

Planning for Transportation Systems Management and Operations

WITHIN SUBAREAS



A DESK REFERENCE



U.S. Department of Transportation
Federal Highway Administration

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16. Abstract This desk reference is designed to equip State, regional, and local transportation operations and planning professionals with the knowledge and tools necessary to effectively plan for and implement transportation systems management and operations (TSMO) within a subarea context. Its purpose is to support transportation planners and operations staff in planning for and applying TSMO activities within subareas to achieve a more reliable, efficient, and livable outcome from their existing and planned transportation infrastructure. This desk reference highlights a planning for operations approach at a subarea level to focus on issues (e.g., mobility, reliability, and safety) from a multi-modal perspective and provides a variety of tools to advance TSMO within subareas.			
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SI* (MODERN METRIC) CONVERSION

FACTORS APPROXIMATE CONVERSIONS TO SI UNITS				
SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
In.	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in. ²	square inches	645.2	square millimeters	mm ²
ft ²	square feet	0.093	square meters	m ²
yd ²	square yard	0.836	square meters	m ²
ac	acres	0.405	hectares	ha
mi ²	square miles	2.59	square kilometers	km ²
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft ³	cubic feet	0.028	cubic meters	m ³
yd ³	cubic yards	0.765	cubic meters	m ³
NOTE: volumes greater than 1,000 L shall be shown in m ³				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m ²	cd/m ²
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in. ²	poundforce per square inch	6.89	kilopascals	kPa

SI* (MODERN METRIC) CONVERSION (continued)

APPROXIMATE CONVERSIONS TO SI UNITS				
SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
mm	millimeters	0.039	inches	in.
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm ²	square millimeters	0.0016	square inches	in. ²
m ²	square meters	10.764	square feet	ft ²
m ²	square meters	1.195	square yards	yd ²
ha	hectares	2.47	acres	ac
km ²	square kilometers	0.386	square miles	mi ²
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m ³	cubic meters	35.314	cubic feet	ft ³
m ³	cubic meters	1.307	cubic yards	yd ³
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact degrees)				
°C	Celsius	1.8C+32	Fahrenheit	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m ²	candela/m ²	0.2919	foot-lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in ²

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LIST OF ACRONYMS

ATDM	active transportation and demand management
ATM	active traffic management
DOT	department of transportation
DTA	dynamic traffic assignment
FHWA	Federal Highway Administration
ICM	integrated corridor management
ITS	intelligent transportation systems
LOS	level of service
LRTP	long-range transportation plan
MPO	metropolitan planning organization
PennDOT	Pennsylvania Department of Transportation
PSRC	Puget Sound Regional Council
RCTO	regional concept for transportation operations
SHRP2	Strategic Highway Research Program 2
SMART	Specific, measurable, agreed-upon, realistic, and time-bound
SMF	smart mobility framework
SSP	safety service patrol
TDM	transportation demand management
TIM	traffic incident management
TIM-BC	Traffic Incident Management Benefit Cost Analysis
TIP	transportation improvement program
TMC	transportation management center
TrEPS	Traffic Estimation and Prediction System
TSMO	transportation systems management and operations
TSP	transit signal priority
TOPS-BC	Tool for Operations Benefit Cost Analysis
WRTM	weather-responsive traffic management

CHAPTER 1. INTRODUCTION

OVERVIEW OF DESK REFERENCE

Over the past decade, transportation agencies have increasingly integrated transportation systems management and operations (TSMO) in planning at the statewide and metropolitan levels. Using an objectives-driven, performance-based approach, State departments of transportation (DOTs) and metropolitan planning organizations (MPOs) around the country are working with local jurisdictions, transit agencies, law enforcement, toll authorities, and other partners to manage traffic congestion, improve system reliability, increase safety, and enhance multi-modal options using operations solutions. Rather than relying solely on new road, parking, and transit capacity, this approach recognizes that TSMO strategies (e.g., enhanced incident management, traffic signal coordination, transit signal priority (TSP), and traveler information) can often be low in cost, highly effective, and implemented in concert with infrastructure to enhance transportation system performance.

More recently, transportation and planning agencies are increasingly witnessing the presence of connected-vehicle and smart-city technologies, which pose new challenges to management and operations but also offer unique opportunities. Again using an objectives-driven, performance-based approach, transportation agencies and MPOs are beginning to work with automobile manufacturers, telecommunications providers, software and sharing-economy service providers, and other private-sector partners to collect, integrate, and synthesize rich vehicle and device-derived data to manage subarea mobility and livability goals.

*A **subarea** is a defined portion of a region, such as a local municipality (city or county), a downtown or central business district, an activity center, or a neighborhood. Transportation planning for a subarea addresses more details than area-wide or regional planning and generally incorporates broader planning context. Subarea plans typically provide a greater level of detail in the analysis and recommendations unique to the obstacles and opportunities in that area.*

Planning for operations involves identifying operations objectives and performance measures, which guide the identification, prioritization, and selection of investments, programs, and strategies. The result is implementation of programs, projects, and collaborative efforts to better manage and operate transportation systems and services to preserve capacity and improve the security, safety, and reliability of the transportation system. Today, many State DOTs and MPOs have adopted policies to improve transportation operations by managing travel demand and applying transportation management techniques before they take the steps toward considering additional capacity.

While many statewide and regional policies and programs are advancing implementation of effective TSMO strategies, more benefits will occur when TSMO is considered and applied strategically at a smaller scale where many critical implementation decisions are made. Transportation planning within subareas presents new opportunities for agencies to plan for operations both at a more refined geographic scale and at a level where specific, actionable plans can be developed. The availability of connected-vehicle and smart-city technologies expands subarea transportation planning opportunities even further.

Increasingly, transportation agencies recognize the value of the subarea approach instead of looking at individual transportation projects on a piecemeal or single-facility basis. A subarea approach takes a broader view of the interconnected factors that influence travel to, from, and within a subarea and enables more creative and collaborative approaches to addressing subarea transportation problems.

Traditional transportation planning focuses on improving the performance of transportation facilities. Performance metrics can include speed, throughput, lane capacity, safety, etc. Transportation planners and operators view transportation infrastructure as an interconnected network of facilities and services. Subarea planning—in a transportation context—also focuses on improving performance, but of a specific place. Planners and operators view the subarea as an interconnected but geographically limited and bounded amalgam of facilities and services. Performance metrics are more holistic in subareas and range from objective “hard” measures such as the volume, speed, and safety of goods and people moving in a subarea to the broader measures of performance such as congestion, emissions, energy consumption, and land. Qualitative or “soft” performance measures are more subjective and include such elements as “mobility” and “livability,” which are impacted by innumerable factors beyond the physical; e.g., zoning, parking, delivery, and shared-service policies.

Transportation Systems Management and Operations is...?

“... [a set of] 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.”

It “includes - (i) actions, such as traffic detection and surveillance, corridor management, freeway management, arterial management, active transportation and demand management, work zone management, emergency management, traveler information services, congestion pricing, parking management, automated enforcement, traffic control, commercial vehicle operations, freight management, and coordination of highway, rail, transit, bicycle, and pedestrian operations; and (ii) coordination of the implementation of regional transportation system management and operations investments (e.g., traffic incident management, traveler information services, emergency management, roadway weather management, intelligent transportation systems, communication networks, and information sharing systems) requiring agreements, integration, and interoperability to achieve targeted system performance, reliability, safety, and customer service levels.”

Source: 23 United States Code Section 101(a)(30).

Managing mobility in a subarea requires understanding, measuring, and leveraging many factors and is but one aspect of subarea planning, which is an approach used today by most government planning agencies across the United States to improve mobility.¹ The advent of connected-vehicle and smart-city technologies, and their associated data, has great potential to improve the ability of planning agencies to better manage subareas. This desk reference describes an approach for TSMO planning within a subarea context that incorporates the metropolitan planning concept of looking beyond a single factor (i.e., a transportation facility or particular land use, parking, or other policy) to focus more holistically on the performance of the subarea's transportation system from a user's perspective.

Transportation agencies and stakeholders, including planners, often begin subarea studies from an investments perspective to address traffic level-of-service (LOS) and other infrastructure related issues. This approach results in proposals for expensive capital investments, which often cost more than the available resources can support. Moreover, while TSMO may be a priority from a statewide or regional perspective, TSMO strategies often are applied at a broad scale (i.e., via a statewide incident management program, regional ridesharing program, or traveler information systems) without connecting these programs to a specific subarea's needs or targeting them to a subarea's unique challenges and conditions.

This desk reference equips subarea planning and operations professionals with the knowledge and tools necessary to effectively plan for and implement TSMO in a subarea context. Its purpose is to support transportation planners and operations staff in planning for and applying TSMO activities within subareas to achieve more reliable, efficient, and livable outcomes from their existing and planned transportation infrastructure. Utilizing a planning-for-operations approach at a subarea level can help operators focus on issues (e.g., mobility, livability, reliability, and safety) from a more holistic perspective and reveal cost-effective demand management and operations solutions that may not otherwise have been fully considered.

This desk reference describes planning for TSMO within subareas so that readers can tailor and apply this approach in a variety of subarea contexts. This desk reference is founded upon three themes for success that encompass all TSMO planning efforts:

- Using an objectives-driven, performance-based approach.
- Collaborating across agencies, jurisdictions, and modes.
- Linking to overarching planning processes at the metropolitan or statewide level.

This desk reference connects readers to other tools and resources developed by the Federal Highway Administration (FHWA) and partners to support a more in-depth understanding of several topics introduced in this document. It draws upon concepts, such as integrated corridor management (ICM), active transportation demand management (ATDM), and principles of metropolitan planning, that are increasingly focusing attention on collaboration across multi modal system operators and planners to address subarea conditions. Quick reference sheets provide examples of subarea operations objectives, performance measures, and management and operations strategies that can be applied as readers move forward in applying the components of planning for and implementing TSMO within subareas.

¹ U.S. Department of Transportation, *Integrated Subarea Management (ICM) Knowledge and Technology Transfer* (factsheet), FHWA-JPO-14-151. Available at: http://www.its.dot.gov/factsheets/pdf/ICM_KTT_V5.pdf.

This desk reference is a companion to the FHWA document, *Planning for Transportation Systems Management and Operations within Corridors Desk Reference*, which is a resource that addresses the specific needs of organizations planning for TSMO in corridors.²

WHO SHOULD USE THIS DESK REFERENCE?

This desk reference is intended for the transportation planning or operations professional looking to address specific questions on planning for TSMO within subareas as well as the professional who wants to gain a comprehensive understanding of how to successfully improve travel and goods movement within a subarea. This desk reference brings together planning and operations approaches, practices, and lessons learned that have been developed over the past 10 years and provides consolidated assistance on planning for TSMO within subareas. Several sections serve as launching points to related FHWA documents that provide more in-depth information and tools.

A GUIDE TO NAVIGATING THIS DESK REFERENCE

The desk reference is organized into six chapters:

► *Chapter 1: Introduction*

Briefly introduces TSMO within subareas and planning for TSMO in a variety of subarea contexts. It helps readers identify the need for TSMO planning at the subarea level.

- Related technical assistance materials: *Advancing Metropolitan Planning for Operations: An Objectives-Driven, Performance-Based Approach – A Guidebook*.³

► *Chapter 2: Planning for Transportation Systems Management and Operations Planning Within Subareas*

Makes the case for TSMO planning to achieve a coordinated, strategic implementation and ongoing use of TSMO strategies. It provides an overview of the planning context for TSMO within subareas and describes examples of current practice.

Related technical assistance materials:

- *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*.⁴
- *Performance Based Planning and Programming Guidebook*.⁵

2 Available Fall 2016 at: <http://www.ops.fhwa.dot.gov/publications/fhwahop16037/>.

3 Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, FHWA-HOP-10-026 (Washington, DC: 2010). Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10026/>.

4 Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, FHWA-HOP-10-027 (Washington, DC: 2010). Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10027/>.

5 Federal Highway Administration, *Performance Based Planning and Programming Guidebook*, FHWA-HEP-13-041 (Washington, DC: September 2013). Available at: http://www.fhwa.dot.gov/planning/performance_based_planning/pbpp_guidebook/.

- *Statewide Opportunities for Integrating Operations, Safety and Multimodal Planning: A Reference Manual.*⁶
- *The Collaborative Advantage: Realizing the Tangible Benefits of Regional Transportation Operations Collaboration.*⁷
- *Regional Transportation Operations Collaboration and Coordination: A Primer for Working Together to Improve Transportation Safety, Reliability, and Security.*⁸

► Chapter 3: Approach to Subarea Planning for TSMO

Lays out a common sense approach to planning for TSMO within a subarea for a variety of subarea contexts. It takes the reader from building a team for the effort to selecting TSMO strategies that will best achieve, from a transportation perspective, subareas operations objectives. It provides easy-to-use quick reference sheets for a range of operational objectives relevant to subareas, including travel time to, from, and within a subarea; traffic signal management; transit priority; bicycle and pedestrian accessibility; efficiency; and the broader concepts of mobility and livability.

Related technical assistance materials:

- *Operations Benefit/Cost Analysis Desk Reference.*⁹
- *The Role of Transportation Systems Management & Operations in Supporting Livability and Sustainability: A Primer.*¹⁰
- *Guide for Highway Capacity and Operations Analysis of Active Transportation and Demand Management Strategies.*¹¹
- *PlanWorks: Linking Planning and Operations.*¹²

► Chapter 4: Moving to Implementation: Transportation Systems Management and Operations within Subareas

Offers information on how to progress from plans for TSMO to implementing, monitoring, and maintaining TSMO strategies. This includes obtaining funding for TSMO, agreeing upon organizational roles and responsibilities, applying systems engineering, and regularly evaluating the effectiveness of the implemented strategies in relation to the subarea objectives.

6 Federal Highway Administration, *Statewide Opportunities for Integrating Operations, Safety and Multimodal Planning: A Reference Manual*, FHWA-HOP-10-028 (Washington, DC: June 2010). Available at: <http://www.fhwa.dot.gov/planning/processes/statewide/practices/manual/index.cfm>.

7 Federal Highway Administration, *The Collaborative Advantage: Realizing the Tangible Benefits of Regional Transportation Operations Collaboration*, FHWA-HOP-08-001 (Washington, DC: August 2007). Available at: http://www.ops.fhwa.dot.gov/publications/benefits_guide/index.htm.

8 Federal Highway Administration, *Regional Transportation Operations Collaboration and Coordination: A Primer for Working Together to Improve Transportation Safety, Reliability, and Security*, FHWA-OP-03-008 (Washington, DC: 2003). Available at: http://ntl.bts.gov/lib/jpodocs/repts_te/13686.html.

9 Federal Highway Administration, *Operations Benefit/Cost Analysis Desk Reference*, FHWA-HOP-12-028 (Washington, DC: May 2012). Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop12028/index.htm>.

10 Federal Highway Administration, *The Role of Transportation Systems Management and Operations in Supporting Livability and Sustainability: A Primer*, FHWA-HOP-12-004 (Washington, DC: January 2012). Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop12004/>.

11 Federal Highway Administration, *Guide for Highway Capacity and Operations Analysis of Active Transportation and Demand Management Strategies*, FHWA-HOP-13-042 (Washington, DC: June 2013). Available at: <http://ops.fhwa.dot.gov/publications/fhwahop13042/fhwahop13042.pdf>.

12 Federal Highway Administration, *PlanWorks: Linking Planning and Operations*, Web site. Available at: <https://fhwaapps.fhwa.dot.gov/planworks/Application/Show/7>.

Related technical assistance materials:

- [*Applying a Regional ITS Architecture to Support Planning for Operations: A Primer*](#).¹³
- [*Programming for Operations: MPO Examples of Prioritizing and Funding Transportation Systems Management and Operations Strategies*](#).¹⁴
- [*Designing for Transportation Management and Operations: A Primer*](#).¹⁵

► **Chapter 5: Toolbox for Effective Transportation Systems Management and Operations Planning**

Introduces several tools to help ensure effective planning for TSMO within subareas, including scenario planning, analysis tools, and benefit-cost analysis.

Related technical assistance materials:

- [*The Regional Concept for Transportation Operations: A Practitioner's Guide*](#).¹⁶

► **Chapter 6: Taking Action**

Describes key actions that readers can take to jump start their efforts to advance TSMO within a subarea.

TRANSPORTATION SYSTEMS MANAGEMENT AND OPERATIONS WITHIN SUBAREAS

►► **What is Transportation Systems Management and Operations?**

Transportation systems management and operations, or TSMO, encompasses a broad set of strategies that aim to optimize the safe, efficient, and reliable use of existing and planned transportation infrastructure for all modes and geographical areas, including subareas. TSMO is undertaken from a systems perspective, which means that these strategies are coordinated with related strategies and across multiple jurisdictions, agencies, and modes. TSMO strategies range from regional traffic signal systems management to shared-use mobility initiatives (see Table 1 on page 9 for an expanded list of strategies). TSMO includes efforts to operate the multi-modal transportation system and activities to manage travel demand.

TSMO proactively addresses a variety of transportation system user needs by:

- Influencing travel demand in terms of location, time, and intensity of demand.
- Effectively managing the traffic or transit crowding that results.

13 Federal Highway Administration, *Applying a Regional ITS Architecture to Support Planning for Operations: A Primer*, FHWA-HOP-12-001 (Washington, DC: February 2012). Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop12001/index.htm>.

14 Federal Highway Administration, *Programming for Operations: MPO Examples of Prioritizing and Funding Transportation Systems Management and Operations Strategies*, FHWA-HOP-13-050 (Washington, DC: September 2013). Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop13050/index.htm>.

15 Federal Highway Administration, *Designing for Transportation Management and Operations: A Primer*, FHWA-HOP-13-013 (Washington, DC: February 2013). Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop13013/index.htm>.

16 Federal Highway Administration, *The Regional Concept for Transportation Operations: A Practitioner's Guide*, FHWA-HOP-11-032 (Washington, DC: July 2011). Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop11032/index.htm>.

- Anticipating and responding to planned and unplanned events (e.g., traffic incidents, work zones, inclement weather, and special events).
- Providing travelers with high-quality traffic and weather information.
- Ensuring that the unique needs of the freight community are considered and included in all of the above.¹⁷

TSMO strategies are supported by both institutional and technology-based activities. For example, TSMO is enabled by memoranda of agreement among agencies, operational policies and procedures, and shared resources (e.g., interoperable communications systems, centralized traffic signal operations, and closed circuit television video sharing).

►► *What are the Benefits of Transportation Systems Management and Operations?*¹⁸

TSMO strategies have allowed transportation agencies to address transportation issues in the near-term, with lower-cost solutions. TSMO strategies deliver a variety of benefits and, particularly for subareas, are evaluated based on broader transportation objectives. These include:

- **Safer travel:** For example, freeway ramp metering has been demonstrated to reduce crashes by 15 to 50 percent.
- **More free time:** Among other time-saving TSMO strategies, traffic signal retiming decreases delay on roads by 13 to 94 percent, and TSP reduces transit delay by 30 to 40 percent.
- **Improved reliability:** Strategies that reduce unexpected delays (e.g., incident management, road weather management, and work zone management) enable the public and freight shippers to reduce unexpected delays. TSP improves transit on-time performance.
- **Less wasted fuel:** Traffic incident management (TIM) programs help to clear incidents safely and quickly. They reduce time lost and fuel wasted in traffic backups. For example, Georgia's TIM program (NaviGator) reduced annual fuel consumption by 6.83 million gallons per year. National studies have shown that integrating traveler information with traffic and incident management systems could improve fuel economy by about 1.5 percent.
- **Cleaner air:** TSMO strategies result in cleaner air by encouraging alternative modes of transportation (e.g., transit, ridesharing, biking, walking, and telecommuting) and reducing excess idling due to congested bottlenecks. Electronic toll collection reduced harmful emissions at Baltimore, Maryland, toll plazas by 16 to 63 percent.
- **Improved livability:** TSMO strategies for subareas can specifically focus on many non facility/non-vehicle-type goals (e.g., transit accessibility, bicycle and pedestrian mode share, carbon intensity, transportation affordability, land consumption, bicycle and pedestrian safety, and LOS).

¹⁷ U.S. Department of Transportation, Federal Highway Administration Office of Operations, "The Operations Story." Presentation by Jeffrey Lindley (no date).

¹⁸ U.S. Department of Transportation, Intelligent Transportation Systems Joint Program Office, *Investment Opportunities for Managing Transportation Performance through Technology*, January 2009. Available at: http://www.its.dot.gov/press/pdf/transportation_tech.pdf.

▶▶ *Sample of Transportation Systems Management and Operations Strategies Relevant to Subareas*

Many TSMO strategies are applicable and effective at the subarea level. Table 1 lists TSMO strategies that agencies can consider when looking to improve the operation of their subareas.

Table 1. Sample of transportation systems management and operations strategies relevant to subareas.

TSMO Strategies	Supporting Activities
Traffic Management and Operations	<ul style="list-style-type: none"> • Traffic surveillance. • Traffic signal control: <ul style="list-style-type: none"> ◦ Enhanced multimodal traffic signal operations. ◦ Synchronized traffic signals. ◦ Emergency vehicle preemption. ◦ Transit signal priority. ◦ Truck signal priority. • Warning systems (queue, curve, intersection, size, and speed). • Roadside truck electronic screening/clearance programs. • Bicycle and pedestrian crossing enhancements (e.g., pedestrian count-down signals and detection of bicycles at demand-actuated traffic signals). • Parking management. • Special event management. • Use of connected vehicles for management.
Parking Management	<ul style="list-style-type: none"> • Variably priced parking (e.g., by time of day; dynamic based on demand). • Real-time parking information systems. • Parking reservation. • Overflow transit parking. • Delivery truck parking.
Traveler Information	<ul style="list-style-type: none"> • Local/regional multi-modal traveler information. • Roadside traveler information dissemination. • Predictive traveler information. • Real-time transit arrival information. • Parking availability information. • Trip planning and routing systems.
Road Weather Operations	<ul style="list-style-type: none"> • Road weather information systems. • Winter roadway operations.

Table 1. Sample of transportation systems management and operations strategies relevant to subareas (continued).

TSMO Strategies	Supporting Activities
Maintenance and Construction Management	<ul style="list-style-type: none"> • Maintenance and construction activity coordination. • Work zone management.
Incident and Emergency Management	<ul style="list-style-type: none"> • Traffic incident management. • Emergency management. • Computer-aided dispatch integration. • Emergency vehicle routing.
Public Transportation Management	<ul style="list-style-type: none"> • Advanced transit operations management. • Electronic fare collection and integration. • Transit surveillance and security. • Multimodal travel connections.
Transportation Demand Management	<ul style="list-style-type: none"> • Traveler information marketing campaigns. • Route planning tools. • Employer programs and commuter incentives. • Rideshare and bikeshare support. • Telecommuting. • Congestion pricing. • Subarea investments to support mode transfers or trip ends.
Shared Use Mobility/ Mobility on Demand	<ul style="list-style-type: none"> • Bicycle sharing. • Carsharing. • Dynamic ridesharing. • Multimodal hubs.
Complementary Strategies that Support TSMO	<ul style="list-style-type: none"> • Bottleneck removal. • Access management. • High performance transit.

TSMO = transportation systems management and operations.

►► *Transportation Systems Management and Operations within Subareas: Understanding the Subarea Contexts*¹⁹

When developing strategies for TSMO within subareas, it is critical to understand the context of the subarea, including:

- Any specific activity centers in the subarea, such as a university of corporate campus, a public or entertainment venue, etc.
- Surrounding land uses and development patterns.

¹⁹ Caltrans, *Smart Mobility 2010: A Call to Action for the New Decade* (Sacramento, CA: 2010).

- Available travel options, such as:
 - Highways.
 - Road networks.
 - Transit.
 - Non-motorized options.
- Who the system users are, such as:
 - Freight.
 - Commuters.
 - Interstate, intrastate, and local travelers.
- Users' needs and priorities.

A subarea generally includes multiple modes of travel, mixed land uses, arterials, streets and substreets, transit, paratransit and ride-share services, bicycle and pedestrian connections, park-and-ride lots, and other rideshare services.

Different types of subareas are found in urban, suburban, and rural contexts. Some subarea plans include multiple localized contexts (e.g., urban center, transit station area, and lower-density residential areas). For instance, a subarea plan could be conducted on a citywide or countywide scale, or at the level of some other subunit of a metropolitan region, and would include a diverse array of contexts. To optimize performance of the transportation system within a subarea and meet its users' needs, TSMO should reflect the unique form, use, and needs of the subarea.

Some typical types of contexts are listed below:

- **An urban center.** An urban center, which may be a downtown, is generally characterized as a dense area with high levels of activity and where complex, multi-modal transportation systems offer options for driving, taking transit, walking, and biking. Subarea planning in urban centers may focus on the broader objective of area mobility.

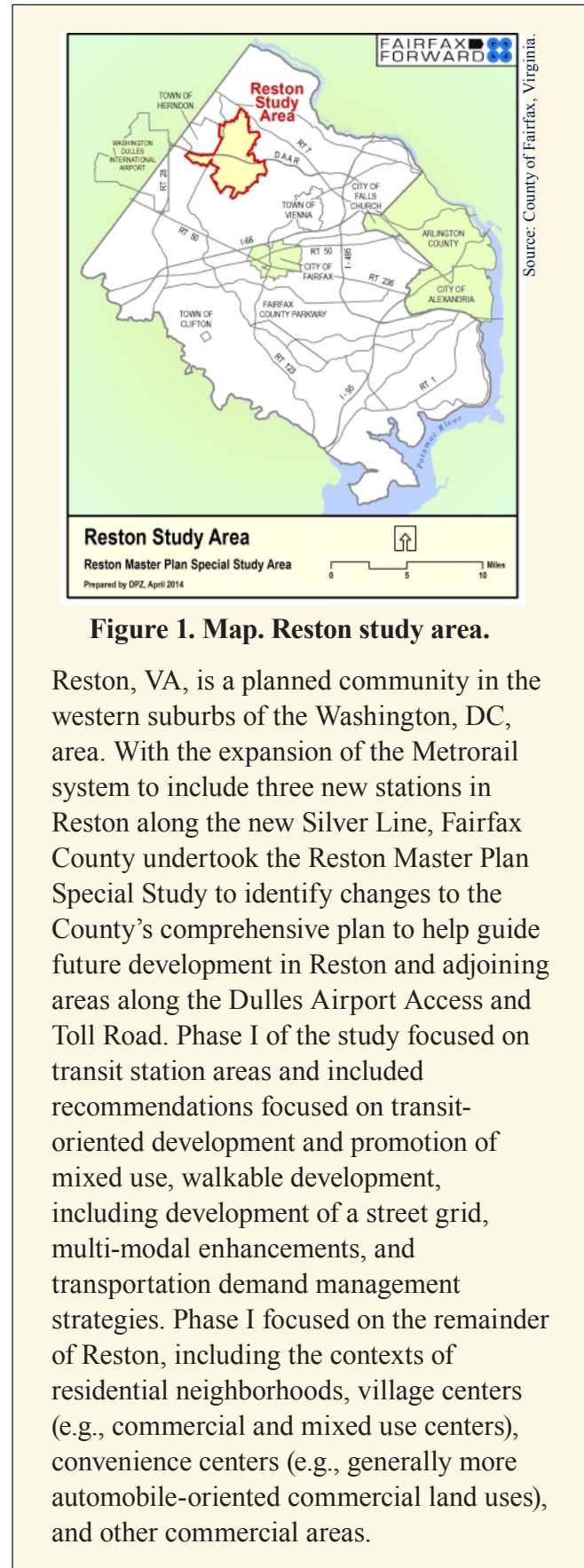


Figure 1. Map. Reston study area.

Reston, VA, is a planned community in the western suburbs of the Washington, DC, area. With the expansion of the Metrorail system to include three new stations in Reston along the new Silver Line, Fairfax County undertook the Reston Master Plan Special Study to identify changes to the County's comprehensive plan to help guide future development in Reston and adjoining areas along the Dulles Airport Access and Toll Road. Phase I of the study focused on transit station areas and included recommendations focused on transit-oriented development and promotion of mixed use, walkable development, including development of a street grid, multi-modal enhancements, and transportation demand management strategies. Phase I focused on the remainder of Reston, including the contexts of residential neighborhoods, village centers (e.g., commercial and mixed use centers), convenience centers (e.g., generally more automobile-oriented commercial land uses), and other commercial areas.

TSMO strategies for an urban center may focus on multi-modal system performance and managing travel demand and may include a wide array of strategies, including parking management, TSP, dynamic ridesharing, bikesharing, pedestrian count-down signals, real-time multi-modal traveler information, and traffic signal coordination.

- **A transit station area.** A transit station area provides a unique context, with the focal point typically being a transit rail station, major bus transfer facility, or intermodal facility. Often, transit station area plans focus on transit-oriented development as well as circulation of buses, general traffic, and pedestrians and bicycles within the vicinity of the station.
- **A suburban activity center or lower density mixed-use and residential area.** Suburban communities are less dense than a downtown core, and a subarea plan addressing such an area will often address neighborhood and environmental preservation, recreational facilities, and mobility, including traffic, transit, and bicycle and pedestrian access. For these subareas, TSMO strategies may focus on managing traffic and incidents to provide predictable travel times to and from the subarea, shifting demand to transit and ridesharing, and balancing travel loads across the network. Examples of TSMO investments may include dynamic high-occupancy vehicle (HOV) or managed lanes, parking management systems, and dynamic merge or junction control.
- **Rural areas.** In rural areas, there is a reduced amount of development, which is often dispersed, and travel options are often limited. While congestion is generally a minor concern, traffic safety and weather

California Department of Transportation (Caltrans) Place Types²⁰

Many States and communities define subarea contexts in their own unique ways. For instance, in its Smart Mobility Framework (SMF), Caltrans has defined seven “place types” that are used to create distinct contexts for transportation investments and operational performance, including urban centers, close-in compact communities, compact communities, suburban communities, rural and agricultural lands, protected lands, and special use areas. These different contexts are used to define appropriate sets of strategies, encompassing both infrastructure investments and operational strategies. For instance, Caltrans notes that reliability is a key objective guiding investment and operations in urban centers, which provides people with the ability to conveniently use walk, bike, and high-capacity transit modes and supports street and intersection operations that focus on providing predictable travel times with traffic and incident management. Conversely, rural and agricultural lands have fewer modal options due to their more limited activity areas.

²⁰ California Department of Transportation, Smart Mobility 2010: A Call to Action for a New Decade, February 2010. Available at: <http://www.dot.ca.gov/hq/tpp/offices/ocp/smf.html>.

conditions (e.g., snow, ice, rain, and fog) are often significant concerns. Subareas in rural areas typically experience seasonal, off-peak congestion due to tourism or events (e.g., festivals). In addition, in some small towns, stretches of State highways serve as main streets and may attract pedestrian and bicycle use. Given the infrequent congestion on rural roads, the more aggressive TSMO strategies used in urban and suburban subareas may not warrant deployment. TSMO strategies for rural subareas require a flexible approach tailored to the specific characteristics of the subarea and may include strategies such as road weather management and dynamic routing.

These are just a few examples of ways in which subarea contexts can differ. It is also important to consider that the context may change throughout a subarea, and the different segments may warrant different TSMO strategies.

While at a smaller scale than a region, a subarea will typically have multiple agencies responsible for different components of transportation system operations, including traffic signals, transit services, and traveler information systems, as well as an array of partners and stakeholders involved in event management, parking management, law enforcement, and other functions that affect mobility, safety, and other aspects of transportation system performance. Consequently, involving a wide range of agencies with responsibilities for mobility in a subarea is critical to taking a successful approach to TSMO.

►► *Who Performs Transportation Systems Management and Operations within Subareas?*

The lead agencies in managing and operating the transportation system components in subareas are typically the owners or operators of the facilities (i.e., State and local DOTs, roadway authorities, parking authorities, transit agencies, taxi authorities, and shared-use service providers), but many other partners are involved in and affect transportation system operations within local areas, and these relationships are critical for optimum subarea management.

For example, effective TIM involves coordination among several different groups, including responders from a variety of disciplines (e.g., law enforcement, fire and rescue, parking, towing, and recovery agencies), as well as the DOT or transportation management center (TMC). Implementation of TSP requires coordination among transit agencies that operate services and DOTs that are responsible for arterial and city roadway operations. Work zone management involves coordinating alternate routes among agencies and their contractors involved in construction and infrastructure renewal, other transportation agencies and services that use a facility or connect to a facility, as well as TMC and public relations staff who provide information to the public. Transportation demand management (TDM) programs often work directly with employers to promote travel options to their employees and may include efforts to support customized travel planning in communities, support for school-based programs to support bicycling and walking, and other options.

At a subarea level, local governments play a key part in transportation system operations through their roles in traffic signal operations, parking management and enforcement, and maintenance. However, it is important to recognize the role of State DOTs, regional planning agencies, and transit agencies in TSMO programs that will affect subareas. For example, the Denver Regional

Council of Governments provides engineering support to cities and counties in the region for signal retiming. The National Capital Region's Transportation Planning Board manages the Washington region's Commuter Connections program, which provides regional marketing and services (e.g., guaranteed ride home program and ridematching); these services support and complement local programs operated by counties, which work directly with employers to support telecommuting, ridesharing, transit, walking, biking, and other options.²¹

Over the past decade, and more recently over the last few years with the advent of connected vehicle and smart city technologies, TSMO has benefited from rapidly advancing technology (e.g., better data and data analytics). These have facilitated an increased emphasis on cost effective transportation solutions and improvements in mobility management and livability. TSMO now appears to be headed into an era where State DOTs and regional planning agencies are elevating TSMO as a top priority and systematically increasing their operational capabilities. MPOs are consistently planning and programming for TSMO and spearheading regional collaboration for TSMO. Local governments, with responsibility for operating traffic signals, transit services, road maintenance, and snow removal; local police forces; and other services play an increasingly important role as TSMO strategies become part of subarea plans. Again, the significant advances in vehicle and infrastructure technology and communication systems (e.g., connected vehicles and smart city systems) promises to shift the paradigm of how infrastructure, people, vehicles, and operators interact to change the way safe, efficient, and reliable transportation and mobility in subareas is provided.

A wide range of transportation-related agencies often play a role in how transportation is managed and how it operates in subareas, including:

- Local transportation agencies, which are responsible for arterial traffic signals, pedestrian signals, and crosswalks as well as snow removal and winter weather operations.
- Transit agencies—regional and/or local—operate public transportation services within the subarea, which may include bus services, commuter rail, or other rail transit services.
- State DOTs typically operate freeway management systems, 511 traveler information, and park-and-ride lots and often are responsible for snow removal on major freeways or other roadways within the subarea.
- Parking authorities that are responsible for building, managing, and operating parking facilities; regulating private parking facilities and street parking; and enforcing parking regulations in support of various transportation management objectives.
- MPOs may operate regional rideshare or TDM programs and could initiate targeted efforts to communities and businesses in the subarea.
- Local transportation management associations or organizations serve businesses or communities within the subarea.
- Toll authorities.
- Port authorities.

