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# Policies and Processes that Support Mainstreaming Transportation Systems Management and Operations

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## SI\* (MODERN METRIC) CONVERSION FACTORS

### APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
<b>LENGTH</b>				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
<b>AREA</b>				
in <sup>2</sup>	square inches	645.2	square millimeters	mm <sup>2</sup>
ft <sup>2</sup>	square feet	0.093	square meters	m <sup>2</sup>
yd <sup>2</sup>	square yard	0.836	square meters	m <sup>2</sup>
ac	acres	0.405	hectares	ha
mi <sup>2</sup>	square miles	2.59	square kilometers	km <sup>2</sup>
<b>VOLUME</b>				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft <sup>3</sup>	cubic feet	0.028	cubic meters	m <sup>3</sup>
yd <sup>3</sup>	cubic yards	0.765	cubic meters	m <sup>3</sup>
NOTE: volumes greater than 1,000 L shall be shown in m <sup>3</sup>				
<b>MASS</b>				
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")
<b>TEMPERATURE (exact degrees)</b>				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
<b>ILLUMINATION</b>				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m <sup>2</sup>	cd/m <sup>2</sup>
<b>FORCE and PRESSURE or STRESS</b>				
lbf	poundforce	4.45	newtons	N
lbf/in <sup>2</sup>	poundforce per square inch	6.89	kilopascals	kPa
<b>APPROXIMATE CONVERSIONS FROM SI UNITS</b>				
Symbol	When You Know	Multiply By	To Find	Symbol
<b>LENGTH</b>				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
<b>AREA</b>				
mm <sup>2</sup>	square millimeters	0.0016	square inches	in <sup>2</sup>
m <sup>2</sup>	square meters	10.764	square feet	ft <sup>2</sup>
m <sup>2</sup>	square meters	1.195	square yards	yd <sup>2</sup>
ha	hectares	2.47	acres	ac
km <sup>2</sup>	square kilometers	0.386	square miles	mi <sup>2</sup>
<b>VOLUME</b>				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m <sup>3</sup>	cubic meters	35.314	cubic feet	ft <sup>3</sup>
m <sup>3</sup>	cubic meters	1.307	cubic yards	yd <sup>3</sup>
<b>MASS</b>				
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
<b>TEMPERATURE (exact degrees)</b>				
°C	Celsius	1.8C+32	Fahrenheit	°F
<b>ILLUMINATION</b>				
lx	lux	0.0929	foot-candles	fc
cd/m <sup>2</sup>	candela/m <sup>2</sup>	0.2919	foot-Lamberts	fl
<b>FORCE and PRESSURE or STRESS</b>				
N	newtons	2.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in <sup>2</sup>

\*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

ATM	Active Traffic Management
CAV	connected and automated vehicle
DOT	department of transportation
FHWA	Federal Highway Administration
ITS	intelligent transportation systems
MAG	Maricopa Association of Governments
MDOT SHA	Maryland DOT State Highway Administration
MPO	metropolitan planning organization
PennDOT	Pennsylvania Department of Transportation
TMC	traffic management center
TAMP	transportation asset management plan
TOAST	Traffic Operations Assessment Systems Tool
TSMO	transportation systems management and operations

## 1. INTRODUCTION

Transportation agencies use transportation systems management and operations (TSMO) to enhance the reliability and safety of their systems. There are numerous ways to support mainstreaming TSMO throughout transportation agencies and to support the advancement of TSMO as a method of doing business. The Federal Highway Administration (FHWA) has developed a series of White Papers focused on mainstreaming TSMO through the application of policies and processes, changes in agency culture, advances in decisionmaking and information management, and development of business cases for TSMO. This White Paper focuses on the use of policies and processes to advance mainstreaming TSMO in transportation organizations.

### **Objectives of the White Paper**

The objective of this White Paper is to assist departments of transportation (DOTs) and other agencies engaged in managing and operating transportation systems in mainstreaming TSMO through their policies and processes. Formal and informal policies and processes can be used to introduce and integrate TSMO principles, strategies, and tactics across an agency's business areas. Examples include policies that require TSMO strategies to be considered in project planning and development, and multidisciplinary TSMO teams that explore opportunities to implement TSMO strategies across disciplines. Policies and processes within agencies can encourage, promote, and support the consideration and advancement of TSMO agency-wide.

This Paper discusses policies and processes, organized by six themes, that have helped agencies advance mainstreaming. The six themes are:

- Develop TSMO committees
- Incorporate TSMO formally into planning and project development
- Include TSMO in agency manuals and guidance documents
- Integrate TSMO in business practices
- Develop TSMO-focused organizational structure and staff positions
- Integrate TSMO into agency-wide performance management

Chapter 2 provides an understanding of why policies and processes matter when mainstreaming TSMO. Chapter 3 describes the six themes identified in the bullets above that have helped agencies to mainstream TSMO. Chapter 4 presents the gaps, challenges, and opportunities to using policies and processes for mainstreaming TSMO, drawing on examples from transportation agencies. Chapter 5 concludes the paper with key takeaways and lessons based on the examples collected.

### **Intended Audience**

This White Paper is written for transportation agencies—State DOTs and local and regional agencies who work in coordination with State DOTs—interested in mainstreaming and integrating TSMO into agency-wide activities. It is specifically aimed toward TSMO leaders, department heads, or functional unit leaders. It is intended to help agency personnel in multiple



disciplines, not just TSMO and operations staff, understand ways TSMO can complement and integrate with their business practices.

### **Why Mainstream TSMO?**

Transportation agencies have focused on the design, construction, and maintenance of transportation facilities. TSMO expands this focus by looking to operational improvements to existing facilities to maintain and restore system performance before adding physical capacity. Mainstreaming in the context of business processes is defined as “[P]roducts and services which are readily available to and appealing to the general public, as opposed to being of interest only to a very specific subset of the public” (Lexico 2020). Mainstreaming TSMO makes management and operations strategies readily understood, considered, appealing, and available to agency leadership and staff, regardless of where they sit in the organization, as well as to the system users (public).

Typically, TSMO has been initiated in operations and maintenance business areas within transportation agencies, often evolving with intelligent transportation systems (ITS) technologies and functions that involve ITS deployment programs and other operations (e.g., maintaining signal systems, and detecting and clearing incidents). Mainstreaming TSMO allows a broader range of strategies to be integrated throughout transportation departments and related agencies and organizations. Mainstreaming TSMO engages planners, designers, operators, and system users (public and private sector), and touches all aspects of mobility, including congestion, air quality, sustainability, safety, security, reliability, and related quality of life concerns. The goal of mainstreaming is to routinely include TSMO strategies as an “equal player” in addressing transportation needs within a community or region, along with other options for improving transportation system performance.

## 2. WHY POLICIES AND PROCESSES ARE IMPORTANT TO MAINSTREAMING TSMO

Policies and processes direct and inform the day-to-day business of transportation agencies. They can formalize TSMO and advance it from an idea to reality, integrate TSMO across divisions and functional groups, and make TSMO meaningful to staff in their everyday work and specific areas of responsibilities. Policies and processes also communicate expectations, increase consistency of execution, and move from champion-driven to sustainable TSMO initiatives. Policies and processes can elevate TSMO and support an agency to evolve and change practices in all aspects of TSMO-related decisionmaking and application.

Policies and processes can mainstream TSMO by formalizing practices that support a culture that values TSMO within and across an organization. Incorporating TSMO clearly into an agency's policies and processes raises awareness of TSMO and helps agencies include its principles, strategies, and approaches in business functions on a daily basis.

