AASHTO

Transportation Operations Manual

1st Edition

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Preface

Introduction

The *Transportation Operations Manual*, first edition (2023), commonly called the TOM, provides a holistic view of transportation system management and operations (TSMO) and encompasses a broad range of topics and tactics that exist within this discipline. Its ultimate goal is to serve as the authoritative source for developing, deploying, and sustaining the operational capabilities and strategies necessary to preserve and optimize transportation system performance. The Manual was created to actively guide transportation agencies as a resource they can utilize to define and support their TSMO efforts.

23 U.S.C. § 101 defines TSMO as "integrated strategies to optimize the performance of existing infrastructure through the implementation of multimodal and intermodal, cross-jurisdictional systems, services, and projects designed to preserve capacity and improve security, safety, and reliability of the transportation system." According to the Federal Highway Administration (FHWA) Office of Operations' *Enhancing Transportation: Connecting TSMO and Planning* (2018), TSMO allows "agencies to target the underlying operational causes of congestion and unreliable travel through innovative solutions that typically cost less and are quicker to implement than adding capacity. TSMO expands the range of mobility choices available to system users, including shared mobility and nonmotorized options."

Development and Intended Value

The idea of a transportation operations manual began to coalesce in 2015. The second Strategic Highway Research Program (SHRP2; 2006–2015) conducted several research projects to establish a taxonomy of TSMO strategies, technologies, and services. These collective efforts enhanced the management of an agency's road infrastructure assets while reminding transportation professionals of how complex but worthy and achievable the challenge was to ensure the safety and mobility of the traveling public and the goods and services they benefited from.

AASHTO's Committee on Transportation System Operations (CTSO; previously known as the Subcommittee on Systems Operations and Management) continued to advance the study of TSMO. The Committee strategically framed the purpose of TSMO by convening practitioners and leading TSMO experts to discuss, prioritize, and capture the practices state and local agencies were developing under the emerging TSMO mantra.

The National Operations Center of Excellence (NOCoE), the brainchild of AASHTO, ITE, and ITS America in partnership with the Federal Highway Administration, helped to further champion and mature TSMO through storytelling and compiling of TSMO practices and impacts. Thus, the TOM is not state DOT-centric, but rather speaks to the innovations taking place across the entire TSMO community—public and private, state and local.

The original project proposal led to approval for National Cooperative Highway Research Program (NCHRP) funding in 2018 with the objective "to research, outline, and begin writing an Operations Manual that would inform, guide, and organically reflect and mainstream TSMO practices." AASHTO believes the first edition of the TOM has lived up to its charge. The Manual's authors and TSMO-practitioner reviewers have produced a multi-chapter electronic first edition. This living document will now serve as the common denominator for TSMO professionals to discuss, elaborate, share, apply, evaluate, and improve what their work is all about.

How to Use the TOM

The TOM is more than a one-time product. It offers a framework for transportation leaders and practitioners to enhance safety and mobility, and it can play a key role within surface transportation for the TSMO community. The Manual complements the transportation sector's family of guidance resources, and it can serve as an authoritative

companion to AASHTO's Green Book (*A Policy on Geometric Design of Highways and Streets*), AASHTO's *Highway Safety Manual*, TRB's *Highway Capacity Manual*, FHWA's *Manual on Uniform Traffic Control Devices* (MUTCD), and other accepted industry guidance manuals.

The TOM serves as a single reference for all elements of TSMO—strategic, programmatic, and tactical. Previous practice relied on numerous, often disparate sources and procedures, which were developed by various agencies and organizations independently of one another. Many references were singular in nature or fragmented in approach and did not span the entire breadth of TSMO functions. This Manual provides agencies and their partners a single, organized, and aligned resource to help them gain knowledge and familiarity with generally accepted operational improvements and provides a platform to further engage the industry in developing appropriate future applications. The TOM is both a document unto itself and a source of links to recommended supplemental materials that represent another level of detail into the state of practice for specific application areas. In sum, the TOM expands current practice through a more cohesive approach.

The TOM is intended to serve as a comprehensive reference manual but is not intended to be prescriptive in nature or supersede the judgment and decision making of TSMO professionals, informed by their own unique settings.

Governance and Future Editions

Recognizing the complexity of the transportation system and the evolving capabilities necessary for effective management, this first version is intentionally broad, an initial step in a continuing process of guidance development, expansion, and detailing. Like other AASHTO manuals, a technical committee will oversee revisions to the TOM to ensure the Manual will be a living document.