21 See the National Capital Region Transportation Planning Board, Metropolitan Washington Council of Governments web page at: <http://www.commuterconnections.org/>.

Typically, there are many different partners that should help to inform or play a role in transportation system operations, such as:

- Law enforcement, responsible for incident management and parking enforcement.
- Fire and rescue.
- Local governments, responsible for street and off-street parking policies, zoning, and access management.
- Local businesses and venues that serve as activity centers.
- Ports, freight distribution centers, and other goods management facilities.
- Neighborhood associations and other community groups.

TSMO strategies, whether or not they are implemented and operated by a single entity or agency, involve building consensus around needs, priorities, performance measures, resources, and responsibilities. As a result, the subarea planning or study process should recognize the importance of key stakeholders in the subarea who will be affected by—and whose support is needed to identify and advance—appropriate TSMO strategies in the subarea, including non traditional groups or entities (e.g., private stakeholders). Local businesses, neighborhood associations, bicycle/pedestrian advocates, and others will likely be engaged in the decision-making process. In the context of connected vehicles and smart cities, automobile makers, cellular carriers, automobile insurers, and shared-mobility service providers may need to become partners. And all will need to be informed of alternatives, benefits, and potential or perceived negative effects of TSMO strategies under consideration. Rather than optimizing individual services or facilities, effective subarea transportation operations involves optimizing transportation options from a holistic, overall system perspective.

CHAPTER 2. PLANNING FOR TRANSPORTATION SYSTEMS MANAGEMENT AND OPERATIONS WITHIN SUBAREAS

WHY IS PLANNING FOR TRANSPORTATION SYSTEMS MANAGEMENT AND OPERATIONS WITHIN SUBAREAS NEEDED?

The benefits of transportation systems management and operations (TSMO) within subareas are achieved through coordinated, strategic implementation and ongoing support through day-to-day operations and maintenance, and this requires planning. All TSMO strategies require some investment of resources, which could be in the form of funding, data, equipment, technology, or staff time. To obtain these resources and then make the best use of them, planning is needed. If TSMO is to be implemented effectively within subareas, there are a number of planning activities that should occur prior to implementation, including:

- Properly scoping the TSMO effort by obtaining input from all stakeholders within the subarea.
- Collaborating among all agencies or parties involved in the TSMO effort.
- Identifying and agreeing on the need for action and desired objectives (or outcomes) for the subarea.
- Considering alternative solutions.
- Estimating impacts (good and bad) within the subarea.
- Identifying resource needs and sources.
- Gaining approval from relevant decision makers.
- Planning for ongoing operations and maintenance.

Traditionally, transportation planning and TSMO have been largely independent activities. Planners typically focus on long-range transportation plans (LRTPs) and project programming. Operators are primarily concerned with addressing immediate system needs (e.g., incident response, traffic control, and work zone management). Planning for TSMO connects these two vital components of transportation, bringing operational needs and solutions to the planning processes and likewise bringing longer term, strategic thinking to operations managers.

The following examples demonstrate the need for planning for TSMO within subareas. The examples are a small set of commonly missing opportunities for improving the operational performance of the subarea transportation network through TSMO planning.

▶▶ ***Incorporating Transportation Systems Management and Operations as a Consideration into Subarea Planning Processes Led by Planning Groups***

When planning groups develop subarea plans, the TSMO perspective often is absent. This may occur because planners lack familiarity and experience with operations strategies. TSMO activities generally occur outside of the plan, design, and build functions for capital infrastructure investment. Often, TSMO is afforded a place alongside system maintenance activities in agency organizational charts, relegating TSMO activities to what happens after the planning, design, and build out is complete. As a result, agencies miss the opportunity to integrate TSMO with the tools and benefits that can help address community needs and achieve community goals. By incorporating TSMO planning practices and strategies into the goal setting, existing conditions assessment, alternatives development and analysis, and project selection stages, final projects will have a balanced plan featuring both operational and infrastructure investments that make them more financially feasible and achievable in the near term.

▶▶ ***Linking Subarea Network Optimization Efforts Led by Operations Groups with the Overarching Policy Framework and Plans of Their Agency***

Coordination activities and integration with long-range planning efforts are often overlooked when advancing transportation operations projects. For example, a regional traffic operations group initiates a process to provide real-time parking information in a central business district (CBD). Their vision is to install several variable message signs at key portals into the CBD to transmit data on parking availability. By coordinating during the overarching planning process, the traffic operations group can align the operational benefits with the broader goals identified in LRTPs to draw champions at the local and regional levels, who will in turn open doors to funding and other resources, including integration with other projects.

▶▶ ***Using the Systems Engineering Process to Plan for Intelligent Transportation System or Transportation Systems Management and Operations Deployments***

The use of the systems engineering process to support the implementation of intelligent transportation system (ITS) or TSMO deployments in a subarea is occasionally overlooked. As an illustrative example, agency planners forecast 50 percent traffic volume growth in a subarea within 10 years. In response, the traffic operations group decides to install adaptive signal control technology. The agency procures equipment and software without completing a systems engineering process. Implementation falters with the discovery that the selected solution fails to meet key needs. Benjamin Franklin wrote, “If you fail to plan, you are planning to fail!” This holds particularly true for complex technology solutions like ITS. When agencies use good planning practices, like systems engineering, to clarify needs, goals, and requirements, they minimize the risk of failure. Failed projects, especially when highlighted by the media, make it harder to secure funding and to achieve buy-in from the public and key decision-makers for future projects.

PLANNING CONTEXTS FOR TRANSPORTATION SYSTEMS MANAGEMENT AND OPERATIONS WITHIN SUBAREAS

►► *Advancing Transportation Systems Management and Operations within Several Planning Contexts*

Before focusing specifically on planning contexts for subarea TSMO planning, it is important to understand the larger context for TSMO planning, which may involve statewide, district, metropolitan, corridor, or local or subarea planning.

At the **statewide** level, planning for TSMO takes many forms. Planning for how TSMO will be conducted may be incorporated broadly in the State's long-range transportation plan, which is developed by the State DOT in collaboration with the State's MPOs and other transportation stakeholders. The State's long-range transportation plan may contain TSMO elements that are part of a larger multi-state initiative that individual States agree to support (e.g., a multi-state road-weather information system or traveler information system). TSMO planning also may be performed at the **district level** or across a state, where each State DOT district develops its own strategic operations plan in coordination with MPOs and local agencies within each DOT district. Alternatively, TSMO planning may occur at the **corridor level**, across the state, especially where a State has identified priority corridors where there are specific needs (e.g., improved goods movement from a seaport; more efficient commuter options to and from major employment areas; or better access to major entertainment, recreational, or sports venues). The 2012 surface transportation authorization act, Moving Ahead for Progress in the 21st Century, requires that "[t]he statewide transportation plan and the transportation improvement program developed for each State shall provide for the development and integrated management and operation of transportation systems and facilities..."²² States are encouraged to include TSMO in their long-range transportation plans developed through performance-based planning.²³ For more information on planning for TSMO at the Statewide level, readers should consult the Federal Highway Administration's (FHWA's) *Statewide Opportunities for Integrating Operations, Safety and Multimodal Planning: A Reference Manual*.²⁴

At the **metropolitan** level, planning for TSMO often is led or facilitated by the MPO, which convenes a group of TSMO stakeholders, typically including State DOT district or regional offices, to advance TSMO in the region. Metropolitan planning for operations is frequently conducted in coordination with the development of the metropolitan transportation plan as a means of including TSMO priorities and strategies into the overall plan and including TSMO program and projects in the transportation improvement program (TIP). FHWA recommends that planning for TSMO at the metropolitan (as well as statewide) level be driven by outcomes-oriented objectives and performance measures. Rather than focusing on projects and investment

22 Title 23 United States Code Section 135(a).

23 Federal Highway Administration, *Model Long-Range Transportation Plans: A Guide for Incorporating Performance-Based Planning*, FHWA-HEP-14-046 (Washington, DC: August 2014). Available at: http://www.fhwa.dot.gov/planning/performance_based_planning/mlrtp_guidebook/.

24 Federal Highway Administration, *Statewide Opportunities for Integrating Operations, Safety and Multimodal Planning: A Reference Manual*, FHWA-HOP-10-028 (Washington, DC: June 2010). Available at: http://www.fhwa.dot.gov/planning/processes/statewide/practices_manual/index.cfm.

plans, the planning-for-operations approach first emphasizes developing objectives for transportation system performance and then using performance measures and targets as a basis for identifying solutions and developing investment strategies. This is called the “objectives-driven, performance-based approach.” FHWA provides more information on using this approach to integrate TSMO into the metropolitan transportation planning process in a key document: *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*.²⁵

Corridor planning focuses on planning for a linear system of multi-modal facilities in which an existing roadway or transit facility will typically serve as the “backbone” of the corridor. The travel-shed helps determine the length and breadth of a corridor area, which usually connects major activity centers or logical destinations. Corridors can range in length from a few miles in an urban location to hundreds of miles for State or multi-State corridors. In addition to different spatial scales, corridors also may have different modal foci (e.g., freight rail corridor, high capacity passenger rail corridor, limited-access highway corridor, or bus rapid transit corridor). Usually, corridor planning focuses on a combination of modes and a network of facilities.

Local or subarea planning refers to planning which addresses

“A defined portion of a region (such as a county) in more detail than area-wide or regional plans. Subarea studies are similar to corridor studies, with the distinction that a subarea study generally addresses more of the total planning context and the broader transportation network for the area.”²⁶

Because subarea planning addresses a fairly broad planning context, this often involves a larger number of potentially affected stakeholders and comprehensive visioning for the area. Local studies may address a municipality (city or county) or other area, and may include a wide array of different issues, including transportation (motorized and non-motorized mobility), land use, and urban design. Corridor planning for TSMO also occurs at the local level (e.g., when one or more local agencies want to address mobility issues on an individual corridor within the local jurisdiction).

Statewide and metropolitan long-range transportation plans establish the policy framework for corridor, local, and subarea planning and provide guidance in terms of regional and statewide priorities related to goals, objectives, strategies, and transportation investments. MPOs, counties, and cities commonly lead local and subarea planning efforts. On the other hand, corridor studies and planning activities are often performed by State DOTs and MPOs.

Statewide and regional TSMO or ITS plans and associated architectures are a resource that can inform corridor, local, and subarea planning activities. These plans typically include existing and planned TSMO strategies that have been identified for statewide or metropolitan area use. Some include suggested TSMO strategies or implementation projects for specific subareas or an entire toolbox of potential strategies to consider.

25 Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, FHWA-HOP-10-027 (Washington, DC: 2010). Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10027/>.

26 Federal Highway Administration, *Guidance on Using Corridor and Subarea Planning to Inform NEPA* (Washington, DC: April 2011). Available at: http://environment.fhwa.dot.gov/integ/corridor_nepa_guidance.asp#toc212.

►► *The Who, Why, When, and Where of Transportation Systems Management and Operations Planning within a Subarea*

The context for TSMO planning at the subarea level provides answers to the basic questions of *why, who, where, and when* (Figure 2).

► *Motivation for Transportation Systems Management and Operations Within Subareas (Why)?*

The answer to why provides the **primary motivation for considering TSMO strategies within the subarea**. The motivation can be

the result of the broader planning process where a specific subarea is identified as an area requiring significant improvements or corrections (as in Example Context 1), or it could come through a coalition of local and regional partners that identifies a particular subarea as critical to mobility and economic activity throughout a larger area. For example, central business districts (CBD) may develop pedestrian malls, off-street parking, bicycle sharing, and other amenities to attract businesses, employers, tourists, and consumers to that area as a means of stimulating economic activity. The need for subarea improvements also could come from within operating agencies that see opportunities for providing a higher level of service (LOS) to travelers in the subarea (e.g., through more accurate and timely traveler information, better synchronized signals, or improved incident management in the subarea). The example provided in Context 1 illustrates how frequent incidents in roadways that travel into and through CBDs require a range of stakeholders because of the potential effects of improvements on businesses, nearby neighborhoods, transit services, pedestrians, bicyclists, and others. Investments required to implement improvements may be integrated into regional transportation plans and may provide the motivation for implementing TSMO strategies and tactics in a subarea.

The *why* also might be the result of growing concerns about congestion, safety, air quality, reliability, or other recurring problems within a subarea, or in search of ways to stimulate economic activity within the subarea, which may or may not be addressed in regional transportation plans. The motivation also might come as a result of a desire to improve the livability of a subarea within a larger region (see Example Context 2). Interest in TSMO strategies in a subarea also might arise in conjunction with new development projects when integrating TSMO strategies and tactics can be most cost effective (see Example Context 3).



TSMO=transportation systems management and operations.

Figure 2. Diagram. Context for transportation systems management and operations planning within subareas.

Example Context 1:

TSMO applications within the subarea are outside the regional planning process, such as incident management on roadways in the central business district.

- **Why** – Data indicate a high number of incidents at signalized intersections within the central business district, causing delays and traffic diversion onto nearby neighborhood streets.
- **Who** – Local law enforcement and response agencies are used as a starting point to identify the potential response team. Other potential stakeholders include local agency traffic operations staff, if they operate any part of the signal system, and local police, fire, and medical responders. See Example Context 2 for expanded stakeholders.
- **Where** – The subarea limits (in this case, defined by past high-incident intersections) help identify the specific stakeholders that may be required, such as city police instead of State police, local neighborhood representatives, nearby businesses, transit operators, and others who depend on mobility in the subarea.
- **When** – Initiate the planning process as soon as performance metrics first indicate an issue on the roadway.

Example Context 2:

Supports subarea planning.

- **Why** – The need for a specific subarea planning study has been identified as part of a regional or agency transportation systems management and operations (TSMO) planning effort based on operational deficiencies within the subarea.
- **Who** – The key stakeholders who operate transportation systems and related services (e.g., parking, bike share programs, transit services, urban delivery) within the subarea have been identified as part of the larger regional transportation system and should be used as a starting point. A subarea TSMO committee comprised of local transportation agency leaders and other stakeholders also may provide a sounding board for input throughout the study.
- **Where** – The subarea limits help identify expanded stakeholders (e.g., businesses, neighborhoods, freight, etc.) within the subarea that are impacted.
- **When** – The planning includes TSMO from start to finish.

► **Who?**

The who for TSMO planning for subareas **establishes responsibility for planning and implementing TSMO strategies** within a subarea that may span multiple jurisdictions (e.g., city and county) and requires interagency and multi-jurisdictional agreements regarding responsibilities for planning, designing, implementing, operating, monitoring, and maintaining TSMO strategies and tactics. This could be an authority acting on behalf of multiple entities (e.g., a toll authority or regional transit authority) or a single entity designated as the lead agency on behalf of other jurisdictions or agencies. Alternatively, if the subarea of interest is within a single jurisdiction, responsibility may lie with a single agency within the jurisdiction, but, even in

this case, there are likely to be other agencies and jurisdictions that are affected by decisions made with respect to the subarea of interest, thus communication and coordination with these agencies and jurisdictions is important to the success of the TSMO improvements in the subarea.

Example Context 3:

A study does not include transportation systems management and operations (TSMO) as initial focus, such as developing bicycle routes, off-street parking, or a pedestrian mall.

- **Why** – A subarea study is initiated to consider limiting vehicle access to a commercial area (e.g., pedestrian mall), reducing or narrowing vehicle lanes to accommodate bicycle lanes, or enhancing off-street parking services.
- **Who** – The initial team may only include city or county planners. A subarea TSMO champion could reach out to the study team and offer education and assistance with an evaluation of TSMO strategies that may help address the problem. See Example Context 1 for expanded stakeholders.
- **Where** – The project boundaries inform operational responsibilities. For example, a city may need help from its State department of transportation, which operates a regional or statewide traveler information system or owns and operates signal systems that pass through the subarea.
- **When** – As soon as a subarea TSMO champion is aware of the study, the champion should approach the project team about incorporating TSMO into the study. If a champion is in place at the executive level, they may be able to add TSMO to the study during the scoping process.

The *who* in TSMO planning for subareas reflects **the capacity and experience of the responsible agency or agencies**. Agencies with considerable experience in TSMO planning will have the tools needed to evaluate various TSMO strategies and will understand the data available to evaluate these strategies. Agencies with less institutional knowledge and experience with TSMO strategies and tactics can draw on external expertise to assist in integrating TSMO into subarea planning. Moreover, those with less experience may find institutional resistance to considering and committing resources to TSMO improvements and may need to enlist the support of champions who can help make the case for TSMO as a means for improving transportation system performance within the subarea, particularly as it relates to other subarea priorities (e.g., economic development, livability).

In some cases, a regional entity, such as an MPO or the major jurisdiction (e.g., city, county, or parish), will serve as the lead or facilitating entity for convening multiple agencies and jurisdictions to develop operations objectives for the subarea under consideration, especially if the subarea improvements have implications beyond the subarea (e.g., restrictions on vehicle access, changes in parking availability). State DOT district or regional offices also may be involved because, in some States, the State DOT is responsible for maintenance and operations of signal systems within local jurisdictions. Other local and State agencies, such as law enforcement, also may be engaged, because they are often the entities most visible to the traveling public and will have significant responsibility for implementing and enforcing new operations strategies.

► *Where?*

The *where* of TSMO planning for subareas is critical both to identifying key **entities responsible** for planning and implementing TSMO strategies and tactics and to determining **who will benefit** or be otherwise affected by TSMO strategies and tactics considered for the subarea. For example, improving signal synchronization in a CBD will improve mobility for travelers who wish to move through an area quickly; on the other hand, local business along the route may perceive (rightly or wrongly) that they are less accessible due to higher average speeds, pedestrians may feel that they are at greater risk because of traffic flows, and adjacent neighborhoods may perceive (again, rightly or wrongly) that they are given lower priority (seen as longer cycle times for the primary roadway).

Subareas of interest are often within major population centers, and both mobility and accessibility are critical to the well-being of the people, the quality of services (e.g., schools and hospitals), and the success of businesses within the subarea. Mobility and accessibility involve moving goods and people into, within, and through the subarea and the adjacent, broader region. The examples provided in the next section illustrate the variety of geographic boundaries that may fall within a subarea, depending on the issues that drive decisions regarding investments in TSMO strategies.

► *When?*

The *when* of TSMO subarea planning considers both the point at which TSMO planning takes place and the timeframe for TSMO strategies and tactics. TSMO subarea planning is most effective when integrated into the planning process for a new facility, when an existing facility is expanded or undergoing major renovation, or when other major investments are being made within the subarea (e.g., major utility improvements that require affect mobility during installation, major commercial developments that will affect future traffic demand and flows). At that time, plans for TSMO projects that require the installation of technology (e.g., cameras, fiber optics, transit priority options, and dynamic message signs) or roadway features (e.g., turn lanes and dedicated lanes) can be included in the design most effectively. However, in many cases, TSMO strategies are considered only when issues arise that require attention to transportation operations or highlight the need for new services (e.g., transit routes and schedules, parking management).

In addition to when the TSMO subarea plans are developed and implemented, the TSMO planning process considers the timeframe for implementation and operation of the TSMO investments. TSMO investments typically have short returns-on-investment (ROI) relative to other investments in transportation infrastructure and so can be justified based on much shorter life cycles than can major capacity expansion projects. Further, in subareas, transportation system performance may not be the only—or even the most important—aspect of investments in TSMO. For example, a smartphone app that points vehicle operators to available parking may be primarily designed to encourage visits to a commercial district rather than expedite vehicle movements. On the other hand, TSMO investments tend to be technology intensive and, with relatively rapidly changing technology, investments in these strategies should be made with an eye toward next-generation technologies and capabilities. As more advanced technologies emerge in sensors, vehicles, communications, visualization, etc., TSMO subarea planning should consider how current TSMO investments will accommodate future upgrades and new capabilities that may make past

investments less attractive. For example, growth in shared mobility services (e.g., Zipcar™ or Uber™) may lead to integrating accommodations for and real-time information about these shared service into subarea TSMO plans.

EXAMPLES OF CURRENT PRACTICES

Below are brief examples of current practices for TSMO planning at the subarea level. These help to illustrate the wide breadth of activities that are considered to be planning for TSMO within subareas.

- **East Metro Connections Plan (Metro, Portland, Oregon)**²⁷ – This subarea plan was born out of an agreement by the county and four cities that transportation solutions are necessary to advance economic development. A phased 20-year action plan identified specific transportation, community, and economic development projects. Analysis to develop the action plan considered land use, local aspirations, pedestrian, bicycle, management and operations, freight, highway, road, and transit solutions to address subarea needs and issues.
- **Downtown in Motion (City of Salt Lake City, Utah)**²⁸ – The city developed this plan to improve traffic flow efficiency and facilitate multiple modes and transportation uses throughout downtown. TSMO strategies were a key component of the plan. The final plan was informed by a concurrent long-range downtown vision study and extensive stakeholder input, community leaders, and the public.
- **Midtown in Motion (New York City DOT (NYC DOT), New York, New York)**²⁹ – This award winning project improved travel times by 10 percent within a 110-square block zone through the implementation of TSMO strategies (e.g., travel time measurement, advanced traffic signal control, a wireless communications network, and an integrated multi-agency TMC). Planning efforts for this project stemmed from NYC DOT’s 2008 Sustainable Streets Strategic Plan,³⁰ which identified policies and actions for safety, mobility, world-class streets, infrastructure, greening, global leadership, and customer service.

27 Metro, Portland, Oregon, *East Metro Connections Plan*, June 2012. Available at: <http://www.oregonmetro.gov/east-metro-connections-plan>.

28 City of Salt Lake City, *Downtown in Motion: Salt Lake City Downtown Transportation Master Plan*, November 6, 2008. Available at: <http://www.slcgov.com/transportation/transportation-downtown-motion-salt-lake-city-downtown-transportation-master-plan>.

29 New York City Department of Transportation, *NYC DOT Announces Expansion of Midtown Congestion Management System, Receives National Transportation Award*, June 5, 2012. Available at: http://www.nyc.gov/html/dot/html/pr2012/pr12_25.shtml.

30 New York City Department of Transportation, *Sustainable Streets: Strategic Plan for the New York City Department of Transportation 2008 and Beyond*, 2008. Available at: <http://www.nyc.gov/html/dot/html/about/stratplan.shtml>.

- **Strategic Regional Thoroughfare Plan (Atlanta Regional Commission, Georgia)**³¹ – The purpose of the plan was to identify existing regional arterial thoroughfares and then focus on using TSMO and maintenance strategies to maintain or enhance multimodal mobility around the region. The plan conducted evaluations at both the corridor and subarea levels. The subarea evaluation used macro analysis tools, including dynamic traffic assignment (DTA). The corridor evaluation used micro traffic simulation to study the detailed operational characteristics of the corridor.
- **Safe and Sustainable, Multi-modal, Accessible, Reliable and Resilient, and Technology Corridors/Congestion Management Process (PSRC, Washington)**³² – Although termed “corridors,” PSRC has identified 12 subareas that encompass a four-county area to provide a framework to support local and corridor analyses. Three categories of strategies (i.e., TSMO, alternative mode support, and transportation demand management (TDM)) are used in the planning process. Their purpose is to reduce or mitigate congestion within each subarea.
- **South Bay Cities Smart Mobility Framework Pilot (Los Angeles County, California)**³³ – This pilot project evaluated how to apply Caltrans’ Smart Mobility Framework (SMF)³⁴ to a subarea LRTP. This particular pilot used the SMF to identify transportation improvements in combination with land-use strategies to attain sustainable community objectives for the South Bay Cities subarea and identified performance metrics, data needs, and recommended analysis approaches. Five scenarios with a variety of land uses and transportation improvements (e.g., traditional and TSMO-focused, including mobility hubs, shared lanes, and neighborhood electric vehicle subsidies) were analyzed (using tools such as the travel demand model and regional household travel survey data) and reported to a dashboard that compares SMF performance metrics. The pilot project includes conclusions and findings (e.g., a recommendation to develop a tool to prioritize projects using quantifiable metrics).

31 Atlanta Regional Commission, Strategic Regional Thoroughfare Plan, January 2012. Available at: <http://www.atlantaregional.com/transportation/roads--highways/strategic-regional-thoroughfare-plan>.

32 Puget Sound Regional Council, Congestion Management Process, 2010. Available at: <http://www.psrc.org/transportation/cmp/>.

33 Caltrans Office of Community Planning, *Implementing the Smart Mobility Framework into a Sub-regional Long Range Transportation Plan*, September 2014. Available at: http://www.dot.ca.gov/hq/tpp/offices/ocp/Appendix_K_PA2_Recommendations_Report_Final.pdf.

34 Caltrans, *Smart Mobility 2010: A Call to Action for the New Decade*, February 2010. Available at: <http://www.dot.ca.gov/hq/tpp/offices/ocp/smf.html>.

CHAPTER 3. APPROACH TO SUBAREA PLANNING FOR TRANSPORTATION SYSTEMS MANAGEMENT AND OPERATIONS

This chapter provides information on fundamental activities that should typically occur when planning for transportation systems management and operations (TSMO) at a local or subarea scale. Recognizing that subarea planning typically focuses on issues such as land use and zoning, development densities and urban design, the environment and recreational facilities, and transportation together, rather than on TSMO specifically, this chapter puts TSMO planning into the context of a more comprehensive planning study process. Figure 3 provides an overview of a comprehensive approach to planning for TSMO within subareas and is used throughout the next two chapters to highlight the major activities. This approach to TSMO planning in subareas builds upon the framework of an objectives-driven, performance-based approach to planning for operations that has been developed for advancing TSMO at the metropolitan or regional scale.

Key steps in this approach include:

- Getting started – scoping the effort and building a team.
- Gathering information on current and future context and conditions.
- Developing an outcome-oriented operational concept, including operations objectives.
- Identifying operations performance needs, gaps, and opportunities.
- Developing an integrated TSMO approach:
 - Identifying TSMO strategies based on operations objectives and performance needs.
 - Evaluating TSMO strategies.
 - Selecting TSMO strategies.

GETTING STARTED – SCOPING THE EFFORT AND BUILDING A TEAM

Successfully advancing TSMO in a local or subarea plan requires a foundation of effectively scoping the effort and building a team of partners and stakeholders to bring into the planning process (Figure 4).

Subarea planning typically includes significant public engagement (involvement of community groups and residents), given the local scale of planning. Because these plans typically include a significant focus on land use and development, they often engage discussions about density and design of development; street network and street scape improvements; and issues related to affordable housing, schools, and recreational facilities. While transportation is an important

component, subarea plans traditionally have not engaged discussions about transit management, parking management, traffic incident management (TIM), and other operational considerations. Therefore, key questions to consider in scoping the effort include:

- What do we want to accomplish/address from a transportation system operations perspective?
- What are the pressing issues in terms of mobility, reliability, and transportation safety in the area of study?
- What agencies, organizations, and stakeholders are involved in aspects of TSMO? Who beyond the traditional participants should be involved in this planning process, why, and how?

Tools that can be leveraged to scope the effort and build a team include:³⁵

- **Statewide or regional intelligent transportation system (ITS) architecture** – Most States and large metropolitan areas already have an ITS architecture in place. This framework for planning, defining, and integrating ITS can provide insights into the management and operations services, stakeholders, and performance measure data that may play a role in a subarea plan.
- **Regional concept for transportation operations (RCTO)** – An RCTO is an objectives driven, performance-based approach to planning for one or more specific operations areas (e.g., traveler information or traffic incident management (TIM)). The RCTO, which typically includes roles, responsibilities, and resources needed to achieve specific operations objectives, can be used as a tool to develop and implement TSMO strategies at the subarea level.



TSMO=Transportation Systems Management and Operations

TSMO=transportation systems management and operations.

Figure 3. Diagram. Approach to planning for transportation systems management and operations within subareas.

35 For more information, see: Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: An Objectives-Driven, Performance-Based Approach – A Guidebook*. Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10026/>.

- **Statewide or regional corridor planning guide**
 - Some State departments of transportation (DOTs) and metropolitan planning organizations (MPOs) have developed TSMO strategic plans or program plans to guide their efforts. For instance, Metro, the MPO for the Portland, Oregon, region, developed a Regional TSMO Plan.³⁶ This plan identified four investment focus areas (multi-modal traffic management, traveler information, TIM, and transportation demand management (TDM)) and identified investment priorities, which could be used to support local area planning efforts. A number of State DOTs also have developed TSMO programs and associated plans to help provide direction on priorities. For instance, Florida DOT developed a TSMO Strategic Plan and a TSMO Business Plan and has been working across its Districts to prioritize TSMO strategies.³⁷ A regional or statewide TSMO plan can provide direction on objectives and strategies to consider at a subarea level.

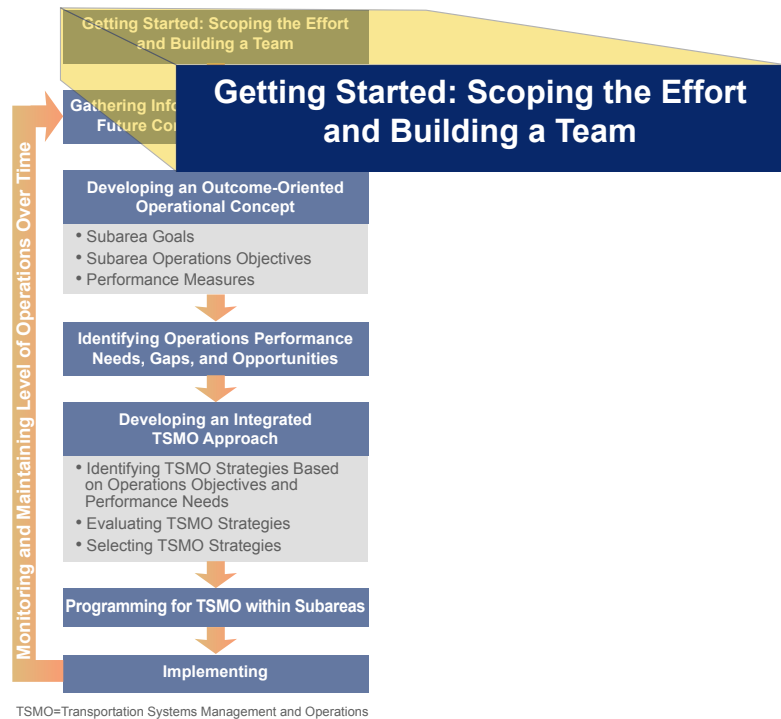


Figure 4. Diagram. The “Getting Started” activity of the approach for planning for transportation systems management and operations within subareas.

The team that focuses on TSMO within a subarea planning study should interact with and be integrated into the broader study team for the subarea to ensure that TSMO strategies and operational issues are explored in the context of a full array of planning goals and issues. For instance, goals and priorities driving a subarea study may include topics such as increasing accessibility for pedestrians and bicyclists, increasing transit ridership, and supporting economic vitality. TSMO strategies should be considered together with investments in infrastructure and programs that support these goals, such as investments in bicycle lanes and improved pedestrian crossings.

³⁶ For more information, see: *Metro, Regional Transportation System Management and Operations: 2010-2020*. Available at: http://www.oregonmetro.gov/sites/default/files/062010_regional_transportation_system_management_operations_plan_executive_summary.pdf.

³⁷ For more information, see: Florida Department of Transportation, *Transportation System Management & Operations*. Available at: <http://www.dot.state.fl.us/trafficoperations/TSMO/TSMO-home.shtm>.

Chapter 1 includes a preliminary list of transportation-related stakeholders that should be considered to support TSMO in a subarea study. Effectively engaging the team involves developing a shared understanding of roles, responsibilities, and the needs of key constituencies (e.g., partnering agencies, authorities, network owners and operators, stakeholders, and the users of the subarea transportation system). The team will then work together to define needs in the study area, agree upon goals and objectives, develop preliminary consensus on pragmatic concepts for strategies or combinations of strategies that realistically address specified goals and objectives, and develop viable operating scenarios under which the concepts and strategies can be analyzed.

Although there is no universal approach to team building, the following approaches have worked for some regions:³⁸

- **Build on an existing collaborative group** – Draw from an existing operations group or a committee that has already been used to develop a regional ITS architecture or RCTO as a starting point for identifying stakeholders. An existing operations group may be able to incorporate the subarea project into its meeting agendas.
- **Ensure at least one committed champion for TSMO** – Ideally, the champion has a clear vision of desired outcomes, brings the stakeholders together, ensures they are engaged, and works to get the support needed to achieve the desired outcomes.
- **Gather support from elected or appointed officials and agency leadership** – Identifying an advocate for TSMO who is an elected or appointed official or is at the executive leadership level within a transportation agency can help enhance the success of bringing in TSMO strategies.
- **Engage participants** – It is important to identify and engage the array of operating agencies and stakeholders that will play a role in, and ultimately be critical to, operations within the study area. Typically, this will include local transportation agencies, a State DOT, transit agencies, and representatives of local governments and community groups. Law enforcement, emergency responders, and major employers also may be important participants. If some participants, such as emergency management agencies, are unable to attend project committee meetings, better success may be realized by taking the project to other established forums held by those stakeholders.³⁹
- **Form a tiered collaborative structure with a strong mandate** – The use of a steering committee with agency leaders can provide project guidance and make high-level decisions, while a working group comprised of technical staff can help shape the technical approaches needed to deliver on the leaders' vision.

►► *Benefits of Collaboration*

Enhancing collaboration and coordination among agencies involved in TSMO within a subarea is vital to developing solutions for optimizing performance across the transportation network; this is particularly true in complex urban areas with many different operators and choices of modes and

³⁸ For more information, see: Federal Highway Administration, *The Regional Concept for Transportation Operations: A Practitioner's Guide*. Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop11032/>.

³⁹ For suggested stakeholders based on operational objectives, see: Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: An Objectives-Driven, Performance-Based Approach – A Guidebook*, FHWA-HOP-10-026 (Washington, DC: 2010). Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10026/>.

routes. Collaboration produces tangible benefits both to participating agencies and jurisdictions as well as to system users and other stakeholders who depend on effective multi modal transportation system operations in moving people and goods. These benefits fall into three general groups:

- Access to and use of existing resources.
- Improvements in current operations.
- Better outcomes for system users and other stakeholders.⁴⁰

► *Expanded Access to Resources and More Efficient Use of Existing Resources*

The visible and immediate benefits of collaboration among operating agencies and stakeholders in a subarea may be realized through strategies such as:

- Pooling funds to avoid duplicate investments or purchases.
- Participating in joint training activities.
- Taking advantage of special expertise or experience that may reside in some, but not all, agencies.
- Adopting common standards for technology that can simplify interagency and multijurisdictional interactions and mutual support.
- Acquiring and maintaining more current and more effective hardware and software systems.

Each of these approaches, or several in combination, can improve the use of available resources.

