff champions promote Operations Performance Measures and Management. Emphasis on TSMO varies among jurisdictions.	Jurisdictions' senior management understands Operations Performance Measures and Management business case and educates decisionmakers/public. Educational material is provided to staff new to Operations Performance Measures and Management to help them integrate Operations Performance Measures and Management into their routine solutions set.	Jurisdictions' mission statements identify Operations Performance Measures and Management and Operations Performance Measures and Management benefits, and a formal Operations Performance Measures and Management program achieves wide public visibility/understanding; Most employees have previous involvement in some aspect of performance management. Operations Performance Measures and Management training is a routine part of professional development activities.	Customer mobility service commitment accountability accepted as formal, top level core program of all jurisdictions; Data-driven decisionmaking based on real-time information is adopted, multi-agency coordinated operations is the norm.
Culture (Changing Culture and Building Champions)	**Actions to Advance to All Higher Levels:** Develop a persuasive business case for Operations Performance Measures and Management, especially how it supports TSMO; Develop a communications/outreach plan/branding for stakeholders; produce outreach documents and presentations that promote the business case.			

Table 3. Operations Performance Measures and Management capability maturity framework (continuation).

DIMENSIONS	LEVEL 1 PERFORMED, Low Level	LEVEL 2 MANAGED, Medium Level	LEVEL 3 INTEGRATED, High Level	LEVEL 4 OPTIMIZED, Highest Level
Organization/ Staffing (Improving Capability of Workforce)	A limited number of Operations Performance Measures and Management champions exist in the agency, but Operations Performance Measures and Management principles have not been adopted; information technology support for Operations Performance Measures and Management data system is minimal; data analysis skills and software are severely limited or nonexistent.	TSMO managers have implemented some Operations Performance Measures and Management principles; Innovation/new process may not be commonly adopted; internal or contracted IT services are available for Operations Performance Measures and Management data systems; analysis skills of agency personnel limited.	TSMO Managers have direct reporting to top management; Operations Performance Measures and Management training is a routine part of professional development activities for TSMO personnel; agency personnel are assigned to caretake Operations Performance Measures and Management data and are knowledgeable of information technology; agency personnel are trained in Operations Performance Measures and Management data analysis.	TSMO senior managers at equivalent level with other jurisdiction services and staff professionalized; Jurisdiction is a pioneer of new process and innovation.
Organization/ Staffing (Improving Capability of Workforce)	**Advance to All Higher Levels:** Define an appropriate organizational structure for implementing Operations Performance Measures and Management (e.g., at what points in project development should Operations Performance Measures and Management principles be applied); Identify core capabilities needed and develop related staffing and training plan.			

Table 3. Operations Performance Measures and Management capability maturity framework (continuation).

DIMENSIONS	LEVEL 1 PERFORMED, Low Level	LEVEL 2 MANAGED, Medium Level	LEVEL 3 INTEGRATED, High Level	LEVEL 4 OPTIMIZED, Highest Level
Collaboration	Relationships ad hoc, and on personal basis (public-public, public-private); Operations Performance Measures and Management are seen as distinct from other agency transportation management plan activities. Jurisdictions, agencies, and States plan for and manage their own road systems. Project specific improvements occur with project specific coordination between agencies/jurisdictions.	Objectives, strategies and performance measures are aligned among organized key players; Operations Performance Measures and Management and general transportation management plan activities are coordinated but separate. Regional plan discusses the need for regional coordination between adjacent traffic management systems. When competing for regional funding, additional points are awarded to projects that include coordination between agencies.	Operations Performance Measures and Management is integrated with general transportation management plan activities. Multiple agencies (across modes) work jointly to coordinate activities, plan for future improvements, and monitor performance.	Operations Performance Measures and Management is fully integrated into all related agency functions and used to create planning and programming documents on equal footing with all other functional areas (performance-based planning and programming, performance-based practical design, and the congestion management plan)
Collaboration	**Advance to All Higher Levels:** Participate in joint activities with public safety partners, including training for TSMO activities and emergency response; Align partners' TSMO objectives and interact on a regular basis; Conduct regular reviews with personnel responsible for implementing non-TSMO congestion relief improvements.			

(Source: Federal Highway Administration, modified for this report.)

USING THE OPERATIONS PERFORMANCE MEASURES AND MANAGEMENT CAPABILITY MATURITY FRAMEWORKS TO GUIDE THE ADOPTION OF OPERATIONS PERFORMANCE MEASURES AND MANAGEMENT

Full adoption of operations performance management within an agency or region is not a fast and easy process. Agency business processes, culture, and training require time to shift from their current activities and attitudes to those that reflect the business view of performance management. The CMF is an excellent guide for helping make that transition.