A new committee, the Transportation Operations Manual Technical Committee (TOM TC), has been organized under the CTSO Steering Committee with relationships to other relevant AASHTO committees and partner organizations. This committee has been established to guide and oversee future updates to this Manual. The Technical Committee will identify and consider new effective practices and oversee the development and documentation of additional key concepts, content, and references in this single, formally recognized source. For example, it is anticipated that the industry and technology trends section of the Manual will continue to evolve with advancements in technology and industry capabilities. These are not technologies for their own sake; they reflect the diligence of the TSMO community to establish use cases and evaluative tools to ensure their effective application and viable impact.

Finally, the Manual—by synthesizing an array of operational tactics that have evolved over time—identifies how important it is that areas like freight operations, public transit, and other dimensions of surface transportation be more front-of-mind in organizing and integrating TSMO priorities and practices. The TOM is an important starting point, and future editions will benefit from this more coordinated approach.

It is hoped that this first edition will serve as a basis for future revisions that reflect the needs of the TSMO community as their needs change and evolve. To accomplish this, TSMO professionals around the country are encouraged to communicate with AASHTO and the TOM Technical Committee to offer feedback. What is useful? What should future editions correct or add? Are there ways to better navigate the document as a useful tool among practitioners? How can the TOM stay current to embrace emerging and best practices to help address the challenges of the future?

Acknowledgements

As is the case for any work of immense scale, thanks go to many for the genesis, development, review, and publication of this first edition of the Transportation Operations Manual.

The idea of a manual to inform transportation operations has long existed, but the leadership of AASHTO's Committee on Transportation Systems Operations (CTSO) and its spearheading NCHRP funding for the Manual has been uppermost in making it more than a dream. Past and current CTSO Chairs Don Hunt, Shailen Bhatt, Bill Panos, Jennifer Cohan, and Scott Marler are among those who helped lead the way.

As the Manual took on the form of an NCHRP project, the 20-7 (03-126) technical panel became responsible for the Manual's oversight, working closely with CTSO and AASHTO's key staff. Panel members included:

- Brent Cain, Arizona DOT, Chair
- Neil Boudreau, Massachusetts DOT
- Jennifer Portanova, North Carolina DOT
- Dave Holstein, Ohio DOT
- Mandar Khanal, Boise State University
- Richard Easley, E-Squared Engineering
- Theodore Trepanier, Inrix, Inc.
- Jim Hunt, FHWA/US DOT Liaison
- Gummada Murthy, AASHTO Liaison
- Richard Cunard, TRB Liaison
- Anthony Avery, NCHRP/TRB Staff
- Zuxuan Deng, NCHRP/TRB Staff

The contractor and stable of consultants for the work—led by WSP's Les Jacobson, who served as principal investigator—researched and assembled the array of broadly accepted best practices and initiatives that fall under the TSMO umbrella and offered a viable framework from which the Manual emerged.

Many members of CTSO then stepped up, alongside the project panel, to undertake a robust review that gave the research team technical feedback to improve the Manual. Additional reviews embraced an even broader audience of all CTSO members and invited those from other AASHTO committees to weigh in as well. Too numerous to name, these reviewers have ensured that the Manual is a worthy first effort to capture effective transportation system management and operations (TSMO) strategies, tactics, and practices. Nevertheless, all involved underscored that the TOM must be a living document, responsive to and predictive of the continuous technological innovations and management practices that the field embodies.

Throughout the process, the AASHTO team, led by Gummada Murthy, managed the process and kept the CTSO membership informed of the Manual's status. The team included the AASHTO publications team and AASHTO CTSO staff members Patrick Zelinski and Robert White and consultants Linda Preisen, Kyle Garrett, John Nisbet, Adam Hopps, and Thomas Kern.

One

Transportation Operations Manual Introduction

As the nation's surface transportation system evolves to meet safety, mobility, and reliability challenges, a range of emerging and innovative operational strategies, together known as transportation systems management and operations (TSMO), are being applied by state and local transportation agencies. These strategies represent approaches that differ from traditional transportation improvements that relied heavily on building new lanes or roadways to address transportation problems. Several factors have led to the increasing recognition that TSMO is a critical component of a transportation agency's program, capable of producing significant performance improvements.

- The evolution of a more holistic view that places transportation agencies as stewards of the transportation system with the responsibility to get the most out of existing facilities. This evolution may influence and require variances in traditional geometric design elements.
- Increases in crashes and collisions at a pace that would make it difficult and costly to address through traditional roadway expansion.
- Increasing congestion and environmental challenges in a context of constrained capacity and financial resources, leading to the realization that the growing costs and impacts of continuing to address transportation problems nearly exclusively through new construction are no longer sustainable.