► *Improved Agency Operations*

Beyond more efficient access to and use of resources, collaboration enables cooperating entities to perform their missions more effectively. These improvements can result in:

- Sharing information among system operators and owners so that they have greater awareness of current and anticipated events affecting other agencies (i.e., traffic management specialists know when there is a transit disruption, and vice versa).
- Developing standard protocols and procedures among agencies that operate within the subarea.
- Improving responsiveness to events and incidents by sharing information, assets, and responsibilities.
- Working cooperatively to leverage all available assets, skills, and personnel to improve efficiency.

Each of these and other strategies can enhance working relationships during routine operations and offer the added benefit of providing the foundation for preparing for and responding to emergency situations, crashes, intentional attacks on transportation assets or other infrastructure, planned special events, or major weather events.

⁴⁰ For more information, see: Federal Highway Administration, *The Collaborative Advantage: Realizing the Tangible Benefits of Regional Transportation Operations Collaboration*, FHWA-HOP-08-001 (Washington, DC: August 2007). Available at: http://www.ops.fhwa.dot.gov/publications/benefits_guide/index.htm.

► *Better Outcomes or Results for Travelers, Suppliers or Shippers, and Other Stakeholders*

Ultimately, system users and communities benefit through effects such as:

- Safer transportation facilities (e.g., transit stations and bicycle/pedestrian paths and lanes).
- Lower fuel consumption through more efficient traffic operations combined with more and better alternatives to private-vehicle use.
- Shorter travel times achieved through congestion mitigation strategies and more effective system management and operation.
- More accurate, timely, and relevant information about past, current, and anticipated travel conditions, modes, schedules, travel times, and travel options so that travelers, shippers, and others can make more informed travel decisions.

Over time, these benefits will prove to be the most important because they are the outcomes that are valued by travelers, shippers, environmental organizations, neighborhood associations, bicycle/pedestrian advocates, residents, and others who have a stake in the subarea.

►► *A Framework for Collaboration and Coordination in a Subarea*

Five key, or foundational, elements characterize the collaboration and coordination necessary for effective TSMO within a subarea. As shown in Figure 5, these five elements are connected, interactive, iterative, and build upon foundational elements that can be applied at multiple scales.⁴¹

The starting point for collaboration and coordination is the structure, or the means through which individuals and agencies come together to identify needs, establish priorities, make commitments, allocate resources, and evaluate performance. In a subarea, which may be a city or county jurisdiction, business district, unincorporated area, or other area, a structure might be formalized in a working group that brings together agencies that play a role in transportation system operations. This group could be convened as part of a local government transportation or planning agency, a transportation management association, or other organization.

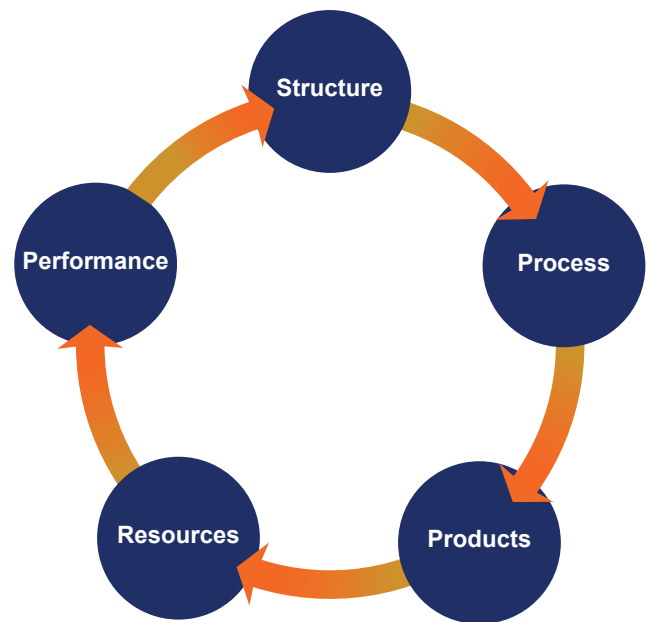


Figure 5. Diagram. The framework for collaboration and coordination in a subarea.

Source: Federal Highway Administration. *Regional Transportation Operations Collaboration and Coordination: A Primer for Working Together to Improve Transportation Safety, Reliability, and Security*.

⁴¹ Federal Highway Administration. *Regional Transportation Operations Collaboration and Coordination: A Primer for Working Together to Improve Transportation Safety, Reliability, and Security*, FHWA-OP-03-008 (Washington, DC: 2003).

The *process* is the course of action taken through which options are created and decisions are made. The process could involve formal activities like a structured set of meetings as part of a subarea planning process or informal activities.

The *products* are the agreements, arrangements, and commitments to move forward with agreed upon strategies. The product may include identified priorities in a subarea plan, a concept of operations, operating plans and procedures, or other documents.

Resources reflect the commitments made in terms of funding, people, equipment, facilities, support, and other assets needed to implement the strategies identified for the subarea.

Finally, *performance* measurement provides the feedback to determine how well the agreed upon strategies have been implemented and executed, and the effect these strategies have had on outcomes of interest relative to the agreed-upon goals and objectives.

►► ***Connections to Broader Planning and Operations Efforts***

Planning efforts to enhance transportation operations within a subarea should build off of broader planning efforts for TSMO as well as existing operations programs and strategies at a local, regional, and State level. Regardless of the size of the area, planning for enhanced transportation system operations in a subarea should recognize and build upon existing programs, including:

- ITS infrastructure (e.g., fiber-optic networks, variable message signs, and traffic cameras).
- State and/or regional traveler information systems, which can be utilized to help provide real-time information on incidents, speeds, and other aspects of operating conditions for highways, arterials, and transit in the subarea.
- Regional incident management and response programs, which can be expanded or targeted to address subarea-specific issues.
- Work zone management strategies used in transportation management plans for significant projects.
- Regional TDM programs, which often include ridematching services, employer outreach, and public outreach and incentives to encourage use of alternatives to driving alone, as well as local TDM programs, which may be administered by a local government or transportation management association.
- Existing parking management programs, including policies associated with municipal parking lots, garages, and meters as well as parking permit programs and real-time parking availability information.
- Transit operations, including scheduling, transfer policies, and real-time transit information.
- Existing traffic signal programs.

National Capital Region Subarea Transportation Demand Management Programs

Transportation demand management (TDM) program services and incentives can be targeted to specific subareas. For instance, in the Washington, DC, metro area, individual counties and the District of Columbia operate TDM programs that are targeted to employers, employees, and residents in their jurisdictions. For instance, the Arlington County Commuter Services operates programs such as Arlington Transportation Partners, which provides TDM outreach to businesses, multi-family residential communities, developers, and hoteliers; BikeArlington and WalkArlington programs, which promote active transportation; and Capital Bikeshare Arlington and other programs to encourage alternatives to driving. Several jurisdictions also have local transportation management associations that provide TDM services to smaller areas, particularly suburban activity centers, such as Tysons Corner in Northern Virginia and Bethesda in suburban Maryland. These programs utilize regional ridematching, a guaranteed ride home program, and regional marketing through the regional Commuter Connections program, operated by the Metropolitan Washington Council of Governments.

For more information, see: <http://www.commuterconnections.org/about-us/>.

In developing goals, operations objectives, and performance measures and identifying and selecting appropriate strategies for application, the approach to planning for TSMO in a subarea should build upon existing planning efforts that relate to system operations, including:

- **Priorities identified in State and regional transportation plans** – Statewide and metropolitan transportation plans identify policies and priorities that can be used to inform identification of potential TSMO strategies for a subarea. For instance, some plans emphasize demand management or include a policy to prioritize strategies that increase transit, ridesharing, and non-motorized travel over single-occupancy vehicle travel.
- **State or metropolitan area TSMO program plans** – As noted earlier, some State DOTs have developed TSMO program plans that identify key priorities and strategies, and these may help to inform strategies that are applicable within the subarea. For instance, Wisconsin DOT's Traffic Operations Infrastructure Plan provides traffic operations infrastructure deployment recommendations for priority and emerging priority corridors in the State. It and also provides Metro node summaries, which might be consulted in developing a subarea plan.⁴² A number of MPOs also have developed regional TSMO plans. For instance, the Baltimore Metropolitan Council developed a Regional Management and Operations Strategic Deployment Plan, which includes goals, objectives, and strategies as well as screening factors to suggest an implementation order for projects. Similarly, the Southeastern Wisconsin Regional Planning Commission completed a Regional Transportation Operations Plan in 2012, which identifies short-range actions recommended

⁴² Wisconsin Department of Transportation, *WisDOT Traffic Operations Infrastructure Plan*, April 2008. Available at: http://www.topslab.wisc.edu/its/toip/Final%20Reports/WisDOT_TOIP_ExecutiveSummary.pdf.

for implementation over a 5-year period. While these plans are often high-level, where available, they will serve as a very strong basis for more detailed subarea-focused efforts.

- **Regional ITS architectures** – A regional ITS architecture provides a common framework for planning, defining, and integrating ITS across a State or region. A regional ITS architecture can be used by State and local planning agencies and organizations to identify integration opportunities and support incorporation of operational needs in transportation planning. For instance, the North Jersey Transportation Planning Authority, in coordination with New Jersey DOT, is developing an ITS Strategic Deployment Plan and TSMO Strategic Plan known as “The Connected Corridor” to serve as a shared vision by transportation agencies to more effectively plan, program, and operate the region’s transportation system with operational strategies.⁴³ The plan recommends a set of strategies to be applied at the Statewide, corridor, and local levels. For instance, strategies in the plan that could be explored within a subarea study include real-time monitoring of park-and-ride lots (i.e., number of available spaces), implementation of transit signal priority (TSP), updating signal timing parameters on State and local arterials on a more frequent basis, and expanding adaptive signal control operations.
- **Regional TDM plans** – Some metropolitan areas have developed TDM plans, which can provide a basis for developing subarea-specific demand management efforts. For instance, the Atlanta Regional Planning Commission developed a Regional TDM Plan that defines a framework for developing and integrating TDM strategies into planning, project development, and system operations investment decision-making.⁴⁴ The plan identifies key goals and strategies that are intended to be addressed with partners from Georgia DOT, the Georgia Regional Transportation Authority, local governments, and others.

Effectively planning for TSMO in subareas will build upon existing plans and programs and will ensure that subarea plans are compatible with, and take advantage of, these broader efforts. It is important to recognize that transportation activities within a jurisdiction or local area are part of a larger transportation network, and the policies and strategies being identified at the regional and State levels should help to inform the more geographically focused effort. At the same time, the plans, strategies, and operational relationships that will be effective within a subarea will reflect the specific travel needs, place type, constraints, and opportunities of the subarea.

43 New Jersey Transportation Planning Authority, *The Connected Corridor: Final Report: New Jersey’s TSM&O Strategic Plan and ITS Architecture*. Prepared by CH2M in association with Advantage Engineering Associates, December 2014. Available at: <http://www.njtpa.org/planning/regional-studies/intelligent-transportation/theconnectedcorridor.aspx>.

44 Atlanta Regional Commission, *Atlanta Regional Transportation Demand Management Plan*, 2013. Available at: <http://www.atlantaregional.com/transportation/commute-options/regional-tdm-plan>.

GATHERING INFORMATION ON CURRENT AND FUTURE CONTEXT AND CONDITIONS

Gathering information about current transportation system performance and the future context is a key early step in the development of a subarea plan or strategy for TSMO (Figure 6). Data, both qualitative and quantitative, play a vital role in a performance-based approach to planning for TSMO.

Baseline information helps define the existing conditions in the subarea, including identification of challenges and problem areas. Data on expected changes in population, land use, and travel conditions also will help to inform understanding of potential future challenges that should be addressed during subarea planning. Data gathered during this phase also are a starting point for identifying opportunities for potential operations strategies that may be applied within the subarea and are used in analysis tools and evaluation to assess the effectiveness of these strategies. Given the critical role of data in a performance-based approach, gathering quality data and accurate information is imperative.

Often, a technical advisory committee or some other type of stakeholder partner group will play a key role in defining subarea objectives and in providing guidance on data and information gathering. Members with operations data expertise will play an important role in bringing forth operations data to inform the planning process as well as to explain data limitations.

Common sources of information include previous plans and studies; data sets on current and past system performance, including archived operations data; and forecasts of future conditions.

A review of existing studies, reports, and plans provides information about the broader planning context and may include recent multi modal transportation plans, pedestrian and bicycle plans, land-use and development plans, and infrastructure condition reports. These documents offer insight into the long-term, big-picture vision for the study area and transportation policies or practices. Policies or practices with implications for TSMO include the use of complete street design principles or road diets. Complete streets and road diets often involve the reduction or repurposing of traffic lanes and a greater focus on all road users (e.g., transit passengers, bicyclists, pedestrians). Existing studies, reports, and plans also can provide data on anticipated future conditions, such as changes in land use, population, jobs, transit services, and vehicle or passenger trips.

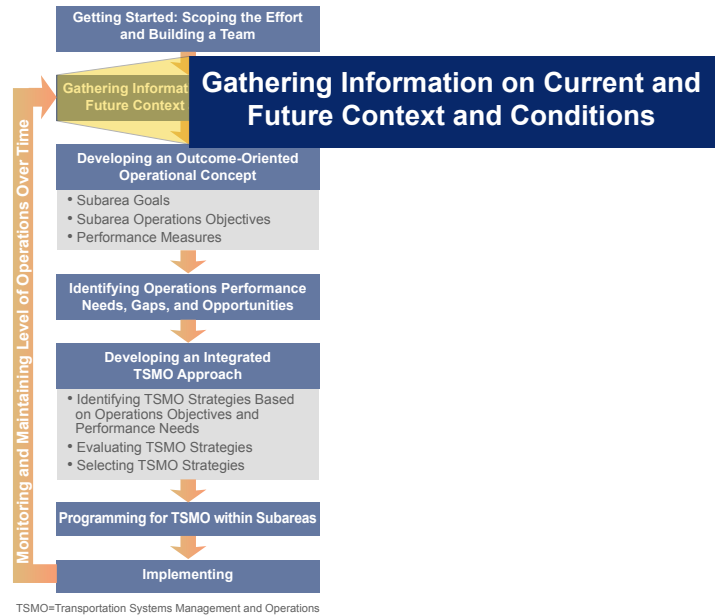


Figure 6. Diagram. The “Gathering Information on Current and Future Context and Conditions” activity of the approach for planning for transportation systems management and operations within subareas.

Neighborhood Traffic Management Program: Centennial, Colorado

Centennial, Colorado, is a city in the Denver metropolitan region with a population of about 107,000. Over the years, the local government saw an increase in requests for neighborhood traffic mitigation, and developed the Neighborhood Traffic Management Program (NTMP) to help communities develop context-sensitive solutions for traffic calming improvements. The program's objectives are to: improve traffic safety on neighborhood streets by reducing speeding and cut-through traffic; foster pedestrian safety; efficiently allocate the use of public resources; and encourage citizen involvement in solutions to neighborhood traffic problems.

NTMP works closely with residents to develop neighborhood traffic mitigation plans. The program has identified a suite of mitigation tools appropriate for the neighborhood context. These tools include physical improvement and TSMO strategies, such as speed monitoring displays and upgrading traffic signage (restricted moving signs, truck restriction, etc.)

Neighborhood involvement is a critical component of the planning process. Projects are first identified when a citizen submits an application for consideration (this person serves as the neighborhood liaison for the project), and residents are engaged throughout the plan development process. The project liaison is responsible for demonstrating neighborhood support for the project through either an online survey, petition, or email/phone responses. Additionally, the NTMP holds a series of meetings with residents and other stakeholders to solicit input about the existing traffic issues and the range of strategies that are appropriate for the neighborhood context; and then later to solicit comments on the draft plan. These other stakeholders include resident organizations or districts, emergency service providers, nearby schools, parks and recreation facilities, nearby businesses, and other individuals or organizations that may be directly affected by the plan.

Source: City of Centennial, *Neighborhood Traffic Management Program Manual*, May 20, 2013. Available at: http://www.centennialco.gov/uploads/files/NTMP%20Manual%20052013_Revised_web.pdf.

Additionally, information should be gathered on existing operational strategies being used in the subarea and the available ITS infrastructure. The organizational capabilities of operating organizations for TSMO is also an important component of understanding the existing context. Information on current TSMO strategies and the capabilities of agencies in the subregion for advancing operations will provide key input when composing an integrated approach for TSMO in the region. In support of gathering information on current organizational capabilities, agencies can use the FHWA capability maturity frameworks (CMFs) to assess their current strengths and weaknesses in one of six TSMO areas:⁴⁵

- Road weather management.
- Planned special events.
- Traffic incident management.

⁴⁵ Federal Highway Administration, "Business Process Frameworks for Transportation Operations" Web page. Available at: <http://www.ops.fhwa.dot.gov/tsmoframeworktool/index.htm>.

- Traffic management.
- Traffic signal management.
- Work zone management.

The CMFs are also designed to lead agencies in developing a targeted action plan for the program area.

► *Current Transportation System Components and Features*

A range of information may be available on the current transportation system components and features within the study area. For instance, the data on the multi-modal transportation network in a subarea may include information on existing and planned infrastructure and services (e.g., highways, arterials and local streets, intersections and crosswalks, transit services, parking facilities, bicycle lanes and paths, and sidewalks). Moreover, beyond infrastructure and services, baseline information should document existing operational assets, partnerships, relationships, and programs that affect system operations. Examples include ITS components, ramp metering, traveler information systems, incident management programs, TSP, and TDM programs, among others. Documenting the current and planned application of these system components or strategies will be important as a baseline for understanding the context in the subarea.

► *Understanding Travelers*

Understanding travel markets is important in defining both needs and possible strategies that will be effective. In a subarea, particularly an urban activity center, there are many different trip types and purposes, which may include commuting by employees coming from within and outside the area, recreational and shopping trips of residents and visitors, and freight deliveries. The mixture of vehicle types (e.g., buses, trucks, and automobiles) on the road and of different modes (e.g., walking, bicycling, transit, and driving) within the area often means that consideration needs to be given to the balance, tradeoffs, and identified priorities across different components of the multi-modal transportation system.

Understanding the unique characteristics of travelers in a subarea (i.e., recognizing how they access information and make travel decisions) will be useful in assessing potential strategies that may be targeted to specific types of travelers. Possible markets may include daily commuters traveling regularly to and from work or school, leisure travelers going to local destinations (running errands, entertainment, etc.), long-distance commuters or tourist travelers passing through, and freight or commerce vehicles transporting goods (see Table 2).

Table 2. Characteristics of travelers in subareas.

	Local Commuter	Leisure Traveler	Long Distance/ Interstate Traveler	Freight/Commerce
Description	Reside locally, travel regularly between work or school.	Reside locally, traveling to local destinations (running errands, entertainment, recreation, etc.).	Non-local travelers traveling to or through the subarea; less familiar with local conditions or alternative routes.	Transportation of goods to local stores and businesses or to regional distribution centers.
Key Concerns	Reliability of route and avoidance of traffic delays; information about transportation options.	Avoiding traffic congestion; parking availability; information about transportation options.	Notification of travel delays due to construction or incidents; access to stopover points (rest stop, gas stations, restaurants, etc.).	Reliability of travel time for on-time delivery; availability of preferred routes (particularly those that can accommodate freight vehicles).
Possible Strategies	Dynamic ridesharing; predictive traveler information; real-time transit and parking information; dynamic shoulder lane use.	Dynamic parking reservation; real-time travel information; off-peak parking discounts.	Real-time travel information; advance information to take alternative route well in advance to avoid congested area.	Variable speed limits; queue warning; adaptive signal control.

►► *Information on Current System Performance*

In addition to information about the physical assets, subarea conditions, and traveler characteristics, data on current system performance are needed. Data on traffic volumes, peak hour volume, commute mode split, transit ridership, on-time transit performance, bicycle counts, and other data on travel patterns convey important information to assess needs. Level-of-service (LOS), which is a function of traffic volumes, traffic composition, roadway geometry, and the traffic control at the intersection, is widely used in traffic studies and reports. However, LOS does not capture the source or extent of congestion, especially non-recurring congestion (due to traffic incidents, work zone, bad weather, special events, etc.). Better data on actual travel

speeds and delay in a subarea can be critical to understanding existing conditions. To incorporate operations strategies into the subarea plan, a more detailed account of the causes and impacts of congestion, as well as performance data across all modes, is helpful.

Archived operations data from ITS programs can be used to assess important operational conditions, including system reliability, on-time transit performance, and the role of specific factors, such as weather conditions, on traffic congestion or traveler delay. Archived travel time data forms the basis for understanding a wide variety of performance metrics (e.g., congestion, reliability, and freight mobility). Chapter 5, Toolbox for Effective TSMO Planning, contains additional information on archived operations data.

Safety data are useful for identifying challenges and problem areas that may be addressed by operations strategies. Types of safety data include incident data such as fatalities, injuries, and property damage; crash data by type including rear-end, left-turn, etc.; weather conditions; light conditions; and the spatial distribution of crashes.

►► *Information about Future Conditions and Contexts*

Information about anticipated conditions and contexts is important as well. This includes forecasted data about socio-economic factors (e.g., population, demographics, etc.) as well as the planned land uses and level of development for the subarea. Because many subarea plans focus on land use, zoning, and urban design, understanding these future plans and contexts is critical to developing compatible and effective operations strategies. For instance, if an urban activity center or transit station area plan is designed to foster increased transit-oriented development and multimodal choices—through land-use and infrastructure strategies including higher density, mixed-use development; implementation of a street grid system where one currently does not exist; and improved bicycle and pedestrian crossings—this future context needs to be the basis for planning effective TSMO strategies. In this case, TSMO strategies should support the future vision of the subarea by incorporating operational strategies that support safe bicycle and pedestrian movement, increase transit reliability, and encourage use of non-automobile modes rather than strategies simply to improve traffic flow. Travel demand modeling, including simulation modeling, will provide important information on anticipated traffic problems or potential multimodal

Questions to Gather Stakeholder Input

Below are sample questions to facilitate a dialogue with stakeholders and the public to capture input about incorporating operations in subarea planning:

- *How do you travel in the subarea? Where do you go? What problems do you encounter?*
- *What is important to you, to your neighborhood, to the local area, and to the region (e.g., transportation, community, environment) in the subarea?*
- *Do you have any comment on the problems and opportunities that have already been identified for the subarea?*
- *How would improving the subarea through working with a private developer and considering options, such as parking pricing impact your support of the solutions?*

Source: Linking Planning and Operations Application, PlanWorks, Federal Highway Administration. Available at: <https://fhwaapps.fhwa.dot.gov/planworks/>.

conflicts. Off-model tools and analysis (e.g., analyses of mode shifts at employment sites due to TDM programs) also will help in assessing anticipated future system performance and the role of TSMO strategies.

►► *Stakeholder and Public Engagement*

In addition to previous studies and information on current and future conditions, input from stakeholders and the public is critical—specifically, their opinions about and preferences for the future of the subarea. The public and stakeholders should play a key role in defining a vision, goals, and objectives for the subarea as well as the performance measures that will be used to assess system performance. In urban areas, there often are tradeoffs to be made in terms of performance of the system in relation to passenger vehicles, public transit, bicycling, and walking, and the public and stakeholders should play a key role in defining and prioritizing objectives. The public, for instance, may be willing to accept lower average motor vehicle speeds to improve the safety and accessibility of pedestrian and bicycle activity. While optimizing system performance along urban and suburban highway subareas might involve diverting heavily congested freeway traffic to parallel arterials, there may be community concerns about the impacts on accessibility in neighborhoods, which need to be considered. Consequently, it is important to engage the public and stakeholders in clearly defining goals and operations objectives and in articulating priorities and values.

Methods for gathering information from stakeholders and the public include conducting qualitative research (e.g., interviews, focus groups, and workshops) or quantitative research (e.g., polls, surveys, etc.), as well as hosting citizens' panels and town hall meetings. Planning tools like scenario modeling and visualization techniques can be used in subarea studies. These public participation tools help communities and stakeholders better understand the interactions among different planning issues in an area (e.g., transportation, housing, energy use, and the environment) and the range of possible outcomes. A comprehensive approach should be used for stakeholder public engagement to capture input from all affected parties within the subarea, including those traditionally underserved by the existing transportation system (e.g., low-income communities, persons with disabilities, minorities, etc.). Engaging with stakeholders and the public early in the process is important, and it presents an opportunity to raise awareness about operations and the role that operational strategies can play. Educating stakeholders and the public about operational strategies will make them better-informed participants throughout the planning process.

Once the information-gathering process is complete, there is solid understanding of the needs, deficiencies, and opportunities to address in the next step: developing an operational concept.

DEVELOPING AN OUTCOME-ORIENTED OPERATIONAL CONCEPT

Effective TSMO involves not only providing highway and transit infrastructure for movement of people and freight but also identifying and applying efficient ways of operating these systems to support mobility, reliability, and safety. Consequently, while subarea planning may involve consideration of, or focus on, certain types of infrastructure improvements (e.g., streetscaping, bicycle and pedestrian infrastructure, etc.), the planning process should focus on desired outcomes for travelers and communities, including outcomes related to how the transportation performs

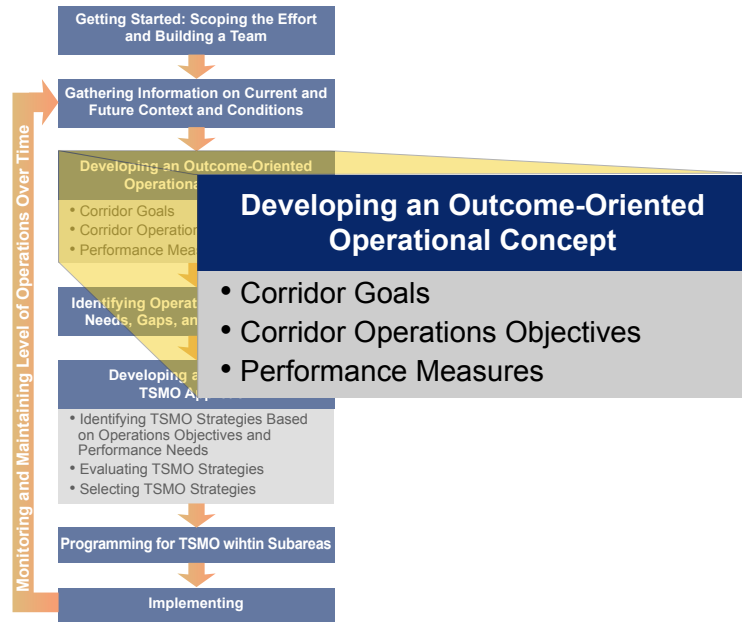
both in typical peak periods and non-peak periods as well as in relation to non recurring issues such as adverse weather and emergencies (Figure 7).

An outcome-oriented operational concept provides the framework for developing and evaluating options that reflect local and regional values, including mobility, air quality, sustainability, livability, safety, security, economic activity, accessibility, and others. The relative priority of these considerations may vary depending on the context and needs of travelers, residential communities, businesses, and other stakeholders in the subarea.

Examples of transportation outcomes commonly used in subarea studies include safety, mobility, and non-motorized accessibility. Other outcomes may include economic vitality, community livability, environmental quality, and other community goals.

Planning for TSMO involves considering a broad range of issues and outcomes associated with how transportation systems are managed and operated. For instance, a subarea plan with a greater focus on TSMO may include specific discussion of *reliability* as an outcome. In addition to general travel time, travelers and freight shippers are often concerned about the variability in travel time from day to day or hour to hour. If it typically takes 20 minutes to travel from one side of town to the other off-peak, and 30 minutes during peak congestion, travelers can plan for the extra travel time. However, if travel times are highly unpredictable—sometimes 30 minutes during rush hour but other times 60 minutes or more—this creates significant problems for making tightly scheduled appointments or delivery times. Studies show that travelers and freight shippers strongly value reliability in travel time; therefore, this is an important issue. High variability in travel times often is caused by traffic incidents, poor weather conditions, special events, and construction work zones, which can be considered in the context of subareas.

Substantial experience in TSMO planning at the regional level shows that rather than just defining goals and strategies, a key foundation for advancing TSMO in planning is to define an outcome-oriented operational concept that brings together goals; specific, measurable operations objectives; and performance measures that are focused on outcomes important to the transportation system users (Figure 8). In a regional context, use of operations objectives and performance measures support consideration of and selection of TSMO strategies for the long-range transportation plan (LRTP) and transportation improvement program (TIP).⁴⁶ Similarly, areawide operations



TSMO=Transportation Systems Management and Operations

Figure 7. Diagram. The “Developing an Outcome-Oriented Operational Concept” activity of the approach for planning for transportation systems management and operations within subareas.

⁴⁶ For more information, see: Federal Highway Administration, *Advancing Metropolitan Planning for Operations: An Objectives-Driven, Performance-Based Approach – A Guidebook*. Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10026/index.htm>.

objectives and performance measures help to focus attention on system performance outcomes within a subarea or its key components (e.g., transit services, intersections, and roadways) and are a key element to support consideration of TSMO strategies. Developing an outcome-oriented operational concept is, by nature, an iterative process that involves developing an understanding of local community and traveler values that affect or influence priorities in the subarea, and translating those priorities into observable and measurable outcomes that guide development of outcome-oriented objectives.

The outcome-oriented operational concept describes, at a high level, how the subarea should operate to realize the desired outcome(s). The operational concept does not specify strategies to be implemented. It will likely draw upon a collection of individual and complementary strategies in response to the operations objectives for the subarea and an assessment of the costs and benefits of each. In some locations, active transportation and demand management (ATDM) concepts (e.g., active traffic management, active demand management, and active parking management)⁴⁷ may prove to be attractive strategies; in others, other strategies that rely less on real-time data may prove effective (e.g., improvements in TIM, seamless integration of public transportation alternatives, and better integration of non-motorized alternatives). These and other concepts can be incorporated into an overall operational concept to be included within a subarea plan.

The operational concept can be formalized within the framework of goals, objectives, and performance measures. The goals and objectives translate the values and priorities into statements that describe what is to be achieved with respect to transportation in the subarea that support higher level regional goals. The goals for the subarea should link to high-level regional goals and then lead to objectives, expressed in measurable terms that can be used to help develop and evaluate strategies for achieving the objectives.

Note that, in developing an outcome-oriented operational concept, specific solutions (strategies and tactics) are not considered, except to the extent that they may inform planners and operators about what is possible within available or anticipated technology solutions, legal and institutional arrangements, and fiscal constraints. Otherwise, the goals and objectives that characterize the operational concept should be open to new ideas about *how* to achieve the objective until after a range of feasible strategies and tactics is identified and evaluated using performance measures that relate directly to the objectives.

►► **Operations Goals**

Operations goals are the high-level statements of what transportation in the subarea would look like if it reflects the needs, values, and priorities of the key stakeholders and transportation providers that use, depend upon, or operate transportation facilities and services.

The City of Salem, Oregon developed a transportation plan, which contains at least one operations goal. The focus of the *Salem Transportation System Plan* is to maximize mobility through investments in the city's multi-modal transportation system. The plan is comprised of individual elements that address various modes of travel or other aspects of the transportation system. One of these sections is the "Transportation System Management Element," which identifies ways to

⁴⁷ See Federal Highway Administration, "Active Transportation Demand Management" Web page. Available at: <http://ops.fhwa.dot.gov/atdm/index.htm>.

maximize the capacity of the street system and reduce demand on it, using TSMO strategies that are typically low cost and have a low impact to surrounding communities. The Transportation System Management Element provides an operations goal, objectives, and policies for utilizing system management techniques. The operations goal is:

“To maximize the efficiency of the existing surface transportation system through management techniques and facility improvements.”⁴⁸

Other examples of high-level goals that could be adapted to more specific aspects of planning for subarea management and operations are provided in FHWA’s *Advancing Metropolitan Planning for Operations: An Objectives-Driven, Performance-Based Approach – A Guidebook*.⁴⁹

►► **Specific Outcome-based Operations Objectives**

The high-level goals are the starting point for developing operations objectives, which are the basis for subarea TSMO planning. Operations objectives define desired outcomes for the subarea in relation to how the transportation system will perform. Operations objectives go beyond broad statements of goals, which often are loosely defined and difficult to assess. Operations objectives are specific, measurable statements developed in collaboration with a broad range of partners who have interests or who are affected by subarea transportation systems performance. They may be multi-jurisdictional in nature if the subarea of interest extends beyond or affects more than a single jurisdiction. Operations objectives generally lead directly to measures of performance that can be used to assess whether or not the objective has subsequently been achieved.

Operations objectives should be specific, measurable, agreed-upon, realistic, and time-bound (SMART):

- **Specific** – The objective provides sufficient specificity to guide formulation of viable approaches to achieving the objective without dictating the approach.
- **Measurable** – The objective facilitates quantitative evaluation, saying how many or how much should be accomplished. Tracking progress against the objective enables an assessment of effectiveness of actions.
- **Agreed** – Planners, operators, and relevant planning participants come to a consensus on a common objective. This is most effective when the planning process involves a wide range of stakeholders to facilitate collaboration and coordination among all parties that use or manage the subarea of interest.
- **Realistic** – The objective can reasonably be accomplished within the limitations of resources and other demands. The objective may require substantial coordination, collaboration, and investment to achieve. Factors, such as land use, also may have an impact on the feasibility of the objective and should be taken into account. Because how realistic the objective is cannot be fully evaluated until after strategies and approaches are defined, the objective may need to be adjusted to be achievable.

48 City of Salem, *Transportation System Plan*, February 2016. Available at: <http://www.cityofsalem.net/Departments/PublicWorks/TransportationServices/TransportationPlan/Pages/default.aspx>.

49 For these examples, see Federal Highway Administration, *Advancing Metropolitan Planning for Operations: An Objectives-Driven, Performance-Based Approach – A Guidebook*, “Chapter 3. 3.0 Developing Operations Goals and Objectives,” Section 3.1 Develop Operations Goals, FHWA-HOP-10-026 (Washington, DC: 2010). Available at: http://www.ops.fhwa.dot.gov/publications/fhwahop10026/chap_3.htm#s31.

- **Time-Bound** – The objective identifies a timeframe within which it will be achieved (e.g., “by 2017”).

Specifically, an operations objective identifies targets regarding a particular aspect of subarea performance, such as traffic congestion, travel time reliability, emergency response time, or incident response. By developing SMART operations objectives, system performance can be examined and monitored over time.

Examples of operations objectives that may be applicable or could be adapted to subarea management and operations are provided in Federal Highway Administration's (FHWA) *Advancing Metropolitan Planning for Operations: An Objectives-Driven, Performance-Based Approach – A Desk Reference* (Figure 8).

By including operations objectives that address system performance issues (e.g., recurring and non-recurring congestion, emergency response times, connectivity among modes, safety, and access to traveler information) rather than focusing primarily on system capacity, the planning effort for a subarea will elevate operations to play a more important role in investment planning, addressing both short-range and long-range needs.

