SOUTHWEST REGION TSMO PLANNING IN TRANSPORTATION CORRIDORS

GUIDEBOOK FOR INTEGRATING TRANSPORTATION SYSTEMS MANAGEMENT AND OPERATIONS INTO CORRIDOR PLANNING

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PREPARED FOR:

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WSDOT

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INTRODUCTION

This guidebook is designed to equip state, regional, and local transportation operations and planning professionals with the knowledge, tools, and processes necessary to effectively plan for and implement Transportation System Management and Operations (TSMO) strategies in corridors with varied geographic, social, and institutional contexts. Its purpose is to support transportation planners and operations staff in planning for and applying TSMO activities within corridors to achieve a more reliable, efficient, equitable, and livable outcome from their existing and planned transportation infrastructure.

The guidebook brings together planning and operations approaches, practices, a package of project deployments and lessons that have been developed over the past two decades and provides consolidated assistance on planning and operations for TSMO at the corridor level with an effective and sustainable strategy. Utilizing a planning for operations approach at a corridor level can help to focus on key issues (e.g., mobility, reliability, and safety) from a multimodal perspective and result in a package of cost-effective solutions and programs that may not otherwise have been fully considered.

The document describes planning for TSMO at the corridor level so that readers can tailor and apply this approach in a variety of corridor contexts. This guidebook is founded upon three Federal Highway Administration (FHWA) themes for success that cut across all TSMO planning efforts:

1. Use of an objectives-driven, performance-based approach
2. Collaboration across agencies, jurisdictions, and modes
3. Linking to overarching planning processes at the metropolitan, regional, or statewide level where applicable

Note: This guidebook is an adaptation of the FHWA publication, *Planning for Transportation Systems Management and Operations Within Corridors: A Desk Reference* (2016)[1], modified to reflect WSDOT's specific TSMO program goals and contexts specific to corridor planning at WSDOT. Material from the FHWA publication that was deemed relevant to corridor planning in WSDOT was carried over into this guidebook.

RECOMMENDATIONS TO MAINSTREAM THE TSMO APPROACH IN CORRIDOR PLANNING

In the course of developing this guidebook, the project team identified several programmatic recommendations to mainstream the TSMO approach in corridor planning. These recommendations are:

- Make this guidebook an essential resource for Southwest Region (SWR) corridor planning staff
- Incorporate M2 (multimodal, multidisciplinary) Team review into the formal process
- Get endorsement from leadership; have a champion so TSMO is supported from the top down
- Make sure the guidebook can be reproduced for other regions across the state

[1] FHWA: https://ops.fhwa.dot.gov/publications/fhwahop16037/index.htm

WHAT IS TSMO?

Transportation Systems Management and Operations (TSMO), as defined by Federal Highway Administration, refers to a set of strategies that focus on operational improvements that can maintain and even restore the performance of the existing transportation system before extra capacity is needed. WSDOT has incorporated TSMO into its *Practical Solutions*[2] approach as a key tool to improve the operations and management of the integrated multimodal transportation system. TSMO strategies often make use of Intelligent Transportation System (ITS) technologies, including Work Zone Management, Road Weather Management, Incident Response, and Transportation Demand Management (TDM). But TSMO also encompasses non-technology solutions, including land use, cooperative agreements, and access control. TSMO is also complementary to WSDOT's *Complete Streets*[3] initiatives. While broader in scope and breadth than Complete Streets, TSMO solutions can be applied to achieve the objectives of Complete Streets. As stated in the WSDOT TSMO Program Plan, TSMO solutions address safety, multimodal access, improved operations, and improved reliability at a much lower cost than expansion projects.

FHWA'S TSMO DEFINITION

An integrated set of 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.

23 USC 101 (a) (3)

ALIGNING TSMO WITH CORE WSDOT VALUES

EFFECTIVE TSMO STRATEGIES MEET THE FOLLOWING VALUES

Safety: Keep people safe and help achieve target zero.

Sustainability: Improve energy efficiency, reduce pollution, and enhance resiliency.

Equity: Create equitable access to reliable and affordable transportation options.

Performance: Balance the priorities of safety, efficiency, and reliability to increase multimodal mobility.

WSDOT TSMO Program Plan (2022)

As reflected in the WSDOT TSMO Program Plan, the agency prioritizes TSMO strategies and approaches that support the agency's core values, including safety, sustainability, equity, and performance.

[2] https://wsdot.wa.gov/engineering-standards/advancing-practical-solutions

[3] https://wsdot.wa.gov/construction-planning/complete-streets

WSDOT'S BUSINESS CASE FOR TSMO

The business case for TSMO is fundamentally about using cost-effective solutions that are easily implemented to address safety and mobility on WSDOT's multimodal system. There are more needs than funds available to address transportation problems throughout the state and it is WSDOT's duty to preserve and maintain the billions of dollars of investments already made. By applying cost-effective solutions, WSDOT can direct more funds toward preservation and maintenance of the existing system. (See examples and benefits of cost-effective solutions at tsmowa.org).

EXAMPLES OF TSMO IN WSDOT

WSDOT Regions have been at the forefront of TSMO implementation in the state. A few notable examples are highlighted below.

- **SR-14 Bus on Shoulder** Pilot Project with C-TRAN in the Southwest Region improved bus speeds by 33.2 percent during the bus route's slowest timeframe (7:30 – 8:00 am) and reduced the need to place extra buses into service.

- **I-5 Active Traffic Management** project in the Northwest Region brought 1.3 percent reduction in weekday collisions and 14 percent reduction in weekend collisions using variable speed limits, lane controls, and queue warning systems.

- **Argonne Road Automated Traffic Signal Performance Measures (ATSPMs)** project in the Eastern Region (Spokane) installed ATSPM on the corridor to monitor traffic conditions in real-time and enabled rapid identification of issues and adjustments to signal timing to improve travel times throughout the day. The project resulted in 20 percent reduction in northbound travel times and four percent in southbound.

- **I-5 Woodland Smart Work Zone System** implementation in the Southwest Region provided motorists real-time delay information, traffic queue warnings, and merging guidance ("zipper merges") to reduce project duration, reduce collisions, and improve traffic flow around the work zone.

- **Urban Freeway Corridor Operations (UFCO) Study** in the Southwest Region identified a tiered set of near-term operational and system management TSMO strategies on I-5, I-205, SR 500 and SR 14. The low-cost capital improvements and technology-based TSMO tools provided both flexibility and guidance to WSDOT in prioritizing investments that align with specific system needs, funding sources, and existing and future priorities.

STATEWIDE TSMO GUIDANCE

WSDOT's TSMO vision is to prioritize cost-effective solutions that improve the accessibility and efficiency of the multimodal transportation system. Realizing this vision requires more than just identifying TSMO strategies, however. Effective TSMO requires operational considerations and performance-oriented decision-making to be integrated throughout the project development process—from policy, to planning, design, construction, and operations and maintenance. Therefore, TSMO must also entail institutional and programmatic changes to business processes, organizational structure, culture, and internal and external partnering to ensure that all WSDOT elements are aligned.

The 2022 WSDOT TSMO Program Plan is the primary resource for statewide TSMO guidance. It can be accessed on the TSMO WA website, https://tsmowa.org/, along with various other resources, including links to relevant publications and WSDOT TSMO case studies, which are maintained on the continually updated Resources page.

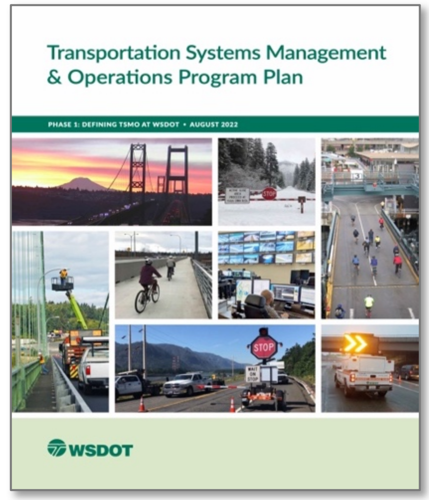
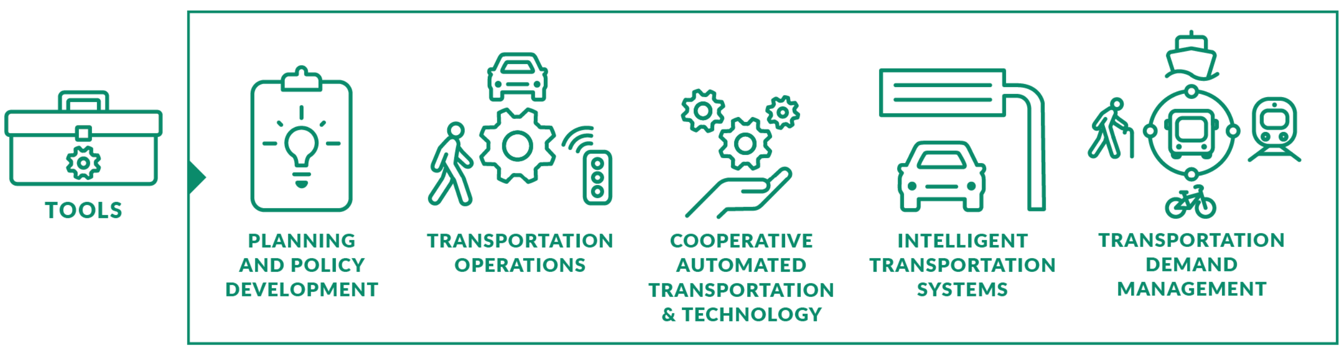


FIGURE 1: WSDOT STATEWIDE TSMO PROGRAM PLAN

The TSMO WA website defines the five broad categories of strategies and concepts that comprise the toolbox of TSMO solutions: Planning and Policy Development, Transportation Operations, Cooperative Automated Transportation & Technology, Intelligent Transportation Systems, and Transportation Demand Management (TDM).



1. **Planning and Policy Development:** Efforts to further integrate TSMO into WSDOT's guiding policies and documents. Examples include the Long-Range Transportation Plan, Highway System Plan, various modal plans, and other policy guidance for project development from the very early stages of planning through preservation and maintenance.

2. **Transportation Operations:** Focuses on moving people and goods safely and efficiently. The seven traffic management centers throughout the state serve as the nerve center for traffic management activities connecting to thousands of sensing devices to manage congestion and enabling quick response to incidents. Examples include peak-use shoulders, high-occupancy vehicle (HOV) lanes, ramp meters, bus rapid transit, and freight truck parking systems.

3. **Cooperative Automated Transportation & Technology:** Focuses on technologies to support the use of safe and sustainable modes of transportation. The advancement of wireless technology, data aggregation, and real-time analysis enables WSDOT to support smart mobility options. Examples include micro mobility, the use of connected vehicle technology, and freight automaton support.

4. **Intelligent Transportation Systems:** The integration of advanced communications technology in transportation infrastructure and vehicles to enhance mobility and safety across modes. ITS solutions are cost effective and can be quickly implemented when compared to traditional capacity improvements. ITS solutions can also collect data for insights on safety and performance of the transportation network. Examples include variable message signs notifying drivers of weather or congestion, road weather cameras so travelers can check their trip route before heading out, and smart work zone practices.

5. **Transportation Demand Management:** Describes programs and projects that aim to provide more competitive transportation options to driving alone, reduce trips, and improve traffic congestion without building more roads. Strategies include education, incentives, and disincentives to reduce the need for vehicle trips, and to shift to higher occupancy modes like transit and ridesharing.

Finally, the TSMO WA website also provides a comprehensive list of TSMO strategies and concepts that are recognized by WSDOT and partnering stakeholders on the Strategies & Concepts tab. This section of the website allows the user to learn more about various TSMO strategies, filtered and customized based on Category, Setting/Locations, WSDOT Regions, Cost, Technology, and Collaboration.

In addition to those key characteristics, each strategy includes a description, guidance on when to use the strategy, what is needed for implementation, links to related strategies, and conditions (e.g., travel times, accommodating multiple modes) addressed by the strategy.

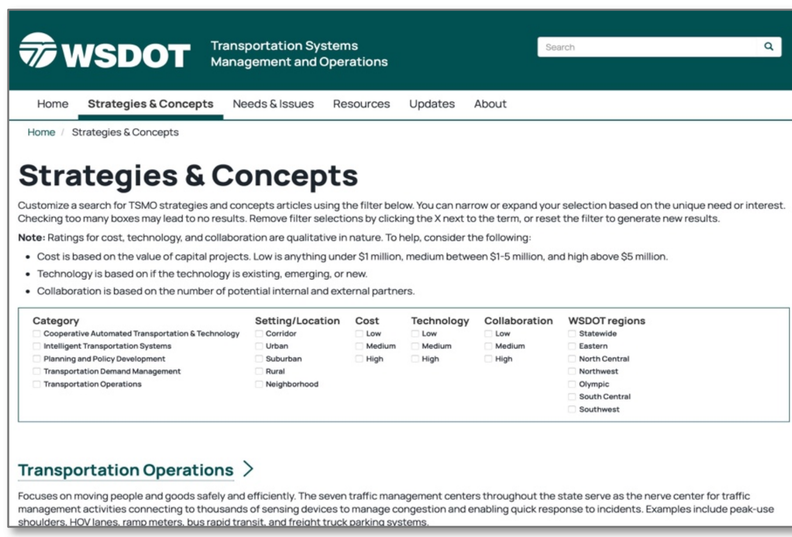


FIGURE 2: TSMO STRATEGIES REFERENCE INFORMATION ON TSMO WA WEBSITE

WHY IS PLANNING FOR TSMO IN CORRIDORS NEEDED?

The benefits of TSMO within corridors 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. Obtaining these resources and making best use of them is a planning function.

If TSMO is to be implemented effectively within corridors, there are several planning activities that need to occur prior to implementation:

- Properly scoping the TSMO effort by obtaining input from all stakeholders in the corridor
- Collaboration between all agencies or parties involved in the corridor planning effort
- Identification and agreement on the need for action and desired corridor objectives (or outcomes)
- Consideration of alternative solutions
- Estimation of benefits and impacts on the corridor
- Identification of resource needs and sources
- Approval from relevant decisionmakers
- Plan for ongoing corridor operations and maintenance

EXAMPLE INTEGRATION OPPORTUNITIES AND BENEFITS

Traditionally, transportation planning and TSMO have been largely independent activities. Planners typically focus on long-range transportation plans and project programming. And historically, planning has identified capacity expansion versus use or reallocation of existing space. Operators are primarily concerned with addressing immediate system needs, such as incident response, traffic control, and work zone management. Planning for TSMO connects these two vital components of transportation, bringing operations needs and solutions to the corridor planning processes and likewise bringing longer-term, strategic planning to operations managers.

The following examples demonstrate the need for planning for TSMO within corridors. The examples are a small set of commonly missed opportunities for improving the operational performance of corridors through TSMO planning.

Incorporate TSMO as a consideration in the corridor planning processes led by the Planning Group.

- **Issue:** When planning groups conduct corridor-level plans, the TSMO perspective is often 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. In this way, agencies miss the opportunity to integrate TSMO with the tools that can help address community needs and achieve community goals.

- **Opportunity:** By incorporating TSMO planning practices and strategies into the stages of goal setting, existing conditions assessment, alternatives development and analysis, and project selection, the result is a more balanced plan that includes both operational and infrastructure solutions. These investments are often more cost-effective and achievable in the near term.

Link Operations Group-led corridor optimization efforts with WSDOT's overarching policy framework and planning process.

- **Issue:** 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 traveler information along a major corridor, including freeway and arterial travel times. Their vision is to install several variable message signs along the corridor facilities and support it with travel time data from a third-party data provider.

- **Opportunity:** By coordinating with the overarching planning process, the traffic operations group can align the operational benefits with the broader goals identified in long-range transportation plans to draw champions at the local and regional levels, who may, in turn, open doors to funding and other resources, including integration with other projects.

Incorporate land use considerations into corridor planning.

- **Issue:** Land use often predicts travel demand and, conversely, high-capacity routes often determine land uses. The relationship between land use and transportation is manifested by the volume of travel demand, an indicator that people have chosen certain routes connecting the origins and destinations of greatest interest. However, land use has not traditionally been a significant consideration in corridor plans.

- **Opportunity:** When land use and transportation have been well coordinated, travel times are reliable and vehicle miles traveled (VMT) are lower. Existing and expected land use and demographics should be summarized at the corridor level. This includes a brief description of the place types within the corridor area, as well as a general description of local and regional land use, demographic characteristics, broadband, environmental, and development plans.

CORRIDOR CONTEXT CONSIDERATIONS

When developing strategies for TSMO within corridors, it is critical to understand the context for the corridor, including surrounding land uses and development patterns, available travel options (e.g., highway, road network, transit, and non-motorized options), and the types of system users (e.g., freight, commuters, and interstate travelers) and their needs and priorities. A corridor generally includes multiple freeways, arterial roadways, transit services, bicycle and pedestrian connections, park-and-ride lots, and rideshare services serving people traveling in similar directions.