Over the last three decades, what started as a collection of technology applications and transportation management systems, termed intelligent transportation systems (ITS), has evolved into a broad set of TSMO tactics and initiatives that combine ITS and technology, operational strategies, and strategy-specific field procedures

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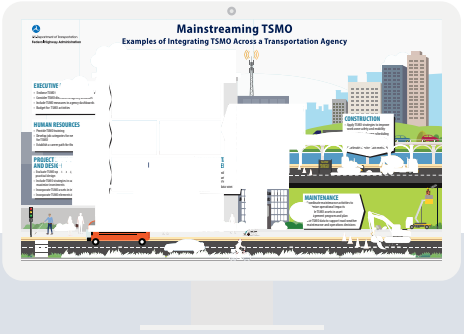


Useful TSMO Websites

FHWA Office of Operations

Institute of Transportation Engineers

National Operations Center of Excellence

See Section 1.6.

and protocols. However, the diversity and pace of change has produced challenges to audiences seeking practical guidance, including:

- Fragmented documentation of the state-of-the-practice, with key gaps in lessons learned.
- Minimal guidance in key areas such as program development, project development, and integration.
- Dispersed location of guidance material by various sponsors in a wide range of publications and websites.
- Guidance narrowly targeted at technical audiences, with minimal material for decision makers and executive management.
- Uneven support from policy and decision makers.
- Lack of access to relevant American Association of State Highway and Transportation Officials (AASHTO) manuals.
- Lack of standardized, centralized guidance on determining benefits for project prioritization, especially when comparing to traditional construction projects.

A range of steps may be taken to assist agencies in developing TSMO strategies to address these challenges, including:

- Developing a range of agency processes that may be needed to optimize transportation operations, and to allow operational improvements to be implemented more effectively, compete on equal footing with traditional capital improvement projects, and be better understood by agency personnel.
- Developing operational strategies and associated elements that should be considered standard capabilities of the highway system.
- Integrating operational strategies, geometric attributes, and analysis techniques to provide new approaches in determining highway design criteria and system elements.
- Leveraging new technologies and industry trends to address transportation challenges.

TSMO as a discipline has lacked a visible, accessible, and useable single source to access guidance and supporting resources. This Transportation Operations Manual (TOM), representing consensus from industry stakeholders, is such a resource. It provides a coherent vision for TSMO and consolidates and presents a broad and deep catalog of technical knowledge to a variety of user audiences.

This version is an initial step in a continuing process of guidance development, expansion, and detailing. The intent is to establish a clear approach to defining and identifying effective practices and developing key concepts, practice, issues, and references that need to be documented in a single source. By doing so, this first edition can serve as a robust basis for future editions as the industry evolves.

The ultimate goal of this Manual is for agencies to actively use this reference in their business practices. This first version is intentionally broad, referring to other resources for more specific technical guidance. As practitioners adopt this Manual and technology and tactics evolve, future versions will likely not only increase the breadth of the Manual, but also the depth in many topic areas.

1.1 Introduction to Transportation Operations

In this Manual, transportation operations are meant to incorporate all of the activities within a transportation agency that are focused on optimizing the performance of the transportation system. This includes making the most of existing infrastructure to address safety, congestion, and reliability concerns. Transportation operations, as distinct from traditional maintenance and operations, is embodied in TSMO, and the two terms are often used interchangeably. TSMO is defined by Title 23 Section 101 of the United States Code as "integrated strategies to optimize the performance of existing infrastructure through the implementation of multimodal and intermodal, cross-jurisdictional systems, services, and projects designed to preserve capacity and improve security, safety, and reliability of the transportation system" (see *Section 1.6*).

According to the Federal Highway Administration (FHWA) Office of Operations *Enhancing Transportation: Connecting TSMO and Planning* (2018; see *Section 1.6*), TSMO allows "agencies to target the underlying operational causes of congestion and unreliable travel through innovative solutions that typically cost less and are quicker to implement than adding capacity. TSMO expands the range of mobility choices available to system users, including shared mobility and nonmotorized options." This requires knowledge, skills, and techniques to administer comprehensive solutions. This Manual describes programmatic efforts required for TSMO to be effective, such as TSMO program planning, TSMO performance management, organization and workforce, and collaboration and outreach. It also describes the "systems, services, and projects," or tactics that can be used to optimize the performance of the transportation system.