While outcome-oriented objectives are preferred because they are most closely related to the level of service (LOS) provided to systems users, in some cases, outcomes are difficult to measure or observe directly. Outcome-oriented objectives focused on outcomes to the user include travel times, travel time reliability, and access to traveler information. The public cares about these measures, and in many areas, data may be available to develop specific outcome-based operations objectives.

In cases where developing outcome-based objectives is difficult, a planning study may develop operations objectives that are activity-based and support desired system performance outcomes. For example, it may not be possible to develop a specific objective related to incident-based delay experienced by travelers in subarea if data are unavailable for this type of delay. However, it may be possible to develop an objective that relates to incident response times, which may be more easily established and measured.

Other examples of activity-based objectives include the percentage of traffic signals re-timed, the number of variable message signs deployed, and the share of bus stops with real-time transit information. Although these objectives are not as ideal as outcome-based objectives because they tend to focus on specific strategies or approaches, they may serve as interim objectives until more outcome-based objectives can be established and measured. Working together to develop the objectives themselves may help to elevate management and operations discussions among planners and operators and lead to initiatives to collect additional data.

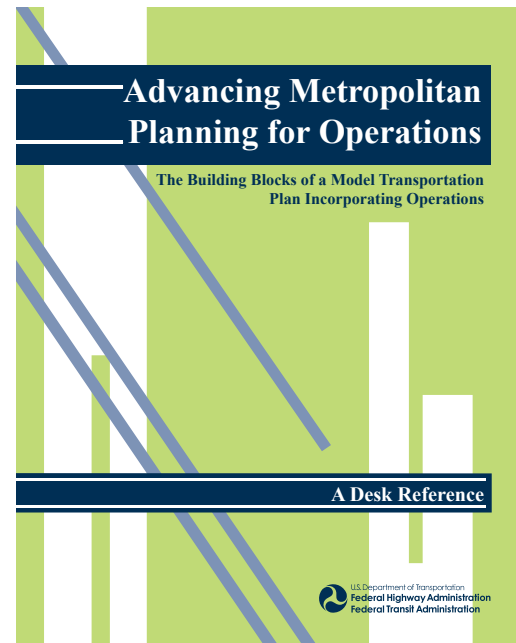


Figure 8. Image. Cover of Federal Highway Administration's Advancing Metropolitan Planning for Operations Desk Reference.

One technique for organizing outcome-oriented and activity-based objectives is to develop an objectives tree that structures objectives in a hierarchical manner, with each top-level objective supported by lower level sub-objectives. The lower level objectives, taken together, identify what must be achieved to realize the high-level objectives; the high-level objectives give the purpose for achieving the lower level objectives. In many cases, the lower level objectives will be activity-based objectives that relate to functions that must be performed to achieve high-level outcome-oriented objectives. Figure 9 illustrates how lower level activity-based objectives support higher level outcome-oriented objectives, all acting in support of goals for the subarea.

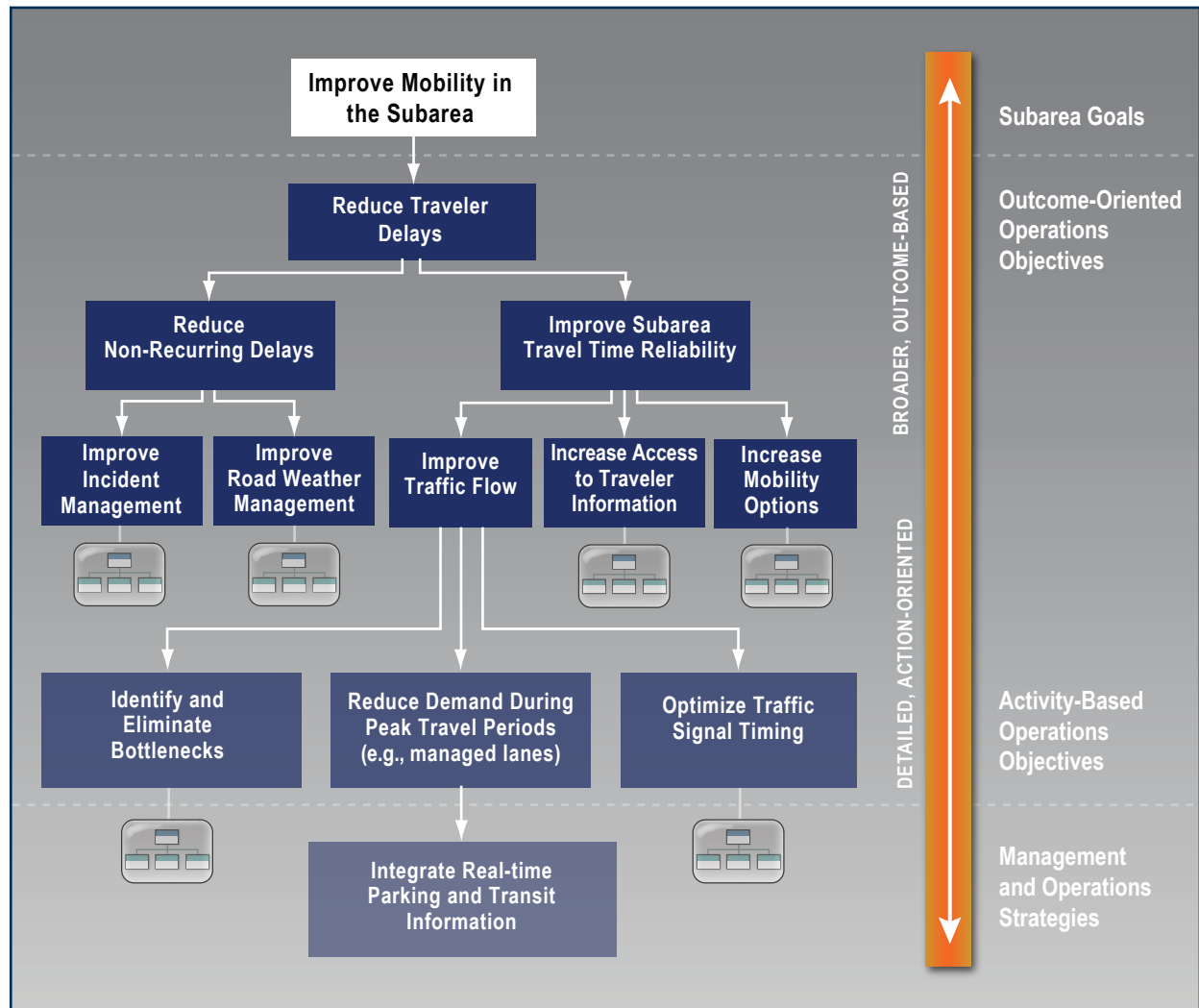


Figure 9. Diagram. Illustrative objectives tree for subarea-based transportation systems management and operations.

►► *Performance Measures*

One of the key attributes of SMART objectives is that they are measurable. Performance measures are associated with operations objectives and provide a measurable basis for:

- Understanding existing performance, including performance gaps.
- Assessing future projected gaps in performance.
- Supporting assessment of, and comparisons of, potential strategies to meet objectives.

The idea that “what gets measured gets managed,” recognizes that performance measurement focuses the attention of decisionmakers, planners, stakeholders, and the public on important characteristics of the transportation system. Developing performance measures involves considering:

- How do we want to define and measure progress toward a certain operations objective? For instance, is transit ridership a key metric that is important for assessing livability and access? Or would bicycle/pedestrian activity be a better measure? Or do both provide value?
- What are the implications of selecting a specific measure? For instance, if travel speeds are a key measure of performance in a subarea, this would imply different strategies and results than focusing on improving reliability of travel times. Using a measure focused on person-travel rather than vehicle-travel might lead toward strategies that give more priority to high-occupancy modes (e.g., like public transit or high-occupancy vehicle (HOV) lanes) than to those driving alone.

It is important to recognize that there are tradeoffs among different goals and objectives (e.g., traffic throughput, increasing transit ridership, and enhancing pedestrian and bicycle access); therefore, defining an appropriate and balanced set of performance measures for a subarea is important.

Performance measures are indicators of how well the transportation system is performing and are inextricably tied to operations objectives. A range of performance measures may come from developing operations objectives. The performance measures selected should provide adequate information to planners, operators, and decision makers on progress toward achieving their operations objectives. However, this is an iterative process as operations objectives may be refined once performance measures are developed and baseline data have been collected.

Performance measures should be developed based on the individual needs and resources of each agency that provides services within the subarea. For example, transit agencies typically use a number of measures that are of interest to their customers, such as on-time performance, average passenger load, and total ridership. Local DOTs typically use measures of mobility such as facility LOS, travel time, and travel delay. These performance measures help planners focus on the day-to-day experience for their users. This provides important balance in settings where planners have focused on long-term development in the subarea. With greater focus on the day-to-day operations, planners appreciate the issues faced by system operators and travelers. The result is that mid- and long-term planning now reflect greater consideration of operations and the associated investment needs within the subarea.

Some examples of performance measures likely to be associated with subarea operations objectives are shown in Table 3. These performance measures are primarily drawn from the FHWA document, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*.⁵⁰

Table 3. Illustrative performance measures to guide subarea transportation systems management and operations planning.

Performance Area	Illustrative Performance Measures
<p>Travel Time: Travel time measures focus on the time needed to travel along a selected portion of the subarea, and can be applied for specific roadways, subareas, transit lines, or at a regional level. At the subarea level, travel time may be a function of mode choice. Also, “travel time” may need to take into account both travel time on major roadways and travel time on local surface streets and in neighborhoods.</p>	<ul style="list-style-type: none"> • Average travel time, which can be measured based on travel time surveys. • Average travel speeds, which can be calculated based on travel time divided by segment length or measured based on real-time information collection. (Note that traffic calming measures may be implemented to avoid excessive travel speeds in some subareas). • Travel time index: the ratio of peak to non-peak travel time, which provides a measure of congestion.
<p>Congestion Extent: Congestion measures can address both the spatial and temporal extent (duration). Depending on how these measures are defined and data are collected, these measures may focus on recurring congestion or address both recurring and non-recurring congestion. In a subarea, congestion may be a sign of economic activity; thus measures of congestion should take this into account (e.g., reduced congestion may signal less economic activity rather than more effective system performance).</p>	<ul style="list-style-type: none"> • Lane miles of congested conditions (defined based on volume to capacity (V/C) ratio, level of service (LOS) measures, or travel time index). • Number of intersections experiencing congestion (based on LOS). • Percent of roadways congested by type or roadway (e.g., freeway, arterial, collector). • Average hours of congestion per day. • Share of peak period transit services experiencing overcrowding.
<p>Delay: Delay measures take into account the amount of time that it takes to travel in excess of travel under unconstrained (ideal or free-flow) operating conditions, and the number of vehicles affected. These measures provide an indication of how problematic traffic congestion is, and can address both recurring and non-recurring congestion-related delay.</p>	<ul style="list-style-type: none"> • Vehicle-hours of recurring delay associated with population and employment growth. • Vehicle-hours of nonrecurring delay associated with incidents, work zones, weather conditions, special events, etc.

50 See: Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, FHWA-HOP-10-027 (Washington, DC: 2010). Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10027/>.

Table 3. Illustrative performance measures to guide subarea transportation systems management and operations planning (continued).

Performance Area	Illustrative Performance Measures
<p>Incident Occurrence/Duration: Incident duration is a measure of the time elapsed from the notification of an incident until the incident has been removed or response vehicles have left the incident scene. This measure can be used to assess the performance of service patrols and incident management systems. Incident occurrence also can be used to assess the performance and reliability of transit services.</p>	<ul style="list-style-type: none"> • Median minutes from time of incident until incident has been removed from scene. • Number of transit bus breakdowns. • Average number of transit rail system delays in excess of X minutes.
<p>Travel Time Reliability: Travel time reliability measures take into account the variation in travel times that occur on roadways and across the system.</p>	<ul style="list-style-type: none"> • Buffer time, which describes the additional time that must be added to a trip to ensure that travelers will arrive at their destination at, or before, the intended time 95 percent of the time. • Buffer time index, which represents the percent of time that should be budgeted on top of average travel time to arrive on time 95 percent of the time (e.g., a buffer index of 40 percent means that for a trip that usually takes 20 minutes, a traveler should budget an additional 8 minutes to ensure on-time arrival most of the time). • Percentage of travel when travel time is X percent (e.g., 20 percent) greater than average travel time. • Planning time index, defined as the 95th percentile travel time index. • 90th or 95th percentile travel times for specific travel routes or trips, which indicates how bad delay will be on the heaviest travel days. • Percentage of weekdays each month that average travel speed of designated facilities fall more than X MPH below posted speed limit during peak periods.
<p>Transportation Demand Management (TDM): Examines travel demand as well as the impact of strategies to manage that demand.</p>	<ul style="list-style-type: none"> • Awareness – Portion of potential program participants aware of a TDM program. • Utilization – Number or percentage of individuals using a TDM service or alternate mode. • Mode split – Proportion of total person trips that uses each mode of transportation. • Vehicle Trips or Peak Period Vehicle Trips – The total number of private vehicles arriving at a destination.

Table 3. Illustrative performance measures to guide subarea transportation systems management and operations planning (continued).

Performance Area	Illustrative Performance Measures
<p>Person Throughput: Examines the number of people that are moved on a roadway or transit system. Efforts to improve this measure are reflected in efforts to improve the flow of traffic, increase high occupancy vehicle movement, or increase transit seat occupancy on transit.</p>	<ul style="list-style-type: none"> • Peak hour persons moved per lane. • Peak hour persons moved on transit services. • Number of bicycle trips completed for other than recreational purposes.
<p>Customer Satisfaction: Examines public perceptions about the quality of the travel experience, including the efficiency of system management and operations.</p>	<ul style="list-style-type: none"> • Percent of the population reporting being satisfied or highly satisfied with mobility and accessibility options and conditions, including non-motorized options • Percent of the population reporting being satisfied or highly satisfied with access to traveler information, including the media through which information is disseminated (e.g., smartphone apps, message boards). • Percent of the population reporting being satisfied or highly satisfied with the reliability of transit services.
<p>Availability of or Awareness of Information: These measures focus on public knowledge of travel alternatives or traveler information.</p>	<ul style="list-style-type: none"> • Percent of surveyed population aware of travel alternatives and related traveler information, including non-traditional modes (e.g., bicycle, car or ride-sharing options).
<p>Availability of and Accommodations for Travel Options: These measure focus on the extent to which travel choices are available and accommodated in the way the transportation system is implemented and operated.</p>	<ul style="list-style-type: none"> • Accessibility of public transportation services within the subarea (e.g., among major centers of commerce or employment within the subarea). • Access to and accommodations for car or ride-sharing services (e.g. Zipcar™ or Uber™) that minimize conflicts with other vehicles.

LOS = level of service.

TDM = transportation demand management.

MPH=miles per hour.

In summary, the performance measures tie directly to the operations objectives, provide the criteria for evaluating strategies and tactics for improving subarea performance, and direct the gathering of data necessary to identify and prioritize needs and gaps. In summary, the performance measures (1) tie directly to the operations objectives, (2) provide the criteria for evaluating strategies and tactics for improving subarea performance, and (3) direct the gathering of data necessary to identify and prioritize needs and gaps.

IDENTIFYING OPERATIONS PERFORMANCE NEEDS, GAPS, AND OPPORTUNITIES

Gathering and analyzing data for performance measures is critical to identifying gaps between desired outcomes (objectives) and current conditions, and in initial identification of potential opportunities for improvements (Figure 10).

Often a key step following the definition of performance measures is to define scenarios, or to conduct a scenario planning exercise as a basis for understanding current performance gaps and potential opportunities. Operational scenarios should be defined by stakeholders in the subarea and may include (but are not limited to):

- **Normal or daily scenario** – to explore recurring – to explore recurring travel patterns for private vehicles, transit, bicycle, pedestrian, goods delivery, service vehicles, school buses, parking, etc., taking into account both mobility-related activities and other community (or subarea) factors that are affected by mobility patterns (e.g., effects on access to businesses, parks, schools, hospitals, neighborhoods).
- **Incident scenario** – to address major or minor incidents within the subarea that will affect multimodal mobility, in order to develop operational plans for how agencies work together and respond to these incidents. Note that these may be transportation-related incidents or other incidents that affect mobility (e.g., building fires, law enforcement actions, hazardous material release).
- **Planned event scenario** – to address a major sporting event, festival, entertainment venue, major convention, or activity that attracts large crowds to a major venue within the subarea and creates an atypical level activity and resulting congestion for pedestrians, vehicles, transit riders, etc.

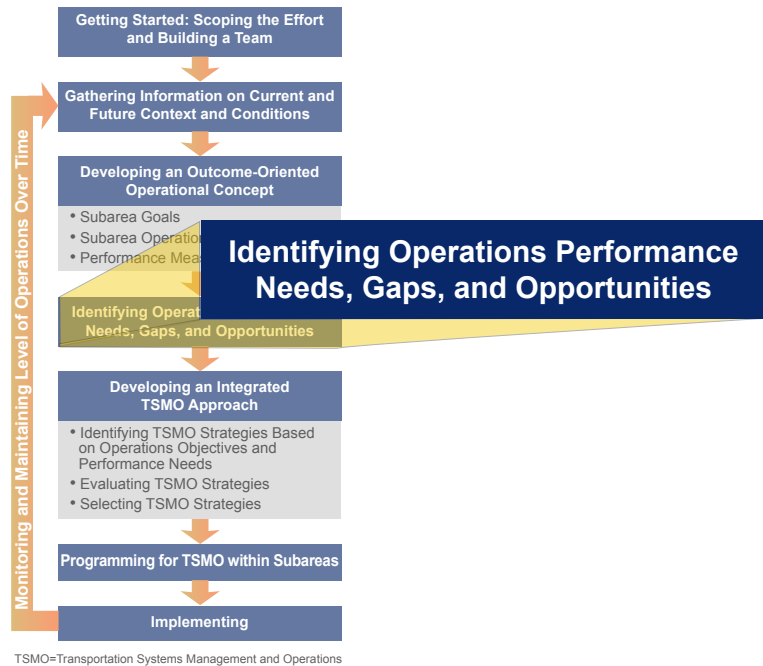


Figure 10. Diagram. The “Identifying Operations Performance Needs, Gaps, and Opportunities” activity of the approach for planning for transportation systems management and operations within subareas.

- **Weather-related, emergency, or evacuation scenario** – to consider unplanned events that may require more dynamic decision making and coordination among stakeholders within the immediate subarea and with agencies and jurisdictions in surrounding areas.
- **Major work zone scenario** – to address major construction or reconstruction projects in roadways, utilities, or building sites that limit or significantly delay transportation services and related operations in the subarea and require coordination with project planning and construction to minimize impacts on travelers, businesses, and the local community.

By defining scenarios, the participants in the subarea often can identify existing gaps, performance needs, as well as potential opportunities for improvements. Moreover, discussions to identify gaps aid planners and operators in clarifying and documenting problems within the subarea and highlight opportunities for improving mobility and related functions in the subarea. In many cases, performance data are available that clearly demonstrate where problems exist and need attention, investment, and priority in the planning process and may be tied to specific types of situations or scenarios where performance improvements would be most important.

Planners and operators must be cautious in depending on performance measures alone to identify gaps and opportunities, especially activity-based performance measures, since the performance measures may be specific to existing systems and may focus attention on improving existing operations strategies rather than considering alternatives that take advantage of new operational concepts, new technology, new institutional arrangements, and new or emerging user expectations. For example, if the performance measures suggest the need to reduce delay on surface streets in the subarea by increasing average speeds, planners and operators may be tempted to focus on strategies such as adaptive signal controls that improve the flow of vehicles by reducing the delays at traffic signals. While this may appear to be attractive, other stakeholders may see this as a deterrent to business located in the area or to access and egress for neighborhoods in the subarea. As a result, other measures should also be considered (e.g., traffic circles or other approaches for managing flow that control speed, provide access, and avoid unnecessary delay). This does not mean that adaptive signal controls are inappropriate, only that performance measures, if they do not take context into account, can result in focusing on the “efficiency” of current approaches rather than in how outcome-oriented objectives are achieved.

In the end, the performance measures point toward deficiencies in achieving goals and objectives for the subarea and can also be helpful in identifying opportunities for improving subarea performance taking into account both mobility and other important considerations.

DEVELOPING AN INTEGRATED TRANSPORTATION SYSTEMS MANAGEMENT AND OPERATIONS APPROACH

Once the TSMO planning team has agreed upon operations objectives for what the subarea should look like with respect to mobility and identified the performance gaps, it can begin to identify a system of TSMO strategies that will be implemented in the subarea to reach to the operations objectives (Figure 11). This system of TSMO strategies forms an integrated TSMO approach to improving performance in the subarea. Taking into account mobility and related functions the selected TSMO strategies should work together in the context of the subarea; strategies should not be selected and implemented in isolation from each other and related

subarea needs. Planning for an integrated set of strategies allows planners and operators to leverage synergies among strategies. For example, the needs of first responders to access traffic incidents or other life-threatening incidents in the area should be considered when setting up work zones, including utility work zones that affect local streets; and, likewise, traffic incident management plans may need to consider pre-designation and communication of alternate routes to manage vehicles in areas of reduced capacity due to work zones.

▶ *Key Considerations in Developing an Integrated Transportation Systems Management and Operations Approach*

▶ *Ensuring a System Solution Rather than “Stand Alone” Activities*

The traditional approach to transportation operations has traditionally involved individual agencies (State DOTs, local transportation agencies, toll authorities, transit service providers, etc.) managing their own assets and services, such as freeways, arterials, toll roads and bridges, and transit services. Yet, increasingly, a more effective and efficient approach is being used that involves a more holistic approach to managing operations by viewing the transportation facilities as a system instead of a group of stand-alone assets. Under this approach, operators work together to make investments and real-time operations decisions to effectively shift travel demand across modes and routes to manage congestion, improve safety, and enhance system reliability (i.e., identifying operations strategies that enhance walkability and bikeability by minimizing multi-modal conflicts in areas with high concentrations of pedestrians or bicyclists).

▶ *Moving Toward Active and Dynamic Transportation Systems Management*

The use of operations strategies supports proactive and dynamic management of the transportation system, in which system performance is continuously assessed and the system is managed through real-time implementation of adjustments (via traveler information, adjustments to signal timing, ramp metering, or other freeway operations) to achieve performance objectives (e.g., travel time reliability, person throughput, incident management, etc.). This approach requires collaboration, engaging partners to help influence travel choice and behavior within the subarea. Travel choice and behavior are influenced through active demand management, active traffic management,

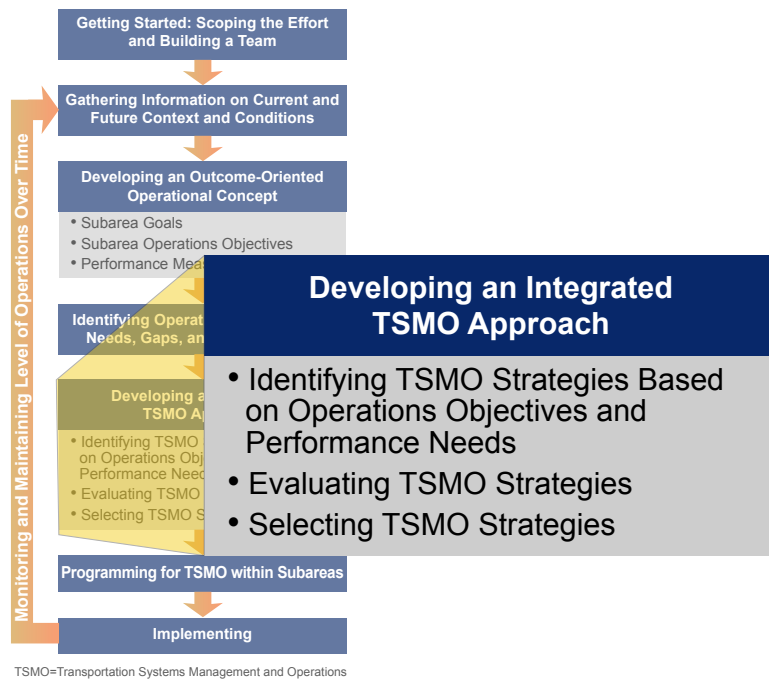


Figure 11. Diagram. The “Developing an Integrated TSMO Approach” activity of the approach for planning for transportation systems management and operations within subareas.

and, in urban areas, through active parking management. Technology and innovation are critical to active and dynamic transportation system management, supporting this data-driven approach implemented through information technology systems.

► ***Focusing on the Traveler, Rather than Just Vehicles***

A customer-focused and place-based perspective serves as the underpinning of an integrated approach to subarea management; rather than looking at enhancing vehicle throughput, this approach begins by examining traveler mobility needs and explores the most effective ways to meet those needs in a manner that is appropriate for the characteristics of the subarea (land use, community aesthetics, etc.). This approach sets the context for developing a more efficient system for the end user that is well-integrated into the subarea. The TSMO approach is based on a fundamental understanding of how travelers decide which mode to use, what time to travel, which route to take, and at what time. Selecting operations strategies also requires segmentation of the travel market that differentiates among the various types of travelers (including commuters, non-commuter travelers, and freight movement), and understanding their travel behaviors, needs, and challenges to accurately inform the selection and implementation of operations strategies.

► ***Considering Community Values and Neighborhoods***

Transportation plays a key role in mobility, but is more than just about moving people and goods. The transportation network contains lifelines for communities, often linking neighborhoods, businesses, and jobs, and can serve as vibrant public spaces. A subarea's transportation system should reflect the character and values of the surrounding community. Integrating operational strategies into subarea planning is not a uniform approach; the set of strategies selected for a subarea should be customized and tailored to respond to the unique issues, challenges, and opportunities present. Therefore, successful TSMO integration into the planning process requires engaging the partners (the various agencies that operate within the subarea), as well as community stakeholders and the general public.

► ***Recognizing Resource Constraints***

Although TSMO strategies are typically low cost, especially in comparison to expansion projects, a successful approach to implementing operational strategies is including them as part of an integrated approach within a broader project or plan. In many cases, lower-cost solutions can be implemented, or TSMO strategies can be implemented over time, in phases, to advance operations improvements in stages over time. When prioritizing TSMO strategies for deployment, benefit-cost analysis, stakeholder and public input, and exploring the logical phasing of strategies are all useful analysis methods.

► ***Developing an Incremental Approach to Transportation Systems Management and Operations***

Transportation agencies engage in TSMO activities at varying degrees of complexity. For some agencies, a basic traffic signal system meets the management needs of its transportation network, while other agencies rely on a set of advanced and integrated TSMO strategies to meet the mobility needs of the community. In either case, planning for TSMO allows agencies to advance operational strategies in a measured, organized fashion, whether in a section of the subarea or throughout it.

A key distinction in implementing TSMO strategies is that installation is just the starting point. Agencies must be prepared to expend the necessary resources to operate and maintain a collection of TSMO investments. The most effective TSMO activities are differentiated not by budgets or technical skills alone, but by the existence of critical processes and institutional arrangements tailored to the unique features of TSMO applications. Applying an incremental approach to TSMO strategies in a subarea is a clearer path to successful implementation by allowing time to gain experience with the strategy and institute operational processes.

One of the current areas of research is in analytical tools that support consideration of multiple TSMO strategies, and it is expected to provide more support in the future to developing an integrated TSMO approach. Currently, there are limited options for quantitatively examining the impacts of one TSMO strategy on another. The sections below describe the main activities necessary for developing an integrated approach to TSMO in a subarea.

► *Identifying Transportation Systems Management and Operations Strategies Based on Operations Objectives and Performance Needs*

TSMO strategies that could be implemented to address causes of the shortfalls in performance or gaps can be identified in several ways. This section provides example approaches for identifying TSMO strategies based on operations objectives and performance needs in a subarea. FHWA has developed some basic mappings between goals or objectives and TSMO-related strategies, but this has occurred primarily at the State and regional levels are where practitioners look to match strategies to needs within a specific context.

FHWA guidance on livability and sustainability recommends a “balanced approach” to identifying TSMO strategies. This is consistent with planning for operations in a subarea, where mobility objectives and other subarea objectives should be considered together. More specifically:

- Maximizing the livability and sustainability benefits of M&O [management and operations] strategies requires a balanced approach to M&O. Not all M&O strategies support livability and sustainability outcomes equally. For example, traffic signals that prioritize vehicle traffic flow but do not consider the mobility and access needs of pedestrians, bicycles, and transit can actually work against livability and sustainability principles. In contrast, signal timing plans and roundabouts that support livability and sustainability objectives will provide improved mobility in a way that balances vehicular and bus traffic, pedestrians, and bicycle access, in order to support community vitality, safety, and the environment.
- A balanced approach to M&O provides a framework that helps practitioners consider tradeoffs, better understand potential impacts on livability and sustainability, and avoid unintended results. Most importantly, this framework encourages practitioners to evaluate transportation system operations from a variety of perspectives and consider how the system can be optimized in multiple ways to achieve different performance measures and goals.⁵¹

51 Federal Highway Administration, *The Role of Transportation Systems Management & Operations in Supporting Livability and Sustainability - A Primer*, January 2012, FHWA-HOP-12-004. Available at <http://www.ops.fhwa.dot.gov/publications/fhwahopl2004/index.htm>.

The identification of TSMO strategies in a subarea results from a consideration of multiple contextual factors such as land use, network patterns, and available transportation modes. Figure 12 provides a sample of contextual factors for subareas and the relevant operating organizations that are important to consider when selecting TSMO strategies.

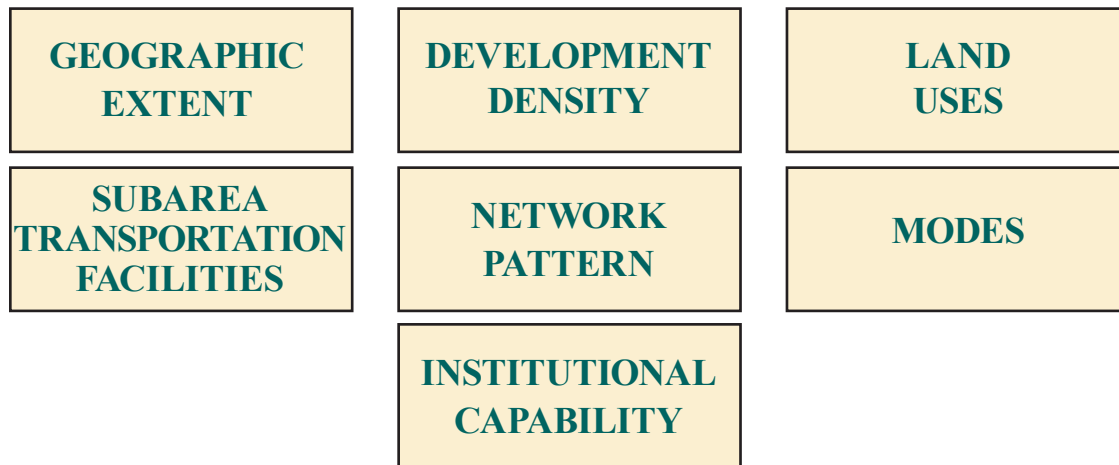


Figure 12. Diagram. Sample of contextual factors to consider when selecting transportation system management and operations strategies for subareas.

As mentioned previously, the City of Salem, Oregon developed the Salem Transportation System Plan, which included specific goals and objectives that helped identify transportation system management and transportation demand management strategies that will achieve those objectives. For example, the transportation system management strategies fall into one of the following categories, which are aligned with the city’s objectives:⁵²

- Traffic management and channelization.
- Intersection modification and widening.
- Access management.
- Improved traffic control devices.
- On-street parking management.

One of Salem’s *goals* is “To maximize the efficiency of the existing surface transportation system through management techniques and, facility improvements.”⁵³ The associated objectives and related operations strategies (or policies) for this goal are:

- Objective Number 1 - A system of traffic control devices maintained and operated at an optimal LOS and efficiency consistent with existing funding levels.
 - Policy 1.1 Improve the Efficiency of the Signal System.
 - Policy 1.2 Maintain Signal System Operations.
 - Policy 1.3 Maintain Clear and Effective Signs and Pavement Markings.

⁵² City of Salem, Oregon, *Salem Transportation System Plan*, Amended February 2016. Available at: <http://www.cityofsalem.net/Departments/PublicWorks/TransportationServices/TransportationPlan/Pages/default.aspx>.

⁵³ Ibid.

- Objective Number 2 - To maximize the effective capacity of the street system through improvements in physical design and management of on-street parking.
 - Policy 2.1 Giving Intersection Improvements Priority.
 - Policy 2.2 On-street Parking Management.
 - Policy 2.3 Bus Bays on Arterial Streets.
- Objective Number 3 - To increase street system safety and capacity through the adoption and implementation of access management standards.
 - Policy 3.1 Development and Adoption of Access Management Standards.
 - Policy 3.2 Incorporate Access Management into Arterial Street Design.
 - Policy 3.3 Access Management Projects.
- Objective Number 4 - To actively manage the operation of the surface transportation system during peak travel periods.
 - Policy 4.1 Real-time System Management.

The objectives and policies are linked to specific transportation system management strategies within each of the categories listed above, including, for example,

- Traffic management and channelization.
 - One-way streets.
 - Reversible traffic lanes.
 - High occupancy lanes on arterials.
 - Bus bays (“pull outs”).
 - Improved signs and markings.
- Intersection widening and modification.
 - Roadway alignment at intersections.
 - Intersection widening.
 - Turn controls.
 - Grade separation at major intersections.
- Access management.
 - Arterial access management.
- Improved traffic control devices.
 - Traffic signal improvements.
 - Improved signs and markings.
 - Arterial surveillance and management.
- On-street parking management.
 - Removal of parking.

Each of the projects and strategies in the plan is linked to a particular location, priority, cost estimate, and lead agency within the Salem city government.

A similar approach was taken for transportation demand management projects and strategies, linking strategies to a goal and related objectives. The overarching *goal* is to "reduce the demands placed on the current and future transportation system by the single-occupant vehicle."⁵⁴ The objectives and related policies (or strategies) related to this goal are:

- Objective Number 1 - The City shall work towards reducing per capita vehicle-miles-traveled in the Salem Urban Area by assisting individuals in choosing alternative travel modes.
 - Policy 1.1 Support the Regional TDM Program.
 - Policy 1.2 Support Adequate and Consistent Funding for the Regional TDM Program.
 - Policy 1.3 Reduce Per Capita Vehicle-miles-traveled.
- Objective Number 2 - Reduce automobile travel demand generated by employment sites, colleges, and schools.
 - Policy 2.1 Target Marketing Efforts.
 - Policy 2.2 Increase Marketing to Employers.
 - Policy 2.3 Assist in the Formation of Vanpools.
 - Policy 2.4 Encourage State Agencies to Reduce Peak Hour Travel Demand.
- Objective Number 3 - Increase public awareness of alternative transportation modes.
 - Policy 3.1 Provide Information Through Public Events.
 - Policy 3.2 Outreach to Schools and Community Groups.
- Objective Number 4 - Coordinate regional TDM efforts.
 - Policy 4.1 Work with Other Agencies and Organizations.
 - Policy 4.2 Monitor TDM Programs Nationwide.
- Objective Number 5 - The City of Salem shall encourage the use of alternative travel modes by serving as an institutional model for other agencies and businesses in the community.
 - Policy 5.1 Employee Incentive Programs.
 - Policy 5.2 Reduce Peak Hour Travel Demand.