Three general corridor context types applicable to the Region are described below. These are:

- **Type 1: Urban Core**
- **Type 2: Suburban or Urbanized Area**
- **Type 3: Rural Area Corridor**

Type 1: Urban Core

Urban centers are dense areas with high levels of activity and where complex, multimodal transportation systems offer options for taking transit, walking, and biking. Corridor planning in urban centers may be focused on a major arterial roadway, a rail line or major bus corridor, or a combination.

FIGURE 3: DOWNTOWN VANCOUVER

Attributes: High complexity, Major arterial and/or transit line “spine”

Regional examples: Vancouver downtown area and more densely developed commercial corridors

Typical areas of need:

- Multimodal system performance
- Managing travel demand

Example TSMO strategies:

- Parking management
- Transit signal priority
- Connected multimodal networks to encourage and support mode shift
- Bike sharing
- Pedestrian countdown signals
- Real-time, multimodal traveler information
- Traffic signal coordination

Type 2: Suburban or Urbanized Area

Suburban communities are less dense than a downtown core, and corridors are often defined based on major highways or arterials that may serve a combination of commuters, other travelers, and freight.

FIGURE 4: SR 503 IN CLARK COUNTY

Attributes: High complexity, Major freeway "spine"

Regional examples: I-5 (in Vancouver, Longview, and Chehalis), I-205, SR 503, and SR 14 (in Vancouver area)

Typical areas of need:

- Managing traffic and incidents to provide predictable travel times
- Shifting demand to transit and ridesharing
- Balancing travel loads across the network

Example TSMO strategies:

- Adaptive ramp metering
- Dynamic high-occupancy vehicle or managed lanes
- Dynamic merge or junction control management
- Land use and zoning to promote compact land use and active transportation

Type 3: Rural Area Corridors

In rural areas, development is limited and dispersed, and travel options are often limited. While congestion is generally a minor concern, traffic safety and weather conditions (e.g., snow, ice, rain, and fog) are often significant concerns. Some rural areas also may 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 areas may not warrant deployment in these locations.

FIGURE 5: SR 4 IN SKAMOKAWA VALLEY

Regional examples: SR 4, SR 6, US 12, SR 504, and SR 14

Typical areas of need: Corridors in rural areas require a flexible approach tailored to specific characteristics of the corridor

Example TSMO strategies:

- Road weather management
- Dynamic routing
- Rural bus stops

APPROACH TO INCORPORATING TSMO IN CORRIDOR PLANNING

This section provides summary-level guidance for practitioners on how to incorporate TSMO-supportive activities within the corridor planning process. Real-world WSDOT and partner agency examples are presented alongside the guidance to help illustrate how key guidance steps have been applied in practice.

OVERVIEW

This guidance comprises seven fundamental activities that will typically need to occur when planning for TSMO on a corridor regardless of the type of corridor and the planning context. Together, these sequenced activities form the basis for an approach to planning and preparing for the implementation of TSMO strategies in corridors. This approach is outlined in Figure 6 below. This figure will be used throughout this section to highlight the major activities. The process outlined here is based on FHWA-developed publications for advancing TSMO at the metropolitan panning level and within corridors. Adaptations were made to account for the specific context of the WSDOT SWR and the priorities of WSDOT planning.

The process includes following seven steps:

1. Begin with a problem statement (external to Planning).
2. Scope the effort and build a team / Establish a corridor operations vision.
3. Analyze current and future context and conditions.
4. Develop goals, objectives, and performance measures.
5. Identify performance needs, gaps, and opportunities.
6. Identify, evaluate, and select TSMO strategies.
7. Program and implement TSMO on the corridor (external to Planning).

Finally, ongoing performance monitoring throughout implementation and operations feeds back into the process, which enables continuous operational improvement and provides insights for future corridor planning efforts.

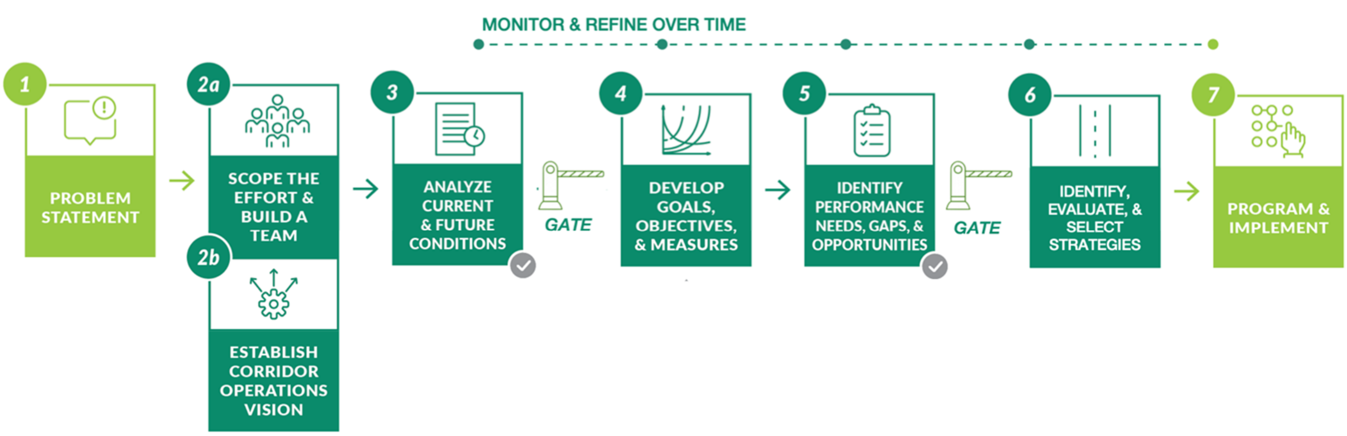
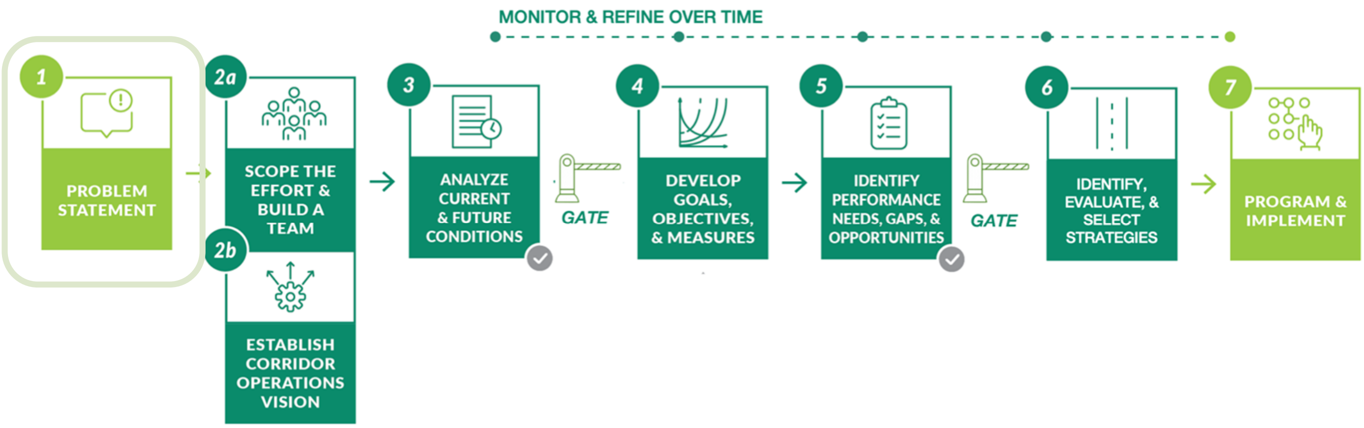


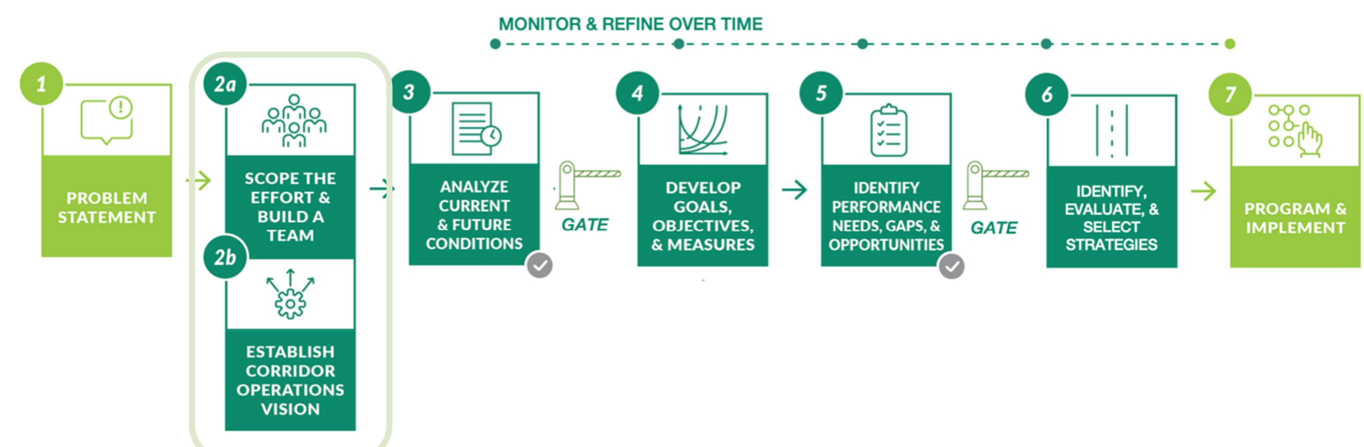
FIGURE 6: MODEL PROCESS FOR TSMO-ORIENTED CORRIDOR PLANNING

1. START WITH THE PROBLEM STATEMENT



The initial step of the model corridor planning process serves as the input to the rest of the flow and often originates externally of the Planning Group. The problem statement is what motivates the initiation of the corridor study and establishes the need. The authorization for the study may come from WSDOT or externally, such as by the Legislature through budget proviso or in partnership with a local agency partner. Often, this initial stage sets loose geographic and scope boundaries for the effort to follow, which in turn defines the stakeholders and facility owners and operators who will be involved.

2. SCOPE THE EFFORT AND BUILD A TEAM / ESTABLISH A CORRIDOR OPERATIONS VISION



Developing an effective corridor plan or system management plan begins with scoping the effort and building a team of partners and stakeholders to work together on its development. However, constituting an effective team and developing a scope depends in part on what the corridor vision entails. For that reason, Step 2 combines two sub-steps—(2a) *Scope the effort and build a team* and (2b) *Establish a corridor operations vision*—which occur together iteratively and inform the outcomes of each. Each stakeholder of the team may have their own ideas for what the vision for the corridor should be. But it is at this stage where the group should come together, drawing from their perspectives and knowledge of the corridor, to reach agreement on an appropriate overall vision for the corridor.

Key Actions:

- ☐ **Develop a clear definition of the corridor.** It should be more than just an individual facility; consider the interconnected nature of travel across facilities in a travel shed.
- ☐ **Identify relevant procedures and guidelines**. Consult WSDOT, Metropolitan Planning Organization (MPO), Regional Transportation Planning Organization (RTPO), local agency, and tribal procedures and guidelines best suited to the effort. Look for documentation of outcome-oriented objectives, performance measurement, conditions analysis, strategy identification and evaluation, and public involvement.
- ☐ **Build an effective, representative team**. A successful team-building effort will seek to build on an existing collaborative group, ensure committed champions, establish an internal communications plan, conduct early public outreach, engage informally with key stakeholders, and collect and use demographic data.
- ☐ **Establish a flexible and creative vision elicitation process.** Allow the vision-setting process to be culture-specific: it can be highly analytical or highly creative, and can take the form of focused discussions, charettes, or sharing divergent experiences and stories.
- ☐ **Craft an overall vision statement for the corridor.** A vision statement can be a compelling description of the future of the study area, function of the corridor, and how it should appear over time (e.g., context sensitive goals). However, it should be realistic and aligned with WSDOT's mission and vision.

DEVELOP A CLEAR DEFINITION OF THE CORRIDOR

While an effort to advance TSMO can focus on one facility, a corridor should be looked upon as more than an individual facility and should consider the interconnected nature of travel across facilities in a travel shed to maximize the effectiveness of the selected TSMO strategies. Components of a corridor may include a freeway; major arterials; local road networks; transit rail and bus services; and transportation services, including rideshare programs and parking facilities. Consider pedestrian, bike, transit, multimodal access, freight, and land use.

Think carefully about the boundaries and definition of a corridor to assess and develop solutions comprehensively. Defining a corridor often begins 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.

IDENTIFY RELEVANT PROCEDURES AND GUIDELINES

Identify the WSDOT, MPO, RTPO, local agency, and tribal procedures and guidelines best suited to the effort regarding items such as outcome-oriented objectives, performance measurement, conditions analysis, strategy identification and evaluation, and public involvement.

Transportation planning in a corridor should build off broader planning efforts for TSMO as well as existing operations programs and strategies at a regional and state level. Regardless of the size of the corridor, planning for corridor operations should recognize and build upon existing programs that can benefit the corridor, including:

- Existing ITS infrastructure, such as fiber optic communications 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 corridor
- Regional incident management and response programs, which can be expanded or targeted to address corridor-specific issues
- Work zone management strategies used in transportation management plans for significant projects
- Regional TDM programs, which often include ride matching services, employer outreach, and public outreach and incentives to encourage use of alternatives to driving alone

BUILD AN EFFECTIVE, REPRESENTATIVE TEAM

The team working on a corridor planning study or operations plan should encompass many different agencies and partners who, together, operate services and influence operations in the corridor. The team may include multiple jurisdictions (state, county, city, other municipality), as well as a range of different agencies and service providers, which may include regional transit providers, local bus services, toll authorities, port authorities, vanpool operators, transportation management associations, or others. In addition, it is valuable to involve planners, traffic engineers, transit operators, law enforcement, and other organizations that play a key role in the corridor. Getting the agencies together is often a critical component of success in gaining an early understanding of who operates in the corridor, what their opportunities are for enhancing operations, and ways to work together to optimize system performance.

- **Build on an existing collaborative group.** Use 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 corridor project into its meeting agendas.
- **Ensure at least one committed champion.** Ideally, the champion has a clear vision of the desired outcome, brings the stakeholders together, ensures they are engaged, and works to get the support needed to achieve the desired outcomes.
- **Establish an internal communications plan.** Developing an internal communications plan should become routine after a few Corridor Plans are completed within a region. However, because staff members and management change over time, you should reevaluate the basic approach to internal communications periodically. After the Corridor Planning Study Team has been identified, make minor adjustments to the internal communications plan to reflect individual needs and communication style preferences.
- **Identify public outreach need and approach.** While the work plan for the corridor study is being drafted, be sure to involve the

EARLY COMMUNITY ENGAGEMENT EXAMPLE: SR 503 COMMUNITY ENGAGEMENT PLAN

Early in the SR 503 corridor study project, the project team developed a comprehensive Community Engagement Plan to ensure that community needs would be adequately captured in the project vision, goals, and objectives. The Plan included milestones and strategies for community engagement, including when to host the online open house and virtual public meeting.

By beginning the engagement planning process early, the team was able to identify the unique need to provide special translation/interpretation services to meet the language needs of a Ukrainian- and Russian-speaking community.

region communications office to ensure that adequate budget is set aside for the appropriate level of community assessment and public involvement activities.

- **Conduct early and informal engagement with stakeholders.** Prior to drafting the final work plan for the corridor study, have an informal discussion with selected stakeholders, including but not limited to MPOs, RTPOs, tribes, cities, and counties. These informal conversations may be better suited to one-on-one and in a casual setting. Each region will have a unique approach to communicating with stakeholders. The important point to remember is that there is never too much communication. During these meetings is a good time to gauge the level of participation that the stakeholders can contribute to your plan. The participation capacity for each stakeholder is different, and you may need to develop creative ways to communicate with certain entities.

- **Collect and use demographic data.** Identifying the size and location of low-income and minority population groups is an important first step toward assessing whether transportation system investments disproportionately burden or fail to meet the needs of any segment of the population. When developing an outreach plan, a demographic analysis should be conducted paying special attention to protected populations including minority, low-income, non-English speaking, senior citizens, and disabled. Once determined, demographic information should be used to shape WSDOT's outreach strategy including how the agency will engage with protected populations and if language translation and interpretation services will be required. An effective tool for performing demographic analyses is the U.S. Environmental Protection Agency's Environmental Justice EJScreen website, formerly called EJView. It uses data from the U.S. Census Bureau and the American Community Survey to calculate demographic data through a geospatial map interface. Reports generated using this website are usually sufficient, though additional data may be needed for Environmental Assessment and Environmental Impact Statement level projects. For further details refer to WSDOT's Community Engagement Plan (https://wsdot.wa.gov/sites/default/files/2021-10/wsdot-community-engagement-plan-2016.pdf).

- **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 corridor. In addition to the Region, this will typically include local transportation agencies, transit agencies, and representatives of local governments and community groups. Law enforcement, emergency responders, and major employers in a corridor 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.