TSMO evolved out of the need to address growing transportation problems in nontraditional ways. Most state and local transportation agencies were initially charged with building and maintaining streets and highways. As demand for transportation grew, especially after World War II, and car ownership increased as the population grew and migrated to the suburbs, new roads and highways were built to meet that demand. These new roads and highways then contributed to the migration from more densely populated areas to more suburban areas by providing more opportunities for travel, which in turn led to an increase in transportation demand. The increased roadway capacity and the increased demand for travel reinforced each other. Decreased population density made serving the increased demand through public transportation options more challenging. The costs to communities and environmental resources from continued road building to address transportation demand meant that new and expanded facilities could not keep up with demand, resulting in congestion and an increase is crashes and traffic fatalities.

New solutions to some congestion and transportation safety problems began to emerge in the 1970s as applications of new technology became more accessible. The cost of communications and technology decreased in both real and relative measures. Technology allowed transportation professionals to better measure and understand the performance and impacts of the transportation system, facilitating development of tools other than road building to address transportation challenges. Transportation professionals looked to more cost-effective and less disruptive methods to address transportation issues. Improved transportation network monitoring, new transportation management methods, and improved communication with travelers resulted. These included traffic management, traveler information, electronic tolling, managed lanes, and systems that support commercial vehicle operations, among others.

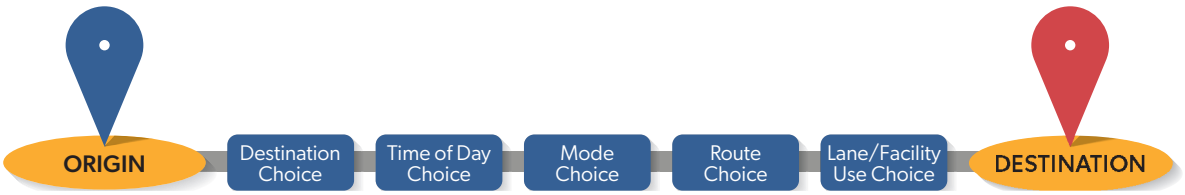
Usually, these new systems and mechanisms were implemented independently. Over time, it became apparent that the benefits of these systems could be enhanced by linking them and operating them in an integrated manner. Transportation agencies also began to realize that they needed to work together and many of their processes that served road building well did not support the development, operation, and maintenance of technology-based systems. The focus on more cost-effective and efficient transportation solutions coupled with the need to integrate systems and collaborate among transportation agencies and organizations that support them led to the emergence of TSMO.

1.1.1 Scope of TSMO

TSMO considers:

- The entire multimodal transportation system and how that system's performance can be enhanced cost-effectively and efficiently while minimizing negative impacts to travelers and their safety.
- The full range of communities that surround transportation facilities.
- The environment.

TSMO can address multiple modes throughout the trip chain, as presented in *Figure 1.1-1*. TSMO tactics can provide information to travelers to affect choice of destination by showing conditions (congestion, weather, etc.) on the transportation system. Historical and real-time traffic information can influence time-of-day choice. Information about travel times, costs, and how to use various modes of travel can influence the mode travelers choose to make their trip. Once en route, information about conditions on various alternate routes can serve as input to route choice decision. Finally, conditions on their route can influence decisions they make while on the facility they chose. Throughout this decision-making process, TSMO tactics can respond to and influence travel conditions on modes and routes through traffic control, pricing, incentives, and priority given to more efficient means of travel.



Source: FHWA, ATDM Overview; see *Section 1.6*

Figure 1.1-1 Transportation Trip Chain

TSMO encompasses a broad range of multimodal tactics, services, and transportation treatments to manage travel and impacts to travel on the transportation network, considering the needs of all travelers (for example, motorists, pedestrians, transit users, freight). TSMO combines traditional transportation approaches, advanced technology, and operational management concepts. TSMO tactics focus on real-time transportation system performance from three perspectives:

- TSMO offers the ability to proactively address a wide range of transportation challenges that make travel unreliable, such as severe weather, disruptions caused by traffic incidents or work zones, and other causes of unexpected severe traffic congestion.
- TSMO addresses conditions that affect the efficiency of transportation, such as inefficient traffic signal timing, poor transit performance, and delay caused by traffic demand exceeding capacity.
- TSMO reduces the likelihood of crashes by smoothing the flow of traffic and mitigating disruptions that can introduce hazardous driving conditions, such as work zones, weather conditions, and downstream incidents.