Developing a TSMO program plan may provide the basis for identifying many of the policies and processes an agency might need or use to mainstream TSMO.

State DOTs can use TSMO program planning to guide TSMO programs and establish policies and processes that advance TSMO and support its mainstreaming across their organization. An important exercise in TSMO program development is to review current policies and processes to determine if they restrict, enhance, or are neutral in advancing TSMO, and to identify areas of need for new policies and processes to support mainstreaming TSMO. This might include review of manuals and standards to determine where TSMO strategies or review processes can be integrated in current practices. It is important to identify and revise policies and processes that hinder mainstreaming TSMO by restricting or discouraging the consideration of TSMO strategies.

Research conducted as part of this White Paper provided numerous examples of policies and processes that have evolved to advance and mainstream TSMO throughout the functional areas of the organization. Examples include:

- Incorporating TSMO formally into project development and planning processes
- Formalizing TSMO contracting and procurement processes
- Appropriating formal funding/budget for TSMO

A **policy** is a set of rules or principles to guide decisions within an agency (Merriam-Webster 2020). This can be in the form of rules, directives, standards, or other guidance that set the direction for decisions and actions. Policies can be formal or informal.

**Processes** are series of actions taken to achieve an outcome. (Lexico 2020).

In transportation agencies, it may be policy to consider low-cost, operational improvements to a roadway segment before investing in capital improvements. The process that is followed to meet the policy may be formal or informal and defines the steps required to determine needs, opportunities, options, analysis, and actions to be taken.

- Creating TSMO staff positions within the organization
- Establishing a TSMO steering committee/task force
- Defining operational responsibilities for TSMO groups within the organization
- Participating with other organizations/universities on TSMO research and development
- Focusing on TSMO-related workforce development and recruiting
- Completing TSMO organizational self-assessments (e.g., capability maturity models) and follow-up improvement actions
- Adopting agency-wide TSMO performance management
- Standardizing ITS technology
- Developing/publishing agency TSMO resources for project planning

Based on the examples gathered, there are six main themes or areas of policies and processes that emerged as either common among States active in mainstreaming TSMO or had strong potential to be effective for mainstreaming TSMO (figure 1). The six theme areas are discussed in Chapter 3, and examples of various agencies’ experiences are provided.

Develop TSMO committees	Incorporate TSMO formally into planning and project development	Include TSMO in agency manuals and guidance documents
Integrate TSMO into business practices	Develop TSMO-focused organizational structure and staff positions	Integrate TSMO into agency-wide performance management

Source: FHWA (developed for this paper).

**Figure 1. Six primary theme areas for mainstreaming transportation systems management and operations with policies and processes emerged from the research for this White Paper.**

Note that these themes are not a comprehensive list of policy and process areas that provide an opportunity to advance TSMO mainstreaming, but they were the most common areas found in the research.

### 3. PRIMARY THEMES FROM LITERATURE REVIEW AND INTERVIEWS

This chapter discusses the efforts agencies have advanced to integrate and mainstream TSMO within their organizations in the six primary theme areas.

#### Theme 1. Develop TSMO Committees

A significant amount of cross-departmental work within State DOTs to mainstream TSMO is performed by permanent or temporary committees and task forces. These committees may arise out of TSMO champions within one or more districts, divisions, or functional areas to formalize and grow a team of champions throughout the agency. The committees may include TSMO champions from outside the DOT, such as metropolitan planning organizations (MPOs) and local agency representatives. A committee is used by several State DOTs to advance TSMO throughout the agency. Table 1 provides examples of TSMO committees or task forces and the related activities that support successful mainstreaming of TSMO.

**Table 1. Examples of TSMO Committee processes for mainstreaming TSMO.**

State DOT	TSMO Committee Examples
Florida DOT District 5 and statewide	Florida DOT District 5 has a TSMO consortium. The group meets quarterly to provide an opportunity for District 5 staff and local and regional agency partners to collaborate on the TSMO program and ongoing efforts. At the statewide level, Florida DOT’s TSMO Leadership Team and TSMO Task Team support TSMO policy and technical development and oversight, respectively.
Iowa DOT	Iowa DOT has a TSMO steering committee and three subcommittees: training and communications, work zones, and project development. The TSMO strategic and program plans developed by Iowa DOT helped define the need for those subcommittees.
Maryland DOT	<p>The Maryland DOT State Highway Administration (MDOT SHA) established a TSMO executive committee to oversee the execution of the agency’s TSMO strategic implementation plan. It created a working group and seven TSMO task forces:</p> <ul style="list-style-type: none"> <li>• Business processes and policy—This task force works to get TSMO mainstreamed into agency processes.</li> <li>• Systems and technology—This task force creates a system of systems and advances them with operational approaches (i.e., integrated corridor management).</li> <li>• Communication and outreach—This task force conducts outreach and focuses on how to make TSMO projects a part of what MPOs and other partners do.</li> <li>• Training and education—This task force develops TSMO-oriented training curricula and is looking to tailor TSMO content to different groups of the DOT.</li> <li>• Data, analysis, and performance measures—This task force is responsible for identifying the next generation of tools.</li> </ul>

**Table 1. Examples of TSMO Committee processes for mainstreaming TSMO (continuation).**

State DOT	TSMO Committee Examples
Maryland DOT (continued)	<ul style="list-style-type: none"> <li>• Connected and automated vehicles (CAVs)–This task force develops strategic actions to prepare Maryland DOT SHA, both institutionally and technologically, for these emerging areas.</li> <li>• Multimodal freight–This task force ensures freight and multimodal considerations are addressed in all the other task forces.</li> </ul> <p>The task forces consult representatives from different units of Maryland DOT as needed to define actions, roles, responsibilities, and resources to advance their task force area. Those recommendations are then presented to the TSMO executive committee for decisions on the proposed actions. Upon approval from the TSMO executive committee, the action items are implemented through various offices and districts.</p>
Ohio DOT	<p>Ohio DOT developed the TSMO Council, an executive committee called to prioritize and champion TSMO activities, including advocacy of funding. The TSMO Council members are members of executive management across the DOT. The deputy directors for Operations and Engineering are co-chairs. The deputy directors for Planning and Construction, as well as one-half of the district directors, are members of the TSMO Council. Ohio DOT also has a technology council and a funding council.</p>

**Theme 2. Incorporate TSMO into Planning and Project Development**

This section contains examples of approaches agencies take to incorporate TSMO considerations into formal planning and project development processes. Based on the research for this White Paper, this appears to be one of the most active areas for mainstreaming TSMO. In many cases, agencies use mobility performance metrics to drive decisions for project and service selection, budgeting, and funding. These efforts enable TSMO to be considered when making investment decisions that can complement traditional approaches of funding construction and maintenance projects. Several of the State DOTs interviewed integrate safety considerations into the same processes they have adopted to mainstream TSMO in the planning, programming, and project development process. Table 2 provides examples of policies and processes that State DOTs use to formally incorporate TSMO into planning and project development.