ESTABLISH A FLEXIBLE AND CREATIVE VISION ELICITATION PROCESS

Developing a vision statement can be a quick effort, but the process used to elicit the vision should be culture-specific and reflective of the breadth and diversity of the team. Participants may use methods ranging from highly analytical and rational to highly creative and divergent. These could include focused discussions, charettes, or sharing divergent experiences and stories.

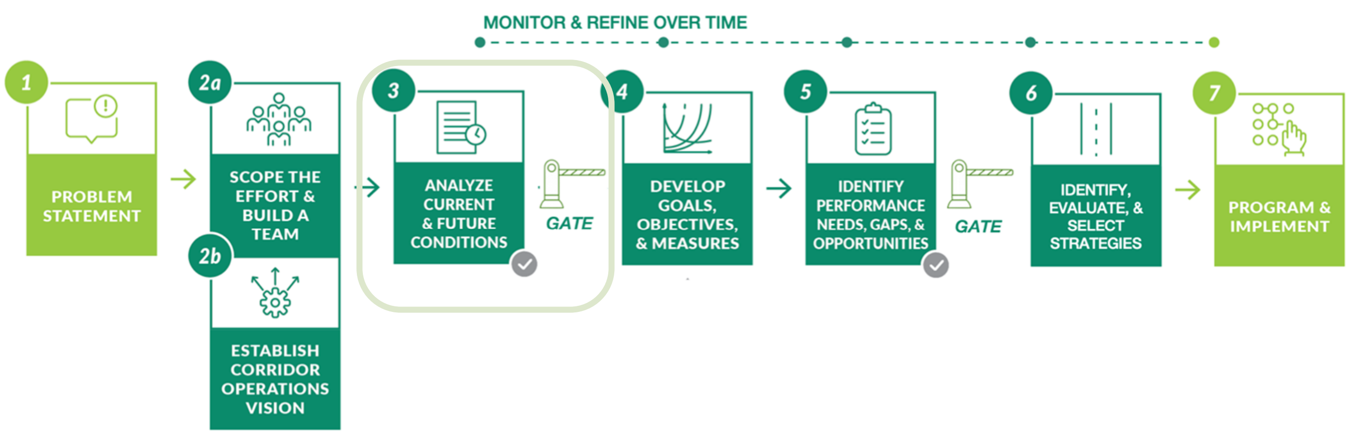
CRAFT AN OVERALL VISION STATEMENT FOR THE CORRIDOR

A vision statement provides a compelling description of the future of the study area, function of the corridor, and how it should appear over time (e.g., context sensitive goals). However, it should also be realistic. For example, the WA SR 3 Route Development Plan (SR 305 to SR 104) defined the vision as: "SR 3 will be a safe, efficient, multimodal transportation system that, through the use of innovative design solutions, balances local and regional needs while retaining scenic qualities."

> **EXAMPLE VISION STATEMENT:**
>
> "SR 3 will be a safe, efficient, multimodal transportation system that, through the use of innovative design solutions, balances local and regional needs while retaining scenic qualities." —WA SR 3 Route Development Plan (SR 305 to SR 104)

The vision statement encapsulates the overall goals of the corridor and is used in subsequent planning stages to develop specific goals, objectives, and needs. Ultimately, all objectives, needs, measures, and TSMO strategies developed over the course of the corridor planning process should be traceable back to and supportive of the initial corridor vision.

3. ANALYZE CURRENT AND FUTURE CONTEXT AND CONDITIONS



Once the corridor vision has been established, gathering information about the corridor (including current conditions and future context) is a key early step in the development of a corridor plan or strategy. Data, both qualitative and quantitative, play a vital role in a performance-based approach to planning for TSMO in a corridor, and allow the team to identify appropriate goals, objectives, and performance measures in the next step.

At this point it is recommended that the project team revisit the corridor vision established in the prior step to test whether it needs to be extended or modified in light of any corridor conditions findings from the current step. It is an opportunity to confirm the corridor vision before moving to future steps establishing the goals, objectives, and measures to be aligned with that vision.

Key Actions:

- ☐ **Review previous studies, reports, and plans.** Consider recent multimodal transportation plans, pedestrian and bicycle plans, land use and development plans, environmental condition reports, and infrastructure condition reports.
- ☐ **Understand the users of the corridor.** Closely examine existing users of the corridor and their travel needs because these will be important in defining both needs and possible strategies that will be effective.
- ☐ **Gather information about the corridor.** Baseline information helps define the existing conditions in the corridor, 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 corridor challenges that should be addressed during a corridor planning process.
- ☐ **Gather information about future conditions and contexts.** Include forecasted data about socio-economic factors, modeled future travel demand, and information on planned improvements in the near future.
- ☐ **Incorporate stakeholder and community input.** A comprehensive approach should be used for stakeholder and public engagement to capture input from all affected parties along the corridor, including those traditionally underserved by the existing transportation system.
- ☐ **Revisit and confirm the corridor operations vision.** Whether with the Technical Advisory Committee or project stakeholder group, use this opportunity to obtain or reconfirm stakeholder agreement on what has been established and where the plan is headed.

REVIEW PREVIOUS STUDIES, REPORTS, AND PLANS

A review of existing studies, reports, and plans provides information about the broader planning context and may include recent multimodal 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 corridor and surrounding study area. They also can provide data on anticipated future conditions in a corridor, such as population, jobs, housing units, and vehicle or passenger trips.

A range of information may be available on the current transportation system components and features within the corridor study. For instance, topographical maps provide information about the corridor surface and geographical features. Documentation of the overall transportation network also is useful, including information about the existing multimodal transportation network, such as highways, transit services, and side and perpendicular streets (intersection types and traffic control measures used). Moreover, beyond the infrastructure, baseline information also should document existing operational assets, partnerships, relationships, and programs that affect system

SR 503 CORRIDOR STUDY LESSONS LEARNED: ENSURE RESOURCE REVIEW INCLUDES REGIONAL TSMO AND ITS PLANS

One resource that was not initially included as part of the SR 503 corridor study review was the Southwest Washington Regional Transportation Council (RTC) Vancouver Area Smart Track (VAST) Regional TSMO Plan (published in 2011 and subsequently updated in 2016 and 2021). This plan contains relevant information on ITS infrastructure on the corridor and key operational performance measures. The VAST committee is also a valuable stakeholder to include as part of the study.

operations. Examples include ITS components, ramp metering, traveler information systems, incident management programs, and transit signal priority (TSP), among others. Documenting the current application of these system components or strategies will be important as a baseline for understanding the existing context in the corridor.

UNDERSTAND THE USERS OF THE CORRIDOR

Understanding travel markets and users of the corridor is important in defining both needs and possible strategies that will be effective. Some corridors carry significant freight truck activity, while others do not. Some also handle significant interstate through traffic, while others carry largely localized trips.

While some freeway management and incident management strategies (e.g., variable speed limits and queue warning) will benefit all motorists and help system operators to have better information to adjust system operations, it is important to consider the needs of different types of travelers. Understanding the unique characteristics of travelers in the corridor and their key concerns also will be useful in assessing potential strategies that may be targeted to specific types of travelers.

Recognizing how corridor travelers access information and make travel decisions will aid in tailoring TSMO strategies. Possible traveler groups include:

- Daily commuters and students traveling regularly to and from work or school
- Non-commuting travelers going to local destinations (e.g., running errands, entertainment)
- Long-distance commuters or tourists passing through
- Freight or commerce vehicles transporting goods

Table 1 provides a sample of potential corridor users, their concerns, and TSMO strategies that planners and operators may consider addressing those concerns.

GATHER INFORMATION ABOUT THE CORRIDOR

Data, both qualitative and quantitative, play a vital role in a performance-based approach to planning for TSMO in a corridor. Baseline information helps define the existing conditions in the corridor, including identification of challenges and problem areas. Data on expected changes in population, land use, and travel conditions also help to inform understanding of potential future corridor challenges that should be addressed during a corridor planning process.

Data gathered during this phase also are a starting point for identifying opportunities for potential operations strategies that may be applied within the corridor 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 plays a key role in defining corridor objectives and in providing guidance on data and information gathering. Members with operations data expertise play an important role in bringing forth operations data to inform the corridor planning process, as well as to explain data limitations.

TABLE 1: POTENTIAL CORRIDOR USERS, CONCERNS, AND TSMO STRATEGIES

	LOCAL COMMUTER	LOCAL NON-COMMUTING TRAVELER	LONG DISTANCE / INTERSTATE TRAVELER	FREIGHT / COMMERCE
DESCRIPTION	Reside locally, travel regularly between work/ school during peak travel times.	Reside locally, trips may be during non-peak times and direction; wide range of users, including disabled, elderly, and children	Non-local travelers traveling to or through the corridor, less familiar with local conditions or alternative routes.	Transportation of goods to local stores and businesses, to regional distribution centers, and warehouse-to-home delivery
KEY CONCERNS	Reliability of route and avoidance of traffic delays Information about transportation options	Safe and comfortable multimodal facilities Avoiding congestion and delays Information about available transportation modes Parking availability	Notification of travel delays due to construction/incidents Access to stopover points (e.g., rest stop, gas stations, restaurants)	Reliability of travel time for on-time delivery Availability of preferred routes (particularly those that can accommodate freight vehicles) Curb space and loading availability for on-street deliveries
POSSIBLE STRATEGIES	Multimodal commute (biking, transit) Dynamic ridesharing Predictive traveler information Real-time transit and parking information Dynamic shoulder lane use	Multimodal commute (biking, transit) Parking reservations 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 Freight signal priority Dynamic curb management

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.

Key data inventory includes:

- Physical assets: multimodal infrastructure, traffic signals, access type/spacing, parking facilities, ITS equipment
- Traveler characteristics
- System performance: traffic volumes and travel patterns convey important information on corridor performance; other data may include average daily travel, peak-hour volume, and mode-split.
- 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. Note that LOS does not capture the source, cause, impact 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 corridor can be critical to understanding existing conditions. To incorporate operations strategies into the corridor plan, a more detailed account of the causes and impacts of congestion along the corridor is needed.

- Archived operations data, from ITS programs, also can be used to assess important operational conditions, including system reliability; on-time transit performance; and the role of factors, such as weather conditions, on traffic congestion. Archived travel time data form the basis for understanding a wide variety of performance metrics, such as congestion, reliability, and freight mobility.

- Analysis tools like Travel Demand Models, Sketch Planning Tools, and Simulation Tools can be leveraged to evaluate policy-based and corridor 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, analyze the performance of isolated or small-scale transportation facilities, evaluate a range of improvements and strategies at corridor levels, conduct sensitivity testing to reflect variability in traffic demands or incident severity and support environmental assessment.

- Safety data are very useful for identifying challenges and problem areas along the corridor that may be addressed by operations strategies. Types of safety data include incident data (e.g., fatalities, injuries, and property damage, incident response time and efforts needed); crash data by type (e.g., rear-end, left turn), weather conditions, and light condition (e.g., daylight, dusk); and the spatial distribution of crashes.

- Including standard access metrics that capture both the quantity of destinations along the corridor and users' level of access to those destinations (e.g., how many destinations can someone reach on foot/bike/bus in a 15-/30-min travel time from select spots along the corridor) can be a good tool for system performance measurement to emphasize on the land use connection. It can also be looped back for review after the improvements are implemented.

GATHER 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, density, employment), as well as information from transportation modeling in regard to future anticipated travel demand. It also is important to document improvements slated for implementation in the near future. Information on future projects may come from consulting the Regional Transportation Plan (RTP), metropolitan transportation improvement program (TIP), the statewide TIPs, or local plans.

INCORPORATE STAKEHOLDER AND COMMUNITY INPUT

In addition to previous studies and information on current and future conditions, input from stakeholders and the public is critical; specifically, their opinions about issues experienced on the corridor and preferences for the future of the corridor. The public and stakeholders should play a key role in defining goals and objectives for the corridor, as well as the performance measures that will be used to assess system performance. In urban corridors, 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 the specific objectives for the corridor. 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 corridors 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 corridor goals and operations objectives and in articulating priorities and values.

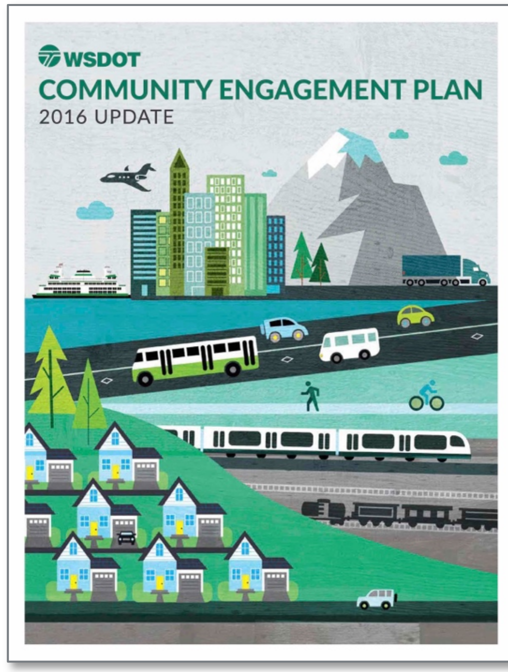


FIGURE 7: WSDOT COMMUNITY ENGAGEMENT PLAN

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), as well as hosting citizens' panels and town hall meetings. A comprehensive approach should be used for stakeholder public engagement to capture input from all affected parties along the corridor, including those traditionally underserved by the existing transportation system (e.g., low-income communities, persons with disabilities). Engaging with stakeholders and the public early in the process is important and presents an opportunity to raise awareness about operations and the role that operational strategies can play along the corridor. Educating stakeholders and the public about operational strategies will make them better-informed participants throughout the remainder of the corridor 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.

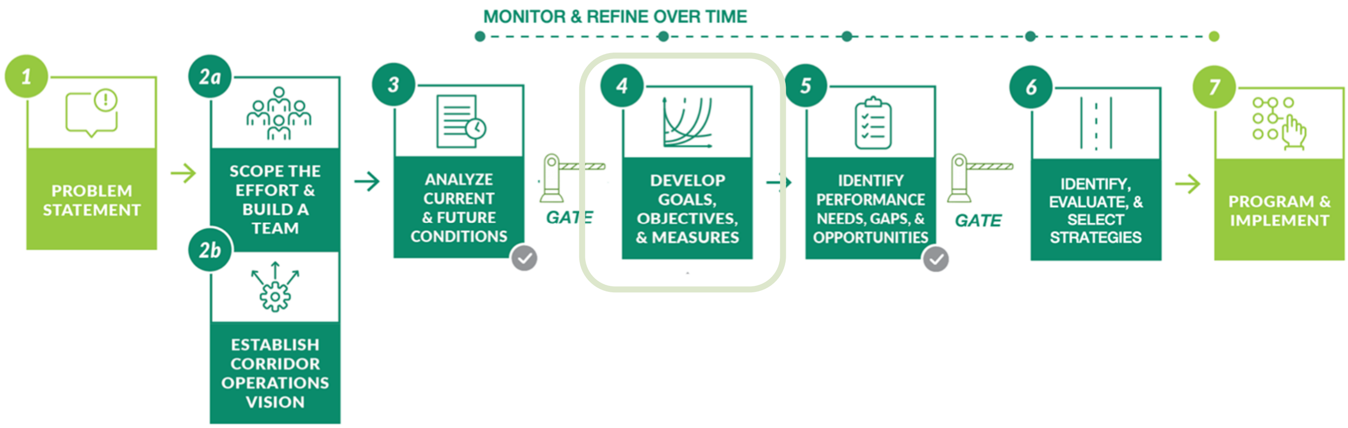
Below are sample questions to facilitate a dialogue with stakeholders and the public to capture input about incorporating operations into corridor planning:

- *How do you travel in the corridor? 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 corridor?*
- *Do you have any comment on the problems and opportunities that have already been identified for the corridor?*

- *How would improving the corridor through working with a private developer and considering options, such as tolling, impact your support of the solutions?*

The final action prior to advancing to Step 4 is to revisit and confirm the corridor operations vision.

4. DEVELOP CORRIDOR OPERATIONS GOALS, OBJECTIVES, AND MEASURES



This may be the most important step in the process because it ***establishes how the corridor 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 corridor. 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 corridor TSMO strategies.

Key Actions:

- ☐ **Develop an outcome-oriented operational concept.** Identify the desired outcomes for corridor travelers and communities, including outcomes related to how the corridor is managed and operated. This provides the framework for developing and evaluating options for the corridor that reflect local and regional values (e.g., mobility, air quality, sustainability, livability, safety, security, economic activity, accessibility).

- ☐ **Develop high-level operations goals.** High-level statements of what transportation in the corridor will 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.

- ☐ **Develop specific, outcome-based operations objectives.** Objectives go beyond broad statements of goals, which often are loosely defined and difficult to assess. Operations objectives are specific, measurable statements.

- ☐ **Select relevant performance measures.** Performance measures should be selected that support the quantitative evaluation of the operations objectives and help to assess whether goals and objectives have been accomplished.