The City of Salem's transportation plan provides additional detail for each of these policies, describing exactly how each policy will be implemented, including marketing and outreach efforts, financial incentives and disincentives, and other mechanisms for reducing dependence on single occupancy vehicles and related trips.

Note, in particular, that the TSMO strategies and projects within the subarea are linked to the agreed to goals and objectives developed through a collaborative process with key stakeholders and responsible agencies within the subarea, in this case a city within a larger region.

⁵⁴ City of Salem, Oregon, *Salem Transportation System Plan*, February 2016. Available at: <http://www.cityofsalem.net/Departments/PublicWorks/TransportationServices/TransportationPlan/Pages/default.aspx>.

In a similar manner, Chapters 5 and 7 of the Dakota County, Minnesota transportation plan⁵⁵ are built around two of this subarea’s primary goals. Chapter 5 addresses their Goal 2, which “directs Dakota County in the development and integration of a comprehensive transit system, bicycle and pedestrian network, and other non-automobile modes for people and freight to maximize the efficiency of the transportation system by providing safe, timely, and efficient connections between communities, activity generators, and employment centers.” Chapter 7 addresses Goal 4, which is “Management to Increase Transportation System Efficiency, Improve Safety and Maximize Existing Highway Capacity.” Within each of these chapters, the Dakota County plan presents policies and strategies designed to help them achieve their goals, with many of these drawing on relatively low cost TSMO strategies.

► *Evaluating Transportation Systems Management and Operations Strategies*

While many operations strategies (e.g., variable speed limits, queue warning systems, and dynamic ramp metering) have benefits, because they differ from conventional capacity investments in terms of cost, service life, and requirements, it is not always clear how to assess strategies. After identifying potential TSMO strategies for a subarea, there are several methods that are available to evaluate the strategies to determine which ones are most suitable to the subarea context and work together to provide the most benefit. This often takes place in two phases: screening the strategies for feasibility, and then conducting a more detailed evaluation prior to selecting strategies to move forward with funding and implementation. The evaluation factors may include technical and institutional feasibility, return on investment, or others relevant to the subarea stakeholders.

Numerous methods and tools are currently available to evaluate TSMO strategies as part of subarea planning. They vary in purpose served, complexity, input and output data, and the strategies that they analyze. Four main categories of analysis tools could apply to the evaluation of TSMO strategies: (1) travel demand models; (2) sketch-planning tools; (3) analytical/deterministic tools; and (4) simulation models, as well as many hybrid approaches. Sketch-planning tools allow for the basic screening of strategies, while deterministic tools and simulation typically go beyond the results of travel demand models to enable more detailed analysis of TSMO strategies. When selecting a tool, it is important to not only match the tool’s capabilities to the subarea team’s objectives, but also to consider other factors (e.g., budget, schedule, and resource requirements). The team should avoid trying to apply a tool that is more complex and time-consuming than needed. Conversely, the team should not use a tool that lacks the sensitivity or detail to address its need.

Travel demand models are useful in screening and evaluating subarea-wide strategies, such as congestion pricing and ridesharing programs, because they support an assessing mode choice and travel pattern or volume impacts. Travel demand models supply data to simulation models, sketch-planning tools, and post-processors that can analyze TSMO strategies. They are useful for generating traffic origin-destination patterns or volumes for input into simulation models. They are limited in their ability to analyze TSMO strategies, however, as they miss the impacts of incidents, work zones, and special events.

⁵⁵ See Dakota County, Minnesota, *Dakota County 2030 Transportation Plan*, 2010, at <https://www.co.dakota.mn.us/Transportation/PlanningPrograms/Documents/2030TransportationPlan.pdf>, for the entire Dakota County Transportation Plan, which includes detailed descriptions of their goals and related strategies and policies.

Sketch-planning tools are intended to provide quick analysis using generally available information and data. They provide a quick order-of-magnitude estimate with minimal input data in support of preliminary screening assessments. Sketch-planning tools are appropriate early on when prioritizing large numbers of strategies or investments for more detailed evaluation. They are typically spreadsheets or simple databases that are based on built-in assumptions of impacts and benefits for various strategies.

FHWA developed TOPS-BC, a benefit-cost analysis sketch-planning tool that is available to help subarea teams screen multiple TSMO strategies. It provides order-of-magnitude benefit cost estimates using default parameters that can be customized using local data. TOPS BC is available for download from the FHWA Planning for Operations Website.⁵⁶ FHWA is continuing to develop products to assist practitioners in applying benefit-cost analysis for TSMO strategies.

Analytical or deterministic tools typically implement the procedures of the *Highway Capacity Manual*.⁵⁷ These tools quickly predict capacity, density, speed, delay, and queuing on a variety of transportation facilities and are validated with field data, laboratory test beds, or small-scale experiments. The primary example of a tool within this category is the Highway Capacity Software, which implements the procedures defined in the Highway Capacity Manual for analyzing capacity and determining LOS for signalized and unsignalized intersections, urban streets, freeways, weaving areas, ramp junctions, multi-lane highways, two-lane highways, and transit. These tools are applicable for evaluating TSMO strategies for a subarea since they are mainly for individual intersections or small-scale facilities and are widely accepted for examining different types of traffic control strategies (e.g., uncontrolled, stop controlled, and signalized).

Simulation tools cover a range of software that is available to model transportation system operations and can be applied specifically to subareas. Simulation models are typically classified according to the level of detail at which they represent the traffic stream. Macroscopic simulation models simulate traffic flow, taking into consideration aggregate traffic stream characteristics (i.e., speed, flow, and density) and their relationships. Microscopic simulation models simulate the characteristics and interactions of individual vehicles. Mesoscopic simulation models simulate individual vehicles, but describe their activities and interactions based on aggregate (macroscopic) relationships.

Agencies use simulation tools to analyze operations of both traffic and transit to conduct needs assessments, alternatives analysis, and environmental impact studies. A key advantage of these tools is their ability to simulate conditions, such as incidents, and analyze conditions under multiple scenarios. Some specific strategies that can be simulated include ramp metering, express lanes, and variable speeds limits. Most simulation models also produce graphical or animated displays of the results. These can be invaluable in presenting key findings and results to a broad range of audiences beyond transportation professionals. The primary challenges associated with simulation tools are related to the resources required to develop and apply such models. These include the level of expertise needed, data and computing requirements, and the amount of time required to adequately and accurately calibrate models to real-world conditions.

⁵⁶ Tool for Operations Benefit Cost Analysis can be downloaded from: <http://www.ops.fhwa.dot.gov/plan4ops/topsbctool/index.htm>.

⁵⁷ Transportation Research Board, *Highway Capacity Manual* 2010 (Washington, DC: 2010). Available from: <http://www.trb.org/Main/Blurbs/164718.aspx>.

Activity-based models are increasingly being used as a region's travel demand model and may be useful in evaluating TSMO strategies within subareas. They typically function at the level of individual traveler and represent how the person travels across the entire day. They provide detailed performance metrics but take much longer to run and have greater development and maintenance costs. They can evaluate pricing strategies, travel demand management programs, and many other TSMO strategies.

Dynamic traffic assignment (DTA) also is emerging as a practical tool for numerous planning and operations applications. DTA is a type of modeling tool that combines network assignment models, which are used primarily in conjunction with travel demand forecasting procedures for planning applications, with traffic simulation models, which are used primarily for traffic operational studies. DTA involves the capability to assign or re-assign vehicle trip paths based on prevailing conditions. For example, a vehicle may be re-assigned to a different path in the middle of its trip due to the congestion on its original path. DTA enables evaluating operational strategies that are likely to induce a temporal or spatial pattern shift of traffic. It enables estimating travel behavior from various demand and supply changes and interactions. It is suitable for analyses involving incidents, construction zones, ATDM strategies, ICM strategies, ITS, managed lanes, congestion pricing, and other TSMO strategies. However, the application of DTA does generally require a significant investment of resources and expertise in both demand and simulation modeling.

►► *Selecting Strategies to Best Achieve Objectives*

Building on the assessment of potential strategies using analysis tools, the subarea plan will involve selecting a set of promising strategies to achieve the operations objectives for the subarea. Given the wide array of potential strategies to consider, including those that focus on highway/traffic operations, transit operations, demand management, and capacity, selecting strategies for a subarea often will involve both quantitative analysis, as well as qualitative assessments of what would work best to fit within the specific context of the subarea.

It is important to recognize that effective subarea management will typically involve implementation of a number of complementary strategies rather than a single strategy, or even a set of strategies applied to different modes. One of the key values of exploring subarea operations is recognizing the interconnections among different roadway facilities, transit, and other modal options. Consequently, a number of individual strategies may be grouped together and considered as a package of improvements. For instance, improving arterial operations may involve a combination of traffic signal coordination, TSP, and parking management strategies. Typically, planners and operators will work together to identify and evaluate potential strategies, and then define a package or several possible packages of improvements. The alternative subarea strategies can then be evaluated as to their performance relative to defined operations objectives, within the context of community values, and with recognition of available resources for implementation. Some strategies also may not require investments in infrastructure or technology deployment in the field, but could be fostered through improved data sharing and communications practices.

Prioritizing strategies or packages of strategies for selection often involves making tradeoffs in deciding what approach would be most effective to meet subarea objectives. For instance, use of a highway shoulder as a lane for buses could help improve transit reliability, but it should be considered in the context of road safety and the potential benefit for travelers in relation to the costs of upgrading the shoulder and lane markings, in comparison to other potential strategies. Similarly, on an urban arterial, traffic signal improvements, including retiming or TSP, need to consider an array of issues and potential impacts, including effects on road traffic, transit, and bicycles and pedestrians in terms of travel time and safety.

To the extent possible, using common evaluation methods for comparative assessments of strategy alternatives is valuable. For instance, if travel time reliability (i.e., consistent or predictable travel times and on-time transit performance) is a key objective for the subarea, then integrating reliability performance measures into the selection of strategies can help ensure that strategies are prioritized that best support the TSMO objectives for the subarea. TSMO strategies that improve reliability include a wide range of strategies: information systems, incident management, managed lanes, TSP, and transit and freight vehicle tracking. As a result, using reliability performance measures does not define a singular strategy but is helpful in comparing the estimating impacts of different strategies.

In addition to using the outputs of tools described above, approaches that can be used to compare strategies or packages of strategies include:

- **Analyzing cost-effectiveness:** Using a cost-effectiveness approach involves calculating the overall cost effectiveness (cost per unit of benefit) for each strategy based on defined benefits. Tools available to calculate reliability benefits include sketch planning, model post-processing, simulation, and multi-resolution/multi-scenario modeling. Once the cost effectiveness of each strategy is determined, strategies can be ranked in order from highest to lowest.
- **Benefit-cost analysis:** Benefit-cost analysis can be a useful tool for comparing different options, if sufficient data are available on key metrics, such as travel times and safety, to monetize these effects in relation to costs. Valuing travel time and delay is typically accomplished using surveys of travelers to determine their perceived benefit of travel time.⁵⁸
- **Multi-criteria scoring:** Another approach is to use performance measures along with scoring criteria to assess how different alternatives support subarea performance objectives. For instance, if several key objectives have been defined for a subarea related to system operations (e.g., safety, transit on-time performance, highway reliability, etc.), then strategies are given scores in relation to each objective to prioritize the most promising strategies.

Commonly, the process of analyzing and selecting potential strategies or combinations of strategies will yield some approaches that are most promising.

58 Transportation Research Board, Strategic Highway Research Program, *Guide to Incorporating Reliability Measures into the Transportation Planning and Programming Processes* (Washington, DC: 2014). Available at: http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_S2-L05-RR-2.pdf.

PUTTING IT ALL TOGETHER

As described above, operations objectives are essential elements of TSMO planning. The following section provides a set of easy-to-use reference sheets for operations objectives that are relevant to subareas. Each reference sheet provides an overview of the operations objective area, a menu of operations objective statements and associated performance measures, a description of data needs and potential providers, and possible TSMO strategies to achieve the operations objectives. They are intended as a resource for subarea planners and operators who are searching for ideas for potential operations objectives and performance measures. The sheets help to lead planners and operators through the some of the major considerations of planning for TSMO in subareas: gathering stakeholders, developing operations goals, developing operations objectives and performance measures, collecting data to support the measures, and identifying associated TSMO strategies. The quick reference sheets draw from FHWA's *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations – A Desk Reference*, and were adapted for application to subarea planning.⁵⁹

⁵⁹ Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, FHWA-HOP-10-027 (Washington, DC: 2010). Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10027/>.

System Efficiency: Subarea Travel Time

These objectives are focused on reducing the amount of time it takes to travel within a subarea. Travel time is a measure of the average time spent in travel, which is a function of both travel speed and distance. The objectives can be made multimodal to account for transit, truck and bicycle travel in the subarea, where appropriate.⁶⁰

Stakeholders	<ul style="list-style-type: none"> • State, county, or city agencies responsible for roadways. • Toll authorities. • MPOs, if there are any regional rideshare or travel demand programs. • Transportation network companies. • Traffic management center(s). • Parking authorities. 	<ul style="list-style-type: none"> • Transit agencies. • Local businesses, freight distribution centers, event centers, and neighborhood associations. • Ports, if applicable. • Business improvement districts, if applicable. • Media.
Goals	<ul style="list-style-type: none"> • Reduce subarea travel time experienced by travelers. 	
Subarea Operations Objectives	<ul style="list-style-type: none"> • Improve average travel time during peak periods by X percent by year Y. • Improve average commute trip travel time by X percent by year Y. • Annual rate of change in subarea average commute travel time will not exceed subarea rate of population growth through year Y. 	
Performance Measures	<ul style="list-style-type: none"> • Average travel time during peak periods (minutes). • Average commute trip travel time (minutes). 	
Anticipated Data Needs	<ul style="list-style-type: none"> • Peak period and free flow travel time and speeds. • Person travel along subarea routes (e.g., vehicle volume multiplied by vehicle occupancy). • Trip length. • Annual subarea population. 	
Data Resources and Partners	<p>State DOTs, counties, cities, traffic management centers, and private sector sources can provide travel time data including speeds and volumes. Transit agencies can provide transit travel time, speed data, and passenger counts. The U.S. Census Bureau can provide population data.</p>	
TSMO Strategies to Consider	<p>Strategies designed to reduce recurring peak period congestion, such as traffic signal coordination, and transportation demand strategies that encourage shifts in travel mode, time or route. If the objective includes transit or bicycles, strategies can include transit signal priority or bicycle traffic signals.</p>	

⁶⁰ U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, 2010, FHWA-HOP-10-027. Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10027/>.

System Reliability: Non-Recurring Delay in Subareas

This set of objectives is focused on minimizing non-recurring delay within subareas. This type of travel-time delay is caused by transient events as opposed to delay caused by geometric limitations or a lack of capacity. These objectives focus on non-recurring delay due to scheduled disruptions and unscheduled disruptions to travel.⁶¹

Stakeholders	<ul style="list-style-type: none"> • State, county, or city agency responsible for roadways, including maintenance crews. • Toll authorities. • MPOs, if there are any regional rideshare or travel demand programs. • Traffic management center(s). • Transit agencies. • Incident responders. • Contractors. • Utility agencies/companies. • Weather forecast services. • 911 center(s). • Law enforcement. • Fire and rescue agencies. • Emergency medical agencies. • Tow industry. • Hazardous materials industry. • Local businesses, freight distribution centers, event centers, and neighborhood associations. • Ports, if applicable. • Media.
Goals	<ul style="list-style-type: none"> • Minimize non-recurring delay (scheduled and non-scheduled disruptions) within subareas.
Subarea Operations Objectives	<ul style="list-style-type: none"> • Reduce total person hours of delay in subarea by time period (peak, off-peak) caused by: <ul style="list-style-type: none"> ◦ Scheduled events (i.e. work zones, system maintenance, special events) by X hours in Y years. ◦ Unscheduled disruptions to travel (i.e. crashes, weather, debris) by X hours in Y years. ◦ All transient scheduled and non-scheduled events by X hours in Y years.
Performance Measures	<ul style="list-style-type: none"> • Travel time delay during scheduled and/or unscheduled disruptions to travel within the subarea. • Total person hours of delay during scheduled and/or unscheduled disruptions to travel within the subarea.
Anticipated Data Needs	<ul style="list-style-type: none"> • Average travel time by person or vehicle during non-recurring events such as traffic incidents, special events, and work zones. • Average travel time by person or vehicle during free flow travel conditions within the subarea.

61 U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, 2010, FHWA-HOP-10-027. Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10027/>.

System Reliability: Non-Recurring Delay in Subareas (continued)

Data Resources and Partners	Travel time data during non-recurring events may be difficult to collect using traditional methods, particularly during unscheduled events such as incidents and severe weather. Instead, collection and synthesis of data from connected vehicles/ devices and smart cities applications may be viable methods of collecting travel time data. Traffic management centers and/or public safety organizations are likely needed to assist in identifying the locations and times of traffic incidents. Road and track maintenance staff will be needed to identify upcoming work. Data on travel times during unscheduled events may need to be extracted after collection from ongoing travel-time data based on the time and location of events. The National Weather Service may also need to be involved in identifying times and locations of severe weather that may have impacted travel.
TSMO Strategies to Consider	Strategies to reduce non-recurring delay include those that focus on reducing the delay caused by incidents, work zones, special events, weather, and other non-recurring events that affect traffic flow.

System Options: Mode Shares

This set of objectives focus on increasing the use of travel modes other than the single occupancy vehicle to improve the overall efficiency of the transportation system.⁶²

Stakeholders	<ul style="list-style-type: none"> • State, county, or city agency responsible for roadways. • MPOs, if there are any regional rideshare or travel demand programs. • Transportation network companies. • Traffic management center(s). • Transit agencies. 	<ul style="list-style-type: none"> • University research centers. • Ports, if applicable, local businesses, freight distribution centers, event centers, and neighborhood associations. • Pedestrian and bicycle advocacy groups.
Goals	<ul style="list-style-type: none"> • Reduce single occupancy vehicle trips by promoting other mode choices. 	
Subarea Operations Objectives	<ul style="list-style-type: none"> • Reduce per capita single occupancy vehicle (SOV) commute trip rate within subarea by X percent in Y years. • Increase non-SOV mode share for all trips within subarea by X percent within the next Y years. • Increase active transportation (bicycle/pedestrian) mode share within subarea by X percent by year Y. • Reduce SOV trips by X percent within subarea through travel demand strategies (e.g. employer or residential rideshare) by year Y. • Achieve X percent non-SOV mode share in subarea transit station communities by year Y. 	
Performance Measures	<ul style="list-style-type: none"> • SOV commute trips per capita within subarea. • Share of employees within subarea walking, bicycling, telecommuting, carpooling/vanpooling, riding transit, driving alone. • Share of trips by each mode of travel within subarea. • Percent of all trips made using alternative modes in subarea transit station communities. 	
Anticipated Data Needs	<ul style="list-style-type: none"> • Survey data, such as the U.S. Census Journey to Work Survey or other mode share surveys within subarea. • Subarea employer surveys of employee commuting patterns. • Subarea household surveys of travel behaviors including mode choice, frequency of trip making, and vehicle occupancy. 	
Data Resources and Partners	<p>Employers, transportation management associations, travel demand management programs, transit agencies, state and local DOTs, commuters, non-auto advocacy groups, and research firms may be resources for data. Connected vehicles/devices and smart city applications may also provide real-time data that can be synthesized for analysis.</p>	

62 U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, 2010, FHWA-HOP-10-027. Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10027/>.

System Options: Mode Shares (continued)

TSMO Strategies to Consider	Strategies to increase non-SOV mode share by encouraging the use of other modes include travel demand management strategies, parking management, and congestion pricing strategies. Many of these strategies are described in more detail later in this section.
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System Options: Bicycle and Pedestrian Accessibility and Efficiency

This set of objectives focus on improving the accessibility and efficiency and safety of bicycle and pedestrian modes to offer travelers feasible and attractive travel options within a subarea.⁶³

Stakeholders	<ul style="list-style-type: none"> • State, county, or city agency responsible for roadways. • Traffic management center(s). • Transit agencies. • University research centers. • Ports, if applicable. • Local businesses, freight distribution centers, event centers, and neighborhood associations. • Pedestrian and bicycle advocacy groups.
Goals	<ul style="list-style-type: none"> • Improve bicycle and pedestrian accessibility and efficiency. • Provide attractive bicycle and pedestrian travel options within a subarea.
Subarea Operations Objectives	<ul style="list-style-type: none"> • Decrease average delay for pedestrians and bicyclists on primary pedestrian and/or bicycle routes by X percent in Y years. • Increase system completeness within subarea for pedestrians and/or bicyclists by X percent within Y years. • Increase the number of intersections with pedestrian and/or bicycle safety features (countdown pedestrian signal heads, bicycle signals, painted crosswalks/bike boxes, etc.) to X percent by year Y. • Increase average pedestrian (or bicyclist) comfort level by X points in Y years.
Performance Measures	<ul style="list-style-type: none"> • Average delay for pedestrians and bicyclists on primary pedestrian and/or bicycle routes within the subarea. • Percent of subarea transportation network with pedestrian and/or bicycle facilities. • The percentage of intersections with pedestrian and/or bicycle safety features. • Number of pedestrian/bicyclist injuries/fatalities. • Average pedestrian and/or bicyclist comfort level as measured by survey.
Anticipated Data Needs	<ul style="list-style-type: none"> • Average wait time for pedestrians and bicyclists at intersections or path impediments by time period. • An inventory of bicycle and pedestrian infrastructure. • Survey information on pedestrian and/or bicyclist comfort level. • Pedestrian and bicycle injuries and deaths.
Data Resources and Partners	State and local DOTs, MPOs, counties, cities, highway districts and universities are sources for pedestrian and bicycle travel data. Private sector crowdsourcing data can also be utilized to inventory conditions and comfort level. Pedestrian and bicycle advocacy groups can be a source of data.
TSMO Strategies to Consider	Pedestrian countdown signals, bicycle lanes, wayfinding signage, crossing signals where bicycles and pedestrians cross major roadways.

63 U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, 2010, FHWA-HOP-10-027. Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahopl0027/>.

Arterial Management: Traffic Signal Management

These objectives improve the management of traffic signal operations on arterial roadways within a subarea through advanced technology, increased reviews, and planning.⁶⁴

Stakeholders	<ul style="list-style-type: none"> • State, county, or city agency responsible for roadways. • Traffic management center(s). • Traffic signal technicians. • Incident responders. • Contractors. 	<ul style="list-style-type: none"> • Transit agencies. • Local businesses, freight distribution centers, event centers, and neighborhood associations. • Ports, if applicable.
Goals	<ul style="list-style-type: none"> • Improve arterial traffic signal operations for day-to-day operations during peak and off-peak periods. • Improve arterial traffic signal operations during scheduled or non-scheduled events. 	
Subarea Operations Objectives	<ul style="list-style-type: none"> • Evaluate arterial signal timing within subarea every Y years. • Increase the number of subarea arterial intersections running in a coordinated, closed-loop, or adaptive system by X percent in Y years. • Prepare and implement special subarea arterial timing plans for use during freeway incidents, roadway construction activities, or other special events by year Y. • Crash data for subarea arterial roadways is reviewed every X years to determine if signal adjustments can be made to address a safety issue. 	
Performance Measures	<ul style="list-style-type: none"> • Number of years between traffic signal timing evaluation on arterial. • Number of intersections running in a coordinated, closed-loop, or adaptive system. • Completion of at least one special timing plan for incidents, construction, or events within subarea. • Number of times per year a special timing plan is used within subarea. • Number of years between reviews of crash data on all subarea arterials for possible signal timing impacts. 	
Anticipated Data Needs	<p>Reports from operating agencies on frequency of signal retiming evaluation, current traffic signal capabilities, special timing plans, and crash data reviews. Number of freeway corridor ramp meters and year of installation.</p>	
Data Resources and Partners	<p>Partner agencies that operate arterials and agencies that maintain traffic crash records. as State DOTs, cities, counties, and transportation management centers.</p>	
TSMO Strategies to Consider	<p>Regular evaluation of traffic signal timing, enhanced traffic signal systems, special subarea timing plans for events, incidents, and work zones, and regular review of subarea crash data.</p>	

⁶⁴ U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, 2010, FHWA-HOP-10-027. Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10027/>.

Freeway Management: Transportation Management Center (TMCs)

The objectives in this section focus on monitoring the operation of the subarea transportation system and initiating control strategies that effect changes in the operation of the network.⁶⁵

Stakeholders	<ul style="list-style-type: none"> • State, county, or city agency responsible for roadways. • Traffic management center(s). • Transit agencies. • 911 center(s). • Law enforcement. • Fire and rescue agencies. • Emergency medical agencies. • Local businesses, freight distribution centers, event centers, and neighborhood associations. • Ports, if applicable. • Media.
Goals	<ul style="list-style-type: none"> • Improve overall subarea transportation system operations during peak periods, scheduled and unscheduled events.
Subarea Operations Objectives	<ul style="list-style-type: none"> • Increase the level of transportation management center (TMC) subarea field hardware (e.g. cameras, dynamic message signs, ITS applications) by X percent by year Y. • Increase the hours of TMC operation and level of staffing for the subarea by X percent by year Y. • Increase the percent of the subarea transportation system monitored by the TMC for real-time performance.
Performance Measures	<ul style="list-style-type: none"> • Total amount of subarea TMC equipment. • Number of hours of TMC operation and number of staff serving the subarea. • Percent of subarea transportation system monitored by the TMC for real-time performance.
Anticipated Data Needs	<ul style="list-style-type: none"> • Subarea TMC equipment deployed. • Changes in TMC hours of operation and staffing levels. • TMC operational data, such as level of subarea performance monitoring, number of subarea events managed, level of services provided to aid travelers within subarea.
Data Resources and Partners	Operators of transportation management centers and partners, such as State DOTs, cities, counties, transit agencies, and emergency management agencies.
TSMO Strategies to Consider	Strategies include managing the operation of the subarea transportation system by communicating travel condition information, making necessary modifications to traffic and transit control systems, and directing response activities.

⁶⁵ U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, 2010, FHWA-HOP-10-027. Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10027/>.

Transit Operations and Management: Transit Signal Priority

The objectives in this section focus on implementation of transit signal priority systems to improve transit performance and reliability within a subarea.⁶⁶

Stakeholders	<ul style="list-style-type: none"> • State, county, or city agencies responsible for roadways. • Transportation management center(s). • Traffic signal technicians. • Transit agencies. 	<ul style="list-style-type: none"> • Local businesses, freight distribution centers, event centers, and neighborhood associations. • Ports, if applicable.
Goals	<ul style="list-style-type: none"> • Improve transit service performance and reliability on subarea roadways with traffic signals. 	
Subarea Operations Objectives	<ul style="list-style-type: none"> • Increase implementation of transit signal priority at X number of intersections over the next Y years. • Decrease traffic signal delay on transit routes within subarea by X percent per year. • Decrease transit vehicle delay within subarea by X percent per year by increasing the use of queue jumping and automated vehicle location (AVL). 	
Performance Measures	<ul style="list-style-type: none"> • Number of transit routes/intersections equipped with transit signal priority capability in subarea. • System-wide signalized stop delay on transit routes. • Travel time delay on routes with queue jumping and automated vehicle location in use. 	
Anticipated Data Needs	<ul style="list-style-type: none"> • Number of transit routes/intersections with transit signal priority capabilities. • AVL data with location and travel time delay. • Signal operations/green time reports. 	
Data Resources and Partners	<p>Transit agencies and traffic signal operating agencies in the region can provide information about implementation and performance of transit signal priority.</p> <p>AVL data can provide transit vehicle travel time.</p>	
TSMO Strategies to Consider	<p>TSMO strategies to increase transit signal priority implementation could involve identification and prioritization of transit routes and signalized intersections that are candidates for implementing transit signal priority systems or queue jumping. Another strategy may include collaboration with the traffic management agency to leverage transit signal priority implementation with traffic signal system upgrades.</p>	

⁶⁶ U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, 2010, FHWA-HOP-10-027. Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10027/>.

Traffic Incident Management

This objective set focuses on improving system efficiency, system reliability, traveler information, and agency efforts for managing traffic incidents on freeways and arterials within a subarea.⁶⁷

Stakeholders	<ul style="list-style-type: none"> • State, county, or city agency responsible for roadways. • MPOs, if there are any regional rideshare or travel demand programs. • Traffic management center(s). • Transit agencies. • 911 center(s). • Law enforcement. • Fire and rescue agencies. 	<ul style="list-style-type: none"> • Emergency medical agencies. • Tow industry. • Hazardous materials industry. • Local businesses, freight distribution centers, event centers, and neighborhood associations. • Ports, if applicable. • Media.
Goals	<ul style="list-style-type: none"> • Reduce traffic incident duration and person hours of delay within a subarea. • Provide travelers with accurate, timely, and actionable information and improve customer satisfaction. • Increase coordination and communication among agencies. • Train incident management staff how to mitigate the traffic impacts related to incidents and how to coordinate with partners. 	
Subarea Operations Objectives	<ul style="list-style-type: none"> • Increase implementation of transit signal priority at X number of intersections over the next Y years. • Decrease traffic signal delay on transit routes within subarea by X percent per year. • Decrease transit vehicle delay within subarea by X percent per year by increasing the use of queue jumping and automated vehicle location (AVL). 	

⁶⁷ U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, 2010, FHWA-HOP-10-027. Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10027/>.

Traffic Incident Management (continued)

Performance Measures

- Reduce subarea mean incident notification time by X percent over Y years.
- Reduce mean time for needed subarea responders to arrive on-scene after notification by X percent over Y years.
- Reduce subarea mean incident clearance time and mean roadway clearance time per incident by X percent over Y years.
- Reduce mean time of incident duration on transit services and subarea facilities by X percent in Y years.
- Reduce the person hours of total delay associated with subarea traffic incidents by X percent over Y years.
- Reduce time between incident verification and posting a traveler alert to traveler information outlets by X minutes in Y years.
- Reduce the time between recovery from incident and removal of traveler alerts for that incident.
- Increase number of repeat visitors to subarea traveler information outlet by X percent in Y years.
- Increase customer satisfaction with subarea incident management efforts by X percent over Y years.
- Increase the percentage of incident management agencies that participate in a coordinated subarea incident response team by X percent in Y years.
- Hold at least X multi-agency after-action review meetings each year with attendance from at least Y percent of the agencies involved in the response.
- Conduct X joint training exercises among incident/emergency operators and responders for the subarea by year Y.
- Average incident notification time of necessary response agencies.
- Mean time for needed responders to arrive on-scene after notification.
- Mean incident clearance time and mean roadway clearance time per incident.
- Mean time of incident duration.
- Person hours of delay associated with subarea traffic incidents.
- Time to alert travelers of a subarea incident.
- Time between recovery from incident and removal of traveler alerts.
- Number of repeat visitors to traveler information outlet.
- Percentage of customers satisfied with subarea incident management practices.
- Number of participating agencies in a subarea coordinated incident response team.
- Number of multi-agency after-action reviews per year.
- Percentage of responding agencies participating in after-action review.
- Number of joint training exercises conducted among incident/emergency operators and responders.

Traffic Incident Management (continued)

Anticipated Data Needs	<ul style="list-style-type: none"> • For each incident of interest within the subarea, incident notification time and on-scene arrival time; specifically, the time of the awareness of an incident and one or more of the following pieces of data: the time the last responder left the scene, the time when all lanes were re-opened, and the time when traffic returned to full operational status. • Total travel time in person hours of travel: a) during free flow conditions, and b) impacted by incidents. • Time of incident verification, time of traveler information outlet activation (e.g. dynamic message sign posting, 511 entry, website log), time of subarea system recovery, and time of travel alert removal. • Customer satisfaction surveys. • Number of agencies participating in a subarea incident management program. • Number of after-action reviews held. • Number of joint training exercises conducted among incident/emergency operators and responders.
Data Resources and Partners	<p>Data (including video feed if applicable) can typically be provided by incident responders, law enforcement/fire and rescue/medical responders or operators at a traffic management center or emergency operations center. Due to the unpredictable nature of traffic incidents, travel time data may need to be collected, stored, and analyzed after incident times and locations are obtained. Customer satisfaction information would need to be gathered from transportation system users that were using the system during the time of the incident.</p>
TSMO Strategies to Consider	<p>Many of the incident management strategies are complementary and work together to achieve the objectives. For example, providing accurate and timely traveler information can help reduce travel time delay by encouraging travelers to avoid the incident area and can also help improve customer satisfaction. Increasing agency participation within the subarea, holding after-action review meetings, and holding joint training can help improve incident detection and verification and help shorten incident clearance time. Other strategies to consider include enhancing inter-agency voice and data communications systems, using or expanding the use of roving subarea patrols, expanding surveillance camera coverage, and training on dissemination of subarea traveler information.</p>

Special Event Management

This objective set focuses on improving system efficiency, system reliability, traveler information, and agency efforts for managing special events within a subarea.⁶⁸

Stakeholders	<ul style="list-style-type: none"> • State, county, or city agency responsible for roadways. • MPOs, if there are any regional rideshare or travel demand programs. • Transportation network companies. • Traffic management center(s). • Transit agencies. • 911 center(s). • Law enforcement. • Fire and rescue agencies. 	<ul style="list-style-type: none"> • Emergency medical agencies. • Special event promoters. • Special event venues. • Parking providers. • Local businesses, freight distribution centers, event centers, and neighborhood associations. • Ports, if applicable. • Media.
Goals	<ul style="list-style-type: none"> • Reduce travel time for entering and exiting a special event. • Minimize the use of single-occupancy vehicles by special event attendees and encourage the use of other modes. • Encourage a more efficient use of parking facilities. 	
Subarea Operations Objectives	<ul style="list-style-type: none"> • Reduce average travel time into and out of the event by X percent in Y years. • Reduce average time to clear event's exiting queue by X percent in Y years. • Reduce non-special event VMT in the event area during events by X percent in Y years. • Decrease the percent of subarea special event attendees traveling to the event in single-occupancy vehicles by X percent in Y years. • Increase the percent of special event attendees using park and ride lots by X percent in Y years. • Increase the percent of special events with dedicated transit or shuttle service by X percent in Y years. • Increase the methods of effectively disseminating subarea special event information to travelers by X percent in Y years. • Increase the percentage of planned special events (with attendance above Z) with information on anticipated and actual travel conditions being disseminated to the traveling public at least X hours prior to the event. • Increase the number of subarea special events that use shared parking facilities (e.g. parking lots of nearby businesses or organizations) by X percent in Y years. • Increase the use of flexible pricing mechanisms near subarea special event locations on X percent of parking spaces in Y years. • Increase on-street parking restrictions on X percent of widely used subarea routes during special events in Y years. 	