TSMO tactics can be implemented at modest cost with less severe environmental impacts and disruption to residents and businesses compared to traditional roadway construction projects. However, while TSMO tactics have advantages, these tactics should be considerate of the broader understanding of the history of highways, especially expansion projects that have also disproportionately impacted already disadvantaged and low-income communities. TSMO tactics should strive to avoid those impacts to communities and populations already disrupted

by highway construction when there is knowledge about the possibility of inequitable impacts and the consideration to circumvent those impacts.

TSMO tactics should be considered first, as they may be able to fully address the problem. If TSMO tactics can't fully address the problem, they can lessen the impact of the problem until other solutions, like traditional construction projects, can be implemented. By using TSMO to manage and improve service, an agency can raise its profile as a responsive government organization that makes the most of its resources to address transportation challenges.

1.2 Manual Need and Purpose

Transportation professionals have relied on well-established manuals for many technical areas—roadway design (AASHTO Green Book, *A Policy on Geometric Design of Highways and Streets*), roadway capacity (*Highway Capacity Manual*), traffic control devices (*Manual on Uniform Traffic Control Devices*), and traffic safety (*Highway Safety Manual*), among others (see *Section 1.6*). The obvious lack of singular guidance on transportation operations led AASHTO to envision a new reference manual encompassing the maturing TSMO field. This Manual provides a holistic view of the operation and management of the transportation system, encompassing a broad range of topics and tactics. The Manual itself is more than a one-time product. It is intended to play a key role within the transportation arena, involving its importance to the TSMO user community, its establishment as a point of departure for continuing guidance development, and its integration within the overall transportation industry framework of guidance, eventually serving as an authoritative companion to the AASHTO Green Book and other accepted industry guidance.

This Manual serves as a single reference for all elements of TSMO—strategic, programmatic, and tactical. Previous practice relied on a numerous, incohesive references developed by various agencies and organizations. Many references are singular in nature or fragmented in approach and do not span the entire breadth of TSMO functions. This Manual provides agencies and their partners a single source to gain knowledge and familiarity with operational improvements and provide a platform to further engage the industry in developing appropriate future applications. This Manual expands current practice through a more cohesive approach.

As part of AASHTO's Resolution Addressing Race, Equity, Diversity, and Inclusion and its commitment to integrate Diversity, Equity, and Inclusion (DEI) into its work, the TSMO Manual's development included a close look at DEI considerations as they relate to TSMO strategies. These considerations have been integrated throughout the Manual and include designing for the safety and convenience of people walking, biking, taking transit, and of people with disabilities; ensuring that benefits and burdens of TSMO tactics are equitably distributed geographically and especially to those underserved communities; and making traveler information widely accessible in a variety of formats for different user groups, especially for the traveling public and those who are transit dependent. This Manual also considers DEI in leadership and TSMO workforce development; consideration for low-income and other unique groups; and creating equitable benefits in road pricing, dynamic transit fare pricing, bike share, and Mobility on Demand (MoD).

1.3 Organization of the Manual

This Manual addresses TSMO at each stage of the program structure and targets specific user needs, including development of agency goals, establishment of a TSMO program structure, TSMO tactic development, project selection, and project development. The structure of this Manual (beyond just strategic and technical content areas) presents topics in a manner that facilitates swift access and use by those responsible for agency policy, strategies, program development, or specific tactics. This Manual is organized in six parts that allow different users to efficiently access the guidance they need, and understand linkages among the parts:

- *Part A, Introduction* to TSMO and the *Transportation Operations Manual*.

- *Part B, TSMO Concepts and Context* including foundational concepts of TSMO, basic operational concepts, functions, performance potential, business case arguments as related to public policy, and stakeholder interests.
- *Part C, TSMO Program Development and Management* focusing attention on key dimensions of an effective program, such as business and technical processes, organizational and workforce configuration, and collaboration.
- *Part D, Project Development* recognizing that progress has often been hampered by challenges related to project development (both traditional projects and TSMO projects). Key project development concepts include relationships to performance-based practical design, the capital program, the project development process, funding, and procurement.
- *Part E, Tactical Elements* encompassing the full range of TSMO tactics and supporting concepts, technologies, and procedures that address causes of congestion (nonrecurring and recurring), safety issues, and environmental impacts.
- *Part F, Industry and Technology Trends* including the rapid introduction of new technologies (such as connected vehicles, big data, and artificial intelligence) and evolution of TSMO-related institutions, business models, and concepts (such as Mobility on Demand, Mobility as a Service (MaaS), and Smart Cities). While many of these trends are at early stages of development or at the cutting edge of practice, they require explicit acknowledgment as they may significantly affect strategic, programmatic, and tactical considerations.