**Table 2. Examples of policies and processes for mainstreaming TSMO in planning and project development.**

State DOT	Examples of TSMO in Planning and Project Development
Arizona DOT	<p>Arizona DOT incorporates TSMO efforts in its planning and program development process. Arizona DOT’s TSMO Division identifies specific projects that address various operational concerns throughout the State. Through the established planning to programming process, TSMO elements can then be incorporated into projects and prioritized for the 5-year construction program. The TSMO Division supports the review, evaluation, and prioritization of projects regarding safety, ITS, and operations. Arizona DOT’s project development group has revised its project review checklist to include safety, ITS, and operational groups in the formal project review process. This ensures that TSMO initiatives are identified, addressed, and included in upcoming construction projects.</p> <p>The State also works closely with the Maricopa Association of Governments (MAG), the Phoenix region’s MPO, to advance TSMO initiatives and secure funding. Arizona DOT partners with MAG on the inclusion of TSMO-focused efforts and strategies in MAG’s systems management and operations plan.</p>
Colorado DOT	<p>Colorado DOT modified its project development process to include steps designed to ensure that operational considerations are identified and evaluated. Colorado DOT requires an operations evaluation for all its projects. The evaluation assesses safety, traffic/maintenance operations, and ITS factors that lead to recommendations to the project team on safety and mobility strategies.</p>
Florida DOT	<p>The <i>Planning for TSM&amp;O Guidebook</i> provides statewide guidance on planning for operations and how to integrate the TSMO program into the transportation planning and project development process at Florida DOT. The guidebook supports incorporating TSMO into the overall process from system-wide planning evaluation to programming to project development. The <i>Project Development and Environment Manual</i> has statewide guidance to include TSMO as a feature of all build alternatives when TSMO does not meet a project’s purpose and need on its own. A flow chart has been developed to guide consideration of TSMO from planning through design and construction.</p>
Iowa DOT	<p>Iowa DOT uses a project development integration team to incorporate TSMO at “pause points” in the planning and project development process.</p>
Maryland DOT	<p>Maryland DOT SHA developed a TSMO Strategic Implementation Plan in 2016 and updated it as part of the 2018 TSMO Strategic Plan effort. The TSMO Strategic Plan identifies goals, objectives, performance measures, and strategies to implement and mainstream a robust TSMO program in planning, engineering, construction, operations, and maintenance activities. Maryland DOT SHA also developed a Reliability Roadmap that provides a travel time reliability analytical framework to inform transportation investment decisions. The roadmap includes products to enhance planning and preliminary engineering. Recently, Maryland DOT SHA has included TSMO alternatives in the long-range transportation plan. Maryland DOT SHA also released a TSMO Master Plan that identifies a tiered and prioritized list of TSMO projects that can be implemented by various offices across the agency.</p>

**Table 2. Examples of policies and processes for mainstreaming TSMO in planning and project development (continuation).**

State DOT	Examples of TSMO in Planning and Project Development
Ohio DOT	<p>Ohio DOT has brought TSMO considerations into the planning and scoping of projects. Their Project Initiation Package includes specific TSMO considerations. The major capital program consists of 18 project prioritization considerations that include whether the project area has an operations master plan, if it would benefit from traffic management center (TMC) coverage, if there are local TSMO infrastructure recommendations, and what existing TSMO infrastructure is in place.</p> <p>Ohio DOT’s Traffic Operations Assessment Systems Tool (TOAST) is an interactive spreadsheet used to track TSMO performance measures and support project prioritization. TOAST considers a variety of TSMO attributes to rank projects, including travel time performance, bottlenecks, incident clearance, secondary crashes, safety performance, volume per lane, and freight corridors.</p> <p>The Project Initiation Package requires applicants to indicate whether the project area contains a hot spot identified in TOAST and its ranking in TOAST. Ohio DOT has set aside \$5 million annually to use for TSMO projects.</p>
Oregon DOT	<p>Oregon DOT developed an Active Traffic Management (ATM) Atlas in 2016 for Region 1 to identify where investments in ATM would benefit highway operations. The goals of the ATM Atlas were to improve safety and reduce the severity and frequency of collisions, improve network reliability, and allow for improved incident and work zone management (Oregon Department of Transportation 2016). The ATM Atlas is used in conjunction with two other Oregon DOT operations planning efforts: (1) the Portland Region Traffic Performance Report and (2) the Corridor Bottleneck Operations Study. The Portland Region Traffic Performance Report helps to identify congestion and bottlenecks, reliability, safety, and delay issues. The ATM Atlas is then used to identify where TSMO-related investments would be most useful. The Corridor Bottleneck Operations Study recommends small-scale operational and safety improvements, such as adding an auxiliary lane at freeway interchanges. The ATM Atlas and the Corridor Bottleneck Operations Study recommend investments be provided as priorities during the development of the statewide transportation improvement program. (Oregon Department of Transportation 2019)</p>
Texas DOT	<p>Texas DOT’s TSMO Statewide strategic plan includes a TSMO evaluation section that contains questions to be used during project planning and development. The evaluation covers areas such as coordination and collaboration with stakeholders, safety, operations, and technology.</p>

**Table 2. Examples of policies and processes for mainstreaming TSMO in planning and project development (continuation).**

<b>State DOT</b>	<b>Examples of TSMO in Planning and Project Development</b>
Washington State DOT	<p>Under the Corridor Sketch Initiative, Washington State DOT divided the State system into approximately 300 corridor segments to analyze mobility and congestion challenges. This effort, led by the Planning Office, identified active traffic and demand management options and other TSMO-focused strategies that are near-term.</p> <p>A separate Washington State DOT initiative, Integrated Scoping, guides the State in the use of TSMO strategies to create integrated investment proposals. The State has completed pilots in several corridors using integrated scoping to combine transit and operations strategies in an investment package that is funded through a variety of sources.</p>



### Theme 3. Include TSMO in Agency Manuals and Guidance Documents

One of the effective ways to mainstream TSMO is to include TSMO-focused actions in agency manuals and guidance documents so they become a part of the normal way of doing business. Several agencies are including new language to address TSMO in their documents or are developing new guidelines and manuals to ensure TSMO is considered in projects and agency functions. Training is often a key component to alert staff to changes in manuals and guides and to help staff turn that into regular practice.

Florida DOT conducted a study, published in 2018, that surveyed Florida DOT practices in each of the eight Florida DOT districts on the current state of the practice of TSMO in each district. It also surveyed TSMO and traffic operations of each State in the United States to identify best practices in TSMO implementation. Recommendations from this study included: “Develop a formalized process and procedure for TSM&O inclusion, provide supportive TSM&O language in FDOT guidelines...[and] place greater importance on TSM&O through policy and procedures.” Florida DOT has included TSMO prescreening in the district project scoping process and in the Project Development and Environment Study process. (Florida Department of Transportation Research Center 2018)

Table 3 provides examples of how Florida DOT, Pennsylvania DOT, Texas DOT, and Arizona DOT are formalizing TSMO by including TSMO in agency guidance.