68 U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, 2010, FHWA-HOP-10-027. Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10027/>.

Special Event Management (continued)

Subarea Operations Objectives (continued)	<ul style="list-style-type: none"> • Increase the percentage of special event stakeholders participating in a subarea event management team to X percent in Y years. • Increase the percentage of subarea special events that include training exercises, pre-event meetings, and post-event briefing by X percent in Y years. • Increase the percent of major subarea special events using ITS-related assets (e.g. cameras, dynamic message signs, vehicle and bicycle detection) to detect and manage special event entry/exit bottlenecks and incidents by X percent in Y years. • Implement special event traffic signal timing plans at X percent of major subarea special events each year beginning in year Y.
Performance Measures	<ul style="list-style-type: none"> • Average travel time to selected special events from a set of locations in the subarea over a year. • Average travel time away from selected special events to a set of locations in the subarea over a year. • Average time to clear event's exiting queue by year per event. • Non-special event vehicle miles traveled (VMT) in the event area during events over a year. • Percent of special event attendees: using single occupancy vehicles and using park and ride lots each year for selected subarea events. • Percent of special events with dedicated transit or shuttle service for selected subarea events during a one-year period. • Number of effective methods to disseminate subarea special event information to travelers. • Percent of subarea special events with attendance over Z that traveler information is disseminated at least X hours prior to the event. • Number of subarea special events that use shared parking facilities. • Percent of subarea parking spaces near special event locations that use flexible parking mechanisms. • Percent of subarea routes widely used during planned special events with on-street parking restrictions. • Number of stakeholders participating in subarea special event management team. • Number of events that include training exercises, pre-event meetings, and post-event briefings. • Percent of subarea special events using ITS assets to detect and manage incidents/bottlenecks at entry/exit routes of the events. • Percent of major subarea special events each year in which a special event traffic signal timing plan was implemented.

Special Event Management (continued)

Anticipated Data Needs	<ul style="list-style-type: none"> • Travel time to and from a set of subarea special events. • Time to clear an event’s exiting queue in terms of vehicles, transit, walking, and bicycling. • Vehicle miles traveled for vehicles not associated with special event. • Number of special event attendees, including associated number of single occupancy vehicles and number using park and ride lots. • Number of subarea special events with dedicated transit or shuttle service. • Count of available traveler information dissemination channels. • Count of major subarea special events with and without the dissemination of traveler information ahead of the event. • Count of special events using shared use parking facilities. • Count of parking spaces near special event locations with and without flexible pricing mechanisms. • Determination of the most widely used subarea routes during special events and count of those routes with on-street parking restrictions. • Number of special event stakeholders and, of them, the number that participate each year in a subarea event management team. • Count of special events with training exercises, pre-event meetings, and post-event briefings. • Number of subarea special events and number of special events with ITS assets used for detecting/managing bottlenecks and incidents at exit/entry routes of events. • Number of major subarea special events where targeted signal timing plans were implemented.
Data Resources and Partners	<p>Agencies that may be involved in collecting data include highway, arterial, and transit facility operators, signal system operators, public safety officials, parking authorities, and special event management staff.</p>
TSMO Strategies to Consider	<p>A wide variety of strategies, particularly travel demand management strategies, are available to help manage special events. Consider developing a subarea special event management plan to identify the most appropriate strategies and to address stakeholder coordination, training exercises, pre-event planning, and post-event debriefs. Consider strategies such as encouraging non-single occupancy vehicle mode choice (e.g. transit, ridesharing, bicycling, walking), transit/shuttle service, park and ride lots, shared parking with nearby facilities, parking pricing, subarea route management, special event traffic signalization, and traveler information.</p>

Road Weather Management

The objectives for managing road weather within a subarea focus on improving system efficiency, system reliability, traveler information, and traffic signal management.⁶⁹

Stakeholders	<ul style="list-style-type: none"> • State, county, or city agency responsible for roadways, including maintenance crews. • Weather forecast services. • MPOs, if there are any regional rideshare or travel demand programs. • Traffic management center(s). • Transit agencies. • 911 center(s). 	<ul style="list-style-type: none"> • Law enforcement. • Fire and rescue agencies. • Emergency medical agencies. • Local businesses, freight distribution centers, event centers, and neighborhood associations. • Ports, if applicable. • Media.
Goals	<ul style="list-style-type: none"> • Improve the clearance time of weather-related debris (e.g. fallen limbs and trees, snow and ice, power lines and poles) from the subarea transportation facilities. • Help travelers avoid segments within subarea that are dangerous and would cause them substantial delay. • Disseminate relevant information to travelers in a timely manner regarding the impact of weather on subarea travel. • Increase the coverage of the subarea (roadway, transit, or bicycle facilities) with weather sensors and communications. • Improve traffic signal management during inclement weather conditions. 	

⁶⁹ U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, 2010, FHWA-HOP-10-027. Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10027/>.

Road Weather Management (continued)

Subarea Operations Objectives	<ul style="list-style-type: none"> • Reduce average time to clear subarea of weather-related debris after weather impact by X percent in Y years • Increase by X percent the number of significant subarea routes covered by weather-related diversion plans by year Y. • Increase the percent of agencies that have adopted multi-agency weather-related subarea transportation operations plans and are involved in operations during weather events to X percent by year Y. • Reduce time to alert travelers of travel weather impacts using traveler information outlets (e.g. dynamic message signs, 511, websites, media) by X (time period or percent) in Y years. • Increase the percent of the subarea covered by weather sensors or a road weather information system (RWIS) by X percent in Y years as defined by an RWIS station within Z miles. • Special timing plans are available for use during inclement weather conditions for X miles of the subarea roadways by year Y.
Performance Measures	<ul style="list-style-type: none"> • Average time to clear selected subarea surface transportation facilities of weather-related debris after weather impact. • Percent of significant subarea routes covered by weather-related diversion plans. • Percent of agencies involved in transportation operations during weather events that have adopted multi-agency weather-related subarea transportation operations plans. • Time from beginning of weather event to posting of information to traveler information outlets. • Percent of subarea within Z miles of an RWIS station. • Number of miles of subarea roadways that have at least one special signal timing plan for inclement weather events.
Anticipated Data Needs	<ul style="list-style-type: none"> • Time in which the subarea surface transportation facilities have been impacted by the debris and the time required to clear the subarea and restore it to full operation. • Number of weather-related diversion plans. • Total number of agencies involved in transportation operations during weather events that have adopted multi-agency weather-related subarea transportation operations plans. • Time of the start of a weather event and the time in which information is given to travelers by traveler information outlets. • Deployment locations of each RWIS station within or near the subarea and length of the subarea roadways. • Reports from operating agencies on subarea signal retiming, signal capabilities, and special timing plans.

Road Weather Management (continued)

Data Resources and Partners	Field data may come from road or rail weather sensors, observations from meteorologists, National Weather Service data, or transportation facility maintenance staff. Agency partners may include the operators (or public safety personnel) of the impacted transportation facilities.
TSMO Strategies to Consider	Many TSMO strategies for road weather management are complementary and work towards achieving multiple objectives. TSMO strategies that support agency operations, and in turn help with system reliability and efficiency, include weather sensors/stations at key subarea locations, pre-positioned debris removal vehicles, preventative techniques such as spreading de-icing material prior to a storm, collaboration with weather forecasting services, and development of alternate route plans in preparation for events through collaboration among jurisdictions and modes. System efficiency can also be improved by developing and implementing special signal timing plans for typical travel demand during weather events. Traveler information strategies that help travelers make informed decisions include current subarea weather and facility information, weather forecasts, status information on operational activities (e.g. map of snow plow activities), and the use of dynamic message signs within the subarea or approaches to key subarea routes.

Work Zone Management

This objective set focuses on improving system efficiency, system reliability, traveler information, and agency coordination efforts for managing work zones within a subarea.⁷⁰

Stakeholders	<ul style="list-style-type: none"> • State, county, or city agency responsible for roadways, including maintenance crews. • Contractors. • Utility agencies/companies. • MPOs, if there are any regional rideshare or travel demand programs. • Traffic management center(s). • Transit agencies. 	<ul style="list-style-type: none"> • 911 center(s). • Law enforcement. • Fire and rescue agencies. • Emergency medical agencies. • Local businesses, freight distribution centers, event centers, and neighborhood associations. • Ports, if applicable. • Media.
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Goals	<ul style="list-style-type: none"> • Reduce travel time delay within subarea work zones. • Reduce the extent of congestion for travelers within work zones. • Reduce the variability in travel time within work zones. • Reduce the overlap in subarea construction projects to reduce the burden on transportation system users. • Inform travelers of ongoing subarea work zones to reduce travel time delays. • Improve customer satisfaction with work zone management.
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Subarea Operations Objectives	<ul style="list-style-type: none"> • Reduce the person hours of total delay associated with subarea work zones by X percent over Y years. • Increase the rate of on-time completion of subarea construction projects to X percent within Y years. • Increase the percentage of subarea construction projects that employ night/off-peak work zones by X percent in Y years. • Reduce the percentage of vehicles traveling through subarea work zones that are queued by X percent in Y year. • Reduce the average and maximum length of queues, when present by X percent over Y years. • Reduce the average time duration (in minutes) of queue length greater than Z miles by X percent in Y years. • Reduce vehicle-hours of total delay in work zones caused by incidents (e.g. traffic crashes within or near the work zone). • Increase the number of capital projects reviewed for subarea construction coordination by X percent in Y years. • Decrease the number of work zones on parallel routes within subarea by X percent in Y years.
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⁷⁰ U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, 2010, FHWA-HOP-10-027. Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10027/>.

Work Zone Management (continued)

Subarea Operations Objectives (continued)	<ul style="list-style-type: none"> • Establish a work zone management system within X years to facilitate coordination of work zones within the subarea. • Provide work zone information and multimodal alternatives to traveler information outlets for at least X percent of subarea work zones over the next Y years. • Increase customer satisfaction with subarea work zone management efforts by X percent over Y years.
Performance Measures	<ul style="list-style-type: none"> • Person hours of delay associated with subarea work zones. • Percent of subarea construction projects completed on-time. • Percent of subarea construction projects employing night/off-peak work zones. • Percent of vehicles experiencing queuing in subarea work zones. • Length of average and maximum queues in subarea work zones. • Average duration in minutes of queue length greater than Z miles. • Vehicle-hours of delay due to incidents related to work zones. • Percent of subarea capital projects whose project schedules have been reviewed. • Percent of work zones on parallel routes within subarea. • Presence of an established work zone management system. • Percent of subarea work zones for which traveler information and multimodal alternatives is available through traveler information outlets. • Percentage of customers satisfied with subarea work zone management practices.
Anticipated Data Needs	<ul style="list-style-type: none"> • Total travel time in person hours of travel: a) during free flow conditions, and b) impacted by work zones. • Work zone information for work and non-work time periods: traffic volumes, travel time, work zone length (average and maximum). • Number of construction projects completed on time. • Number of construction projects employing night/off-peak work zones. • Number of vehicles traveling through work zones. • Number of vehicles traveling through work zones experiencing queuing. • Duration of queue length greater than Z miles. • Hours of incident-related delay in work zones. • Subarea capital projects submitted for review. • Subarea capital project anticipated and actual schedules. • Map of work zones along area maps. • Availability of traveler information and multimodal alternatives for work zones. • Customer satisfaction surveys.

Work Zone Management (continued)

Data Resources and Partners	Data would need to be collected by agencies responsible for maintenance and operation of the transportation facilities. Partners needed include departments of transportation, public safety, contractors, and utility companies.
TSMO Strategies to Consider	Many of the TSMO strategies for work zone management work together in a complementary fashion to achieve the objectives. For example, providing ahead-of-time and real-time multimodal traveler information can help reduce travel time delay and extent of congestion by providing travelers with tools to help them avoid or minimize their exposure to the work zone. This strategy, along with shortening lane closure times particularly during high travel demand periods, also helps improve customer satisfaction. Multi-agency coordination, such as scheduling different work zones for different construction seasons, can help minimize the overall subarea travel impacts. Other strategies to consider include using temporary traffic control devices and practices that minimize the opportunity for crashes, which in turn shortens the incident-related delay in work zones, and using dynamic message signs or portable variable message signs to disseminate traveler information within the subarea or on key approaches to subarea routes.

Transportation Demand Management (TDM): Auto Commuter Trip Reduction

This objective set focuses on reducing the motor vehicle demand for transportation infrastructure by implementing commuter trip reduction programs for employers.⁷¹

Stakeholders	<ul style="list-style-type: none"> • State, county, or city agency responsible for roadways. • MPOs, if there are any regional rideshare or travel demand programs. • Transportation network companies. • Traffic management center(s). • Transit agencies. 	<ul style="list-style-type: none"> • Local businesses, freight distribution centers, event centers, and neighborhood associations. • Ports, if applicable. • Media. • Travelers.
Goals	• Implement commuter trip reduction programs with subarea employers.	
Subarea Operations Objectives	<ul style="list-style-type: none"> • Increase the percentage of major subarea employers (employers with at least Z employees) actively participating in transportation demand management (TDM) programs by X percent within Y years. • Reduce commute single-occupancy vehicle miles traveled (VMT) per subarea employee by X percent in Y years. 	
Performance Measures	<ul style="list-style-type: none"> • Percent of major subarea employers with active TDM programs. • Commuter VMT per subarea employee. 	
Anticipated Data Needs	<ul style="list-style-type: none"> • Number of major subarea employers with and without active TDM programs. • Number of subarea employees and total commute VMT. 	
Data Resources and Partners	Data resources may include employer surveys of employee commuting programs, household travel behavior surveys (for commute mode choice, frequency of trip making, and vehicle occupancy), and data from the US Census Bureau, Department of Labor, and business licensing bureaus. Partners include employers, transportation management associations, travel demand management programs, transit agencies, State and local DOTs, non-auto advocacy groups, research firms, and commuters.	
TSMO Strategies to Consider	TSMO strategies to consider include guaranteed ride home program; commuter financial incentives (parking cash out and transit allowances); alternative scheduling (flextime and compressed work weeks); telework; bicycle parking and changing facilities at major employer locations; worksite amenities such as on-site childcare, restaurants, and shops to reduce the need to drive for errands; company travel reimbursement policies for bicycle or transit mileage for business trips; company vehicles to eliminate the need for employees to drive to work to have their cars for business travel; proximate commuting, which allows employees to shift to worksites that are closest to their home (for employers who have multiple work locations, such as banks and other large organizations); worksite locations that reflect location-efficient development principles; and employer strategies to encourage bicycling and walking, including safe and secure storage for bicycles and shower and locker facilities.	

71 U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, 2010, FHWA-HOP-10-027. Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10027/>.

Transportation Demand Management: Mobility on Demand (MoD)

This objective set focuses on increasing the availability and use of shared mobility options that provide on-demand transportation options.^{72, 73}

Stakeholders	<ul style="list-style-type: none"> • State, county, or city agency responsible for roadways. • MPOs, if there are any regional rideshare or travel demand programs. • Urban Design Experts. • Transportation network companies (e.g., Uber, Lyft, Zipcar, car2go, Drive-Now). • Parking Authorities . • Bicycle share operators (e.g., Citi Bike, Divvy, Spinlister, B-cycle). • Co-working companies (e.g., WeWork, Regus, UberOffices, 1776). • Vehicle original equipment manufacturers (Mobility on Demand, or MoD, advances clean, compact, energy efficient vehicles). 		<ul style="list-style-type: none"> • Electric utilities and/or charging station providers. • On-demand economy companies (e.g., food, dry cleaning delivery, etc.). • Smartphone apps (e.g., RideScout). • Traffic management center(s). Transit agencies. • Local businesses, freight distribution centers, event centers, business improvement districts, and neighborhood associations. • Ports, if applicable. • Media. • Travelers.
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Goals	<ul style="list-style-type: none"> • Promote mobility on demand options like ridesharing and bicycle sharing within subarea to increase transportation options and efficiency of the transportation system.
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Subarea Operations Objectives	<ul style="list-style-type: none"> • Develop and provide travel option services to X identified subarea communities and audiences within Y years. • Promote dynamic rideshare service between X major subarea activity centers and major destinations that are not already accommodated within one-quarter mile by other transit services. • Foster partnerships with transportation network companies (TNC) to extend transportation options to under-served communities.
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72 U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, 2010, FHWA-HOP-10-027. Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10027/>.

73 U.S. Department of Transportation, *Mobility on Demand (MOD) Fact Sheet #1: Overview*. Available at: <http://www.its.dot.gov/factsheets/pdf/MobilityonDemand.pdf>.

Transportation Demand Management: Mobility on Demand (MoD) (continued)

Subarea Operations Objectives (continued)	<ul style="list-style-type: none"> • Create a subarea transportation access guide, which provides concise directions to reach destinations by non-single-occupancy vehicle modes (transit, walking, bike, etc.) by year Y. • Increase real-time, fine-grained mobility demand sensing in X percent of subarea by year Y. • Deploy/enhance real-time management systems that balance vehicle (and parking space) supply and demand in X identified subarea communities within Y years. • Evaluate role of dynamic pricing in mobility demand management for X percent of subarea by year Y. • Reduce the walking distance between on-demand mobility locations by X percent within Y years.
Performance Measures	<ul style="list-style-type: none"> • Share of subarea household trips by each mode of travel. • Percent of subarea residents receiving individualized marketing material on mobility service opportunities. • Availability of mobility on demand services. • Utilization rates of mobility on demand services. • Number of visitors to on-line subarea transportation access guide. • Wait times for on-demand mobility services. • Energy usage, emissions and other ‘livability’ metrics. • Walking distance between on-demand mobility locations (shared car parking spots, bikeshare lockers, etc).
Anticipated Data Needs	<ul style="list-style-type: none"> • Number and type of ridesharing services within subarea. • Count of subarea residents receiving individualized marketing materials. • Utilization rates of on-demand services in subarea (finely grained so we know most popular specific nodes within the subarea network). • On-demand vehicle operating data (time of use, length of time of use, distance traveled, average speed, fuel/power consumption). • Mode share and total trips within subarea. • Count of subarea communities with travel option services. • The real-time location (visualized via smart-phone app) of the subarea’s available on-demand services/vehicles. • Wait times for next available on-demand service/vehicle, and related to that, aggregated data on latencies in the system (pick-up latencies, travel latencies, drop-off latencies). This contributes to getting us to a median latency and in turn allows users to see ‘wait-time’ and plan their (presumed) walking trip to a node. • Walking distances between MoD services.

Transportation Demand Management: Mobility on Demand (MoD) (continued)

Data Resources and Partners	Data resources may include employer surveys of employee commuting programs, household travel behavior surveys (for commute mode choice, frequency of trip making, and vehicle occupancy), and data from the US Census Bureau, Department of Labor, and business licensing bureaus. Partners include rideshare organizations, travel demand management programs, transit agencies, State and local DOTs, non-auto advocacy groups, research firms, and commuters. Resources include the data generated by on-demand vehicles and connected devices (e.g. people's smartphones).
TSMO Strategies to Consider	Key strategies include promoting ridesharing, bicycle sharing, commuter shuttle service and using a targeted marketing strategy to make travelers aware of all the options.

Transportation Demand Management: Parking Management

This objective set focuses on active management of parking resources. Parking management includes parking facilities, street parking, associated parking regulations, motor vehicles, freight vehicles, shared vehicles and bicycles. Additional freight strategies are provided in the next section on goods movement.⁷⁴

Stakeholders	<ul style="list-style-type: none"> • State, county, or city agency responsible for roadways. • Parking providers (infrastructure). • Parking authorities (policy). • MPOs, if there are any regional rideshare or travel demand programs. • Urban designers. • Transportation network companies (e.g. Uber, Lyft, Zipcar, car2go). • Bicycle share operators (e.g. Citi Bike, Divvy, Spinlister, B-cycle). • Traffic management center(s). 	<ul style="list-style-type: none"> • Transit agencies. • Local businesses, freight distribution centers, business improvement districts, event centers, and neighborhood associations. • Ports, if applicable. • Media. • Travelers.
Goals	<ul style="list-style-type: none"> • Manage parking resources more intelligently, equitably, and efficiently. 	
Subarea Operations Objectives	<ul style="list-style-type: none"> • Implement shared parking for X subarea communities every Y years. • Implement parking pricing for X subarea communities every Y years. • Install parking meters along X subarea corridors by year Y in the urban core/transit supportive areas. • Increase the number of subarea residents/commuters receiving information on parking pricing and availability within Y years. • Increase subarea park-and-ride lot capacity by X percent over Y years. • Biannually increased subarea preferred parking spaces for carpool/vanpool participants within downtown, at special events, and among major employers by X percent within Y years. • Implement parking policies to encourage the provision of mobility on demand services within Y years. • Implement complimentary data collection systems that inform land-use and other parking-related policies for X subarea communities within Y years. 	

⁷⁴ U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, 2010, FHWA-HOP-10-027. Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10027/>.

Transportation Demand Management: Parking Management (continued)

Performance Measures	<ul style="list-style-type: none"> • Number of shared-use parking stalls within subarea. • Number of shared-use bicycle parking spaces at defined transportation notes within subarea. • Number of priced parking stalls within subarea. • Number of corridors within subarea urban core/transit supportive areas with parking meters. • Number of residents/commuters receiving information on parking pricing and availability within subarea. • Capacity of park and ride lots within subarea. • Number of preferred parking spaces for carpool/vanpool participants within subarea. • Wait time for available parking spaces within subarea.
Anticipated Data Needs	<ul style="list-style-type: none"> • Count of shared-use parking (vehicles and bicycles) and priced parking stalls within subarea. • Count of corridors with parking meters within subarea. • Count of residents/commuters exposed to parking information within subarea. • Park and ride lot capacity data within subarea. • Count of preferred parking spaces within subarea. • Parking wait time within subarea.
Data Resources and Partners	<p>Data will most likely come from employers, county and city transportation agencies, transit agencies, parking facility operators, and special event managers. Data resources include connected vehicles (CV) and devices. CV potentially allows collection of data on time vehicles are driven in search for parking, and where they search. Smart cities allow collection of parking spot utilization rates (and times), which speaks to supply/demand information that informs land-use & zoning decisions related to parking capacity.</p>
TSMO Strategies to Consider	<p>TSMO strategies to consider include shared parking facilities, parking pricing, increased park and ride lot capacity, preferred parking spaces for carpool/vanpool participants, and traveler information dissemination related to parking availability and pricing. CV data collection and integration strategy.</p>

Transit Operations and Management: Transit Signal Priority

This objective set focuses on improving the efficiency and reliability for urban goods movement and delivery.^{75, 76}

Stakeholders	<ul style="list-style-type: none"> • State, county, or city agency responsible for roadways. • MPOs, if there are any regional travel demand programs. • Traffic management center(s). • Freight industry (can include shippers, carriers, importers, drayage, package delivery companies such as UPS and FedEx). • State trucking association. • Transportation network companies (e.g. Uber, B-Line). 	<ul style="list-style-type: none"> • Ports. • Local businesses, freight distribution centers, event centers, and neighborhood associations. • Media.
Goals	<ul style="list-style-type: none"> • Manage subarea transportation system resources to optimize the efficiency and reliability of goods movement within subareas. 	
Subarea Operations Objectives	<ul style="list-style-type: none"> • Minimize travel time delay on key goods movement routes. • Reduce variability in travel time on key goods movement routes. • Minimize the impact of non-recurring delay on key goods movement routes. • Increase efficiency of on-street parking and loading activity. 	
Performance Measures	<ul style="list-style-type: none"> • Average travel time on key goods movement routes during peak and off-peak periods (minutes). • Buffer time index on key goods movement routes during peak and off-peak travel periods. • Total truck hours of delay within subarea by time period (peak, off-peak) caused by: <ul style="list-style-type: none"> ◦ Scheduled events (i.e. work zones, system maintenance, special events) by X hours in Y years. ◦ Unscheduled disruptions to travel (i.e. crashes, weather, debris) by X hours in Y years. • Availability of parking and loading zones located at optimal node locations in a subarea. 	

75 U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, 2010, FHWA-HOP-10-027. Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10027/>.

76 Frost & Sullivan, *Uber for Trucks: Executive Analysis of the North American Mobile-based Freight Brokerage Market*. Available at: <http://www.frost.com/sublib/display-report.do?id=NF61-01-00-00-00&src=PR>.

Transportation Demand Management: Transit Signal Priority (continued)

Anticipated Data Needs	<ul style="list-style-type: none"> • Vehicle classification counts on key routes in sub-area. • Time of day travel time and speeds. • On and off-street loading zone locations. • Node utilization rates (an understanding of the most in-demand nodes within a subarea: those places that generate the most demand for goods movement trips (delivery/pickup)).
Data Resources and Partners	<p>State DOTs, counties, cities, traffic management centers, and private sector sources can provide travel time data including speeds and volumes. Agencies can also provide vehicle classification count data and on-street loading zone information. Non-recurring data from incidents, planned events, and weather can be provided by both agency and private sources. American Trucking Research Institute (ATRI) and Federal Highway Administration (FHWA) Freight Analysis Framework are sources of origin-destination and commodity flow data.</p>
TSMO Strategies to Consider	<p>Strategies designed to improve travel flow for trucks including traffic signal coordination, truck priority signals, weight-in-motion stations. Travel information, road weather management, and traffic incident management that address non-recurring travel delay. Transportation demand strategies that encourage shifts in person travel mode, time or route can open capacity for goods movement travel in a subarea.</p>

Active Transportation and Demand Management

This objective set focuses on actively influencing traveler choices to better manage travel supply and demand. Active management includes proactive, predictive, and reactive elements.^{77, 78}

Stakeholders	<ul style="list-style-type: none"> • State, county, or city agency responsible for roadways. • Toll authorities. • Parking providers. • MPOs, if there are any regional rideshare or travel demand programs. • Transportation network companies. • Traffic management center(s). 	<ul style="list-style-type: none"> • Transit agencies. • Law enforcement. • Local businesses, freight distribution centers, event centers, and neighborhood associations. • Ports, if applicable. • Media. • Travelers.
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Goals	<ul style="list-style-type: none"> • Actively manage travel supply and demand, traffic operations, and parking by influencing traveler choices related to destination, time of day, mode, route, and facility/lane to improve system efficiency and reliability.
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Subarea Operations Objectives	<ul style="list-style-type: none"> • Increase the amount of subarea travelers receiving information on active transportation and demand management (ATDM) strategies by X percent within Y years. • Increase customer satisfaction with ATDM efforts by X percent over Y years. • Improve average subarea travel time during peak periods by X percent by year Y. • Reduce subarea trips per year by X percent through dynamic ridesharing and active transit management within Y years. • Increase the percentage of subarea travelers with electronic toll collection (ETC) transponders by X percent by year Y. • Increase the share of subarea routes or lanes that are using dynamic pricing to X percent by year Y. • Reduce the number of congestion-inducing crashes occurring within subarea roadways and at subarea freeway ramps by X percent by year Y. • Implement active parking management for X percent of the subarea within Y years
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77 U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration, *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*, 2010, FHWA-HOP-10-027. Available at: <http://www.ops.fhwa.dot.gov/publications/fwahopl0027/>.

78 U.S. Department of Transportation, Federal Highway Administration, *Active Transportation and Demand Management Program*. Available at: <http://www.ops.fhwa.dot.gov/atdm/index.htm>.

Active Transportation and Demand Management (continued)

Performance Measures	<ul style="list-style-type: none"> • Total number of subarea travelers and percent receiving information on ATDM strategies. • Percentage of customers satisfied with subarea ATDM practices. • Average subarea travel time during peak periods (minutes). • Share of household trips by each mode of travel before and after availability of dynamic ridesharing and active transit management. • Percentage of subarea travelers with ETC transponders. • Share of subarea routes or lane miles using dynamic pricing. • Total number of congestion-inducing crashes within subarea roadways and at freeway ramps (per year). • Percent of subarea parking stalls with active parking management.
Anticipated Data Needs	<ul style="list-style-type: none"> • Survey/count of travelers exposed to ATDM information. • Customer satisfaction surveys. • Subarea peak period and free flow travel times and speeds. • Person travel time along subarea links (e.g. vehicle volume multiplied by vehicle occupancy) during free flow conditions and congested conditions. • Trip length. • Mode share and total trips for subarea. • Total number of subarea users (annually) with ETC transponders. • System information (e.g. miles of dynamically priced lanes or facilities). • Total number of congested-related crashes by location within subarea. • Count of total and actively managed parking stalls.
Data Resources and Partners	Data will need to be gathered from transportation management centers, State DOTs, cities, counties, toll authorities, transit agencies, and parking providers.

Active Transportation and Demand Management (continued)

TSMO Strategies to Consider	<p>There are numerous TSMO strategies to consider to achieve ATDM objectives. The strategies are typically categorized as they relate to demand, traffic, or parking:</p> <p>Active Demand Management:</p> <ul style="list-style-type: none"> • Subarea monitoring. • Subarea specific traveler information (including predictive information). • Dynamic ridesharing. • Active transit management: dynamic fare reduction, dynamic transit capacity assignment, on-demand transit, transfer connection protection. • Dynamic/congestion pricing (also electronic toll collection). <p>Active Traffic Management:</p> <ul style="list-style-type: none"> • Adaptive ramp metering. • Dynamic re-routing. • Dynamic truck restrictions. <p>Active Parking Management:</p> <ul style="list-style-type: none"> • Dynamic overflow transit parking. • Dynamic parking reservation. • Dynamic wayfinding. • Dynamically priced parking. <p>Automated enforcement may also be considered to complement some of the strategies such as dynamic pricing.</p>
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CHAPTER 4. MOVING TO IMPLEMENTATION: TRANSPORTATION SYSTEMS MANAGEMENT AND OPERATIONS WITHIN SUBAREAS

This chapter presents several components that are critical to successfully implementing the plans for transportation systems management and operations (TSMO) within a subarea and maintaining those strategies over time. This includes identifying funding for the selected TSMO strategies and using the overarching systems engineering process and regional intelligent transportation system (ITS) architecture to further define the TSMO strategies into specific, implementable systems that work with each other and connect to relevant operations systems already in place. This chapter also highlights the need to consider designing transportation infrastructure and ITS installations to enable and support planned TSMO strategies.

PROGRAMMING FOR TRANSPORTATION SYSTEMS MANAGEMENT AND OPERATIONS WITHIN SUBAREAS

Programming funds for TSMO strategies is a necessary step in making these strategies a reality in subareas (Figure 13). TSMO investments and strategies within a subarea can be funded through a combination of Federal, State, and local sources. There are several Federal programs that offer funding for TSMO activities, and State and local resources also are commonly an important source of funding as well. Monies may come from general funds, local sales taxes dedicated to transportation, toll revenues, vehicle registration fees, or specialized taxes on local businesses or residents in a defined geographic area to fund local improvements, including subarea improvements.

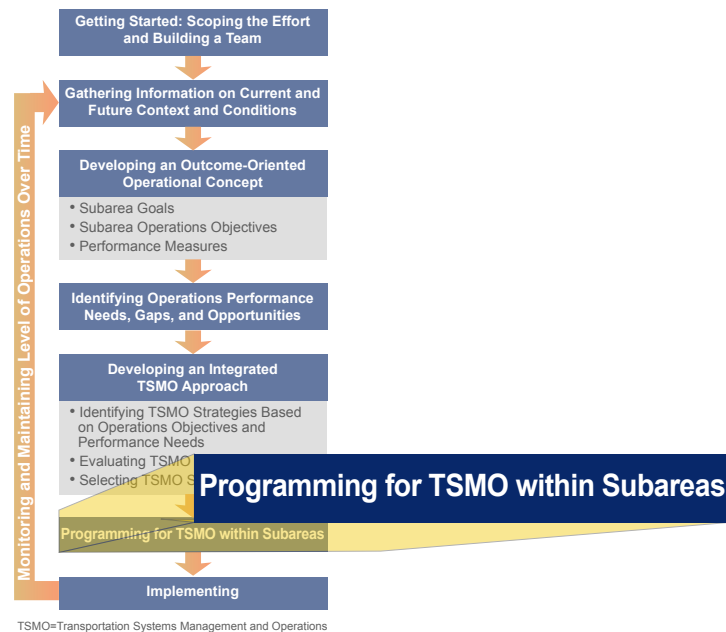


Figure 13. Diagram. The “Programming for Transportation Systems Management and Operations Within Subareas” activity of the approach to planning for transportation systems management and operations within subareas.

There are a few potential approaches for programming TSMO projects, including the following:⁷⁹

- **TSMO funding set-aside:** Some agencies set aside funding for TSMO projects, such that a portion of the available funding is restricted and spent only on TSMO projects. With this approach, amounts may be set aside for specific programs (e.g., traffic signal operations, etc.) or individual TSMO projects (e.g., transit signal priority (TSP) installation). Strategies are selected for funding based on pre-established selection criteria. Some communities have specific operations-focused plans that inform the development of the selection criteria, such as an ITS strategic plan or regional concept for transportation operations (RCTO).
- **Open competition:** TSMO projects might compete with other types of projects for funding. In this approach, the merits of each project are evaluated using criteria that address broad transportation needs. The long-range transportation plan (LRTP) should guide the selection of projects that are funded in the transportation improvement program (TIP). In this way, when all projects compete for general funds, project selection criteria should prioritize projects according to a performance-based approach that aligns with the regional LRTP. One evaluation approach is to rank all projects using a set of common criteria as well as mode-specific criteria (TSMO can be a category with mode-specific criteria). For example, out of a scale of 100, 70 points may be attributed to common criteria, and 30 to mode-specific criteria.
- **A combination or hybrid approach:** Some areas use a combination of set-aside funding for some types of projects, but also with the ability for TSMO projects to compete for general funds.

In addition, it is important to consider prioritization processes used for State and local funding sources, which may serve as a match for Federal funding or may be used entirely to fund operational improvements. See the text boxes for examples.

The Northern Virginia Transportation Authority's Prioritization Process

The Northern Virginia Transportation Authority (NVTA) is responsible for prioritizing a portion of the Northern Virginia tax revenue and bond proceeds for regional transportation improvement projects in the congested Northern Virginia subarea. The NVTA has allocated close to \$1 billion in regional revenues since July 2013. The NVTA uses a systematic project selection procedure, which includes preliminary screening (to ensure projects meet basic criteria for funding), development of a quantitative score for each project using weighted selection criteria, a congestion reduction relative to cost ratio, and consideration of qualitative factors. The quantitative scoring is conducted in relation to defined goals using a rating scale and the assignment of points to each project. The scoring assigns points based on an evaluation of how each project rates in terms of specific factors (e.g., improving the management and operation of existing facilities through technology applications, reducing vehicle miles traveled, and improving the safety of the transportation system). While the NVTA cannot directly fund operations, it can fund infrastructure related to operations, e.g., transit signal priority technology.