The CMF is used in much the same way OPMM is intended to function. That is, the CMF guides a continuous improvement process that consists of measurement, reporting, evaluation, and the taking of actions based on those evaluation results. To use the CMF, the agency would

- Measure and routinely monitor its current condition relative to where it wishes to go, using the CMF as a guide.
- Report that status to decisionmakers.
- Use that information to identify and evaluate the next activities that can be funded and implemented, in order to continue to improve the OPMM implementation.
- Implement those selected activities

The agency then returns to the monitoring task, in order to observe and understand the effectiveness of those activities and to reassess the agency's new condition. The result is a continuous improvement cycle.

Each of these tasks is discussed briefly below. More detailed guidance can be obtained from a number of resources. Two excellent resources are websites developed and maintained by the American Association of State Highway and Transportation Officials (AASHTO) (http://www.aashtotsmoguidance.org/) and guidance made available by the FHWA. https://ops.fhwa.dot.gov/docs/CMFexesum/index.htm#toc.

A key to the process of moving towards a more mature OPMM capability is the need for buy-in and active support of the senior agency leadership. Without senior leadership support it is almost impossible to move from the Performed/Ad-Hoc level of OPMM to the Integrated and Optimized levels of performance management. Senior management support is necessary for both supporting the changes in agency processes and culture, and for the resources needed to implement those technical and procedural changes.

Monitoring Current Status

The starting place for helping an agency, region, or State effectively use operations performance management is to assess the current state or condition of that agency.[46] This step can start with a self-assessment. A good starting place is the AASHTO self-assessment material found at http://www.aashtotsmoguidance.org/one_minute_evaluation/. This AASHTO website also offers

[46] OPMM can be adopted by a single agency. However, it is most effective when adopted by multiple agencies across a larger geographic scale. Thus, OPMM assessment and maturation can occur at the agency, regional, or State levels. For the remainder of this chapter, the term "agency" will be used to represent OPMM improvement activities regardless of whether they are taking place at the agency, region, or State level.

guidance for developing a more customized evaluation. Many agencies hire consultants to help them through this process.

This process typically leads to a self-assessment workshop being held at the agency. It is vital that this workshop include the senior managers for the agency, key technical staff, as well as key managers and staff from partner agencies.

Reporting

A key outcome from the self-assessment workshop and any other self-assessments performed within the agency is the documentation that result. This documentation not only needs to discuss the current status of the agency (region, State) across the six dimension and TSMO activities, but the workshop also identifies actions that need to be taken, and constraints that need to be overcome, the resources that appear to be needed and the timeframe in which these activities can occur.

Evaluation and Decisionmaking

The third step involves the development of an Action Plan. This plan is the outcome of the evaluation of the findings documented in the self-assessment relative to the support for OPMM within the agency and its political oversight bodies. That is, what political support is there for making changes to the agency's business processes, and what resources are available to make those changes.

The result is an Action Plan for maturing the agency's OPMM process. Within that plan identifies specific actions to be taken, the individuals or groups that are to take those actions, the intended outcomes of those actions (both in terms of the technical outcomes and how those outcomes affect the self-assessment outcome of the CMF), the technical issues that need to be resolved, the resource requirements needed, the senior leadership support required to take those actions, and the schedule for taking those actions.

The Action Plan should cover all six dimensions of the CMF. Suggestions for the types of activities that can be included are in the above table. Action items for maturing the agency's effectiveness in collaborating with its partners are divided into planning, outreach, and funding efforts that support collaboration with public safety agencies and MPOs, Regional Transportation Planning Organization, and local governments. Other actions items may apply to outsourcing or adoption of public-private partnerships in order to reduce costs or encourage innovative delivery of services.

Implementation

The fourth step in the process is for the agency to follow through on the Action Plan that was developed in step three. This requires that agency upper management successfully secure the resources to perform the next steps identified through the CMF evaluation process, and provide the leadership required to drive those changes through the current agency culture and business processes.

The implementation task is difficult, in that it involves changing the current business processes and culture. This typically means changes to historical funding priorities and resource allocations. It also pushes staff to think and act differently than they have in the past. Changes always create resistance, and active, vocal support from upper management is needed to encourage these changes to take place.

Repeat Continuously

A key component of OPMM is continuous improvement. Thus, agencies adopting OPMM need to periodically repeat the four-step process described above. That is, they need reassess the status of their agency, determine where and how improvements can be made, identify the actions which both need to be take and can be taken, determine how to obtain the resources needed to undertake those actions, and then implement those actions.

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