DEVELOP AN OUTCOME-ORIENTED OPERATIONAL CONCEPT

An effectively managed corridor involves not only the provision of highway and transit infrastructure for movement of people and freight, but also efficient ways of operating these systems to support mobility, reliability, and safety. Consequently, while corridor planning may involve consideration of, or focus on, certain types of infrastructure improvements (e.g., streetscaping, bicycle and pedestrian infrastructure), the planning process should focus on desired outcomes for travelers and communities, including outcomes related to how the corridor is managed and operated.

An outcome-oriented operational concept provides the framework for developing and evaluating options for the corridor that reflect local and regional values, which may include mobility, air quality, sustainability, livability, safety, security, economic activity, and accessibility, among other considerations. The relative priority of these considerations may vary depending on the context, needs of system users and other stakeholders, and stakeholder groups that are affected by transportation in the corridor.

The 2020 Urban Freeway Corridor Operations (UFCO) Study identified low-cost capital, operational, and ITS strategies to address congestion and safety conditions on I-5, I-205, SR 500, and SR 14 in the Southwest Region. The project established clear goals, specific operations objectives, and performance measures to guide the identification, analysis, and selection of strategies.

Examples of outcomes commonly used in corridor studies include safety and mobility, traditionally assessed in terms of number of incidents, levels of traffic congestion, or hours of delay. Other outcomes reflecting a broader view of how a modern multimodal corridor can function 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 corridor 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 often are very concerned about the variability in travel time from day-to-day or hour-to-hour. If it typically takes 20 minutes to travel a corridor 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 corridors.

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, measurable operations objectives, and performance measures that are focused on outcomes important to the transportation system users. In a regional context, use of operations objectives and performance measures supports consideration and selection of TSMO strategies for the long-range transportation plan and TIP.

Similarly, corridor-based operations objectives and performance measures help to focus attention on system performance outcomes within a corridor 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 regional values that affect or influence priorities in the corridor 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 corridor would operate to realize the desired outcome(s). The operational concept does not specify strategies to be implemented in the corridor. It will likely draw upon a collection of individual and complementary strategies in response to the operations objectives for the corridor and an assessment of the costs and benefits of each. In some corridors, Active Transportation and Demand Management (ATDM) concepts—active traffic management, active demand management, and active parking management—may prove to be attractive strategies; in others, other strategies that rely less on real-time data may prove effective (e.g., improvements in Traffic Incident Management [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 for this corridor.

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 corridor that supports higher-level regional goals. The corridor goals should link to these 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.

DEVELOP HIGH-LEVEL OPERATIONS GOALS

Note that in developing an outcome-oriented operational concept, specific solutions (e.g., TSMO 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 for the corridor.

CORRIDOR OPERATIONS GOALS EXAMPLE: CALTRANS I-880 INTEGRAGED CORRIDOR MANAGEMENT (ICM) PIONEER SITE (OAKLAND, CA)

I-880 Corridor Goals:

1. Improve the efficiency of network operators' individual networks through shared information from, and collaborative operations with, the other networks.
2. Balance demand across the networks to most efficiently utilize the available capacity.
3. Enable travelers to make informed choices among transportation options, based on reliable information about travel conditions.
4. Respond quickly and effectively to service disruptions that may be planned or unplanned, whether based on human or natural causes.

Operations goals are the high-level statements of what transportation in the corridor will 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.

DEVELOP SPECIFIC, OUTCOME-BASED OPERATIONS OBJECTIVES

The high-level goals are the starting point for developing operations objectives, which form the basis for corridor TSMO planning. Operations objectives define desired outcomes for the corridor 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 in or who are affected by corridor transportation systems performance. They may be multijurisdictional in nature if the corridor 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.

Consider two categories of objectives when developing operations objectives:

1. Outcome-oriented objectives
2. Activity-based objectives

Outcome-oriented objectives are generally preferred because they are most closely related to the LOS provided to systems users. (Examples include travel time reliability and access to traveler information.) In cases where developing outcome-based objectives is difficult—perhaps because the outcome is difficult to measure or observe directly—the team may consider developing corridor operations objectives that are *activity-based*, which support the desired system performance outcomes. (For example, identifying the share of bus stops with real-time transit information.) Both categories of objectives are discussed in more detail below.

USING STAKEHOLDER COLLABORATION TO DEVELOP OBJECTIVES: WSDOT US 195 CORRIDOR STUDY (SPOKANE TO IDAHO BORDER)

WSDOT used a technical advisory committee (TAC) composed of regional transportation planning organization, cities, counties, universities, and law enforcement. The community was involved through a survey and various "listening posts," which were informal meet-and-greets at local gathering places like grocery stores, coffee shops, and post offices.

Identify SMART Outcome-Based Operations Objectives

Corridor outcome-oriented objectives focused on outcomes to the user include corridor travel times, travel time reliability, and access to traveler information. The public cares about these measures, and in many regions, data may be available to develop specific outcome-based operations objectives. 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-upon.** 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 corridor 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 in the feasibility of the objective and should be considered. 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.
- **Time-bound.** The objective identifies a timeframe within which it will be achieved (e.g., “by 2030”).

By including operations objectives that address system performance issues—such as 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 corridor will elevate operations to play a more important role in investment planning, addressing both short- and long-range needs.

Identify Activity-Based Objectives

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

Other examples of activity-based objectives include the percentage of traffic signals re-timed in the corridor, 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.

Organize Objectives to Ensure Traceability

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 8 illustrates how lower-level activity-based objectives support higher-level outcome-oriented objectives, all acting in support of goals for the corridor.

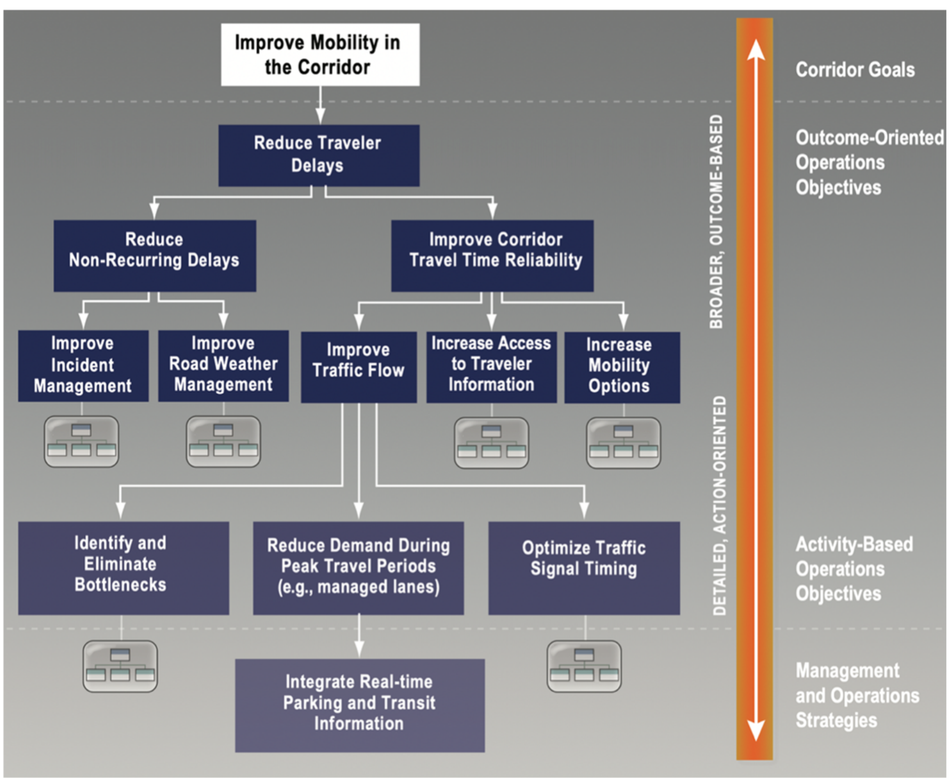


FIGURE 8: ILLUSTRATIVE OBJECTIVES TREE FOR CORRIDOR-BASED TSMO

Operations Objectives Examples

Table 2 highlights common operations objectives by TSMO functional area. Additional examples and further discussion of operations objectives and their applicability to corridor management and operations can be found in FHWA's *Advancing Metropolitan Planning for Operations: An Objectives-Driven, Performance-Based Approach – A Desk Reference*[4].

TABLE 2: COMMON OPERATIONS OBJECTIVES BY TSMO FUNCTIONAL AREA

TSMO-ORIENTED FUNCTIONAL AREA	EXAMPLE OBJECTIVE FOCUS AREAS
ARTERIAL MANAGEMENT: The management of arterial facilities in a manner that provides users with a safe, efficient, and reliable trip.	• Delay • Access Management • Reliability • Traffic Monitoring and Data Collection • Traffic Signal Management
EMERGENCY / INCIDENT MANAGEMENT: Providing users with a safe and efficient transportation system during an emergency situation. Incident management is defined as verifying, responding to, and clearing traffic incidents in a manner that provides transportation system users with the least disruption.	• Incident Duration • Person Hours of Delay • Evacuation Times • Customer Satisfaction • Traveler Information • Inter-Agency Coordination • Training • Use of Technology
SPECIAL EVENT MANAGEMENT: Providing users with a safe and efficiently managed transportation system during a planned special event.	• Entry/Exit Travel Times • Mode Shift from Single Occupancy Vehicle (SOV) • Traveler Information • Parking Management • Multi-Agency Coordination • Training • Use of Technology
TRAVEL DEMAND MANAGEMENT: Providing users with effective travel choices to shift or reduce the demand for travel in congested conditions. Travel demand management oversees two types of travel: commute travel and travel associated with tourism, emergencies, special events, shopping, etc.	• Auto Commuter Trip Reduction Programs • Commuter Shuttle Services • Carpool/Vanpool • Walking/Bicycling • Parking Management • Marketing

[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: https://ops.fhwa.dot.gov/publications/fhwahop10027/fhwahop10027.pdf.

TSMO-ORIENTED FUNCTIONAL AREA	EXAMPLE OBJECTIVE FOCUS AREAS
TRAVEL WEATHER MANAGEMENT: Providing users with a safe and efficient transportation system during and after weather events.	• Clearing Time • Detours for Impacted Roadways • Disseminating Information • Road Weather Information System Coverage • Signal Timing Plans
TRAVELER INFORMATION: Providing users with the information they need to choose the safest and most efficient mode and route of travel.	• Information Dissemination • Trip Planning Tools • Travel Conditions Data Collection and Sharing • Customer Satisfaction
WORK ZONE MANAGEMENT: Organizing and operating areas impacted by road or rail construction to minimize traffic delays, maintain safety for workers as well as travelers, and accomplish the work efficiently.	• Travel Time Delay • Extent of Congestion • Travel Time Reliability • Construction Coordination • Traveler Information • Customer Satisfaction
TRANSIT OPERATIONS AND MANAGEMENT: Operating and managing the transit system in a safe and efficient manner.	• Service Directness • Loading Standards • Traveler Information • Customer Service/Safety • Line-Haul Transit • Transit Signal Priority • Automated Fare Collection • Park-and-Ride Support
FREEWAY MANAGEMENT: Implementing policies, strategies, and technologies to improve freeway performance. The goals of freeway management programs include minimizing congestion (and its side effects), improving safety, and enhancing overall mobility.	• Efficiency • Reliability • Managed Lanes • HOV Lanes • Pricing and Tolling • Ramp Management • Transportation Management Centers
FREIGHT MANAGEMENT: Effective management of the system for freight transportation, to move goods safely, efficiently, and reliably throughout the region. This may range from satisfying the customer (e.g., freight shippers, receivers, and carriers) to actual travel time on the system.	• Customer Satisfaction • Travel Time Delay • Travel Time Reliability • Border Crossing • Intermodal Facilities • Detours and Routing

TSMO-ORIENTED FUNCTIONAL AREA	EXAMPLE OBJECTIVE FOCUS AREAS
SYSTEM EFFICIENCY: Maximizing the benefits of the transportation system to the user while minimizing user costs. Costs to consider include additional travel time, monetary costs, travel distance, and fuel consumption. Operations objectives in the category of efficiency focus on minimizing costs and managing several aspects to congestion: extent, duration, and intensity.	• Extent of Congestion • Duration of Congestion • Intensity of Congestion • Travel Time • Delay • Energy Consumption • Cost of Congestion • Vehicle Miles of Travel • Trip Connectivity
SYSTEM RELIABILITY: A reliable transportation system can be defined as one that provides the users with a consistent and predictable travel time. While reliability could be expanded beyond travel time to cost, comfort, route, and mode availability, those aspects are more appropriately captured in other categories.	• Non-Recurring Delay • Travel Time Buffer Index • Planning Time Index • Travel Time 95th/90th Percentile • Variability • Transit On-time Performance
SYSTEM OPTIONS: Providing a user option to select a mode of travel for a trip from among many within a given timeframe, for a specific purpose, and/or via a certain route. Availability and utilization of multimodal options, such as transit, ridesharing, bicycling, and walking can be important components of a regional strategy to reduce traffic congestion and improve the operation of the transportation system.	• Mode Share • Transit Use • Transit Compared to Auto Travel Time • Bicycle and Pedestrian Accessibility and Efficiency • Modal Options for Individuals with Disabilities

SELECT RELEVANT 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

Performance measures play a central, connective role within the TSMO-focused corridor planning process and provide:

1. A direct link to the operations objectives
2. The criteria for evaluating strategies and tactics for improving corridor performance
3. Direction for the gathering of data necessary to identify and prioritize needs and gaps

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 corridor, 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 like public transit or high-occupancy vehicle lanes than to those driving alone.

It is important to recognize that there are often 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 corridor is important.

Performance measures are indicators of how well the corridor 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 decisionmakers 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 multimodal corridor. 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. An MPO uses 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 exclusively on long-term development of the corridor. With greater focus on the day-to-day characteristics of the corridor, planners appreciate the issues faced by system operators. The result is that mid- and long-term planning now reflect greater consideration of operations and the associated investment needs within the corridor.

Some examples of performance areas and performance measures likely to be associated with corridor operations objectives are shown in Table 3. These performance measures are primarily drawn from the FHWA's *Advancing Metropolitan Planning for Operations: The Building Blocks of a Model Transportation Plan Incorporating Operations - A Desk Reference*.[5]

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[5] 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: https://ops.fhwa.dot.gov/publications/fhwahop10027/fhwahop10027.pdf

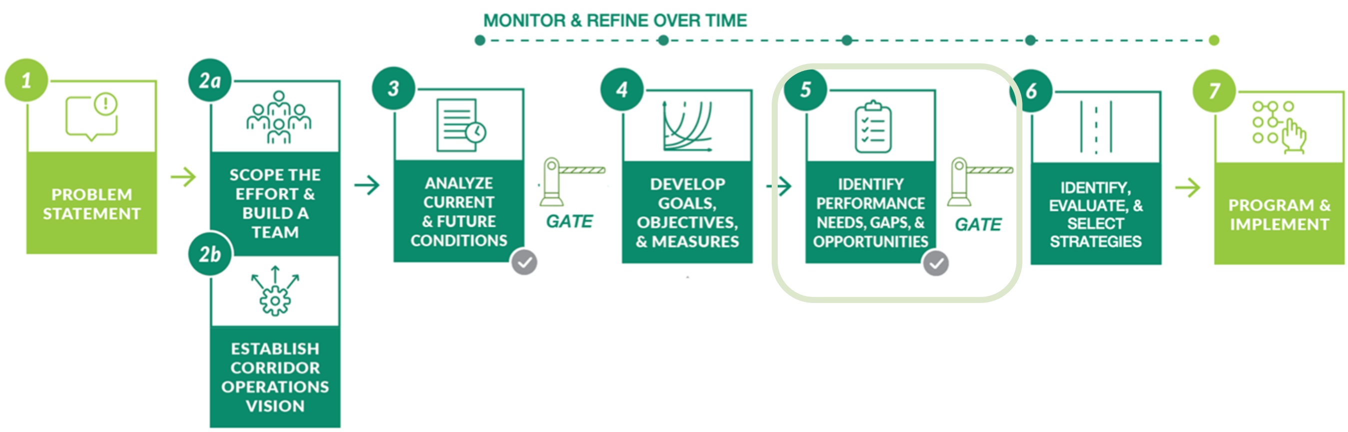
TABLE 3: PERFORMANCE AREAS & PERFORMANCE MEASURES FOR CORRIDOR OPERATIONS OBJECTIVES

PERFORMANCE AREA	ILLUSTRATIVE PERFORMANCE MEASURES
TRAVEL TIME: Travel time measures focus on the time needed to travel along a selected portion of the corridor, and can be applied for specific roadways, corridors, transit lines, or at a regional level.	• 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 • Travel time index: the ratio of peak to non-peak travel time, which provides a measure of congestion
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.	• Lane miles of congested conditions (defined based on volume to capacity [V/C] ratio, LOS measures, or travel time index) • Number of intersections experiencing congestion (based on LOS) • Percent of roadways congested by type of roadway (e.g., freeway, arterial, collector) • Average hours of congestion per day • Share of peak period transit services experiencing overcrowding
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.	• 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
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.	• 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

PERFORMANCE AREA	ILLUSTRATIVE PERFORMANCE MEASURES
TRAVEL TIME RELIABILITY: Travel time reliability measures take into account the variation in travel times that occur on roadways and across the system.	• 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 ratio of the 95th percentile travel time to free-flow travel time • 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 miles per hour below posted speed limit during peak periods
TRANSPORTATION DEMAND MANAGEMENT: Transportation demand management measures examine demand in the corridor as well as the impact of strategies to manage that demand.	• 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
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.	• Peak hour persons moved per lane • Peak hour persons moved on transit services
CUSTOMER SATISFACTION: Examines public perceptions about the quality of the travel experience, including the efficiency of system management and operations.	• Percent of the population reporting being satisfied or highly satisfied with travel conditions • Percent of the population reporting being satisfied or highly satisfied with access to traveler information • Percent of the population reporting being satisfied or highly satisfied with the reliability of transit services

PERFORMANCE AREA	ILLUSTRATIVE PERFORMANCE MEASURES
AVAILABILITY OF OR AWARENESS OF INFORMATION: These measures focus on public knowledge of travel alternatives or traveler information.	• Percent of surveyed population aware of travel alternatives and related traveler information

5. IDENTIFY PERFORMANCE NEEDS, GAPS, AND OPPORTUNITIES



A key step following the definition of performance measures is to conduct an operational scenario planning exercise as a basis for understanding current performance gaps, potential opportunities, and roles and responsibilities among corridor partners under different situations.