**Table 3. Examples of integrating TSMO policies and processes into agency manuals and guides.**

State DOTs	Examples of TSMO Integrated into Agency Manuals and Guides
Arizona DOT	Arizona DOT developed a TSMO plan upon establishment of its TSMO Division that provides the framework for how the Division functions. The State is updating and revising agency manuals and guidance documents to incorporate TSMO.
Florida DOT	<p>In 2017, Florida DOT released the <i>Planning for Travel Time Reliability Guide</i> that describes how Florida DOT’s employees and consultants can better incorporate travel time reliability into its planning process for capacity expansion and the planning process for operational improvements. The guide highlights opportunities for collaboration, how to adjust tools to incorporate travel time reliability, and funding options for improvements that address travel time reliability. (Florida DOT 2017)</p> <p>In January 2018, Florida DOT published a study, <i>Evaluation of Project Processes in Relation to Transportation System Management and Operations (TSM&amp;O)</i>, that considered opportunities for mainstreaming TSMO in its project development process. It included a number of recommendations and suggestions for a formalized process and procedure</p>

**Table 3. Examples of integrating TSMO policies and processes into agency manuals and guides. (continuation)**

State DOTs	Examples of TSMO Integrated into Agency Manuals and Guides
Florida DOT (continued)	<p>to involve TSMO in the planning and design phases of projects. The recommendations included a project checklist documenting TSMO inclusion as projects are vetted, and TSMO review opportunities in the <i>Efficient Transportation Decision Making Manual</i>. It also suggested including TSMO in the <i>Project Management Handbook</i> and the <i>Project Design and Engineering Manual</i>.</p> <p>Florida DOT’s <i>Project Development and Environment Manual</i>, Part 2, Chapter 3 “Engineering Analysis” includes consideration of TSMO strategies and ITS as elements of all build alternatives, even if the TSMO-only alternative did not meet a project’s purpose and need. (Florida DOT 2020) TSMO elements are now identified and refined during the project development and environment study.</p>
Pennsylvania DOT	<p>Pennsylvania DOT is developing a guidebook series that will formalize how TSMO should be incorporated into several functions at the agency, including planning, design, construction, maintenance, and operations. In September 2018, Pennsylvania DOT released the <i>Transportation Systems Management and Operations (TSMO) Guidebook Part 1: Planning</i>, which directs its staff in developing regional operations plans and identifying, classifying, and mitigating congestion. (PennDOT 2018)</p>
Texas DOT	<p>Texas DOT developed guidance within its statewide TSMO strategic plan for Districts to develop their own TSMO program plans. Texas DOT’s Work Zone ITS Guidance and the Chief Engineer directive on traffic management systems are also examples of how Texas has integrated TSMO in its guidance documents.</p>

**Theme 4. Integrate TSMO in Business Practices**

To fully mainstream TSMO in transportation agencies, it is important to consider how business practices may need to be revised or developed to meet the changing demands in an agency. Including TSMO in how the agency performs its work on a day-to-day basis leads to a change in culture and employee mindset toward advancing TSMO. Changes may be needed to contracting and procurement; data management; and partnerships with private businesses, service providers, and research entities. Examples of how State DOTs are addressing this can be seen in Washington, Iowa, Missouri, and Tennessee (table 4).

**Table 4. Examples of integrating TSMO policies and processes into agency business practices.**

State DOT	Examples of TSMO Incorporated into Business Practices
Iowa DOT	<p>In Iowa, the Traffic Operations Bureau works closely with the DOT’s purchasing section to develop technical requirements for unique technical services that support TSMO. By changing these business practices to be more suitable for meeting the needs of TSMO projects, the DOT has helped to mainstream TSMO activities that previously did not fit more traditional construction-oriented purchasing processes.</p> <p>Iowa DOT partners with the Center of Transportation Research and Education at Iowa State University to support operations decisionmaking, the development of system-wide performance measures, and applications development (e.g., using probe data to alert operators of rapidly developing queuing situations). Developing university partnerships and business practices that support data sharing and performance measurement has helped to bring TSMO more effectively into the DOT’s decisionmaking processes.</p>
Missouri DOT	<p>Missouri DOT improved its procurement process for ITS technologies by providing uniformity in equipment and system deployment across regions. Missouri DOT’s statewide TSMO Implementation Teams have focus areas in work zone management, traffic incident management, and advancing technology and roadway departure. These teams have been working in various ways to integrate TSMO into their business practices, including updating job special provisions for identified technologies within work zones, creating handouts for placement of law enforcement within work zones, and creating a CAV vision team, along with many other items.</p>
Tennessee DOT	<p>Tennessee DOT is working to standardize ITS technology with the help of IT staff and DOT region cooperation, including the development of an ITS-approved product list that includes products that can be used by Tennessee DOT.</p>
Washington State DOT	<p>Washington State DOT changed its regional mobility grant application process for public transportation. Washington State agencies applying for those grants must use Washington State DOT’s TSMO website to identify which TSMO strategies are part of their proposed solution.</p>

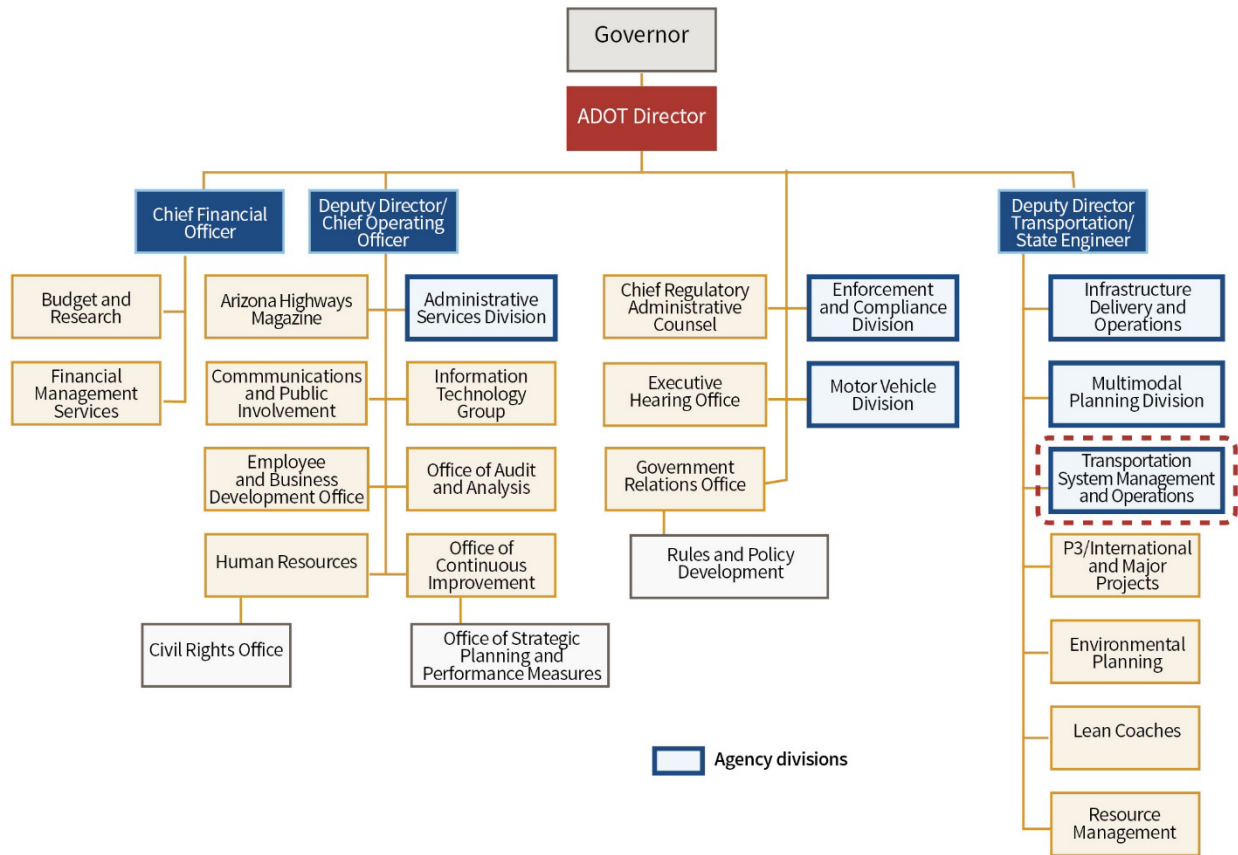
**Theme 5. Develop TSMO-Focused Organizational Structure and Staff Positions**

This theme considers how organizational structure and staff positions are used to mainstream and advance TSMO. This section looks at how State DOTs have organized to address TSMO. It highlights the range of approaches taken by different agencies to mainstream TSMO through various organizational structures. The structure reflects how an agency defines and approaches TSMO and the importance that it gives to TSMO. While more research is needed to determine whether one organizational structure provides more benefit to TSMO than others, it is important to note that this is one of the tools agencies use to promote and more clearly establish TSMO in their organizations. In addition to, or as an alternative to, organizational structure changes, transportation agencies have also designated specific staff positions to serve as TSMO coordinators or TSMO leaders to mainstream TSMO throughout an agency. Different approaches can be seen throughout State DOTs (table 5).