For more information, see: Northern Virginia Transportation Authority, Project Implementation Working Group, Memorandum, NVTA FY2017 Program Project Selection Criteria, November 9, 2015. Available at: <http://www.thenovaauthority.org/wp-content/uploads/XVI-Approval-of-FY2017-Program-Project-Selection-Criteria1.pdf>.

⁷⁹ Federal Highway Administration, Programming for Operations: *MPO Examples of Prioritizing and Funding Transportation System Management & Operations Strategies*, FHWA-HOP-13-050 (Washington, DC: 2013). Available at: <http://ops.fhwa.dot.gov/publications/fhwahop13050/index.htm>.

San Diego Association of Governments Administers County-Wide Tax Funds

The San Diego Association of Governments administers funds from TransNet, a county-wide half-cent sales tax generated for local transportation projects needed to mitigate congestion and improve mobility. The program provides funding for specific projects pulled from the regional transportation plan; these were selected as high priority through public surveys and focus groups and were named in the program ballot measures approved by voters. In addition to these specific projects, some TransNet funds are allocated to the San Diego Association of Governments' member jurisdictions for local street and road projects. Funds may also be awarded to other projects through a competitive process. An Independent Taxpayer Oversight Committee is charged with ensuring that expenditures from the TransNet fund support the implementation of the program's intent to reduce congestion and improve regional mobility.

For more information, see: San Diego Association of Governments, *TransNet Extension Ordinance and Expenditure Plan*. Available at: http://www.sandag.org/uploads/projectid/projectid_341_8806.pdf. Additional information on TransNet at: <http://www.sandag.org/?projectid=341&fuseaction=projects.detail>.

►► *Prioritizing Transportation Systems Management and Operations Strategies for Funding*

The goals and objectives of the LRTP should guide funding decisions and the selection of projects at the State and regional levels. Regions that place importance on system operations in the LRTP have a strong basis for allocating funding for TSMO strategies.

Regional goals, objectives, and performance measures relevant to system operations and management provide a foundation for setting aside funding for TSMO strategies, developing a project prioritization process that enables TSMO strategies to be competitive for general funds, or a combination of both. In addition to the LRTP, some regions develop regional operations or ITS plans. These specific operations-focused plans can further advance the implementation of TSMO strategies.

Aligning a subarea plan with the goals and objectives outlined in the LRTP and developing regional operations or ITS plans will improve the likelihood that the strategies identified in the plan receive funding for implementation.

► *Prioritization of Transportation Systems Management and Operations Projects among All Project Types*

The potential for TSMO projects to be selected in an open, competitive process is highly dependent on the selection criteria used for evaluation. Criteria that address mobility, reliability, and cost-effectiveness help TSMO initiatives compete effectively for funding.

Project Prioritization Method at Genesee Transportation Council

The Genesee Transportation Council, the metropolitan planning organization for the Rochester, New York area, ranks projects using a set of common criteria (up to 100 points) and mode-specific criteria (up to 30 points). The set of common project selection criteria relate to the broader transportation goals and objectives identified in the *Long Range Transportation Plan for the Genesee Finger-Lakes Region 2040*, which include promoting efficient system management and operations, safety for motorized and non-motorized users, and accessibility and mobility options, among others. There also is a set of mode-specific criteria for transportation system management and operations projects that focuses on outcomes (see Figure 14). The other mode specific categories are highway and bridge, public transportation, bicycle and pedestrian, and goods movement. Given the overall ranking of common and mode-specific criteria, transportation system management and operations projects are typically competitive with public transportation and highway projects. Genesee Transportation Council's project evaluation criteria allow for smaller transportation system management and operations projects to be competitive for funding.

System Management and Operations

1. Reduce travel times on major roadways	0	2	4	6	8	10
2. Reduce incident clearance times	0	2	4	6	8	10
3. Increase the productivity of regional transportation agencies/ providers (e.g., cost savings, times savings, etc.)	0	1	2	3	4	5
4. Support or advance existing and/or proposed ITS elements	0	1	2	3	4	5

Source: Genesee Transportation Council's *Transportation Improvement Program Guidebook*.

Figure 14. Genesee Transportation Council's mode-specific project evaluation criteria for transportation systems management and operations projects.

Source: Genesee Transportation Council, *Long Range Transportation Plan for the Genesee-Finger Lakes Region 2040* (New York: June 2016). Available at: <http://www.gtcmop.org/LRTP>.

► *Prioritization of Projects with Funding Dedicated to Transportation Systems Management and Operations Projects*

When a region decides to set aside or dedicate funding for TSMO initiatives, criteria that link to key regional objectives often are used for prioritizing that funding. In addition, a TSMO plan can be used to prioritize funding. For instance, Metro, the Portland, Oregon metropolitan planning organization (MPO), developed a 10-year regional TSMO plan to guide operations investments in the region.⁸⁰ The TSMO plan identifies two categories of actions: (1) those for regional programs and projects that require interagency cooperation, and (2) those for key individual travel corridors and single-agency services. After the allocation of funding for the TSMO program in the TIP, Metro then works with its regional operations collaborative group, called TransPort, to evaluate and select projects to receive TSMO program funds. Of these funds, one-third goes to region-wide projects and two thirds go to area-specific projects.

►► *Incrementally Funding Transportation Systems Management and Operations Strategies within a Subarea*

Investments to support TSMO do not have to be implemented all at one time as part of a large capacity project. Recognizing the scarcity of funding and the value that different TSMO strategies can have, agencies can develop a multi-phased approach to implementing strategies incrementally. Phasing can have the benefit of not only allowing small investments to proceed more quickly, but also can recognize that some potentially effective strategies may require more partner cooperation and more complex institutional arrangements.

►► *Life-Cycle Costing for Transportation Systems Management and Operations Projects*

When evaluating TSMO strategies for a subarea, it is important to consider not just the initial investment required to deploy a strategy, but the costs incurred throughout the life of the strategy. Life-cycle costing is an approach for determining the true cost of a project—the total for acquiring, installing, configuring, operating, maintaining, and disposing of a system throughout the entirety of its intended use.

For TSMO strategies, costs associated with maintenance and day-to-day utilization (e.g., staff time, software, etc.) are particularly critical, because funding the ongoing costs of operations is typically essential to the effectiveness of the strategy.

⁸⁰ Metro, Regional Transportation System Management and Operations Plan, June 30, 2010. Available at: <http://www.oregonmetro.gov/regional-transportation-system-management-and-operations-plan>.

IMPLEMENTATION

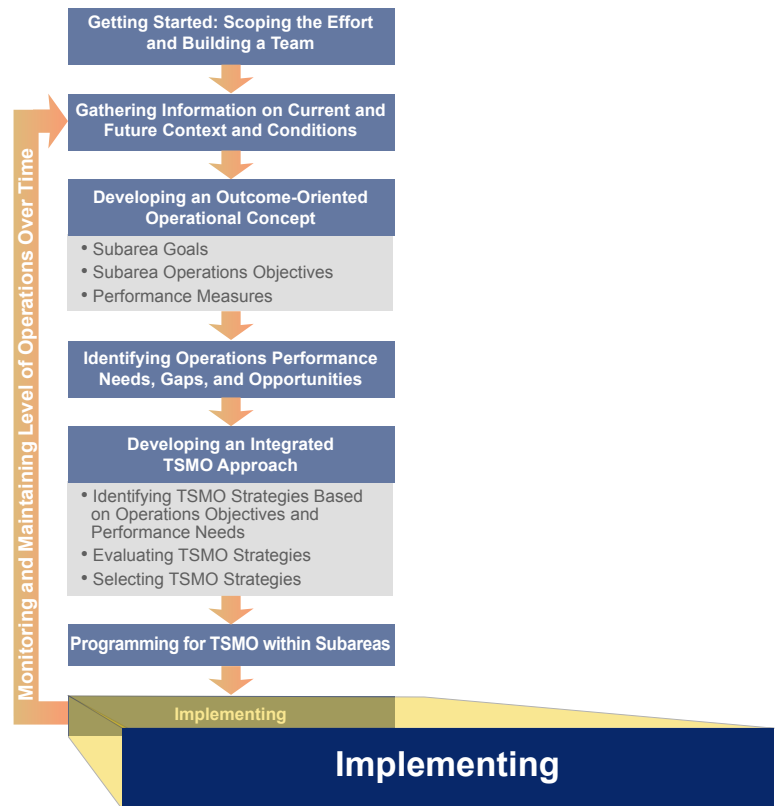
There are several frameworks and methods to consider when preparing for the implementation of an integrated TSMO approach within a subarea (Figure 15). This section provides an overview of those frameworks and methods that can be critically important for successful implementation of TSMO within subareas.

►► *Interagency Agreements*

TSMO within subareas frequently requires close coordination to be successfully implemented among transportation and non-transportation agencies. Interagency agreements are used to facilitate needed collaboration across agencies for subarea operations activities (e.g., traffic incident management (TIM), fiber sharing, special event management, traffic signal optimization, and joint purchasing).

Interagency agreements have become increasingly important as a collaborative transportation operating environment has emerged in the past decade. Individual agencies are increasingly collaborating with other agencies for a variety of reasons: transportation needs exceed resource levels, customer expectations for seamless travel across jurisdictions and modes, and advances in technology that have opened up opportunities and needs for the integration of systems that facilitate operations activities.

Within a single agency, there is an institutional structure for performing operations and allocating resources on an ongoing basis, but as agencies within a region increasingly seek ways to improve their effectiveness and efficiency through working together, they need a mechanism to formalize and codify those relationships to preserve and encourage the collaboration. Agreements provide a framework for facilitating and guiding the collaboration. They are critical to enabling many of the partnerships that are now in existence and avoiding fragmented operations. As resources become involved in the collaboration, agreements can be used to provide a legal means to protect the participating agencies and preserve the intent of the agreement. Interagency agreements are an important mechanism for allowing government agencies to combine services and/or resources, or to follow the same policy direction without giving up their autonomy. Interagency agreements serve a valuable purpose in that they formalize the complex coordination that needs to take place to develop and implement multi agency projects that have different stakeholders and priorities.



TSMO = transportation systems management and operations.

Figure 15. Diagram. The “Implementing” activity of the approach for planning for transportation systems management and operations within subareas.

There is not a standard naming convention or classification scheme for interagency agreements. Interagency agreements can be associated with three large groupings and refer to all types of agreements among government agencies. The first type of agreement (handshake) is not documented. The handshake agreement is a paperless agreement based on good faith. This may be appropriate for more informal collaborative efforts that do not require resource commitments from parties. The next two types of agreements are memoranda of understanding and intergovernmental agreements. A memorandum of understanding is generally less detailed and not legally binding, while the intergovernmental agreement is specific and binding for the signing parties.

As mentioned, general types of interagency agreements include:

- Handshake agreement.
 - Paperless agreement based on good faith.
- Memorandum of understanding.
 - Formal expression of intent by parties to engage in a specific course of action.
 - Defines roles and responsibilities.
 - Establishes common direction for achieving shared policy goals.
 - Documents area of mutual understanding.
 - Generally non-binding.
- Interagency or intergovernmental agreements.
 - Legal pact between two or more units of government.
 - Defines responsibility, function, and liability of each party.
 - Includes any financial or other resource obligations.
 - More detailed procedures for agreed upon activities.

The interagency agreement should serve as the vehicle for establishing an agreed-upon course of action relating to TSMO and can be used to:

- Define the program or project objectives.
- Identify stakeholders.
- Address roles and responsibilities for each stakeholder.
- Establish guidelines for how agencies will work together.
- Identify timelines.
- Facilitate communication.
- Offer an opportunity to resolve any issues encountered during the life of the agreement.

►► Systems Engineering Process

Systems engineering is an organized approach intended to improve the success rate of systems projects by reducing schedule and cost risks and ensuring that user needs and requirements are met. The approach can be applied to any of the TSMO strategies described in this desk reference. Systems engineering analysis is required for all ITS projects using Federal funds per Title 23 Code of Federal Regulations 940.11. Although there are many ways to represent the systems engineering process, the winged “V” (or “Vee”) model diagram shown in Figure 16 has been broadly adopted in the transportation industry.⁸¹

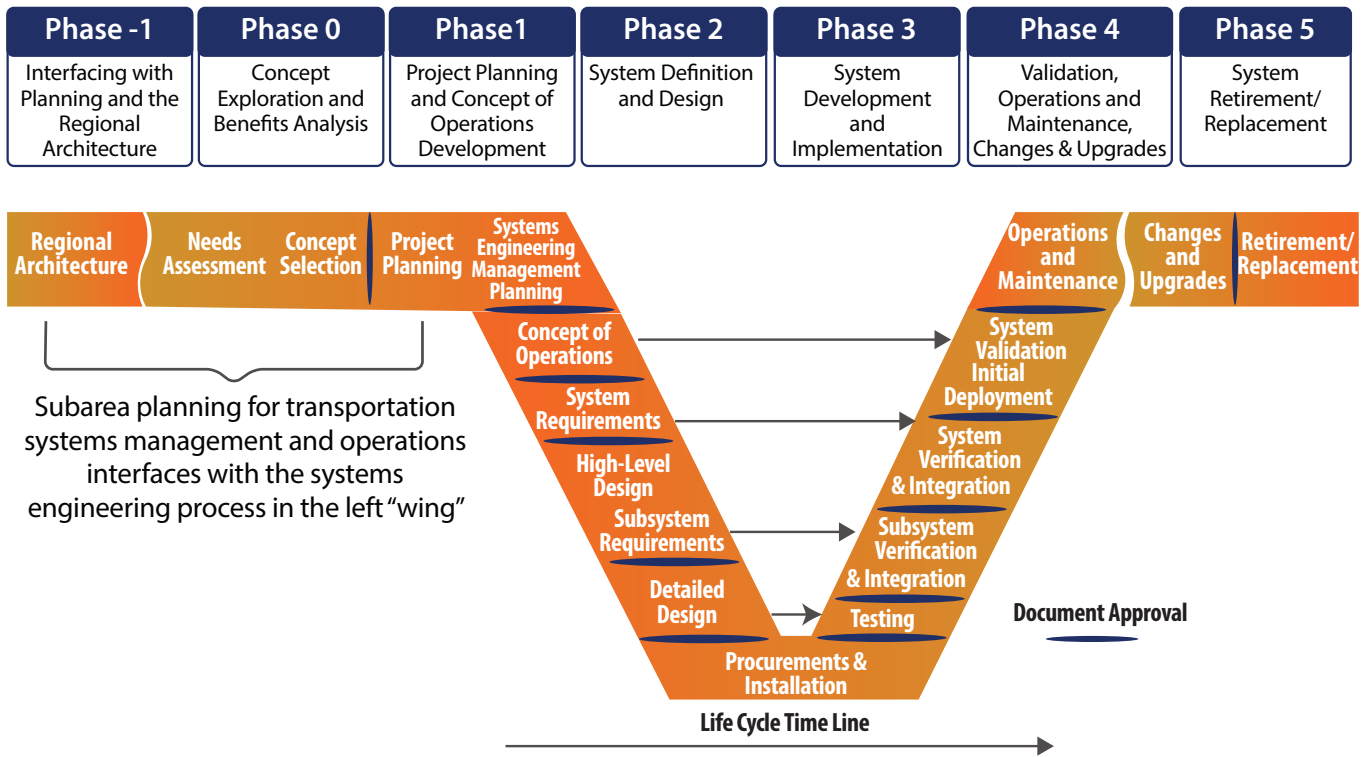


Figure 16. Subarea planning within the systems engineering “V” model.

The left wing of the “V” process shows the regional ITS architecture, feasibility studies, and concept exploration that support initial identification and planning for a project. Subarea planning fits within the left wing. Figure 17 shows how the regional ITS architecture can be used to inform subarea planning and a concept of operations, both of which are described in the next two sections. The operations objectives and performance measures identified during the planning phases should be applied throughout the systems engineering process and be validated once the project reaches the operations and maintenance phase in the right wing of the “V” diagram. This approach provides a systematic method to plan and design systems to achieve the desired operations objectives.

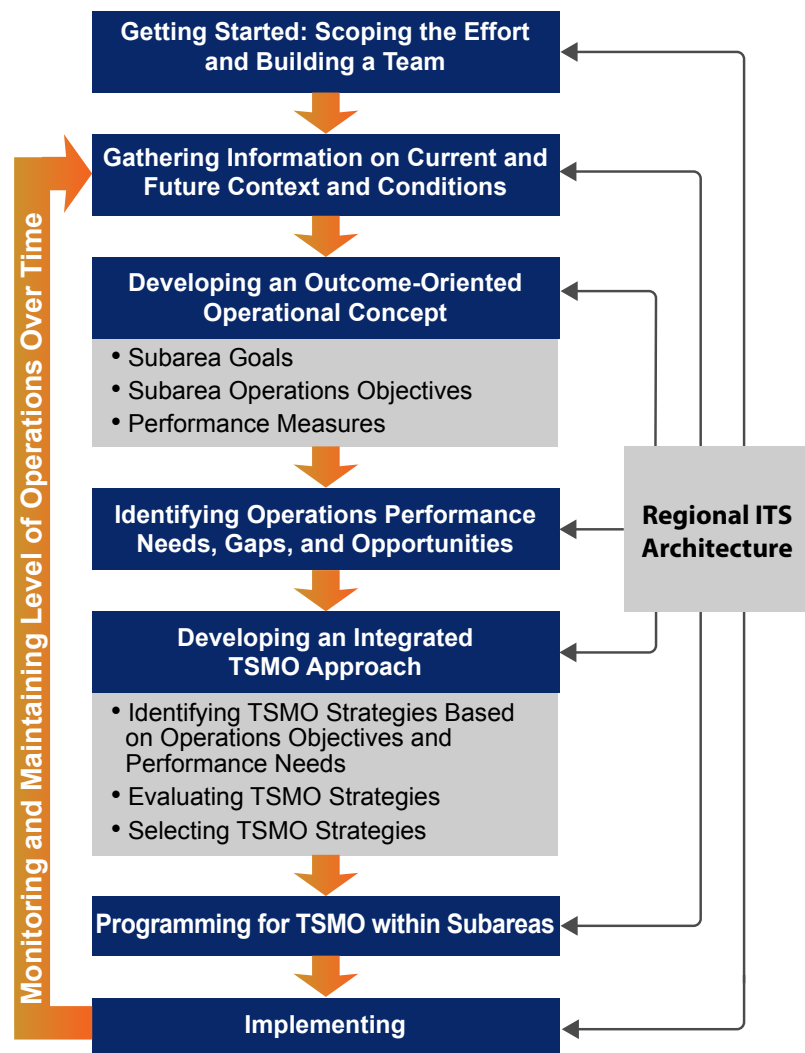
81 For more information, see: Federal Highway Administration, *Systems Engineering for ITS: An Introduction for Transportation Professionals*, FHWA-HOP-07-069, 2007. Available at: <http://www.ops.fhwa.dot.gov/publications/seitsguide/index.htm> or Federal Highway Administration and California Department of Transportation, *Systems Engineering Guidebook for ITS 3.0*, 2009. Available at: <http://www.fhwa.dot.gov/cadiv/segb/>.

►► *Regional Intelligent Transportation Systems Architecture*

A regional ITS architecture is a framework for institutional and technical integration in a particular region. Over 300 regional ITS architectures have been developed; therefore, it is likely that one is available in any region or at the statewide level as a tool to support the subarea planning process. Figure 17 shows how the regional ITS architecture can provide support in an objectives driven, performance-based approach to planning for operations within a subarea.

The regional ITS architecture helps answer important questions, such as:⁸²

- What existing or planned management and operations strategies may be available to help achieve the subarea operations objectives?
- What stakeholders and collaborative relationships can be leveraged as part of the subarea planning process?
- What data are available to monitor transportation system performance and track progress toward subarea operations objectives?
- What parts of the architecture's operational concepts, functional requirements, or other contents can be used to support project development?



TSMO=Transportation Systems Management and Operations

Figure 17. Diagram. Regional intelligent transportation system architecture use in subarea planning.

82 For more information, see: Federal Highway Administration, *Applying a Regional ITS Architecture to Support Planning for Operations: A Primer*, FHWA-HOP-12-001 (Washington, DC: February 2012). Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop12001/index.htm>.

►► *Concept of Operations*

Another crucial step in the systems engineering process is the completion of a concept of operations. Once TSMO strategies have been recommended as part of the needs assessment and concept selection phase of a subarea planning process, the recommended strategies should be carried forward into a concept of operations, which provides a stakeholder view of the system being developed in a non-technical manner with a focus on user needs, activity-based operations objectives, performance measures, roles and responsibilities, and institutional agreements. The concept of operations provides the basis for developing the systems requirements, which is the next step in the “V” diagram.

A successful concept of operations includes these key activities:⁸³

- **Identify stakeholders** – This includes anyone involved in or impacted by the project (e.g., owners, operators, maintainers, users, etc.). Stakeholder identification is described in Chapter 3 of this desk reference and often uses the regional ITS architecture as a starting point.
- **Develop a consensus on roles and responsibilities** – This is typically accomplished by working through operational scenarios for the subarea, such as normal system operation and various fault-and-failure scenarios (e.g., major incident and communications failure). This process also helps identify institutional agreements that may be needed to design and operate the project; for example, an agreement for one agency to implement signal timing adjustments to another agency’s traffic signals on multi-jurisdictional sections of the subarea.
- **Define stakeholder needs** – Capture a clear definition of stakeholder needs and differentiate between what is essential for system operations and “wish-list items” for “wants” and “nice-to-haves.”
- **Define performance measures** – These measures should assess the effectiveness of the system in comparison to the operations objectives of the subarea. The performance measures provide the foundation for the system validation plan used in the systems engineering process.

The size of the concept of operations should be commensurate with the size and complexity of the TSMO strategies selected for the project subarea. A subarea with one or two simple TSMO strategies, particularly ones that expand on existing systems, may only require a document that is several pages. For example, the addition of transit signal priority (TSP) on an arterial corridor within the subarea where TSP is already used by the transit agency in other neighboring jurisdictions may reference other concept of operations but will focus on the roles and responsibilities for the subject subarea. A larger, more complex subarea project, such as instituting special event management in a downtown area, will require a much more extensive concept of operations document to capture numerous systems and stakeholders.

⁸³ For more information, see: Federal Highway Administration, *Systems Engineering for ITS: An Introduction for Transportation Professionals*, FHWA-HOP-07-069 (Washington, DC: January 2007). Available at: <http://www.ops.fhwa.dot.gov/publications/seitsguide/index.htm>.

►► *Designing for Operations*

The success of TSMO strategies in a subarea to be implemented depends in large part on the design of the roadway or transit infrastructure. Examples of roadway design treatments that are important for improving the management and operation of a subarea include:

- Alternative intersection designs.
- Intersection traffic control (e.g., pre-timed, actuated coordinated, closed loop, adaptive control, roundabouts).
- Median treatments (e.g., pedestrian refuge, center turn lanes, raised medians).
- Multimodal transportation facilities – this includes bus stops or turnouts, bus lanes, and bicycle lanes.

Ideally, planning for TSMO within a subarea would occur in conjunction with the initial construction of roads or rails within the subarea so that TSMO strategies could be factored into the infrastructure design. For example, bus or bike lanes, alternative intersections, and pedestrian refuges can be included as part of the road from the beginning. Even after the road or rail is initially built, TSMO planners and operators can take advantage of opportunities to influence design during reconstruction or maintenance projects. For example, laying fiber optic cable to facilitate data collection for performance measures could be considered during reconstruction.

The effectiveness of TSMO strategies also relies on what type, how, and where the ITS and other equipment is deployed to support operations. These physical components that enable TSMO strategies include variable message signs or traffic surveillance equipment. The current and future operational use of ITS equipment should help drive the design decisions. For example, the installation of variable message signs in locations prior to significant route or modal decision points for travelers or common incident areas supports relevant, actionable traveler information to the public.

The FHWA document *Designing for Transportation Management and Operations: A Primer* introduces the concept of designing for operations, describes tools and institutional approaches to assist transportation agencies in considering operations in their design procedures, and points out some specific design considerations for various operations strategies.⁸⁴ The tools and approaches to aid in designing for operations may include checklists for designers to reference operational considerations, formation of a technical advisement committee with operations expertise, or agency policies that instruct designers on how to incorporate operational elements within the project development process. These will benefit multiple practitioner groups, including planners, project designers, scoping engineers, maintenance and traffic managers, and contract development personnel. This primer can be consulted by subarea TSMO teams to learn more about how to integrate design elements that facilitate TSMO strategies within subareas.

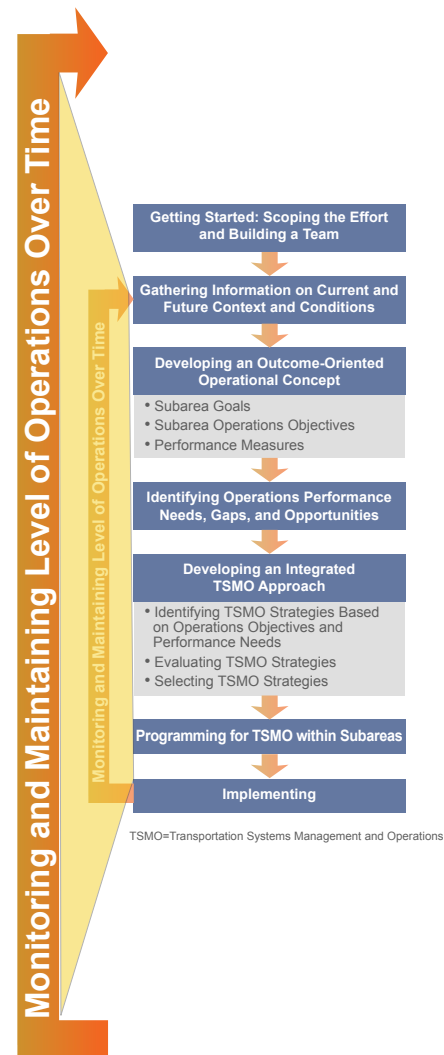
⁸⁴ Federal Highway Administration, *Designing for Transportation Management and Operations: A Primer*, FHWA-HOP-13-013 (Washington, DC: February 2013). Available at: <http://ops.fhwa.dot.gov/publications/fhwahop13013/index.htm>.

►► Life-Cycle Planning – Monitoring and Maintaining Level of Operations Over Time

To fully realize the value of an objectives-driven, performance-based approach, it is necessary to assess how well the subarea strategies meet the objectives immediately after implementation and over the time the strategy is in use (Figure 18). The monitoring and evaluation feedback loop involves several elements:⁸⁵

- **Evaluate the effectiveness of implemented strategies** – Develop a subarea evaluation plan during the planning or design process, and put the plan into action following implementation. Figure 19 provides an example evaluation plan with key steps during design, data collection and validation, data archiving and transformation, data analysis, and performance measure reporting. Some regions already have established performance measures and evaluation plans in place through the regional or metropolitan transportation plan, ITS or TSMO plan, congestion management process, or subarea planning process. These may be tailored to the subarea level.
- **Report subarea performance** – Inform decision makers and stakeholders about trends in subarea system performance. Highlight project benefits for any objectives that have been met or exceeded. For under-performing objectives, proceed to the next step.
- **Assess and refine operations objectives** – If measured subarea performance falls short of meeting a desired objective, consider refining the objective or choosing alternate strategies that may meet the objective.

This process should be repeated on a regular cycle, perhaps in conjunction with other regional planning cycles, to identify any issues and address them to stop the degradation of subarea performance.



TSMO = transportation systems management and operations.

Figure 18. Diagram. The “Monitoring and Maintaining Level of Operations Over Time” activity of the approach for planning for transportation systems management and operations within subareas.

85 Federal Highway Administration, *Advancing Metropolitan Planning for Operations: An Objectives-Driven, Performance-Based Approach- A Guidebook*, FHWA-HOP-10-026 (Washington, DC: February 2010). Available at: <http://www.ops.fhwa.dot.gov/publications/fhwahop10026/>.

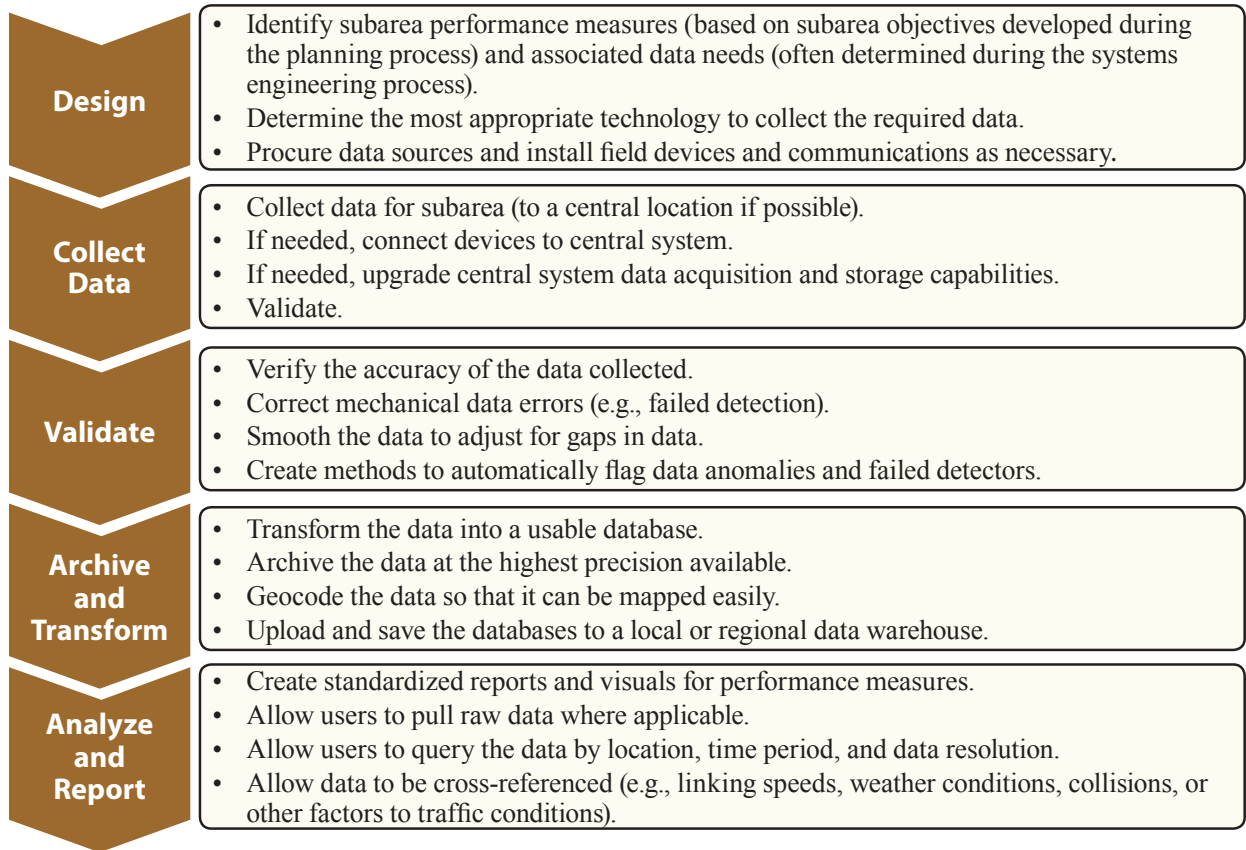


Figure 19. Diagram. Example plan for evaluating the effectiveness of subarea transportation systems management and operations strategies.⁸⁴

⁸⁴ Adapted from: Oregon Department of Transportation and Metro, *Portland Multimodal Arterial Performance Management Implementation Guidance Document*, February 2013. Available at: http://www.oregonmetro.gov/sites/default/files/Arterial_Measures_Guide.pdf.

CHAPTER 5. TOOLBOX FOR EFFECTIVE TRANSPORTATION SYSTEMS MANAGEMENT AND OPERATIONS PLANNING

There are a variety of tools that can support transportation systems management and operations (TSMO) planning within subareas, and many of them have already been discussed prior to this chapter, including analytical tools and simulation models, the regional intelligent transportation system (ITS) architecture, and archived operations data. (Note: The word “tools” is used in this chapter in the broadest sense—anything that can be used to support and enhance TSMO planning on a subarea.) This chapter offers readers a “toolbox” of analysis instruments and planning techniques that can be applied when planning for TSMO within subareas. For several of the tools described, there is at least one additional Federal Highway Administration (FHWA) guide that can give readers a much greater understanding of how the tool may be applied. This chapter begins with two planning techniques and then moves into quick reference sheet-style descriptions of common types of analysis tools. Following the quick reference sheets are overviews of several specific applications that planners and operators can use to address analysis needs directly while planning for TSMO within subareas.

SCENARIO PLANNING FOR TRANSPORTATION SYSTEMS MANAGEMENT AND OPERATIONS WITHIN SUBAREAS

Scenario planning is an important enhancement to planning for TSMO within a subarea. It can be used to incorporate the consideration of factors that are difficult to predict, such as evolving technology, climate change, shifting traveler behavior, financial uncertainty, failing infrastructure, natural and man-made events, and other unknowns into planning and programming decisions. Scenario planning supports the exploration and consideration of different future conditions in a subarea.

Scenario planning is an approach to strategic planning that uses alternate narratives of plausible futures (or future states) to play out decisions in an effort to make more informed choices and create plans for the future. It engages participants in considering the “what ifs” of tomorrow and whether those are desirable or undesirable outcomes. The simple task of imagining a different future can help to challenge the status quo and encourage creative thinking, which ultimately can lead to the development of more thoughtful and resilient plans. Scenarios are developed to enable participants to test out possible decisions, analyze their impacts given the conditions in each scenario, and come to agreement on a preferred course of action.

Scenario planning follows many of the same planning activities as described in Chapter 3, beginning with scoping the effort, examining current conditions and trends, and then identifying goals and objectives. In scenario planning, the leaders and stakeholders would then develop multiple scenarios or descriptions of possible futures, identify the strategies needed to realize each

of the scenarios, and then analyze the impacts of each scenario against reaching their objectives. The scenario planning approach to TSMO is shown in Figure 20.

Generally, there are three types of scenario planning that reflect the different conditions and purposes for which scenario planning may be used. For example, scenario planning for TSMO within a subarea may be used to identify the most effective package of TSMO strategies given an expected change in conditions on the subarea (trend-based type). Alternatively, scenario planning may be used to build consensus on operations objectives by examining multiple desired future conditions and the strategies needed to support those conditions (normative type). Finally, scenario planning can be used to examine different scenarios in response to uncontrollable or unknown future conditions (e.g., to better understand the impacts of global trade changes, extreme weather, etc.). The purpose of this is to guide stakeholders in identifying policies, plans, and strategies that can work best under all extreme conditions (exploratory type).