Key Actions:

- ☐ **Define key operational scenarios.** Conduct an operational scenario planning exercise with stakeholders to define scenarios as a basis for understanding current performance, potential opportunities, and roles and responsibilities among corridor partners under different situations. Typical corridor-related scenarios describe normal operations, incidents, planned events, weather-related emergencies, evacuations, or work zone activities.
- ☐ **Identify gaps, performance needs, and opportunities.** Use scenario analysis to help identify existing gaps, performance needs, and potential opportunities for improvements. Consult performance data to confirm where problems exist and need attention, investment, and priority in the planning process.
- ☐ **Revisit and confirm the corridor goals, objectives, and performance measures.** Whether with the Technical Advisory Committee or project stakeholder group, use this opportunity to obtain or reconfirm stakeholder agreement on what has been established and where the plan is headed. The next step will be to identify strategies, and it is crucial that they be aligned with the operational goals and objectives.

DEFINE KEY SCENARIOS

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 corridor and may include (but are not limited to):

- **Normal or daily scenario –** To explore recurring congestion and typical challenges faced by travelers in the corridor, during peak and/or off-peak periods.
- **Incident scenario –** To address major or minor incidents along a highway, arterial, or transit service, to develop operational plans for how agencies work together and respond to these incidents.
- **Planned event scenario –** To address a major sporting event, festival, or activity that creates an atypical level of travel demand along the corridor.
- **Weather-related emergency or evacuation scenario –** To consider unplanned events that may require more dynamic decision making and coordination among stakeholders.
- **Major work zone scenario –** To address a major corridor construction or reconstruction project, and how transportation services, operations, and coordination will be conducted to minimize impacts on travelers, businesses, and the local community.

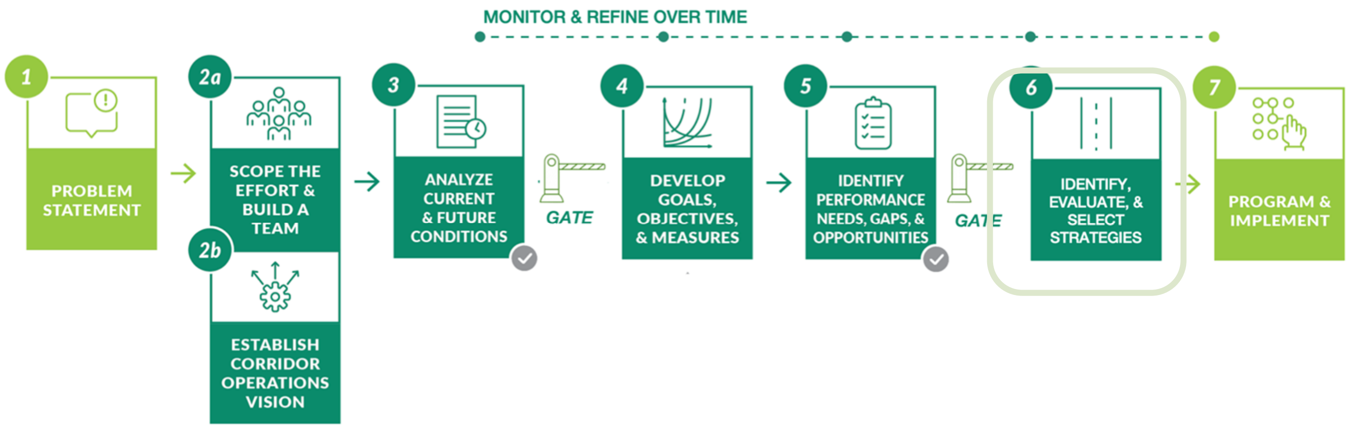
IDENTIFY GAPS, PERFORMANCE NEEDS, AND OPPORTUNITIES

By defining scenarios, the corridor team can often identify existing gaps, performance needs, and potential opportunities for improvements. Moreover, discussions to identify gaps aid planners and operators in clarifying and documenting problems within the corridor and highlight opportunities for improving corridor performance. 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, because 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 in the corridor by increasing average speeds, planners and operators may be tempted to focus on strategies such as adaptive signal controls and may overlook opportunities for transportation demand management approaches that increase use of shared vehicles (e.g., transit, carpools, and parking) or shift demand to other times and routes, making more effective use of available capacity. This does not mean that adaptive signal controls are inappropriate; only that performance measures, if not taken in context, can result in focusing on “efficiency” of current approaches rather than in how well outcome-oriented objectives are achieved.

In the end, performance measures point toward deficiencies in achieving goals and objectives for the corridor and can be helpful in identifying opportunities for improving corridor performance.

6. IDENTIFY, EVALUATE, & SELECT STRATEGIES



Once the corridor TSMO planning team has agreed upon operations objectives for how the corridor should operate and identified the performance gaps, it can begin to identify a system of TSMO strategies that will be implemented on the corridor to achieve the operations objectives and address performance gaps. This system of TSMO strategies forms an integrated TSMO approach to improving performance on the corridor.

Key Actions:

- ☐ **Identify TSMO strategies.** Refer to published WSDOT and Federal guidance on selecting TSMO strategies to address typical corridor objectives, including the “quick reference sheets” provided in the corresponding section of Appendix A. Considerations for identifying appropriate TSMO strategies include:
  - Seek out a “system solution” rather than standalone activities
  - Move toward active and dynamic transportation systems management
  - Focus on the traveler, rather than just vehicles
  - Consider community values and neighborhoods
  - Recognize resource constraints
  - Consider an incremental approach to incorporating TSMO
  - Incorporate land use considerations

- ☐ **Evaluate TSMO strategies.** Conduct assessment and scenario analysis using standard analytic tools, including sketch planning, scenario planning, deterministic tools, travel demand models, simulation tools, and dynamic traffic assignment.

- ☐ **Select and prioritize solutions.** Based on the evaluation results conducted above, develop near-, mid-, and long-range improvement strategy packages based on priority, cost estimate, and available funding.

IDENTIFY TSMO STRATEGIES

It is important to consider TSMO strategies working together in the context of the corridor as opposed to selecting and implementing strategies in isolation. Planning for an integrated set of strategies allows planners and operators to leverage synergies between strategies. For example, the needs of first responders for managing traffic incidents should be considered when setting up work zones and, likewise, TIM plans may consider pre-positioning vehicles to support quick clearance in areas of reduced capacity due to work zones.

Key Considerations for Identifying TSMO Strategies

Seek out a "system solution" rather than standalone activities. The traditional approach to transportation operations has involved individual agencies (state DOTs, local transportation agencies, toll authorities, transit service providers, etc.) managing their own assets and services (e.g., 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 on a corridor by viewing the corridor 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. For instance, when a highway is severely congested due to a traffic incident, travelers may be directed to alternative routes, including parallel arterials, and traffic signal patterns may be adjusted to enable those arterials to better handle additional traffic.

Move 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, corridor throughput, incident management). This approach requires collaboration, engaging partners to help influence travel choice and behavior along the corridor. Travel choice and behavior are influenced through active demand management (i.e., redistributing travel to less-congested routes or times of day and reducing overall trips by promoting mode choice); active traffic management (i.e., dynamically managing recurring and non-recurring congestion by improving travel throughput); and in urban areas, active parking management (i.e., optimizing the performance and utilization of available parking). Technology and innovation are critical to active and dynamic transportation systems management, supporting this data-driven approach implemented through information technology systems.

Focus on the traveler, rather than just vehicles. A customer-focused perspective is the underpinning of an integrated approach to corridor management; rather than looking at enhancing vehicle throughput, a traveler-focused approach begins by examining traveler mobility needs and explores the most effective ways to meet those needs. This approach sets the context for developing a more efficient system for the end user. 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 between the various types of travelers (including commuters, non-commuter travelers, and freight movement), and understanding their travel behaviors, needs, and challenges to inform which operations strategies to implement. In short this means not just drive-alone commute trips, but the full spectrum of users and needs, including multimodal and active transportation with equity in mind.

Consider community values and neighborhoods. Transportation within corridors plays a key role in mobility but is more than just moving people and goods. Transportation within corridors is a lifeline for communities, often linking neighborhoods, businesses, and jobs. The context of corridors should reflect the character and values of the surrounding community. Integrating operational strategies into corridor planning is not a uniform approach; the set of strategies selected for an individual corridor 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 (i.e., the various agencies that operate along the corridor), as well as community stakeholders and the general public.

Recognize 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.

Consider an incremental approach to incorporating TSMO. 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 single corridor or across a city or region. 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 corridor is a clearer path to successful implementation by allowing time to both gain experience with the strategy and institute operational processes.

Incorporate land use considerations. Using TSMO and Land Use Policy as a strategy to manage demand on the transportation system is a Practical Solutions strategy and directly aligns with WSDOT's vision to provide a safe, sustainable, and integrated statewide multimodal transportation system. To make WSDOT's vision a reality, each place must be served by a variety of transportation modes, regardless of which agency owns each component. WSDOT's work to integrate land use and transportation decision-making is not tied to a standalone program. Rather, it is an approach that touches multiple facets both internal and external to the department with the ultimate goal of reducing the overall demand for motorized transportation. The demands placed on our transportation system are strongly influenced by land use decisions. At the same time, the investments made in the transportation system influence land development. Land use and transportation are two sides of the same coin. The former provides the origins and destinations while the latter provides the means to move between them.

These have traditionally been managed independently; after many decades of this approach, WSDOT recognizes that planning for these together is the best approach to achieve the otherwise often-competing statewide goals of improving safety, mobility, equity, and the economy while reducing our combined impacts on the environment. Although WSDOT recognizes the value of concurrent transportation and land use planning, state law currently gives the agency very limited legal authority to influence land use decisions. In the absence of this authority, WSDOT must leverage the tools it does have to influence land use decisions. This effort includes identifying these levers and establishing actions to improve these levers.

Typical TSMO Strategy Areas and Associated Objectives, Gaps, and Relevant TSMO Strategies

Table 4 provides an example of TSMO strategies to consider based on operations objectives and performance gaps. This table focuses on objectives and strategies for an urban arterial that experiences recurring congestion. The desired outcome for improving corridor operations is the reduction of recurring congestion along the corridor. The middle column, "Performance Gap," documents the corridor's shortfalls in achieving any of the corridor's operations objectives. The last column, "TSMO Strategies to Consider," identifies potential TSMO strategies to address the deficiency or gap. To help ensure that an identified TSMO strategy will address the performance gap, the strategy should go through some type of screening and evaluation. All the possible TSMO strategy options to achieve operational objectives can be found on tsmowa.org organized by condition.

TABLE 4: TSMO STRATEGIES TO CONSIDER BASED ON OPERATIONS OBJECTIVES & PERFORMANCE GAPS

TSMO STRATEGY AREA	OUTCOME-ORIENTED OPERATIONS OBJECTIVES	PERFORMANCE GAP	TSMO STRATEGIES TO CONSIDER
EMERGENCY OR INCIDENT MANAGEMENT	• Improve emergency vehicle travel times by X percent in Y years.	Delay at traffic signals for emergency vehicles exceeds Z hours of delay per 1,000 vehicle miles traveled.	• Emergency vehicle preemption • Emergency vehicle routing • Traffic surveillance
TRANSIT OPERATIONS AND MANAGEMENT	• For transit corridors, decrease delay by X percent per year.Improve average on-time performance for corridor transit route by X percent within Y years.	Delay at traffic signals for transit exceeds Z hours of delay per 1,000 vehicle miles traveled.	• Transit signal priority • Transit queue jump
ARTERIAL MANAGEMENT: DELAY AND SIGNAL SYSTEMS	• Decrease the seconds of control delay on the corridor by X percent in Y years. • Increase the number of intersections operating at level of service Z or higher by X percent in Y years. • Evaluate corridor signals for retiming every X years.	Delay at traffic signals for all modes exceeds Z seconds of control delay per traffic signal on the corridor.	• Enhanced traffic signal timing (e.g., re-timing/ optimization, adaptive systems, better detection) • Traffic surveillance
ACCESS MANAGEMENT	• Maintain a distance of X feet between corridor access points for the next Y years.Reduce driveway access points by X percent for all new developments for the next Y years.	Delay at closely spaced intersections or driveways exceeds Z minutes per vehicle at each driveway.	• Access management

TSMO STRATEGY AREA	OUTCOME-ORIENTED OPERATIONS OBJECTIVES	PERFORMANCE GAP	TSMO STRATEGIES TO CONSIDER
SYSTEM EFFICIENCY: TRAVEL TIME	• Improve average travel time during peak periods by X percent by year Y.	Delay at geometric bottlenecks exceeds Z minutes per vehicle per location. Directional imbalance of volume-to-capacity ratio that varies throughout day exceeds Z percent.	• Bottleneck removal (e.g., turn lane additions) • Changeable lane assignment
SYSTEM EFFICIENCY: DURATION OF CONGESTION	• Reduce the daily hours of recurring corridor congestion from X to Y by year Z.	Delay throughout corridor exceeds Z hours per day.	• High-capacity transit • Traffic surveillance • Traffic management center • Transportation demand management

EVALUATE TSMO STRATEGIES

Many TSMO strategies (e.g., variable speed limits, queue warning systems, and dynamic ramp metering) have benefits, but because they differ from conventional capacity investments in terms of cost, service life, and requirements, it is not always clear how to assess strategies adequately. After identifying potential TSMO strategies for a corridor, there are several methods that are available to evaluate the strategies to determine which ones are most suitable to the corridor 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 corridor stakeholders.

EVALUATION APPROACH EXAMPLE: SR 503 STRATEGY EVALUATION MATRIX

For the SR 503 Corridor Plan, the project team developed an evaluation matrix to assess various strategies. Each strategy was assessed against key performance measures and success metrics established earlier in the project. TSMO strategies were part of the evaluation, including traffic signal coordination, enhanced pedestrian crossings (leading pedestrian intervals), and targeted speed reductions.

Numerous methods and tools are currently available to evaluate TSMO strategies as part of corridor planning. They vary in purpose served, complexity, input and output data, and the strategies that they analyze. Six main categories of analysis tools could apply to the evaluation of TSMO strategies:

1. Scenario planning
2. Travel demand models
3. Sketch-planning tools
4. Analytical/deterministic tools
5. Simulation models
6. Emerging hybrid approaches, including activity-based models and dynamic traffic assignment

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 corridor 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.

A more detailed discussion of each of these assessment and scenario analysis tools is provided in *Appendix B – TSMO Strategy Analysis Tools Overview*.