**Table 5. Examples of TSMO-focused organizational structure and staff positions to mainstream TSMO.**

State DOTs	Examples of Organizational Structures and TSMO Staff Positions
Arizona DOT	Arizona DOT created a dedicated TSMO Division under the Deputy Director for Transportation (see figure 2 and figure 3).
Iowa DOT	Iowa DOT’s Traffic Operations Bureau is under its Operations Division, along with several other bureaus: Maintenance, Traffic and Safety, Construction and Materials, and Motor Vehicle Enforcement. By combining these functional areas under Operations, the State DOT is able to integrate TSMO strategies and activities more directly into each of these functions. For example, Iowa DOT has implemented a Traffic Critical Project initiative that applies TSMO strategies to large construction projects to minimize traffic impacts.
Maryland DOT	<p>MDOT SHA has established the TSMO Program Manager/Deputy Director position to provide leadership for TSMO and oversee the development and implementation of its TSMO strategic plan. Responsibilities include managing the TSMO program, TSMO master plan, education and training, communications and outreach, and coordinating and collaborating with the TSMO Executive Committee, working group, partners, and stakeholders (see figure 4).</p> <p>The TSMO Program is developed and implemented through a committee structure. The TSMO Executive Committee provides strategic governance and the cross-disciplinary TSMO task forces provide tactical support. The strategies and action items coming from the task forces are implemented by various MDOT SHA offices and districts. The TSMO Program Manager oversees the activities of various TSMO task forces and reports progress to the TSMO Executive Committee.</p>
Ohio DOT	Ohio DOT has reorganized its central office to bring all aspects of non-recurring events and congestion into one group in an effort to better address TSMO. They have developed TSMO Coordinator positions in the district offices, and at the central office, have introduced TMC Operator positions, including the TMC Specialist position and the ITS Specialist position, which is a higher classification for the Traffic Signal technicians.
Tennessee DOT	Tennessee DOT elevated operations by creating the Traffic Operations Division in 2013, which combined three offices: ITS, traffic signal design, and traffic operations. Over time, Tennessee DOT added new offices and positions to the Division, and now there are four offices within the Division: State Traffic Engineer, ITS Design Office, ITS Deployment Office, and Transportation Management Office. This consolidation of TSMO responsibilities has clarified decisionmaking authority for quicker responses to major incidents.
Texas DOT	Texas DOT has a designated TSMO Coordinator in each of its regions.

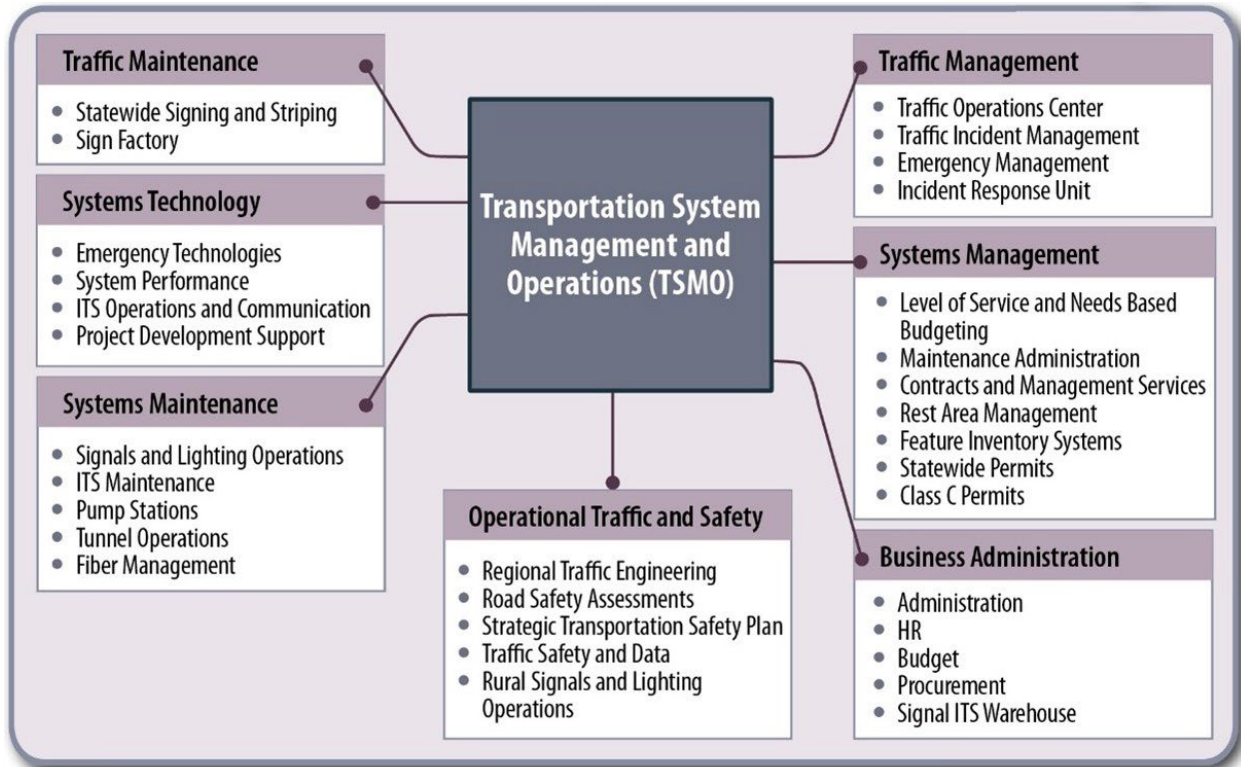
Figure 2 shows TSMO as one of six upper-level divisions within the organizational structure for Arizona DOT.



Source: Arizona DOT, with modification by the Federal Highway Administration.

**Figure 2. Arizona Department of Transportation organizational structure with the Transportation System Management and Operations Division circled.**

Figure 3 illustrates the organizational structure within Arizona DOT’s TSMO Division. The Arizona DOT TSMO Division comprises approximately 300 full-time employees that encompass all aspects of TSMO strategies.



Source: Arizona DOT, with modification by the Federal Highway Administration.

**Figure 3. Organizational structure for the Arizona Department of Transportation Systems Management and Operations Division.**

Figure 4 shows Maryland DOT's TSMO organizational structure according to strategic, tactical, and operational decision paradigms.