1.3.1 The Parts of the Manual and Their Intended Audience

1.3.1.1 Part A, Introduction

Chapter 1, Introduction: The sole chapter in *Part A* provides a high-level introduction to the Manual and its organization. It is intended to be read by anyone who will access any part of the Manual, at least the first time it is used.

1.3.1.2 Part B, TSMO Concepts and Context

Part B is geared toward the executive manager in charge of an agency's TSMO program. A typical title might be "Operations Director" or "TSMO Director." Although executive management is the typical leadership for a TSMO Program, this section could be helpful for TSMO champions in all agencies for recommendations to executive managers.

Chapter 2, TSMO Concepts: *Chapter 2* identifies the unique role played by TSMO in improving transportation service and safety. The chapter explains *why* TSMO is relevant in terms of the challenges addressed and *what* are some specific performance targets and outcomes of TSMO tactics.

Chapter 3, TSMO in the Transportation Agency Context: *Chapter 3* builds on the fundamentals discussed in *Chapter 2* by introducing a set of foundational concepts essential to successfully implementing TSMO strategies, projects, and programs.

Chapter 4, Agency Readiness to Advance TSMO: *Chapter 4* provides an orientation for the TSMO program director on essential resources and concepts necessary to initiate, improve, and sustain an effective TSMO program.

1.3.1.3 Part C, TSMO Program and Planning

Part C is geared toward the day-to-day processes needed for a well-functioning TSMO organization. The primary audience is managers within a TSMO program.

Chapter 5, TSMO Program Planning: *Chapter 5* defines a TSMO program and the strategic, programmatic, and tactical elements that are fundamental to its structure.

Chapter 6, Planning, Programming, and Funding for TSMO Tactics: *Chapter 6* provides an overview of planning, programming, and funding for TSMO tactics. It includes approaches transportation agencies have taken to integrate TSMO into their planning processes and the challenges they face in planning, programming, and funding for TSMO tactics.

Chapter 7, Performance Management: *Chapter 7* defines and provides guidance on TSMO performance management by establishing the context for TSMO performance management and systematically reviewing key steps in the TSMO performance management process.

Chapter 8, Systems Engineering, Interoperability, and Technology Management: *Chapter 8* provides an overview of the application of systems engineering to TSMO and ITS. The related concepts of systems architecture, standards and interoperability, and concepts of operation are explained.

Chapter 9, Organization and Workforce: *Chapter 9* defines and reviews organization and workforce to support operations. It discusses how operations fit within an agency organizational structure and presents several organizational models.

Chapter 10, Collaboration and Outreach: *Chapter 10* reviews where collaboration takes place, its benefits, types, and rationale for both public sector and public–private collaboration. The chapter reviews the need for outreach to support TSMO programs and projects, both internal and external to the agency.

Chapter 11, Culture and Leadership: *Chapter 11* discusses the significance of having a strong culture oriented toward TSMO, and how such a culture is reflected within an agency and its TSMO program.

Chapter 12, TSMO Capability Improvement, Guidance, and Tools: *Chapter 12* reviews the programmatic issues and management principles that are introduced in *Chapter 4* and explored in depth in *Chapters 6* through *11* and describes how the concept of capability maturity can be applied to evaluate and improve an agency's ability to overcome challenges to implementation and improvement.

1.3.1.4 Part D, Project Development

Part D describes how TSMO and project development relate to one another. The intended audiences are 1) TSMO staff who are involved in the project development process and 2) project development staff who incorporate TSMO in other projects or develop TSMO projects.

Chapter 13, Performance-Based Practical Design (PBPD): *Chapter 13* describes PBPD, and how TSMO can support PBPD concepts and PBPD can further TSMO goals and objectives.

Chapter 14, Performance Measures for Operational Improvements: *Chapter 14* discusses performance measures as key aspects of the project development process and how TSMO-focused performance measures can increase the emphasis on operational outcomes when delivering infrastructure programs and projects.

Chapter 15, Linking TSMO to Capital Projects: *Chapter 15* discusses the importance of proactively including TSMO input and review at various steps of the project development process as projects move from planning and programming into project development.

Chapter 16, Procurement: *Chapter 16* discusses typical transportation agency procurement and the unique aspects of TSMO that should be considered when deciding on procurement options.