SELECT AND PRIORITIZE SOLUTIONS

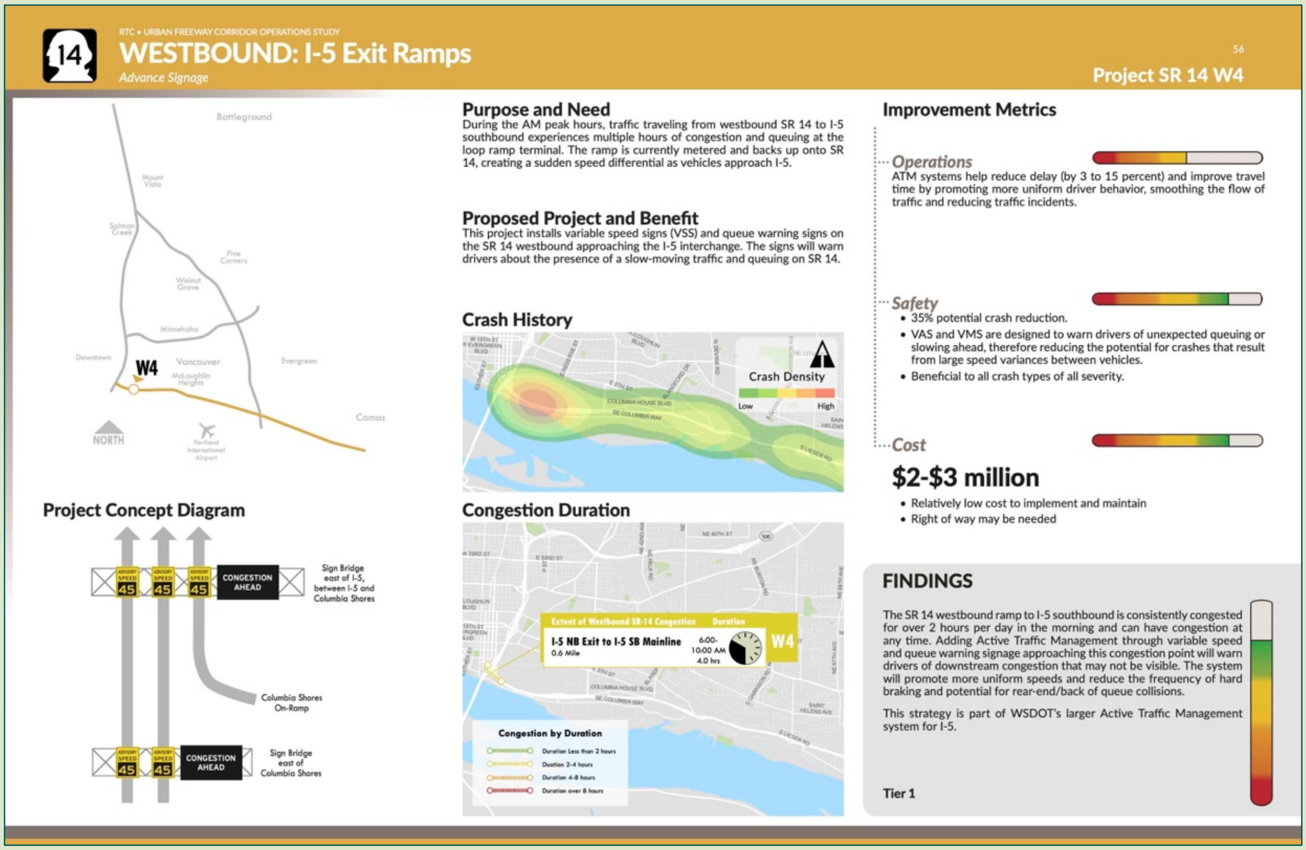
Building on the assessment of potential strategies using analysis tools, the corridor plan will involve selecting a set of promising strategies to achieve the operations objectives for the corridor. Given the wide array of potential strategies to consider, including those that focus on highway/traffic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

It is important to recognize that effective corridor 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 corridor operations is recognizing the interconnections between 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 corridor strategies can then be evaluated in relation to their performance in relation 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 corridor objectives. For instance, use of a highway shoulder as a lane for buses could help improve transit reliability, but it needs to 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.

PRIORITIZING STRATEGIES EXAMPLE: URBAN FREEWAY CORRIDOR OPERATIONS (UFCO) STUDY STRATEGY SELECTION INFO SHEETS

For the UFCO Study in the Southwest Region, the project team identified prioritized TSMO strategies and developed one-page summary sheets for each, highlighting the strategy's performance across various metrics, cost-benefit, and a qualitative prioritization assessment. Here is an example of a Tier 1 Variable Speed Sign and Queue Warning concept proposed for SR 14:



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 corridor, 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 corridor. 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:

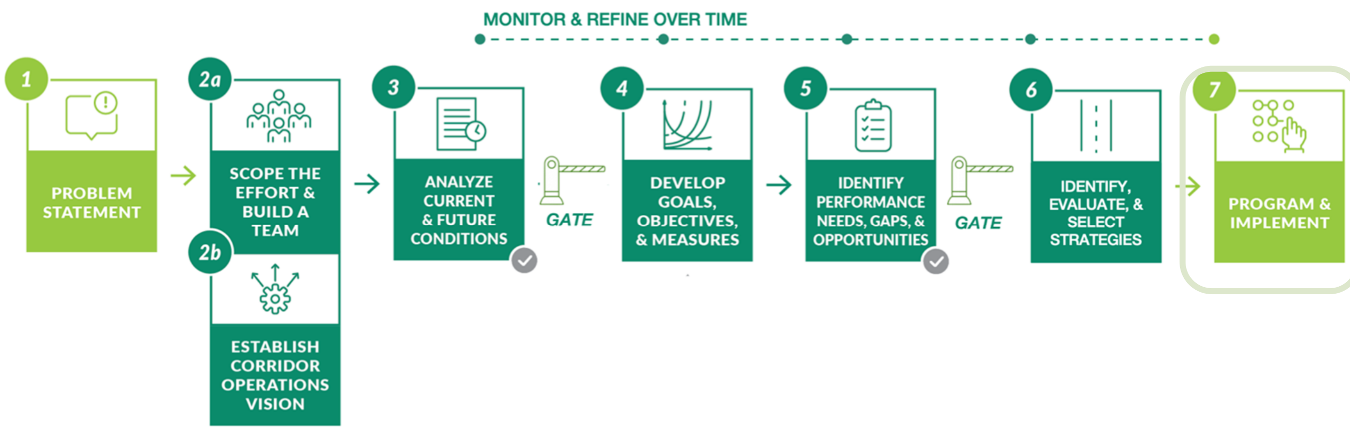
- **Analyzing cost-effectiveness:** Using a cost-effectiveness approach involves calculating the overall cost effectiveness (cost per unit of benefit) for each strategy based on defined benefits. Tools available to calculate reliability benefits include sketch planning, model post-processing, simulation, 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.

- **Multicriteria scoring:** Another approach is to use performance measures along with scoring criteria to assess how different alternatives support corridor performance objectives. For instance, if several key objectives have been defined for a corridor related to system operations (e.g., safety, transit on-time performance, highway reliability), 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.

7. PROGRAM AND IMPLEMENT



The final step is concerned with successfully programming and implementing TSMO plans on a corridor and maintaining those strategies over time. This stage typically involves a handoff from Planning to other groups to carry out the programming and implementation activities. However, a TSMO-oriented project development process and organization structure will create touchpoints for Planning to have a continued role throughout the project's lifecycle. For example, planning staff may aid corridor plans through Project Development to bridge the typical gap.

Key Actions:

Programming

- ☐ **Identify potential TSMO funding sources.** Target eligible Federal, State, and local funding, including grant programs.
- ☐ **Elevate institutional prioritization of TSMO-oriented corridor plans.** To make TSMO-oriented projects more competitive for funding, promote funding criteria that emphasize alignment with long-range plans, performance-oriented evaluation approaches, and achieving mobility, reliability, and cost-effectiveness metrics.

Implementation

- ☐ **Establish a continued role for Planning during project implementation.** Identify opportunities for SWR Planning to provide input and review at key points of the project lifecycle to ensure the implemented system is aligned with the corridor plan vision.
- ☐ **Develop appropriate interagency agreements.** Used to facilitate needed collaboration across agencies for corridor operations activities, interagency agreements can take the form of informal handshake agreements, Memorandum of Understanding, or formal interagency/intergovernmental agreements.
- ☐ **Incorporate systems engineering processes.** A requirement for federally funded ITS projects, systems engineering is an organized approach to improve the success rate of system projects by reducing schedule and cost risks and ensuring that user needs and requirements are met.
- ☐ **Develop a concept of operations (ConOps).** Another frequently required systems engineering element, a ConOps provides a stakeholder view of the system being developed in a non-technical manner. Crucially, it presents the opportunity to formally document the user needs, objectives, performance measures, and stakeholder roles and responsibilities established in the corridor plan to help ensure that they be carried forward into implementation.
- ☐ **Design for operations.** Implement tools and approaches to support the inclusion of operational elements within the project development process. This includes checklists for designers to reference operational considerations, formation of a technical advisement committee with operations expertise, or agency policies to aid designers.
- ☐ **Conduct life cycle planning.** Implement a process to evaluate the effectiveness of implemented strategies, report corridor performance, and assess and refine operations objectives. The process should be repeated on a regular cycle to identify any issues and address them to stop the degradation of corridor performance.

This section presents several components that are critical to successfully programming and implementing the plans for TSMO on a corridor and maintaining those strategies over time. This includes identifying funding for the selected TSMO strategies and using the overarching systems engineering process and regional 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 section also highlights the need to consider designing transportation infrastructure and ITS installations to enable and support planned TSMO strategies.

PROGRAMMING

Projects are typically identified as part of the development of regional or local transportation system plans. In the context of the objectives-driven, performance-based approach to planning for operations, measurable operations objectives should be used to support funding decisions as well as to monitor and evaluate projects so that prioritizations can be modified as necessary. Benefit/cost analysis may also be used to inform the project selection process.

To date many ITS or TSMO plans have been developed separately from regional or local transportation system plans. However, the ITS or TSMO plans are often referenced in the applicable transportation system plan or adopted as an appendix. ITS or TSMO plans typically include a phased implementation plan of projects that often compete for funding with projects from the transportation system plans. More work is needed to bridge the gap between traditional planning and operations planning.

Much of the WSDOT project selection is done by the legislature. When the legislature approves a funding package that focuses on capital projects, WSDOT does not have the power to reject the package and has limits on the flexibility on the use of these funds.

Identify Potential TSMO Funding Sources

TSMO investments and strategies within a corridor can be funded by a combination of federal, state, and local funding sources. Money 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 corridor improvements.

Successfully funding TSMO projects or a TSMO program depends on a combination of capital, operations, and maintenance investments to support active management and operations of the transportation system. The funding sources primarily identify funds that may be used for capital investments; however, funding is also critical for ongoing operations and maintenance. Often operations and maintenance budgets are funded through each agency’s own budget.

Elevate Institutional Prioritization and Programming of TSMO-oriented Corridor Plans

Recognizing the fact of competition for WSDOT regional funding, support is needed for processes that make TSMO-oriented projects more competitive. Namely, promote alignment with long-range plans, performance-oriented evaluation approaches, and an emphasis on mobility, reliability, and cost-effectiveness metrics.

- **Promote achieving goals and objectives of the Long-Range Transportation Plan (LRTP) as basis for funding and project selection.** The goals and objectives of the long-range transportation plan should guide funding decisions and the selection of projects at the state and regional levels. Regions that place importance on system operations in the long-range transportation plan 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 long-range transportation plan, some MPOs, including Southwest Washington Regional Transportation Council (RTC), develop regional operations or ITS plans. These specific operations-focused plans can further advance the implementation of TSMO strategies.

Aligning the corridor plan with the goals and objectives outlined in the long-range transportation plan and developing regional operations or ITS plans will improve the likelihood that the strategies identified in a corridor study receive funding for implementation.

- **Promote project selection criteria based on addressing mobility, reliability, and cost-effectiveness.** The potential for TSMO projects to be selected in an open competition 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.

- **Pursue dedicated TSMO funding programs.** When a region decides to set aside or dedicate funding for TSMO initiatives, criteria that link to key regional objectives are often used for prioritizing that funding. In addition, a TSMO plan can be used to prioritize funding. For instance, Metro, the Portland, Oregon, metropolitan area MPO developed a 10-year regional TSMO plan to guide operations investments in the region. The TSMO plan identifies two categories of actions: (1) those for regional programs and projects that require interagency cooperation, and (2) those for individual travel corridors and single-agency services. After the allocation of funding for the TSMO program in the metropolitan 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 corridor-specific projects. Corridor projects are organized under mobility corridor concepts, in which 24 unique, multimodal corridors in the Portland region connect major activity centers. Each corridor includes a combination of freeways and highways, parallel networks of arterial streets, regional multi-use paths, high-capacity transit, and frequent bus services that connect major activity centers, as defined by the regional growth concept.

- **Identify incremental TSMO implementation opportunities.** Investments to support TSMO do not have to be implemented at one time as part of a large corridor capacity project. Recognizing the scarcity of funding and the value that different TSMO strategies can have, WSDOT can develop a multiphase approach to implement 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.

- **Conduct life cycle costing for TSMO projects.** When evaluating TSMO strategies for a corridor, 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 cost 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) are particularly critical, because the ongoing costs of operations are typically critical to the effectiveness of the strategy.

  Over the life of a program, the costs to operate and maintain a system usually exceed the original investment. This can create challenges if the initial funding planning did not account for the increased costs required to utilize such systems or it can lead to an unused investment. It is important to keep in mind that a system includes the people who are required to operate and manage it.

IMPLEMENTATION

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

Establish a Continued Role for Planning During Project Design and Implementation

Put in place business processes that establish opportunities for SWR Planning to provide input and review at key points of the project lifecycle to ensure that the designed and implemented system remains aligned with the original corridor plan vision.

Develop Appropriate Interagency Agreements

TSMO within corridors 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 corridor operations activities such as traffic incident management, fiber optic cable 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.

General types of interagency agreements include: (1) Handshake agreement, (2) Memorandum of understanding, and (3) Interagency/intergovernmental agreement. Key characteristics of each are show in Table 5.

TABLE 5: INTERAGENCY AGREEMENT TYPES & KEY CHARACTERISTICS

AGREEMENT TYPE	CHARACTERISTICS
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/ INTERGOVERNMENTAL AGREEMENT	• 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. The agreement 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

JOINT OPERATIONS POLICY STATEMENT (JOPS)

For many years, WSDOT, the Washington State Patrol, and the Washington Fire Chiefs have refined joint policy positions regarding areas of mutual interest in the operations of Washington State Highways and Washington State Ferries. Traffic Incident Management, including a 90-minute clearance goal, is a crucial component of the JOPS and used in quarterly performance assessments.

https://wsdot.wa.gov/engineering-standards/all-manuals-and-standards/manuals/joint-operations-

Incorporate Systems Engineering Processes

Systems engineering is an organized approach intended to improve the success rate of system 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 Guidebook. 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 9, has been broadly adopted in the transportation industry. The WSDOT Design Manual (M 22-01) also includes an overview of applying systems engineering for WSDOT projects.

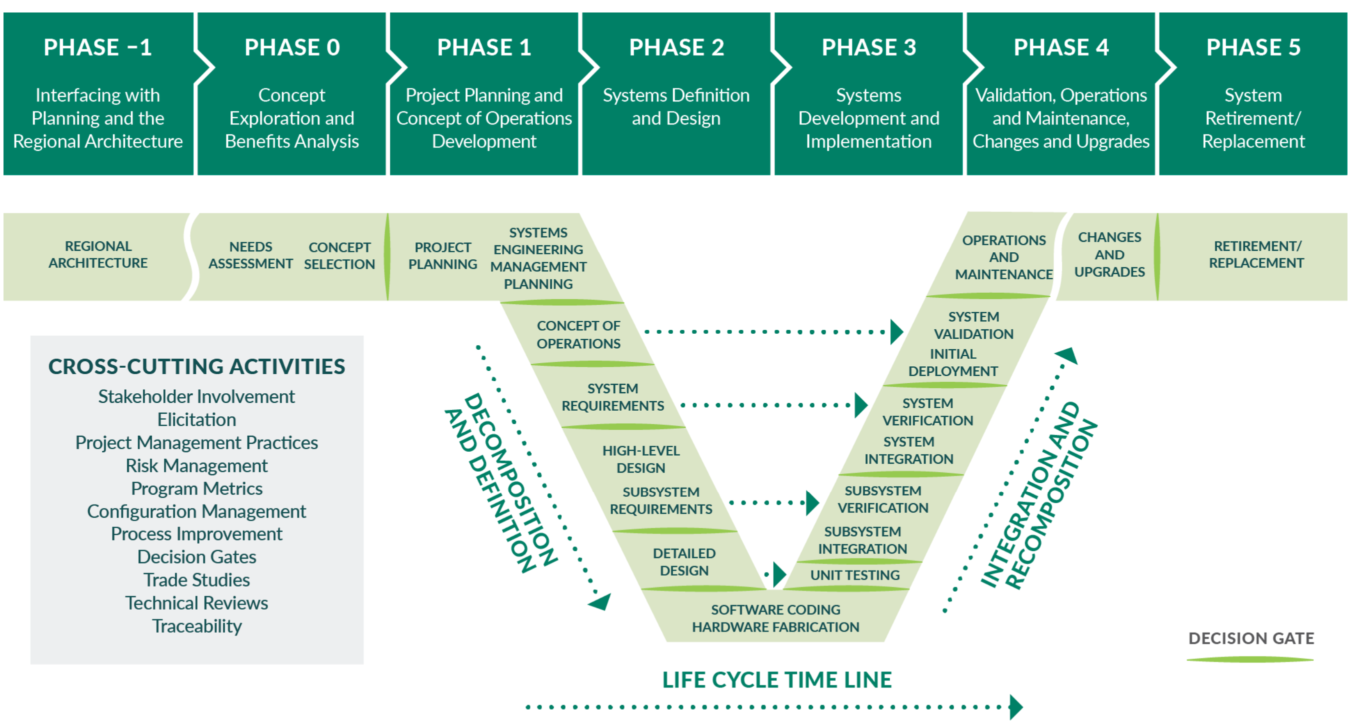


FIGURE 9: "V" MODEL DIAGRAM

Reference Existing Regional ITS Architectures

A regional ITS architecture is a framework for institutional and technical integration in a particular region and can be a valuable tool to support the corridor planning process. In SWR, the Regional ITS Architecture, led by RTC and supported by the VAST agency partners, was last updated in Spring 2022. The Regional ITS architecture can support an objectives-driven, performance-based approach to planning for operations on a corridor. It helps answer important questions, such as:

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

Develop a 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 corridor 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:

- **Identify stakeholders.** This includes anyone involved in or impacted by the project, such as owners, operators, maintainers, users, etc. Stakeholder identification is described in Step 2 of this Guidebook. The regional ITS architecture may also be a good starting point for confirming stakeholders.
- **Develop a consensus on roles and responsibilities.** This is typically done by working through operational scenarios for the corridor, such as normal system operation (e.g., traffic signal operations) 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 (e.g., agreement for one agency to implement signal timing adjustments to another agency's traffic signals on a multijurisdictional corridor).
- **Define stakeholder needs.** This captures a clear definition of stakeholder needs and differentiates 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 corridor. 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 corridor. A corridor 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 TSP on an arterial corridor where TSP is already used by the transit agency within corridors in neighboring jurisdictions may require only a reference to other concepts of operations, but the concept of operations document will focus on the roles and responsibilities for the subject corridor. A larger, more complex corridor project, such as instituting integrated corridor management on a freeway corridor, will require a much more extensive concept of operations document to capture numerous systems and stakeholders.