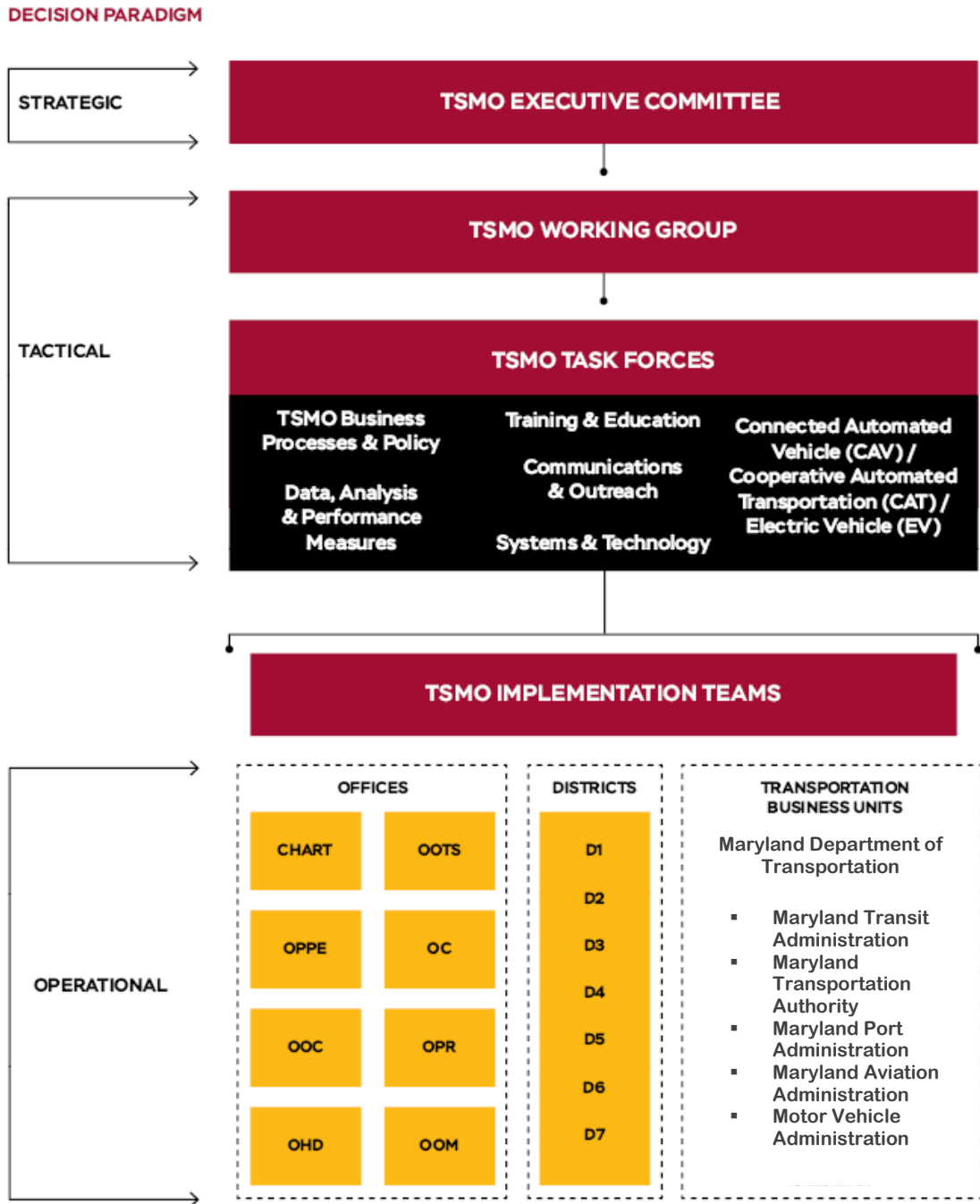


CHART = Coordinated Highways Action Response Team; OOTS = Office of Traffic and Safety; OPPE = Office of Planning and Preliminary Engineering; OC = Office of Communications; OOC = Office of Chief Engineer (Operations); OPR = Office of Policy & Research; OHD = Office of Highway Development; OOM = Office of Maintenance.

Source: MDOT SHA, with modification by the Federal Highway Administration.

**Figure 4. Maryland Department of Transportation State Highway Administration Transportation System Management and Operations organizational structure.**

## Theme 6. Integrate TSMO into Agency-Wide Performance Management

Performance management and measures provide a foundation for performance-based policies and practices. Including TSMO in agency dashboards can increase the visibility of TSMO, place importance on showing positive performance in TSMO-related measures, and increase resources for TSMO to help “move the needle.” Tracking and documenting TSMO benefits and the return on investment, including cost-benefit analysis of TSMO strategies and tactics after implementation, can make the business case for investing in TSMO. These efforts can help formalize and mainstream TSMO throughout an agency. Examples of the use of performance management to mainstream TSMO in State DOTs are highlighted in table 6.

**Table 6. Examples of integrating TSMO into agency performance management processes.**

State DOTs	Examples of Integrating TSMO into Agency Performance Management Processes
Arizona DOT	Arizona DOT’s TSMO Division developed performance measures and targets across all groups within the Division. The measures and targets tie into the agency-wide “scorecard” for identifying resource needs in alignment with agency goals and objectives. The TSMO Division holds monthly meetings to track progress and identify countermeasures to address areas where targets are not being met.
Maryland DOT	Maryland DOT SHA produces its annual <i>Maryland State Highway Mobility Report</i> , a document that applies performance-based monitoring to system reliability. This report looks at congestion and reliability performance trends and documents the effect of various congestion management and reliability improvement strategies. Maryland DOT SHA also developed customized dashboards for different audiences, such as operators, planners, decisionmakers, legislators, or the public. MDOT SHA has partnered with Maryland MPOs and university research centers to ensure the dashboards are consistent from a data governance and management perspective.
Missouri DOT	Missouri DOT posts its performance management <i>Tracker</i> report online on a quarterly basis. TSMO-specific performance management is contained in the “Operate a Reliable and Convenient Transportation System” section of the report, including travel time and reliability measures, traffic congestion measures, traffic incident management measures, work zone impact measures, and management of winter storm events.
Ohio DOT	Ohio DOT has begun to track TSMO-related performance measures. It hired a data architect to build a data warehouse for pulling together data (e.g., speed, weather, work zone, and freeway patrol assist). Ohio DOT has completed some dashboards using the data warehouse and expects to complete more dashboards in the future.
Oregon DOT	Oregon DOT developed a TSMO performance measures plan with the intent of focusing on traffic incident management, systems management, and program management.
Pennsylvania DOT	Pennsylvania DOT developed a TSMO performance program that develops periodic performance reports that analyze various aspects of traffic operations. The initial focus was TMC performance, but it has been continually expanding over time, including work zone-related performance.



**Table 6. Examples of integrating TSMO into agency performance management processes (continuation).**

State DOTs	Examples of Integrating TSMO into Agency Performance Management Processes
Washington State DOT	Washington State DOT calculates the return on investment of its incident response program and publishes the results in the agency’s online quarterly performance and accountability report, <i>The Grey Notebook</i> . The September 2019 update of <i>The Grey Notebook</i> reports that, for every \$1 spent on the Washington State DOT incident response program, drivers receive approximately \$17.51 in economic benefit. (Washington State Department of Transportation 2019)

#### 4. GAPS AND OPPORTUNITIES

Although the research uncovered examples of how transportation agencies have used policies and processes to advance TSMO mainstreaming, it is apparent there are areas that are not yet being addressed or fully considered for TSMO-focused policies and processes. Currently, there are gaps in established policies and processes across agencies, in part because TSMO programs and plans are generally only a few years old, and many recommended strategies or actions have not had sufficient time to be fully implemented or evaluated. Areas where there are gaps for mainstreaming TSMO include:

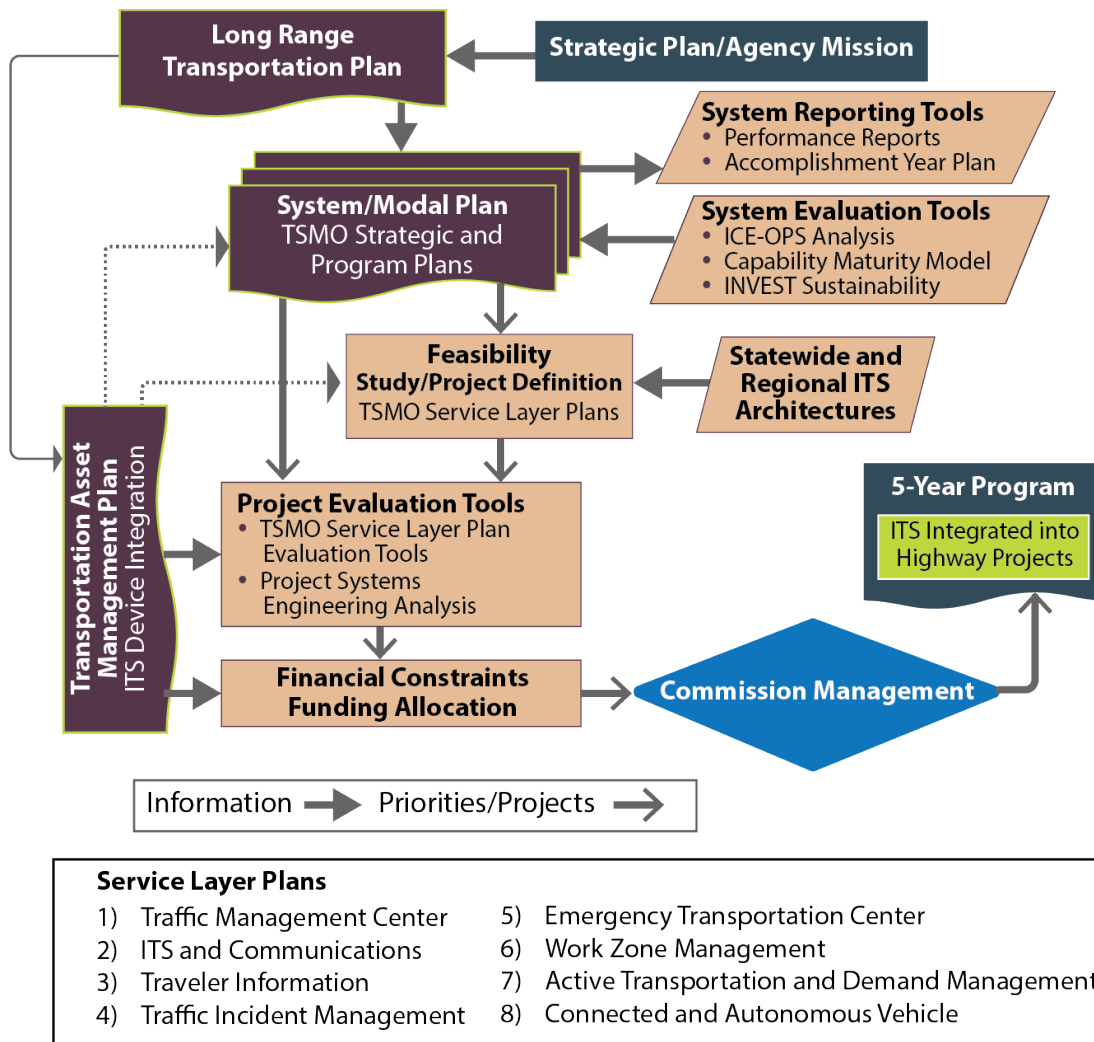
- Planning and programming
- Data management
- Contracting and procurement
- Emerging technology
- Asset management
- TSMO integration with other modes, jurisdictions, and decision support processes.

Each of these areas present opportunities for advancing and mainstreaming TSMO across agencies and they are described briefly below.

##### **Planning and Programming**

A critical area for mainstreaming TSMO is planning and programming. While this is an active area of mainstreaming for several agencies interviewed, generally, transportation agencies have not yet formally included TSMO in their planning and programming processes. Most State DOTs focus on capital construction projects, which may include the construction or deployment of ITS or other capital-intensive TSMO tactics. The integration of TSMO into planning and programming elevates consideration of TSMO strategies to a strategic level within the agency, which can help mainstream TSMO. By examining TSMO options early in the planning process, agencies can start with considering lower-cost, less-intensive strategies and then progress to more-intensive solutions.

Some State DOTs, as highlighted under this theme in Chapter 3, have begun to address this through policy and process changes. According to Washington State DOT's website, "WSDOT is working with policymakers to create a budget structure and legislative policy that allows the agency to fully maximize a Practical Solutions approach to project delivery and daily operations" (Washington State DOT 2020). Washington State DOT's Practical Solutions approach looks at TSMO solutions prior to considering capacity improvements, mainstreaming TSMO directly in the planning process. Iowa DOT integrates TSMO into its planning process and the development of its 5-Year Program, as shown in figure 5, moving TSMO activities from a collection of activities in "the back of the program" to a focused part of the programming process.



Source: Iowa DOT

**Figure 5. Illustration of how TSMO is integrated into Iowa Department of Transportation’s planning and programming.**

These activities illustrate the opportunities created for mainstreaming TSMO by formally incorporating it in programming and budgeting policies and processes. A common approach to funding or budgeting for TSMO is to include operational elements in capital projects. This allows deployment of physical assets but does not necessarily accommodate management and procedural elements, ongoing operations, or asset management, and there is often a risk of the TSMO elements being cut from construction projects when project costs exceed available funding. This approach also makes it difficult to gain a realistic picture of agency investment levels in TSMO. Elevating TSMO to a designated budget category and including it in formal programming processes can be helpful for better establishing TSMO as an important part of how the agency delivers mobility services to its constituents.

Programming and budgeting typically focus on construction and maintenance. Including TSMO as a budget category and revising planning and programming processes to address operational needs and TSMO strategies can be an important step to mainstreaming. Elevating TSMO in the

process shifts the perception of TSMO as a project “add-on” to a viable alternative or complement to address system needs.

## **Data Management**

TSMO strategies and applications can produce and use vast amounts of data. These data can support a wide array of business activities, including planning, design, construction, operations, and maintenance. Effective operations require real-time and historic data to support decisionmaking and system management. TSMO as a source and user of data can benefit from being mainstreamed in agencies’ data management policies and processes by making data usable, sharable, and accessible across the agency. To enable these capabilities, TSMO can work with information technology (IT) staff, or other data management personnel, to develop storage and management policies and procedures and data governance that support all potential users. Additionally, TSMO programs can grow IT capabilities within their staff to allow many of the data management functions to be handled within the program.

TSMO data are often siloed within operations groups or isolated for specific applications, which limits data effectiveness and usefulness. Managing, integrating, and sharing transportation system data from ITS and operational deployments can support more data-enabled decisionmaking and resource allocation. Data shared across an agency can mainstream TSMO by supporting other functional areas and highlighting opportunities for enhancing system management. Mainstreaming TSMO data for use across the agency may require new partnerships between agency staff responsible for supporting data management and potential users. A regional or statewide ITS architecture is an important tool in collaborating across DOT Divisions and with other agencies on the use of data from ITS deployments. Data policies and processes can support the role of TSMO data in enhancing decisionmaking in all functional areas of the agency.