Additional information on how to use scenario planning to advance TSMO can be found in FHWA's *Advancing Transportation Systems Management and Operations Through Scenario Planning*.⁸⁷

USE OF ARCHIVED OPERATIONS DATA

Archived operations data is a critical tool in an objectives-driven, performance-based planning approach to TSMO within subareas. Archived operations data is information that is collected and stored in support of day-to-day efforts to monitor and manage the transportation system. Archived operations data can include traffic, transit, bike, pedestrian, construction, and weather information that is usually collected in real time by ITS infrastructure, such as in-pavement inductive loop detectors, radar detectors, remote traffic microwave sensors, Bluetooth, and EZPass or other unique identification tag readers. It also includes incident or event information entered into electronic logs by transportation or public safety personnel. Transportation planners at the State, metropolitan, and local level are finding that, with archived operations data, they are able to do more, be more accurate, and solve more problems than ever before—relying less on assumptions and modeled data and making more effective, less costly decisions.

There are several advantages to having archived operations data available, including:

- Providing a more accurate picture of system performance.
- Opening up new types of analyses to support the planning process.
- Enabling more advanced modeling.

The following are examples of significant uses for archived operations data in planning for TSMO within subareas:

- **Monitoring and evaluating system performance in support of identifying performance issues/needs, project prioritization, and reporting.** Archived travel time data forms the basis for computing a wide variety of congestion, reliability, and freight performance measures.

⁸⁷ Federal Highway Administration, *Advancing Transportation Systems Management and Operations Through Scenario Planning*, FHWA-16-016 (Washington, DC: 2016). Available at: <http://ops.fhwa.dot.gov/publications/fhwahop16016/index.htm>.



Figure 20. Diagram. Phases of scenario planning for transportation systems management and operations.⁸⁶

88 Federal Highway Administration, *Use of Archived Operations Data in Planning*, FHWA-HOP-16-017 (Washington, DC: 2016). Available Summer 2016 at: <http://ops.fhwa.dot.gov/publications/fhwahop16016/index.htm>.

- **Setting performance targets.** Archived data provides information on past trends that are useful in establishing targets.
- **Evaluation of completed projects.** A key component of performance-based planning is the ability to conduct evaluations of completed projects and to use the results to make more informed investment decisions in the future.
- **Trip-based mobility monitoring and accessibility.** Although archived origin-destination travel time data is just becoming available, it is expected to become more prevalent as technology evolves. Origin-destination data makes it possible to monitor the performance of trips taken by travelers.

FHWA has produced a desk reference (*Use of Archived Operations Data in Planning*) on applying archived operations data to planning aimed toward TSMO planners and their planning partners. This desk reference raises planners' awareness of the opportunities afforded through archived operations data and provides guidance on how to take advantage of that data to expand and improve planning practices⁸⁹ It also identifies new and innovative applications for this data in planning. The desk reference is intended to help planners and their operations data partners overcome the barriers to obtaining and using data.

ANALYSIS TOOLS AVAILABLE FOR TRANSPORTATION SYSTEMS MANAGEMENT AND OPERATIONS PLANNING WITHIN SUBAREAS

Below are the quick reference sheets for several types of analysis tools that can be applied for TSMO planning within subareas. The types of analysis tools covered are travel demand models, sketch planning tools, analytic/deterministic tools, simulation tools, and dynamic traffic assignment (DTA) methods.

⁸⁹ Federal Highway Administration, *Use of Archived Operations Data in Planning*, FHWA-HOP-16-017 (Washington, DC: 2016). Available Summer 2016 at: <http://ops.fhwa.dot.gov/publications/fhwahop16016/index.htm>.

Travel Demand Models

Description	Travel demand models are widely used to compare or screen alternatives by using origin-destination (O-D) patterns, demand-to-capacity ratios, differences in percent volumes, and rough estimates of travel times. These models consider land use, demographics, mode choice, and the transportation system (roadway and transit).
Examples	<ul style="list-style-type: none"> • Types of models: <ul style="list-style-type: none"> ◦ Three-step models (no mode choice). ◦ Four-step models. ◦ Activity-based models. ◦ Mesoscale models Software: TransCAD , Emme , and Cube .
Planning for Operations Uses for Subareas	<ul style="list-style-type: none"> • Supply data (e.g., travel forecast inputs) to sketch-planning tools, simulation models, and post-processors that can analyze subarea operations strategies. • Use traffic O-D patterns or volumes for input into subarea simulation models. • Provide changes in peak-hour turning volumes at major intersections and freeway ramp volumes through refined (subarea) travel demand models. • Extract tables with O-D for trips in a focus area as required input for microscopic subarea simulation models. • Screen and evaluate subarea strategies. • Assess mode choice and travel pattern/volume impacts. • Capture linked trips (e.g., home-to-work-to-shopping-to-home), smart growth, walk/bike trips for parcel-level models, and more accurate O-D estimates for use as inputs to simulation models.
Advantages	<ul style="list-style-type: none"> • Validates models available for most metropolitan areas. • Evaluates subarea impacts. • Is consistent with current planning practices. • Is capable of estimating mode choice and travel pattern change reductions due to transit and smart growth.
Challenges	<ul style="list-style-type: none"> • Limited ability to analyze operational strategies. • High initial costs. • Typical travel day does not capture incident, weather, work zones, and special event conditions.

Sketch Planning Tools

Description	<p>Sketch-planning tools provide quick order-of-magnitude estimates with minimal input data (e.g., traffic volumes and speeds) in support of preliminary screening assessments. These tools are appropriate early in the planning process when prioritizing large numbers of projects or strategies for more detailed evaluation. Tools are often spreadsheets or simple databases that are based on built-in assumptions of impacts and benefits for various strategies. Data from sketch-planning tools, such as the Florida ITS Evaluation Tool (FITSEVAL), can be integrated with travel demand model data to provide analysis of operational strategies.</p>
Examples	<ul style="list-style-type: none"> • Tool for Operations Benefit Cost Analysis (TOPS-BC). • ITS Benefit/Cost Database. • California Life-Cycle Benefit/Cost Analysis Model (Cal-B/C). • Florida ITS Evaluation Tool (FITSEVAL). • QuickZone (work zone analysis tool). • Results from other subarea before-and-after studies.
Planning for Operations Uses for Subareas	<ul style="list-style-type: none"> • Evaluate policy-based and subarea transportation systems management and operations (TSMO) strategies. • Screen a large number of potential TSMO strategies and obtain a general idea of whether a strategy is worth investigating further. • Generate expected impacts of TSMO projects that can be compared with other potential investments, such as traditional roadway capacity improvements.
Advantages	<ul style="list-style-type: none"> • Low cost. • Fast analysis times. • Uses readily accessible data. • View of the “big picture.” • Some tools expressly for evaluating policy-based or subarea strategies. • May be integrated with travel demand model.
Challenges	<ul style="list-style-type: none"> • Limited in scope, robustness, and presentation capabilities. • Results constrained by quality of input data and built-in assumptions of impacts. • Not always transferable between agencies.

Analytical/Deterministic Tools

Description	<p>Most analytical/deterministic tools implement the procedures of the <i>Highway Capacity Manual</i>. The following summarize the <i>Highway Capacity Manual</i> procedures:</p> <ul style="list-style-type: none"> • Closed-form: A practitioner inputs data and parameters and, after a sequence of analytical steps, the <i>Highway Capacity Manual</i> procedures produce a single answer. • Macroscopic: Input and output deal with average performance during a 15-minute or a 1-hour analytical period. • Deterministic: Any given set of inputs will always yield the same answer • Static: Predict average operating conditions over a fixed time period and do not deal with transitions in operations from one system state to another. <p>Analytical/deterministic tools quickly predict capacity, density, speed, delay, and queuing on a variety of transportation facilities.</p>
Examples	<ul style="list-style-type: none"> • Highway Capacity Software (HCS). • Traffix.
Planning for Operations Uses for Subareas	<ul style="list-style-type: none"> • Analyze the performance of isolated or small-scale transportation facilities. • Examine impacts under different demand conditions. • Assess a range of traffic control strategies (e.g., uncontrolled, stop-controlled, signalized).
Advantages	<ul style="list-style-type: none"> • Predicts impacts for isolated or small-scale transportation facilities. • Is widely accepted. • Provides repeatable results.
Challenges	<ul style="list-style-type: none"> • Limited ability to assess many transportation systems management and operations (TSMO) strategies. • Limited ability to analyze broader subarea network or system effects. • Limited output of performance measures.

Simulation Tools

Description	<p>Simulation tools use a variety of formulas and algorithms to simulate travel behavior to analyze operations of traffic and transit to conduct needs assessments, alternatives analysis, environmental impact studies, and operations planning. These tools may be deterministic or incorporate stochastic sampling or perturbation. Simulation tools can be classified as:</p> <ul style="list-style-type: none"> • Macroscopic: Simulates average flow, speed, and density on a segment-by-segment basis. • Mesoscopic: Simulates individual vehicles based on average segment speed and density. • Microscopic: Simulates detailed movement of individual vehicles throughout the network. • Multi-resolution: combines tools of different scales (e.g., mesoscopic and microscopic) to identify trade-offs between computational efficiency and modeling accuracy for critical subareas.
Examples	<ul style="list-style-type: none"> • Macroscopic: PASSER, TSIS-CORSIM (includes TRANSYT-7F), and VISTA. • Mesoscopic: DYNASMART-P, DynusT, DTALite, DynaMIT, TransModeler, TRANSIMS, Aimsun, and Dynameq. • Microscopic: TSIS-CORSIM, Paramics, VISSIM, TransModeler, and Aimsun.
Planning for Operations Uses for Subareas	<ul style="list-style-type: none"> • Evaluate a range of improvements and strategies at subarea levels. • Conduct sensitivity testing to reflect variability in traffic demands or incident severity. • Refine project scope and design. • Support environmental assessment.
Advantages	<ul style="list-style-type: none"> • Simulates operations strategies to varying degrees. • Offers extensive and comprehensive model outputs. • Incorporates traffic variations as observed in the field. • Provides dynamic analysis of incidents and real-time diversion patterns when mesoscopic models are used. • Analyze complex conditions and multi-modal interaction. • Offer visual presentation opportunities.
Challenges	<ul style="list-style-type: none"> • Expertise needed to develop and apply models. • Demanding data and computing requirements. • Calibration may be time consuming. • Extensive outputs may require development of separate post-processing tools.

Dynamic Traffic Assignment

Description	<p>DTA is a simulation tool that assigns vehicles to paths based on traffic conditions instead of pre-defined routes using origin-destination data and link path travel time equilibrium. Simulated vehicles can adapt to prevailing conditions, change start times, choose alternative routes, or change modes. DTA often involves a combination of model types representing multi-resolution modeling. The following are requirements for DTA:</p> <ul style="list-style-type: none"> • Travel demand model (highly recommended). • Data for development and calibration. • Origin-destination estimation technique. • Transportation modeling software with DTA capabilities. • Appropriate transportation modeling skill.
Examples	<ul style="list-style-type: none"> • DYNASMART-P. • DynusT. • DTALite • DynaMIT. • Dynameq.
Planning for Operations Uses for Subareas	<ul style="list-style-type: none"> • Simulate the impact of incidents/events. • Evaluate operational strategies that are likely to induce a temporal or spatial pattern shift of traffic. • Estimate travel behavior from various demand/supply changes and interactions. • Conduct analyses involving incidents, construction work zones, active transportation and demand management (ATDM) strategies, congestion pricing, etc.
Advantages	<ul style="list-style-type: none"> • More realism in estimating traveler response and therefore operations. • Wider range of strategies can be more accurately tested.
Challenges	<ul style="list-style-type: none"> • Is resource intensive. • Requires skill sets of both travel demand modeling and simulation modeling.

WEATHER-RESPONSIVE TRAFFIC MANAGEMENT STRATEGIES AND TOOLS

▶▶ *Application to Planning for Transportation Systems Management and Operations within Subareas*

Inclement weather is known to have disruptive impacts on traffic operations and system performance and may temporarily alter travel demand. Neglecting these impacts and changes may lead to decreased performance of the transportation system. Through FHWA's Road Weather Management Program, predictive weather-responsive traffic system management decision support capabilities have been developed and tested, including the weather-sensitive Traffic Estimation and Prediction System (TrEPS).⁹⁰

Within the TrEPS model is DYNASMART-X, a real-time system that continuously interacts with loop detectors, roadside sensors, and vehicle probes to provide real-time estimates of traffic conditions, network flow patterns, and routing information. TrEPS allows weather-responsive traffic management (WRTM) applications to be used in network modeling and simulation tools and demonstrates the potential of WRTM in evaluating and developing strategies for urban areas and subareas as part of the routine functions of planning and operating agencies. In addition, FHWA is trying to improve integrated modeling for road condition prediction (e.g., better integration with weather forecasts/other traffic events, and improved interfacing with existing systems and TMC databases) by enhancing TrEPS functions.⁹¹

▶▶ *Samples of Use*

FHWA used the TrEPS model, calibrated for the Salt Lake City region, to implement and evaluate weather-responsive traffic signal timing in the Riverdale corridor in Ogden, Utah. The goal was to optimize signal timing in a subarea to reduce the impacts of inclement weather events and to prevent or alleviate congestion. Real-time simulation of the traffic network forms the basis of the prediction capability. It fuses historical data with sensor information, and uses a description of how traffic behaves in networks to predict future conditions and develop control measures accordingly. The estimated state of the network and predicted future states are given in terms of flows, travel times, and other time-varying performance characteristics on the various components of the network. These are used in the on-line generation and real-time evaluation of coordinated signal timing along main arterials, for diversion paths, and for weather-related interventions.

When estimating and predicting traffic, TrEPS uses weather data, which allows traffic signal control intervention to be selected in a systematic and continuous process. Signal control intervention is linked to the TrEPS-predicted conditions, including weather conditions and traffic demand observed via roadway and signal sensors. The signal control interventions are linked to the TrEPS-predicted conditions that reflect weather conditions and traffic demand. Real-time traffic data feeds used as the basis for traffic estimation and prediction are obtained directly from sensors that are driving the vehicle-actuated operation of the signals. An important enabler is a

90 Federal Highway Administration, *Implementation of a Weather Responsive Traffic Estimation and Prediction System (TrEPS) for Signal Timing at Utah DOT*, FHWA-JPO-14-140 (Washington, DC: July 2014). Available at: http://ntl.bts.gov/lib/52000/52600/52623/FHWA-JPO-14-140_v2.pdf.

91 Federal Highway Administration, *Integrated Modeling for Road Condition Prediction Concept of Operations*, Unpublished Project Document, November 25, 2015.

scenario manager that allows relatively easy and timely selection of coordination plans given the predicted states, effectively communicated to the system operator. It is an essential link between traffic estimation and prediction and the traffic signal control decisions.

Figure 21 illustrates the overall architecture of the decision support system. The system supports the TMC signal systems operator's decision making in deploying alternative signal timing plans during a weather event by integrating three components—TrEPS, Scenario Manager, and Scenario Library—into the TMC's signal operations. The Scenario Manager is a scenario generation and management tool that serves as an interface between the TrEPS real-time simulation engine and a human decision maker. It facilitates the process of developing and preparing input scenarios for the TrEPS model and the exchange of information between TrEPS and TMC operators. Deploying a particular signal plan involves setting a large number of control parameters for individual traffic signals. From a practical point of view, it often is not feasible for TMC operators to create a new plan whenever parameter adjustments are needed. Therefore, TMC operators commonly maintain a manageable number of pre-defined “canned” action sets (i.e., a Scenario Library), each of which defines all the parameters and coordination settings associated with each timing plan, and simply switch between these existing plans during traffic signal operation. The Scenario Library approach is introduced to aid this type of operation (see Figure 22).⁹²

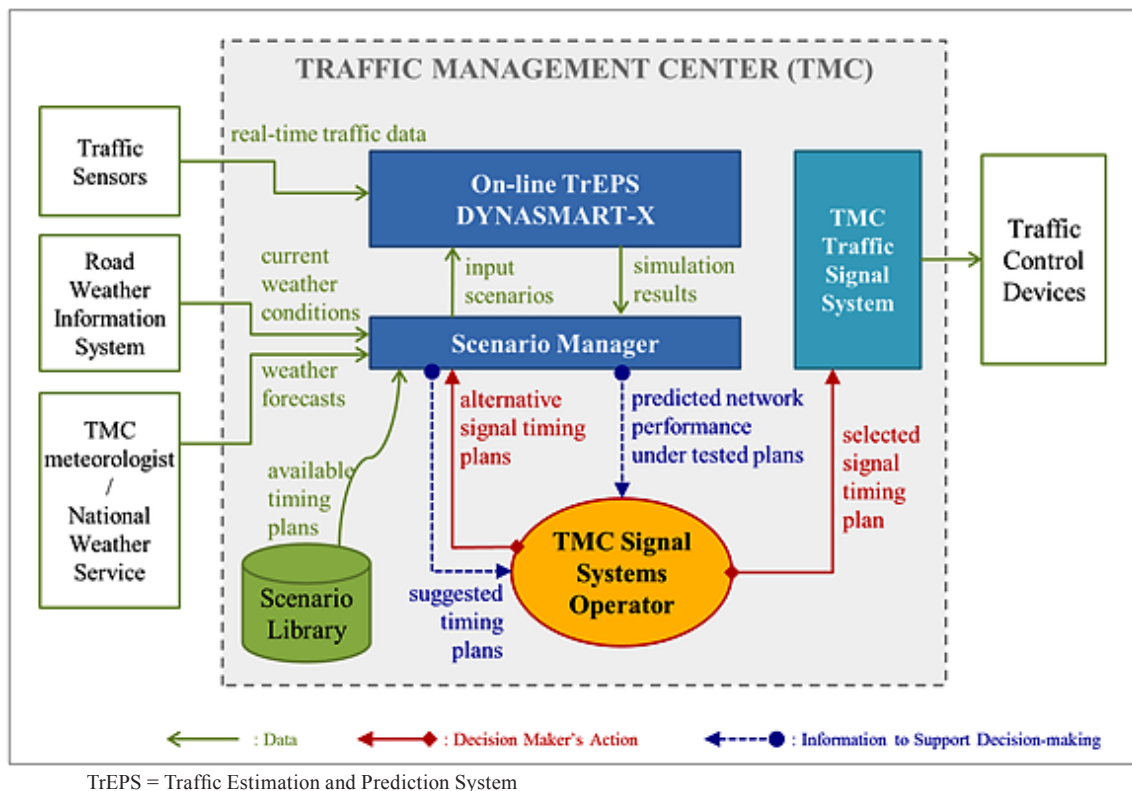


Figure 21. Diagram. Framework of the Traffic Estimation and Prediction System-based decision support framework for weather-responsive traffic signal operations.⁹⁰

92 Federal Highway Administration, Implementation of a Weather Responsive Traffic Estimation and Prediction System (TrEPS) for Signal Timing at Utah DOT, FHWA-JPO-14-140 (Washington, DC: July 2014). Available at: http://ntl.bts.gov/lib/52000/52600/52623/FHWA-JPO-14-140_v2.pdf.

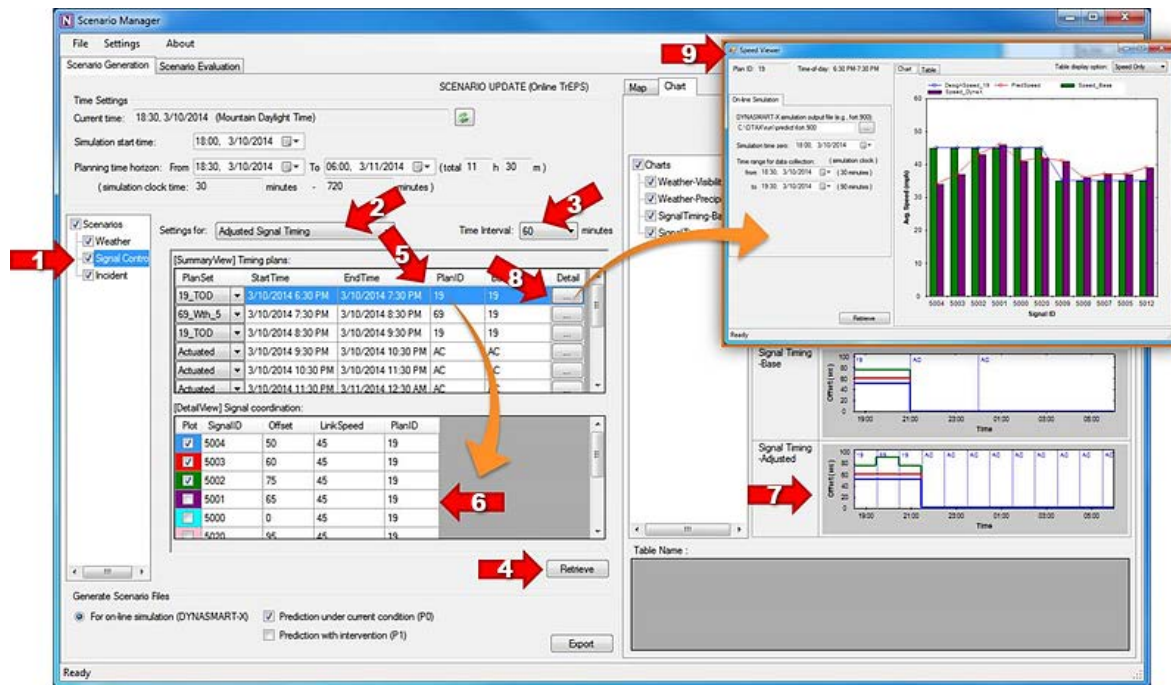


Figure 22. Screenshot. Scenario Manager interface.⁹¹

► Advantages

The potential advantages of TrEPS include:

- Integration of weather effects (from the perspectives of both demand and supply) with traffic estimation and predictions, the results of which form a basis for developing traffic management strategies.
- The use of available real-time measurements to improve the quality of its estimation and future prediction, and thus provide a reliable basis for improved traffic management decisions that anticipate future conditions.
- The use of a Scenario Manager and Scenario Library to simplify and facilitate the human operator's interaction with the predictive system.
- Flexibility in integration of other traffic events (e.g., incidents and work zones) into the analysis framework.
- Flexibility in integration of other operational strategies (e.g., incorporating transit-related and multi-modal capabilities in the interest of greater metropolitan mobility; and integration of fleet routing functionality—for snow removal equipment, preventive sanding, freeze-melting agent spreading, and other logistical processes).

93 Federal Highway Administration, Implementation of a Weather Responsive Traffic Estimation and Prediction System (TrEPS) for Signal Timing at Utah DOT, FHWA-JPO-14-140 (Washington, DC: July 2014). Available at: http://ntl.bts.gov/lib/52000/52600/52623/FHWA-JPO-14-140_v2.pdf.

►► Challenges

While considerable progress has been accomplished to date on the successful deployment of weather responsive TrEPS, there remain several challenges with using the tool:

- Traffic models need to be better integrated with weather forecast systems, and the integration between them (e.g., relationships between rain intensity and roadway capacity reduction) needs to be further studied and quantified.
- Integration with current TMC systems (e.g., interfacing with their database) needs to be strengthened.
- Reliable model performance requires advanced model calibration with large amounts of data, and the calibration depends on data availability, which varies at different TMCs. Therefore, additional real-time data sources (e.g., mobile data and social media) need to be considered in the estimation and prediction process.

TOOL FOR OPERATIONS BENEFIT COST ANALYSIS

The Tool for Operations Benefit Cost Analysis (TOPS-BC) offers a means to determine whether investment in a given TSMO strategy is justifiable in comparison to investment in a traditional capital infrastructure project. The tool was created by FHWA as a sketch-planning benefit-cost analysis tool to support preliminary screening and initial prioritization of TSMO strategies. The TOPS-BC tool has four key functions

- Allows users to look up the expected range of TSMO strategy impacts based on a database of observed impacts in other areas.
- Offers guidance and a selection tool for users to identify appropriate benefit-cost methods and tools based on the input needs of their analysis.
- Supports the ability to estimate life-cycle costs of a wide range of TSMO strategies.
- Enables users to estimate benefits using a spreadsheet-based sketch-planning approach and the comparison with estimated strategy costs.

As a sketch-planning tool, TOPS-BC allows users to quickly understand typical benefits for a range of TSMO strategies and then estimate the benefit-cost ratios for each of those TSMO strategies. The tool also provides a suggested list of analysis tools whose use depends on user selected criteria, such as the level of confidence required, which TSMO strategies are being investigated, key measures of effectiveness, and a few other filters.

The TOPS B-C tool is built on a Microsoft Excel platform and can be downloaded from FHWA's Planning for Operations website at: <http://www.ops.fhwa.dot.gov/plan4ops/topsbctool/index.htm>. TOPS-BC is a companion resource to [FHWA's Operations Benefit/Cost Desk Reference](#).

► *Application to Planning for Transportation Systems Management and Operations within Subareas*

TOPS B-C is a useful tool for analyzing TSMO strategies identified in subarea planning. The strategies included in TOPS B-C are commonly applied in subareas. Table 4 lists those TSMO strategies included in the TOPS-BC tool and indicates whether typical impacts or benefits are provided for the strategy, as well as the availability of more detailed calculation tools for costs and benefits.

Table 4. Strategies included in the Tool for Operations Benefit-Cost Analysis.

TSMO Category	TSMO Strategy	Typical Impacts	Cost	Benefit
Traveler Information	Dynamic message signs.	Yes	Yes	Yes
	Highway advisory radio.	Yes	Yes	Yes
	Pre-trip traveler information.	Yes	Yes	Yes
	Other traveler information strategies.	Yes	No	No
Traffic Signal Coordination Systems	Preset timing.	Yes	Yes	Yes
	Traffic actuated.	Yes	Yes	Yes
	Central control.	Yes	Yes	Yes
	Transit signal priority.	Yes	Yes	No
	Emergency signal priority.	Yes	No	No
Ramp Metering Systems	Central control.	Yes	Yes	Yes
	Traffic actuated.	Yes	Yes	Yes
	Preset timing.	Yes	Yes	Yes
Other Freeway Systems	Traffic incident management.	Yes	Yes	Yes
Advanced Traffic Demand Management	Speed harmonization.	No	Yes	Yes
	Employer-based traveler demand management.	No	Yes	No
	Hard shoulder running.	Yes	Yes	Yes
	High-occupancy toll lanes.	Yes	Yes	Yes
	Road weather management.	Yes	Yes	Yes
	Work zone.	Yes	Yes	Yes
	Advanced public transit systems.	Yes	No	No
Congestion pricing.	Yes	No	No	
Supporting Strategies	Traffic management center.	No	Yes	No
	Loop detection.	No	Yes	No
	Closed circuit television cameras.	No	Yes	No

TSMO = transportation systems management and operations.

► *Samples of Use*

As noted above, the tool exists as a Microsoft Excel spreadsheet with several tabs and color coded cells that clearly identify where the user needs to provide information but also allows the user to modify the spreadsheet as needed.

TOPS-BC calculates an annualized cost for each strategy that incorporates the useful life of the equipment, the replacement cost, and the annual operations and maintenance cost. The net present value of implementing the strategy also is provided, and while default values for the discount rate and time horizon are provided, the user can change those values.

The cost components for each TSMO strategy are broken down into two categories: the one-time costs to create the backbone structure for the strategy (e.g., software and system integration), and the incremental cost of each additional installation (e.g., additional loops, weather stations, and dynamic message signs). Default costs are included in the spreadsheet for all of the cost components. The user simply needs to enter the number of infrastructure deployments and the number of incremental deployments.

The annual benefits calculated by TOPS-BC focus on travel time savings for both recurring and non-recurring congestion, energy/fuel savings, and savings due to reduced crashes. A tab marked “Parameters” includes all of the assumptions used to calculate the benefits, such as:

- Cost of fuel.
- Fuel economy of autos and trucks.
- Cost of hourly travel for autos and trucks.
- Typical percent of trucks on the facility.
- Cost of crashes by severity.
- Typical emissions.
- Typical crash rates by facilities.
- Speed-flow relationships.
- Typical incident delay factors.

If local information is known, in particular the percentage of trucks on the facility and crash rates on the facility by severity, those can be modified to provide a more accurate assessment of benefits. However, if local factors are not known, the default values make the tool ready to use for an approximation of the benefit for the desired TSMO countermeasure.

As with the cost component, each strategy has its own tab to calculate benefits. Again, color-coded cells are used to help the user identify where input is required. A basic benefit analysis requires minimal input from the users. For example, to calculate the benefits for dynamic message signs, the user is required to provide three pieces of information:

- Length of the analysis period.
- Type of traveler information (three options are provided on a pull-down menu).
- Traffic volume passing the sign location(s) during the period of analysis.

There are additional categories where default values are provided, or the user can override those values when location-specific information is known. For example, the ramp meter benefits assessment assumes a freeway free flow speed of 55 miles per hour and a ramp free flow speed of 35 miles per hour. Both of those values can be overridden if local data are known.

In addition to the benefit tabs for each strategy, the tool contains a generic link-based analysis tab that can be used to enter benefits related to a TSMO strategy not specifically identified. The TOPS-BC tool also includes a summary tab that allows the user to select some or all of the strategies for a total benefit-cost summary.

► *Advantages*

The following are advantages of the TOPS B-C tool:

- The tool provides information that can be used in conjunction with benefit-cost analyses for capital infrastructure, which can be useful when comparing TSMO and capital infrastructure projects.
- It is customizable; therefore, if better data is available, the user can easily modify the spreadsheet with project-specific costs or add components.

► *Challenges from Training*

The right-of-way acquisition is an important component that is not captured in the cost-estimating tool.⁹⁴

⁹⁴ For more information and access to the TOPS BC tool, refer to FHWA's TOPS- BC web page at: <http://www.ops.fhwa.dot.gov/plan4ops/topsbctool/index.htm>.

CHAPTER 6. TAKING ACTION

While transportation system management and operations (TSMO) within subareas can be advanced in many ways and can involve coordination among operating agencies and key constituencies in the area, it doesn't have to be a daunting process. The scope of the effort can be scaled to the needs and challenges of the subarea and can be integrated into ongoing operational coordination efforts and planning studies.

The checklist below summarizes the key points presented in this document and can be used to guide the process for developing a TSMO plan for a subarea.

❑ **Scoping the Effort and Building a Team.**

The team working on a subarea planning study or operations plan should encompass many different agencies and partners who together operate services and influence operations in the subarea. The team may come from a range of different agencies and service providers, including transit providers, local bus services, bicycle and pedestrian advocates, chambers of commerce, tourism bureaus, neighborhood associations, utilities, goods movement, and other constituencies affected by changes and improvements in the subarea. In addition, it is valuable to involve planners, traffic engineers, transit operators, law enforcement, and other organizations that play a key role in the subarea. Getting the agencies and other constituencies together is often a critical component of success in gaining an early understanding of who operates in the subarea, what their opportunities are for enhancing operations, and ways to work together to optimize system performance to the benefit of travelers, and others who depend upon or are affected by the transportation system in the subarea.

Transportation planning in a subarea should build off of broader planning efforts for TSMO as well as operations programs and strategies at a regional and State level. Regardless of the size of the subarea, planning for transportation operations should recognize and build upon existing programs that can benefit the transportation system users and operators.

Develop a clear definition of the subarea where TSMO strategies are to be introduced. While an effort to advance TSMO can focus on limited facilities within the subarea, the subarea should be looked upon as more than an individual or independent geographic area and should consider the interconnected nature of movement within, into, and out of the subarea to maximize the effectiveness of the selected TSMO strategies. Components of a subarea may include a surface streets, major arterials, transit rail and bus services, bicycle and pedestrian facilities, parking, and provisions for accommodating rideshare programs.

Think carefully about the boundaries and definition of a subarea to assess and develop solutions comprehensively. Defining a subarea will often start with a review of data on travel patterns (including origin-destination data) and connecting networks and choices available to travelers, which are informed by public perceptions.

❑ **Gathering Information on Current and Future Contexts and Conditions.**

Compile information on the transportation assets, capabilities, and resources that exist within the subarea. Document existing ITS equipment, real-time traffic and bus monitoring, park and ride facilities, traffic signal timing plans, and other technologies and facilities relating to subarea operations, since operational improvements can build upon these assets. In addition, identify available resources, such as transit traveler information systems, ridesharing programs, and incident management programs.

❑ **Developing an Outcome-Oriented Operational Concept – Goals, Objectives, and Performance Measures.**

This may be the most important step in the process since it establishes how the subarea is expected to perform once TSMO strategies are implemented and operated on a day-to-day basis. Operations objectives are developed through interactions with partners and stakeholders who help define the intended objectives and performance outcomes for the subarea. These objectives can be further refined through a study process, but the initial identification of objectives is critical for setting the context for developing and evaluating subarea TSMO strategies. Objectives can be expressed in the form of an objectives tree that shows how higher level objectives are reached by first achieving lower level objectives that support them.

❑ **Identifying Operations Performance Needs, Gaps, and Opportunities.**

Gather and analyze data for performance measures to identify existing gaps between desired outcomes (objectives) and current conditions as well as potential opportunities for improvement. Define scenarios or conduct a scenario planning exercise as a basis for understanding current performance gaps and potential opportunities. By defining scenarios, participants in the subarea can identify existing gaps, performance needs, and opportunities for improvements. In many cases, performance data are available that clearly demonstrate where problems exist and need attention, which leads to understanding where investments are needed and what efforts should be prioritized in the planning process.

❑ **Developing an Integrated TSMO Approach.**

Consider TSMO strategies working together in the context of the subarea as opposed to selecting and implementing strategies in isolation. Planning for an integrated set of strategies allows planners and operators to leverage synergies among strategies. Build on the assessment of potential strategies using available analysis tools so that the subarea plan involves a set of promising strategies that achieve the operations objectives for the subarea. Given the wide array of potential strategies to consider, include those that focus on highway and traffic operations, transit operations, demand management, and capacity. Selecting strategies for a subarea involves both quantitative and qualitative assessments of what would work best to fit within the specific context of the subarea.

❑ **Putting it All Together: Efficiency, Reliability, Travel Options, Non-Recurring Delay, Arterial Management, Freeway Management, and Transit Operations and Management.**

The Federal Highway Administration (FHWA) document *[Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations](#)* provides a guide for assembling a range of complementary TMSO strategies that, together, provide wide-ranging benefits to subarea management and operations. This document, along with other FHWA references and guides, helps to address the range of needs for improving subarea performance.

❑ **Programming for TSMO.**

Identify and understand the various sources of funding for TSMO strategies in the subarea and prioritize TSMO projects based on funding availability and potential benefits. Use an incremental investment approach that gains benefits from early implementation while maintaining a strategic view of fully implemented solutions in the subarea.

❑ **Implementing, Monitoring, and Maintaining Level of Operations over Time.**

Apply well-tested systems engineering processes to ensure that system requirements are properly specified and achieved in systems design and deployment and that the subarea plan includes consideration for life cycle management and operation.

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