Design for Operations

The success of the corridor TSMO strategies 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 the facility include:

- Median crossovers, which allow for incident responders to quickly access the opposite side of the road.
- Crash investigation sites, which reduce impacts associated with collecting incident information.
- Snow fences, which reduce blowing snow and drifts on the road.
- Emergency access between interchanges, which decreases response time to incidents.

Ideally, planning for TSMO within a corridor would occur in conjunction with the initial construction of the corridor's roads or rails so that TSMO strategies could be factored into the infrastructure design. For example, truck-only toll lanes or median breaks and crash investigation sites 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 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 speed harmonization gantries, 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 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. The FHWA document, *Designing for Transportation Management and Operations: A Primer*, introduces the concept of designing for operations and can be consulted by corridor TSMO teams to learn more about how to integrate design elements that facilitate TSMO strategies within corridors into roadway design.

Conduct Life Cycle Planning

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

- **Evaluate the effectiveness of implemented strategies.** Develop a corridor evaluation plan during the planning or design process and put the plan into action following implementation. An evaluation plan will detail the key performance measures to be used and how necessary data will be collected, validated, stored/organized, and reported. Consider automation of this ongoing process during design to reduce staffing resource needs.

- **Report corridor performance.** Inform decisionmakers and stakeholders about trends in corridor 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 corridor performance falls short of meeting a desired objective, consider refining the objective or contemplate alternate strategies that may meet the objective. Sometimes the strategy effectiveness changes based on changing land use and travel demand patterns.

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 corridor performance.

Before-after studies are a common approach to evaluate the performance of TSMO strategies post-implementation and on an ongoing basis. It is important to collect sufficient data ahead of a project implementation and after completion to statistically measure factors like reliability. The cost of performing before and after studies, which has been a barrier, is greatly reduced with technology-based methods.

Evaluation procedures should be defined in the project planning phase. Depending on the study design, performance evaluation can be set up as a one-time before period vs. after period analysis, or as a comparison of before data to after data collected over time. A study design with multiple after periods allows for observations of trends over time. After periods typically occur at specified intervals (e.g., annually). The initial after period typically does not occur until a duration of time passes beyond project construction (e.g., six months). This is so data are not skewed by abnormal behavior that may occur upon installation of new transportation devices in the system. It is important that the before period and after period occur during the same time of year so seasonal differences in traffic and travel conditions do not skew the results. Analysis methods can vary depending on the goals of the evaluation, data structure, and data availability.

APPENDIX

APPENDIX A – TSMO STRATEGY IDENTIFICATION QUICK REFERENCE SHEETS

This section provides quick reference sheets to help identify typical stakeholders, goals, objectives, measures, data needs, data resources, and relevant TSMO strategies for these 11 common corridor operations areas:

1. System Efficiency: Corridor Travel Time
2. System Reliability: Non-Recurring Delay in Corridors
3. System Options: Bicycle and Pedestrian Accessibility and Efficiency
4. Arterial Management: Traffic Signal Management
5. Freeway Management: Ramp Management
6. Transit Operations and Management: Transit Signal Priority
7. Traffic Incident Management
8. Road Weather Management
9. Work Zone Management
10. Active Transportation and Demand Management
11. Integrated Corridor Management

SYSTEM EFFICIENCY: CORRIDOR TRAVEL TIME	The objectives focus on reducing the amount of time it takes to travel through a corridor. 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 corridor, where appropriate.
STAKEHOLDERS	MPO, State, County and City Agencies, Toll Authority, Transit Agency, TMCs, Rideshare Organizations, Media, Corridor Business and Neighborhood Associations etc.
GOALS	Reduce corridor travel time experienced by travelers
CORRIDOR OPERATIONAL OBJECTIVES	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.
PERFORMANCE MEASURES	Average travel time during peak periods (minutes). Average commute trip travel time (minutes).
ANTICIPATED DATA NEEDS	Peak period and free flow travel time and speeds. Person travel along corridor links (e.g., vehicle volume multiplied by vehicle occupancy). Trip length.
DATA RESOURCES AND PARTNERS	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.
TSMO STRATEGIES TO CONSIDER	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.

SYSTEM RELIABILITY: NON-RECURRING DELAY IN CORRIDORS	This set of objectives is focused on minimizing non-recurring delay in corridors. 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 and unscheduled disruptions to travel.
STAKEHOLDERS	MPO, State, County and City Agencies, Toll Authority, Transit Agency, TMCs, Incident Responders, Towing Agency, Contractors, Fire & Rescue Agency, Emergency Medical Agency, Media, Corridor Business and Neighborhood Associations etc.
GOALS	Minimize non-recurring delay (scheduled and non-scheduled disruptions) in corridors.
CORRIDOR OPERATIONAL OBJECTIVES	Reduce total person hours of delay in corridor by time period (peak, off-peak) caused by: • 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	Travel time delay during scheduled and/or unscheduled disruptions to travel in the corridor. Total person hours of delay during scheduled and/or unscheduled disruptions to travel in the corridor.
ANTICIPATED DATA NEEDS	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 in the corridor.
DATA RESOURCES AND PARTNERS	Travel time data during non-recurring events may be difficult to collect, particularly during unscheduled events, such as incidents and severe weather. Transportation 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 also may 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: BICYCLE AND PEDESTRIAN ACCESSIBILITY AND EFFICIENCY	The objectives focus on improving the accessibility and efficiency of bicycle and pedestrian modes to offer travelers feasible and attractive travel options within a corridor.
STAKEHOLDERS	MPO, State, County and City Agencies, Transit Agency, TMCs, Corridor Business and Neighborhood Associations, University Research Centers, Pedestrian & bicycle advocacy groups etc.
GOALS	Improve bicycle and pedestrian accessibility and efficiency. Provide attractive bicycle and pedestrian travel options in a corridor.
CORRIDOR OPERATIONAL OBJECTIVES	Decrease average delay for pedestrians and bicyclists on primary pedestrian and/or bicycle routes by X percent in Y years. Increase system completeness in corridor for pedestrians and/or bicyclists by X percent within Y years. Increase the number of intersections with pedestrian and/or bicycle safety features (e.g., countdown pedestrian signal heads, bicycle signals, painted crosswalks/bike boxes) to X percent by year Y. Increase average pedestrian (or bicyclist) comfort level by X points in Y years.
PERFORMANCE MEASURES	Average delay for pedestrians and bicyclists on primary pedestrian and/or bicycle routes in the corridor. Percent of corridor with pedestrian and/or bicycle facilities. The percentage of intersections with pedestrian and/or bicycle safety features. Average pedestrian and/or bicyclist comfort level as measured by survey. WSDOT's Level of Traffic Stress and Route Directness indices
ANTICIPATED DATA NEEDS	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.
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 crowd sourcing data also can 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, and crossing signals were bicycles cross major roadways.

ARTERIAL MANAGEMENT: TRAFFIC SIGNAL MANAGEMENT	**The objectives focus on improving the management of traffic signal operations in an arterial corridor through advanced technology, increased reviews, and planning.**
STAKEHOLDERS	MPO, State, County and City Agencies, Transit Agency, TMCs, Corridor Business and Neighborhood Associations, Traffic signal technicians, Incident Responders etc.
GOALS	Improve arterial traffic signal operations for day-to-day operations during peak and off-peak periods. Improve arterial traffic signal operations during scheduled or nonscheduled events.
CORRIDOR OPERATIONAL OBJECTIVES	Evaluate signal timing in arterial corridor every Y year. Increase the number of arterial corridor intersections running in a coordinated, closed-loop, or adaptive system by X percent in Y years. Prepare and implement special arterial corridor timing plans for use during freeway incidents, roadway construction activities, or other special events by year Y. Crash data for arterial corridor is reviewed every X years to determine if signal adjustments can be made to address a safety issue.
PERFORMANCE MEASURES	Number of years between traffic signal timing evaluation in arterial corridor. 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 in arterial corridor. Number of times per year a special timing plan is used in arterial corridor. Number of years between reviews of crash data on all arterials for possible signal timing impacts.
ANTICIPATED DATA NEEDS	Reports from operating agencies on frequency of signal retiming evaluation, current traffic signal capabilities, special timing plans, and crash data reviews.
DATA RESOURCES AND PARTNERS	Partner agencies that operate arterials and agencies that maintain traffic crash records.
TSMO STRATEGIES TO CONSIDER	Regular evaluation of corridor traffic signal timing, enhanced traffic signal systems, special corridor timing plans for events, incidents, and work zones, and regular review of corridor crash data.

FREEWAY MANAGEMENT: RAMP MANAGEMENT	The objectives focus on the application of traffic control devices, such as ramp meters, signing, and gates, to regulate the number of vehicles entering or leaving the freeway to achieve operations objectives.
STAKEHOLDERS	MPO, State, County and City Agencies, Transit Agency, TMCs, Incident Responders, Towing Agency, Contractors, Fire & Rescue Agency, Emergency Medical Agency, Media, Law enforcement, 911 Centers, Corridor Business and Neighborhood Associations etc.
GOALS	Improve overall freeway corridor operations during peak periods and during scheduled or unscheduled events.
CORRIDOR OPERATIONAL OBJECTIVES	Increase the percent of interchanges in a freeway corridor operating at LOS Z or higher during peak periods by X percent by year Y. Reduce the number of congestion-inducing incidents occurring at freeway ramps by X percent by year Y. Increase the number ramps in freeway corridor currently metered by X percent by year Y.
PERFORMANCE MEASURES	Number and percent of freeway corridor interchanges operating at LOS Z or above during peak periods (per year). Total number of congestion-inducing incidents at freeway corridor interchanges during peak period (per year). Number of freeway corridor interchanges with ramp meters (by year of installation).
ANTICIPATED DATA NEEDS	Traffic volume and LOS data (e.g., traffic counts) at freeway corridor interchanges. Total number of congestion-related incidents at freeway corridor interchanges. Number of freeway corridor ramp meters and year of installation.
DATA RESOURCES AND PARTNERS	Providers of travel data, including traffic volumes and incidents, such as State DOTs, cities, counties, and transportation management centers.
TSMO STRATEGIES TO CONSIDER	Ramp management strategies typically encompass ramp metering, ramp closure, special use treatments (e.g., High-Occupancy Vehicle (HOV), special events), and ramp terminal treatments.

TRANSIT OPERATIONS AND MANAGEMENT: TRANSIT SIGNAL PRIORITY	The objectives focus on implementing TSP systems to improve transit performance and reliability within a corridor.
STAKEHOLDERS	MPO, State, County and City Agencies, Transit Agency, TMCs, Traffic signal technicians, Corridor Business and Neighborhood Associations etc.
GOALS	Improve transit service performance and reliability on corridors with traffic signals.
CORRIDOR OPERATIONAL OBJECTIVES	Increase implementation of TSP at X number of intersections over the next Y years. Decrease traffic signal delay on transit routes in corridor by X percent per year. Decrease transit vehicle delay in corridor by X percent per year by increasing the use of queue jumping and automated vehicle location.
PERFORMANCE MEASURES	Number of transit routes/intersections equipped with TSP capability in corridor. 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	Number of transit routes/intersections with transit signal priority capabilities. Automated vehicle location data with location and travel time delay. Signal operations/green time reports
DATA RESOURCES AND PARTNERS	Transit agencies and traffic signal operating agencies in the region can provide information about implementation and performance of TSP. Automated vehicle location data can provide transit vehicle travel time.
TSMO STRATEGIES TO CONSIDER	TSMO strategies to increase TSP implementation could involve identification and prioritization of transit routes and signalized intersections that are candidates for implementing TSP systems or queue jumping. Another strategy may include collaboration with the traffic management agency to leverage TSP implementation with traffic signal system upgrades.

TRAFFIC INCIDENT MANAGEMENT	The objectives focus on improving system efficiency, system reliability, traveler information, and agency efforts for managing traffic incidents within a corridor.
STAKEHOLDERS	MPO, State, County and City Agencies, Toll Authority, Transit Agency, TMCs, Incident Responders, Towing Agency, Contractors, Fire & Rescue Agency, Emergency Medical Agency, Hazardous Materials Industry, Media, Corridor Business and Neighborhood Associations etc.
GOALS	Reduce traffic incident duration and person hours of delay on a corridor. Provide travelers with accurate, timely, and actionable information and improve customer satisfaction. Increase coordination and communication between agencies. Train incident management staff.
CORRIDOR OPERATIONAL OBJECTIVES	Reduce corridor mean incident notification time by X percent over Y years. Reduce mean time for needed corridor responders to arrive on-scene after notification by X percent over Y years. Reduce corridor 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 corridor facilities by X percent in Y years. Reduce the person hours of total delay associated with corridor 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 corridor traveler information outlet by X percent in Y years. Increase customer satisfaction with corridor incident management efforts by X percent over Y years. Increase the percentage of incident management agencies that participate in a coordinated corridor 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 corridor by year Y.

TRAFFIC INCIDENT MANAGEMENT	**The objectives focus on improving system efficiency, system reliability, traveler information, and agency efforts for managing traffic incidents within a corridor.**
PERFORMANCE MEASURES	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 corridor traffic incidents. Time to alert travelers of a corridor incident. Time between recovery from incident and removal of traveler alerts. Number of repeat visitors to traveler information outlet. Percentage of customers satisfied with corridor incident management practices. Number of participating agencies in a corridor 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.
ANTICIPATED DATA NEEDS	For each incident of interest in the corridor, 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 (1) during free flow conditions, and (2) impacted by incidents. Time of incident verification, time of traveler information outlet activation (e.g., variable message sign posting, 511 entry, and website log), time of corridor system recovery, and time of travel alert removal. Customer satisfaction surveys. Number of agencies participating in a corridor 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	Data would need to be tracked by the incident responders, 9-1-1 dispatchers, or operators at a transportation management center or emergency operations center with access to video of the scene. The partners needed for these measures would be all incident responders willing to support the objectives.
TSMO STRATEGIES TO CONSIDER	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 also can help improve customer satisfaction. Increasing agency participation along the corridor, 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 corridor patrols, expanding surveillance camera coverage, and training on dissemination of corridor traveler information.

ROAD WEATHER MANAGEMENT	The objectives for managing road weather on a corridor focus on improving system efficiency, system reliability, traveler information, and traffic signal management within a corridor.
STAKEHOLDERS	MPO, State, County and City Agencies, Weather forecast agencies, Transit Agency, TMCs,911 center(s), Incident Responders, Towing Agency, Contractors, Fire & Rescue Agency, Emergency Medical Agency, Hazardous Materials Industry, Media, Corridor Business and Neighborhood Associations etc.
GOALS	Improve the clearance time of weather-related debris (e.g., fallen limbs and trees, snow and ice, and power lines and poles) from the corridor transportation facilities. Help travelers avoid corridor segments that are dangerous and would cause them substantial delay. Disseminate relevant information to travelers in a timely manner regarding the impact of weather on corridor travel. Increase the coverage of the corridor (e.g., roadway, transit, or bicycle facilities) with weather sensors and communications. Improve traffic signal management during inclement weather conditions.
CORRIDOR OPERATIONAL OBJECTIVES	Reduce average time to clear corridor of weather-related debris after weather impact by X percent in Y years. Increase by X percent the number of significant corridor segments covered by weather-related diversion plans by year Y. Increase the percent of agencies that have adopted multi-agency, weather-related corridor 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. variable message signs, 511, websites, social media) by X (time period or percent) in Y years. Increase the percent of the corridor covered by weather sensors or a road weather information system by X percent in Y years, as defined by a road weather information system station within Z miles. Special timing plans are available for use during inclement weather conditions for X miles of the corridor by year Y.