Chapter 17, Project Funding: *Chapter 17* reviews typical funding opportunities for TSMO-related projects, the funding process, and the importance of funding maintenance and operations activities.

1.3.1.5 Part E, Tactical Elements

Part E describes a wide range of TSMO tactics grouped in eleven chapters. This part contains much of what staff involved in TSMO solutions will reference. It is intended that readers will find topics of interest by using the search or find functions of the program used to view the the Manual onscreen.

Chapter 18, Overview of Tactical Elements: *Chapter 18* provides an overview of the chapters included in *Part E*. It emphasizes that efficient management and operations can benefit all users of a transportation network.

Chapter 19, Fundamental Elements of Situational Awareness, Communication, Decision Support, and Control: *Chapter 19* identifies and describes tactical elements used to detect and report conditions in support of fundamental transportation operations and management. These elements are generally needed to implement more advanced tactics and provide input to decision making.

Chapter 20, Event Management: *Chapter 20* provides an overview of tactics that focus on event management. Event management is an umbrella topic that covers several different areas, including crashes and other incidents, planned special events, work zones, and roadway weather.

Chapter 21, Arterial Management: *Chapter 21* describes specific tactics that can be utilized to address mobility and safety challenges on arterial facilities. It explains how an effective arterial management program uses those tactics to increase safety, mobility, and efficiency for all users on the arterial network.

Chapter 22: Freeway Management Tactics: *Chapter 22* provides an overview of tactics that focus on freeway management. Agencies can implement these tactics as part of a comprehensive TSMO program or individually, based on the collective needs of the region.

Chapter 23, Freight Operations: *Chapter 23* presents specific TSMO tactics that can address unique mobility and safety challenges posed by highway freight transport throughout the transportation system.

Chapter 24, Advanced Integrated Tactics: *Chapter 24* discusses integrating various tactics. Tactics addressed in this chapter build sophistication into fundamental tactics or actively manage the transportation system by taking a more holistic approach to operating the network. Topics include active management and TSMO, managed motorways and freeways, integrated corridor management (ICM), and managed lanes.

Chapter 25, Active Demand and Parking Management: *Chapter 25* provides an overview of tactics that fall into the category of active demand management (ADM). ADM can reduce overall travel demand or redistribute demand to alternate modes, routes, or times of departure in an overall effort to better manage the transportation

network. Active parking management can reduce congestion on surrounding roadways by managing the availability and cost of parking.

Chapter 26, Active Transportation: *Chapter 26* addresses a range of active transportation tactics intended to provide enhanced mobility and safety across a range of nonmotorized transportation modes.

Chapter 27, Transit Tactics: *Chapter 27* provides an overview of tactics that focus on enhancing transit operations and the experience of transit passengers. Agencies can implement these tactics in both the freeway and the arterial environment as they see fit, and also as part of larger TSMO programs.

Chapter 28, Tolling and Road Pricing: *Chapter 28* discusses pricing as a TSMO tactic to provide funding, manage facility demand and usage, and enhance operations. It covers tolling, congestion pricing, and cordon pricing.

1.3.1.6 Part F, Industry and Technology Trends

Part F identifies trends and their implications affecting the development, implementation, and operation of TSMO tactics.

Chapter 29, Technology Trends: *Chapter 29* provides an overview of technology trends in transportation operations. As transportation-related technologies change and improve, agencies are presented with new options for implementing innovations that can improve mobility and safety and increase efficiency in operating transportation systems.

Chapter 30, Industry Trends: *Chapter 30* provides an overview of evolving industry trends in transportation operations. Because industry often drives the evolution of these trends, transportation agencies are continuously exploring new industry developments, adapting to trends as they emerge, and applying resources to meet their specific needs. *Chapter 30* also introduces selected industry trends that use new approaches, technologies, and concepts.

1.4 How to Use the Manual

The target audience for this Manual spans a range of public- and private-sector individuals. A primary focus is the public sector, ranging from state agencies to regional planning organizations to local municipalities. Within each governmental body is a range of leadership, managers, and technical roles. Each of these roles is a key to operations and a key audience for the Manual. Outside the public sector, users of the Manual will be diverse, from consultants, designers, and planners to first responders, law enforcement, and data providers.

This Manual is intended to allow readers to navigate to the chapters that are of most interest and use to them. It is not intended to be read from cover to cover. The Manual is designed to be accessed electronically using the navigation features of the application used to access the document. There are additional navigation features in the Manual that can be used if the document is printed by the reader. However, electronic navigation is the most effective.