## **Contracting and Procurement**

Contracting and procurement in DOTs focus on design, construction, and maintenance services. TSMO strategies are generally connected to the construction and maintenance of highway infrastructure. Many of the traditional approaches to procuring and contracting at DOTs may not fit the nature of TSMO activities because TSMO is more service-oriented (e.g., traffic incident management) or involves technology and system applications (e.g., traffic monitoring or system integration). Procurement personnel may not be as familiar or experienced with the standards and specifications for quickly evolving technology or understand the long-term implications of procuring proprietary systems for deployment by their agency. Additionally, standard DOT contract language may not be appropriate for technology applications.

Updating contracting and procurement to better address the services and technologies associated with TSMO enables implementation and acceptance of TSMO strategies. Contracts with data providers are a good example of where traditional contracting may not be prepared to negotiate the value of DOT-provided data in exchange for third-party data. Until such non-traditional contracting and procurement situations are addressed in agency processes and policies, it may be difficult for TSMO to be fully integrated and mainstreamed.

Policies and processes that address data ownership and sharing, value and use of agency right-of-way and assets, management and risk of operational services, and other aspects of contracting and procurement that may arise in the advancement of TSMO are often needed. Policies that require consideration of TSMO strategies in all contracts may also be helpful to mainstream TSMO across agency activities.

### **Emerging Technology**

Technologies that are used to manage and operate the system are emerging and evolving quickly. Emerging technologies are often found in TSMO strategies and tactics. Understanding how these technologies support other business functions, such as planning, design, construction, maintenance, and asset management, can mainstream TSMO. This can be supported through processes that bring the use of TSMO technology and the resulting data or information into these business areas. Examples can be seen in the application of monitoring and traffic management technologies in work zones. Policies and processes for reviewing emerging TSMO technologies and examining their application across business functions could strengthen their deployment and integration to reduce application costs and mainstream their use.

### **Asset Management**

Asset management and TSMO both work to preserve and maximize the functionality of the system. A formal integration of TSMO and asset management through policies that guide how they work together, a review and development of processes that bring TSMO strategies into asset management, and an addition of asset management goals and considerations into TSMO decisionmaking can all support TSMO mainstreaming. State DOTs' relatively new focus on developing transportation asset management plans (TAMPs) and on TSMO program development and plans provides opportunity for the two areas to work cooperatively to preserve and enhance the management and operations of transportation systems. Each State is required by the Moving Ahead for Progress in the 21st Century Act (MAP-21)<sup>1</sup> to develop a risk-based TAMP for the National Highway System. Although not required, States may include TSMO assets in their TAMPs. TSMO provides a strategic approach to system management and operations, and with a growing interest by State DOTs to incorporate ITS and other traffic control devices in their TAMPs, there are increasing opportunities to align and mainstream TSMO in asset management.

Asset management's focus on optimizing the performance and cost-effectiveness of the system aligns with TSMO objectives and provides a natural area for coordination and support. Many TSMO strategies lend themselves to the objectives of asset management, and opportunities exist to include TSMO strategies and principles into asset management planning processes.

### **TSMO Integration with Other Modes, Jurisdictions, and Decision Support Processes**

TSMO maximizes the performance of transportation systems and works across modes, agencies, and disciplines to improve system efficiency, reliability, and safety. In considering gaps in TSMO mainstreaming, it is useful to look at multiple modes, jurisdictions, and disciplines to develop multimodal, multi-agency programs and projects. Integrated corridor

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<sup>1</sup> Pub. L. No. 112-141.

management is an example of how agencies and modes can work together to build an integrated, multimodal approach to system mobility. Traffic incident management is another example of working across jurisdictions and disciplines to provide enhanced reliability and safety. Formalizing business rules and procedures supports mainstreaming these strategies throughout and across agencies and shifts the way organizations work together. Sharing data through formal processes and agreements supports effective decisionmaking (real-time and investment). Successes in more of these applications can provide a foundation for more extensive mainstreaming.



## 5. KEY TAKEAWAYS

DOTs can move toward greater mainstreaming of TSMO through the use of policies and processes. Numerous examples of effective practices have been discussed in this document and provide ideas and approaches for integrating TSMO throughout the agency. Several key takeaways and strategies for enhancing mainstreaming are summarized below.

**Through review of current practices and documents, one of the key lessons learned from successful, as well as ineffective, mainstreaming efforts relates to integrating TSMO into existing processes and requirements rather than creating new processes.** State DOTs, like Iowa and Pennsylvania, that have worked to integrate TSMO in the planning process and in updated guides and manuals have been able to better align TSMO with other functional areas. Washington State DOT successfully integrated TSMO into its new Corridor Sketch Initiative. This new set of planning activities was designed to engage Washington State DOT's partners in a process based on context and performance to identify high-level strategies to address gaps. The initiative was designed with TSMO principles and strategies imbedded in the activities and has resulted in plans that prioritize TSMO strategies and alternatives.

**TSMO committees advance TSMO throughout organizations in a number of States.** TSMO committees comprised of executive-level managers from different functional areas provide an opportunity to explore mutually beneficial TSMO strategies, policies, and procedures. These committees provide a forum for sharing information and developing processes that can mainstream TSMO throughout the agency. Formalizing processes that integrate TSMO evolve from sharing information and creating a common understanding of TSMO and how its principles and strategies can be applied across functional areas.

**TSMO champions play a critical role in advancing TSMO throughout an organization and maintaining progress.** As TSMO becomes more formalized in an agency's organizational structure, policies, and processes, TSMO within the agency becomes less dependent on individuals and can withstand personnel changes.

**TSMO is more easily integrated if it has a high level of visibility in the organization.** There is no single common approach to how TSMO is incorporated in an organization; however, there are a few common factors within State DOTs that are associated with mainstreaming TSMO. Having a high level of visibility does not mean that TSMO needs to be structured as a separate division, but it should also not be hidden in a lower-level office where lead staff are not at the table with functional area leads across the agency. For TSMO to be mainstreamed, it helps to integrate it into job responsibilities at an executive and management level across functional areas. Alternatively, the structure can reflect the importance of TSMO by creating a division or other high-level position that can educate and advocate for TSMO at the executive level.

**Performance management is an increasing focus in DOTs nationally, driven in part by Federal legislation and by the growth in data available for monitoring and evaluating system performance, often supported by TSMO.** TSMO deployments provide real-time and historic data that can identify trends, measure the effectiveness of strategies and applications, and evaluate how well an agency is meeting its strategic and operational objectives. Dashboards,



integrated databases, and TSMO strategies improve system performance and integrate TSMO across functional areas.

**Policies and processes within an agency provide a framework for how work is carried out and can help mainstream TSMO.** Adding TSMO strategies to planning processes, including TSMO considerations in manuals and guidelines, adapting contracting procedures to accommodate nontraditional services, sharing information and perspectives across functional areas in a TSMO committee, and providing performance data relevant to agency goals and objectives can change the way agency personnel see TSMO and the opportunities to include TSMO strategies in all aspects of agency business. Executive-level policies that support TSMO in daily business processes can enhance an understanding of TSMO and mainstream it throughout the organization. TSMO policies and processes build on the work of TSMO champions by formalizing and informing TSMO strategies and applications across the agency. Integrating TSMO at all levels of decisionmaking, strategic to tactical, advances the understanding and acceptance of TSMO so that it becomes an accepted approach to how agencies do their work. Without policies and process, the success of TSMO is dependent on individuals rather than being mainstreamed into everyday business practices.

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