Section 1.3 describes the topics discussed in each of the Manual's chapters and the target audience(s) for each part of the document.

1.5 Resources and Related Activities

There are several reference documents that guide transportation development from the planning stages to final design: AASHTO's *A Policy on Geometric Design of Highways and Streets* (Green Book), the Transportation Research Board's *Highway Capacity Manual* (HCM), and AASHTO's *Highway Safety Manual* (HSM). Transportation professionals rely on these references for decision-making in their respective realms. While each is relatively self-contained, there are overlapping topics and interaction between the documents. This Manual fills a key missing piece in this reference library.

The role of each of the reference documents and how they relate to this Manual is described below:

- *A Policy on Geometric Design of Highways and Streets:* The AASHTO Green Book mostly governs the geometric and physical (dimensional) aspects of roadway design. While some Green Book topics overlap with operations, such as transportation geometric design, this Manual provides guidance on whether design alternatives are needed, and the Green Book focuses on the design of those alternatives. Many operational alternatives (for example, managed lanes) also require significant discussion beyond geometry, such as how they will operate, who will operate them, what hardware and software are needed, and how their performance is measured and managed.
- *Highway Capacity Manual:* The HCM focuses on the various level-of-service metrics for roadway users—freeway density, intersection delay, and pedestrian and bicycle comfort. To minimize overlap between this Manual and the HCM, the Manual focuses on performance management development and evaluation. Guidance within this Manual related to level of service or congestion mitigation focuses on the overall process and refers to the HCM for the specific input and analysis methods.
- *Highway Safety Manual*: The HSM focuses on traffic safety performance, proven countermeasures, and computational methods for predictive analysis. As a newer reference, the HSM provides a good model for interacting with the other references. Crash analysis methodologies within the HSM can lead to design alternatives with proven crash modification factors, but those alternatives and associated benefits must be balanced with changes in design (Green Book) and level of service (HCM). Similarly, guidance and recommendations contained within this Manual focus on operational goals such as reliability and mobility and refer to the HSM for impacts to safety.

Each reference manual is specific to a particular interest: roadway geometry, capacity, safety, and operations. While guidance, alternatives, and recommendations from each will support the best opportunity for that interest, it is the transportation professional's responsibility to evaluate the performance of all options against agency and project goals and resources. As such, this Manual supports a range of alternatives and promotes a holistic evaluation process by not diminishing alternative approaches.

Many other important resource documents referenced in this manual are too numerous to list or describe here. They include guidance documents for the implementation of tactics like freeway management, ramp metering, managed lanes, traffic incident management, and the others covered in *Part E*. They also include documents that describe effective practices agencies have used to address transportation challenges with TSMO. A large body of knowledge is also referenced that helps agencies improve their internal practices and processes to be more effective and efficient at developing and managing a TSMO program.

1.6 References

23 USC 101. Available from *https://www.law.cornell.edu/uscode/text/23/101*

American Association of State Highway and Transportation Officials (AASHTO). Washington, DC. References include:

- *Highway Safety Manual*. 1st Edition with 2014 supplement. HSM-1. 2010. Available from *https://store.transportation.org/search?q=hsm&categoryCode=&index=storeitem&type=storeitem&pageNum=1&pageSize=10&sortBy=Relevance&itemType=All*
- *A Policy on Geometric Design of Highways and Streets*, 7th Edition. GDHS-7. 2018. Available from *https://store.transportation.org/search?q=gdhs&categoryCode=&index=storeitem&type=storeitem&pageNum=1&pageSize=10&sortBy=Relevance&itemType=All*

Federal Highway Administration (FHWA). U.S. Department of Transportation, Washington, DC. Resources include:

- ATDM Overview. Available from *https://ops.fhwa.dot.gov/atdm/about/overview.htm*
- Office of Operations. Available from *https://ops.fhwa.dot.gov*
- *Manual on Uniform Traffic Control Devices*. 2009. Available from *https://mutcd.fhwa.dot.gov/kno_2009r1r2r3.htm*
- *Enhancing Transportation: Connecting TSMO and Planning.* FHWA-HOP-18-096. 2018. Available from *https://ops.fhwa.dot.gov/publications/fhwahop18096/index.htm*

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Transportation Research Board (TRB). *Highway Capacity Manual: A Guide for Multimodal Mobility Analysis*. 6th Edition. Transportation Research Board, The National Academies Press, Washington, DC, 2016. Available from *https://www.trb.org/Main/Blurbs/175169.aspx*