ROAD WEATHER MANAGEMENT	The objectives for managing road weather on a corridor focus on improving system efficiency, system reliability, traveler information, and traffic signal management within a corridor.
PERFORMANCE MEASURES	Average time to clear selected corridor surface transportation facilities of weather-related debris after weather impact. Percent of significant corridor segments covered by weather-related diversion plans. Percent of agencies involved in transportation operations during weather events that have adopted multi-agency, weather-related corridor transportation operations plans. Time from beginning of weather event to posting of information to traveler information outlets. Percent of corridor within Z miles of a road weather information system station. Number of miles of corridor that have at least one special signal timing plan for inclement weather events.
ANTICIPATED DATA NEEDS	Time in which the corridor surface transportation facilities have been impacted by the debris, and the time required to clear the corridor 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 corridor 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 road weather information system station near the corridor and length of the corridor. Reports from operating agencies on corridor signal retiming, signal capabilities, and special timing plans.
DATA RESOURCES AND PARTNERS	Field data may come from fixed road or airport weather sensors (road weather information systems), observations from meteorologists, National Weather Service data, or mobile observations from connected vehicles.

ROAD WEATHER MANAGEMENT	**The objectives for managing road weather on a corridor focus on improving system efficiency, system reliability, traveler information, and traffic signal management within a corridor.**
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 corridor 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 between jurisdictions and modes. System efficiency also can 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 corridor weather and facility information, weather forecasts, status information on operational activities (e.g., map of snow plow activities), and the use of variable message signs on the corridor or approaches to the corridor.

WORK ZONE MANAGEMENT	The objectives focus on improving system efficiency, system reliability, traveler information, and agency coordination efforts for managing work zones within a corridor.
STAKEHOLDERS	MPO, State, County and City Agencies, Weather forecast agencies, Transit Agency, TMCs, 911 center(s), Law enforcement, Utility Agencies, Contractors, Fire & Rescue Agency, Emergency Medical Agency, Hazardous Materials Industry, Media, Corridor Business and Neighborhood Associations etc.
GOALS	Reduce travel time delay within corridor 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 corridor construction projects to reduce the burden on transportation system users. Inform travelers of ongoing corridor work zones to reduce travel time delays. Improve customer satisfaction with work zone management.
CORRIDOR OPERATIONAL OBJECTIVES	Reduce the person hours of total delay associated with corridor work zones by X percent over Y years. Increase the rate of on-time completion of corridor construction projects to X percent within Y years. Increase the percentage of corridor construction projects that employ night/off-peak work zones by X percent in Y years. Reduce the percentage of vehicles traveling through corridor 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 corridor construction coordination by X percent in Y years. Decrease the number of work zones on parallel routes/along the same corridor by X percent in Y years. Establish a work zone management system within X years to facilitate coordination of work zones in the corridor. Provide work zone information and multimodal alternatives to traveler information outlets for at least X percent of corridor work zones over the next Y years. Increase customer satisfaction with corridor work zone management efforts by X percent over Y years.

WORK ZONE MANAGEMENT	The objectives focus on improving system efficiency, system reliability, traveler information, and agency coordination efforts for managing work zones within a corridor.
PERFORMANCE MEASURES	Person hours of delay associated with corridor work zones. Percent of corridor construction projects completed on-time. Percent of corridor construction projects employing night/off-peak work zones. Percent of vehicles experiencing queuing in corridor work zones. Length of average and maximum queues in corridor 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 corridor capital projects whose project schedules have been reviewed. Percent of work zones on parallel routes/along the same corridor. Presence of an established work zone management system. Percent of corridor work zones for which traveler information and multimodal alternatives are available through traveler information outlets. Percentage of customers satisfied with corridor work zone management practices.
ANTICIPATED DATA NEEDS	Total travel time in person hours of travel: (1) during free flow conditions, and (2) impacted by work zones. Work zone information for work and non-work time periods (e.g., traffic volumes, travel time, and 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. Corridor capital projects submitted for review. Corridor 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.
DATA RESOURCES AND PARTNERS	Data would need to be collected by agencies responsible for maintenance and operation of the transportation facilities. Partners needed may include DOTs, public safety agencies, contractors, and utility companies.

WORK ZONE MANAGEMENT	**The objectives focus on improving system efficiency, system reliability, traveler information, and agency coordination efforts for managing work zones within a corridor.**
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 corridor 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 variable message signs or portable variable message signs to disseminate traveler information along the corridor or on approaches to the corridor.

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.
STAKEHOLDERS	MPO, State, County and City Agencies, Toll authorities, Transit Agency, TMCs, Parking providers, Rideshare organizations, Law enforcement, Media, Corridor Business and Neighborhood Associations, Travelers etc.
GOALS	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.
CORRIDOR OPERATIONAL OBJECTIVES	Increase the number of corridor travelers receiving information on ATDM strategies by X percent within Y years. Increase customer satisfaction with ATDM efforts by X percent over Y years. Improve average corridor travel time during peak periods by X percent by year Y. Reduce corridor trips per year by X percent through dynamic ridesharing and active transit management within Y years. Increase the percentage of corridor travelers with electronic toll collection transponders by X percent by year Y. Increase the share of corridor segments or lanes that are using dynamic pricing to X percent by year Y. Reduce the number of congestion-inducing crashes occurring on the corridor and at corridor freeway ramps by X percent by year Y. Implement active parking management for X percent of the corridor within Y years.
PERFORMANCE MEASURES	Total number and percent of corridor travelers receiving information on ATDM strategies. Percent of customers satisfied with corridor ATDM practices. Average corridor 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. Percent of corridor travelers with electronic toll collection transponders. Share of corridor segments or lane miles using dynamic pricing. Total number of congestion-inducing crashes on corridor and at freeway ramps (per year). Percent of corridor parking stalls with active parking management.

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.
ANTICIPATED DATA NEEDS	Survey/count of travelers exposed to ATDM information. Customer satisfaction surveys. Corridor peak period and free flow travel times and speeds. Person travel time along corridor links (e.g., vehicle volume multiplied by vehicle occupancy) during free flow conditions and congested conditions. Trip length. Mode share and total trips for corridor. Total number of corridor users (annually) with electronic toll collection transponders. System information (e.g., miles of dynamically priced lanes or facilities). Total number of congested-related crashes by location on corridor. Count of total and actively managed parking stalls.
DATA RESOURCES AND PARTNERS	Data may need to be gathered from transportation management centers, State DOTs, cities, counties, toll authorities, transit agencies, and parking providers.

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.**
TSMO STRATEGIES TO CONSIDER	There are numerous TSMO strategies to consider in order to achieve ATDM objectives. The strategies are typically categorized as they relate to demand, traffic, or parking: **Active Demand Management:** • Corridor monitoring. • Corridor 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). **Active Traffic Management:** • Dynamic/variable speed control. • Dynamic lane use control and reversal. • Adaptive ramp metering. • Dynamic merge control. • Dynamic queue warning. • Hard shoulder running. • Dynamic re-routing. • Dynamic truck restrictions. **Active Parking Management:** • Dynamic overflow transit parking. • Dynamic parking reservation. • Dynamic wayfinding. • Dynamically priced parking. Automated enforcement may also be considered to complement some of the strategies such as dynamic pricing and dynamic speed control.

INTEGRATED CORRIDOR MANAGEMENT	**This objective set focuses on balancing travel demand across corridor networks and providing multi-agency management of events within a corridor.**
STAKEHOLDERS	MPO, State, County and City Agencies, Toll authorities, Transit Agency, TMCs, Incident responders, Contractors, Law enforcement, 911 Center, Media, Fire & Rescue Agency, Emergency Medical Agency, Corridor Business and Neighborhood Associations, etc.
GOALS	Balance travel demand across networks (freeway, arterial, transit, parking). Provide multi-agency management of events such as incidents, special events, inclement weather, and work zones.
CORRIDOR OPERATIONAL OBJECTIVES	Increase the number of corridor travelers receiving information on ICM strategies by X percent within Y years. Increase customer satisfaction with ICM efforts by X percent over Y years. Balance corridor trips so that each route and mode within the corridor operate at X percent capacity within Y years. Improve average corridor travel time during peak periods by X percent by year Y. Reduce the person hours of total delay associated with non-recurrent events by X percent over Y years. Increase the percentage of agencies that participate in an ICM team by X percent in Y years. Hold at least X multi-agency, after-action review meetings following a corridor event each year, with attendance from at least Y percent of the agencies involved in the response. Conduct X joint-ICM training exercises for the corridor by year Y.
PERFORMANCE MEASURES	Total number of corridor travelers and percent receiving information on ICM strategies. Percent of customers satisfied with ICM practices. Volume-to-capacity ratios for corridor routes and modes. Average corridor travel time during peak periods (minutes). Person hours of delay for the corridor. Number of agencies participating in an ICM team. Number of multi-agency after-action reviews per year. Percent of responding agencies participating in after-action review. Number of joint ICM training exercises conducted.

INTEGRATED CORRIDOR MANAGEMENT	This objective set focuses on balancing travel demand across corridor networks and providing multi-agency management of events within a corridor.
ANTICIPATED DATA NEEDS	Survey/count of travelers exposed to ICM information. Corridor peak period and free flow volumes (i.e., vehicles and occupancy), travel times, and speeds by route and mode. Person travel time along corridor links (e.g., vehicle volume multiplied by vehicle occupancy) during free flow conditions and congested conditions. Trip length. Mode share and total trips for corridor. Number of agencies participating in an ICM team. Number of after-action reviews held. Number of joint-ICM training exercises conducted.
DATA RESOURCES AND PARTNERS	Data may need to be gathered from transportation management centers, State DOTs, cities, counties, toll authorities, transit agencies, public safety agencies, the National Weather Service, and other ICM partners.
TSMO STRATEGIES TO CONSIDER	A wide variety of TSMO strategies may be considered to support ICM objectives. Refer to the other reference sheets on TIM, ATDM, road weather management, work zone management, freeway ramp management, traffic signal management, and TSP for a detailed list of potential TSMO strategies in those areas. Providing ahead-of-time, real-time, and predictive multimodal traveler information tailored to the corridor is key to supporting balanced network demand in addition to route/mode diversion to parallel facilities, short-term ATDM strategies, and longer-term transportation demand management strategies (e.g., rideshare, employer programs, and commuter incentives). Additional TSMO strategies to consider for improving multi-agency coordination include information clearinghouses, common event reporting systems, event pre-planning efforts, system coordination between ramp meters and traffic signals, and responsibility sharing for traffic operations functions (e.g., shared control of traffic signal timing plans).

APPENDIX B – TSMO STRATEGY ANALYSIS TOOLS OVERVIEW

This section provides an overview of the standard methods and tools currently available to evaluate TSMO strategies as part of corridor planning. Six main categories of analysis tools could apply to the evaluation of TSMO strategies:

1. Scenario planning
2. Travel demand models
3. Sketch-planning tools;
4. Analytical/deterministic tools
5. Simulation models
6. Emerging hybrid approaches, including activity-based models and dynamic traffic assignment reference sheets to help identify typical stakeholders, goals, objectives, measures, data

SCENARIO PLANNING

Scenario planning is an important enhancement to planning for TSMO within a corridor. 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 along a corridor.

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, 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.

TRAVEL DEMAND MODELS

Travel demand models are useful in screening and evaluating corridor-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.

CATEGORY	TRAVEL DEMAND MODEL INFORMATION
DESCRIPTION	Travel demand models are widely used to compare or screen alternatives by using origin-destination 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	Types of models: Three-step models (no mode choice). Four-step models. Activity-based models. Mesoscale models Software: VISUM, Cube, Emme, and TransCAD.
PLANNING FOR OPERATIONS USES FOR CORRIDORS	Supply data (e.g., travel forecast inputs) to sketch-planning tools, simulation models, and post-processors that can analyze corridor operations strategies. Use traffic origin-destination patterns or volumes for input into corridor simulation models. Provide changes in peak-hour turning volumes at major corridor intersections and freeway ramp volumes through refined (subarea) travel demand models. Extract tables with origin-destination for trips in a focus area as required input for microscopic corridor simulation models. Screen and evaluate corridor 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 origin-destination estimates for use as inputs to simulation models.
ADVANTAGES	Validates models available for most metropolitan areas. Evaluates corridor 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	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

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.

The FHWA developed the TOPS-BC, a benefit-cost analysis sketch-planning tool that is available to help corridor teams screen multiple TSMO strategies. It provides order-of-magnitude benefit cost estimates using default parameters that can be customized using local data. The TOPS-BC is available for download from the FHWA Planning for Operations Website.[6] The FHWA is continuing to develop products to assist practitioners in applying benefit-cost analysis for TSMO strategies.

CATEGORY	SKETCH PLANNING TOOLS INFORMATION
DESCRIPTION	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 Florida ITS Evaluation Tool (FITSEVAL), can be integrated with travel demand model data to provide analysis of operational strategies.
EXAMPLES	Tool for Operations Benefit CostAnalysis (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 corridor before-and-after studies.
PLANNING FOR OPERATIONS USES FOR CORRIDORS	Evaluate policy-based and corridor 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.

[6] Tool for Operations Benefit-Cost Analysis can be downloaded from: https://ops.fhwa.dot.gov/plan4ops/topsbctool/index.htm.

CATEGORY	SKETCH PLANNING TOOLS INFORMATION
ADVANTAGES	Low cost. Fast analysis times. Uses readily accessible data. View of the “big picture.” Some tools expressly for evaluating policy-based or corridor strategies. May be integrated with travel demand model.
CHALLENGES	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

Analytical or deterministic tools typically implement the procedures of the Highway Capacity Manual.[7] 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, multilane highways, two-lane highways, and transit. These tools have somewhat-limited application for evaluating TSMO strategies for a corridor. 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, signalized, and roundabout).

[7] Transportation Research Board, Highway Capacity Manual 7th Edition (Washington, DC: 2022). Available from: https://nap.nationalacademies.org/catalog/26432/.

CATEGORY	ANALYTICAL/DETERMINISTIC TOOLS INFORMATION
DESCRIPTION	Most analytical/deterministic tools implement the procedures of the Highway Capacity Manual. The following summarize the Highway Capacity Manual procedures: **Closed-form:** A practitioner inputs data and parameters and, after a sequence of analytical steps, the Highway Capacity Manual 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. Analytical/deterministic tools quickly predict capacity, density, speed, delay, and queuing on a variety of transportation facilities.
EXAMPLES	Highway Capacity Software (HCS). Synchro SIDRA Vistro
PLANNING FOR OPERATIONS USES FOR CORRIDORS	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, roundabout).
ADVANTAGES	Predicts impacts for isolated or small-scale transportation facilities. Is widely accepted. Provides repeatable results.
CHALLENGES	Limited ability to assess many TSMO strategies. Limited ability to analyze broader corridor network or system effects. Limited output of performance measures.

SIMULATION TOOLS

Simulation tools cover a range of software that is available to model transportation system operations and can be applied specifically to corridors. Simulation models are typically classified according to the level of detail at which they represent the traffic stream—macroscopic, mesoscopic, or microscopic:

- **Macroscopic** simulation models simulate traffic flow, taking into consideration aggregate traffic stream characteristics (i.e., speed, flow, and density) and their relationships.
- **Mesoscopic** simulation models simulate individual vehicles, but describe their activities and interactions based on aggregate (macroscopic) relationships.
- **Microscopic** simulation models simulate the characteristics and interactions of individual vehicles.

Corridor agencies can 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.

CATEGORY	SIMULATION TOOLS INFORMATION
DESCRIPTION	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: **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.
EXAMPLES	**Macroscopic:** PASSER, TSIS-CORSIM (includes TRANSYT-7F), and VISTA. **Mesoscopic:** DYNASMART-P, DynusT, DynaMIT, TransModeler, TRANSIMS, Aimsun, and Dynameq. **Microscopic:** TSIS-CORSIM, Paramics, VISSIM, TransModeler, and Aimsun.

CATEGORY	SIMULATION TOOLS INFORMATION
PLANNING FOR OPERATIONS USES FOR CORRIDORS	Evaluate a range of improvements and strategies at corridor levels. Conduct sensitivity testing to reflect variability in traffic demands or incident severity. Refine project scope and design. Support environmental assessment.
ADVANTAGES	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 coupled with dynamic traffic assignment (DTA). Analyzes complex conditions and multimodal interaction. Offers visual presentation opportunities.
CHALLENGES	Expertise needed to develop and apply models. Demanding data and computing requirements. Resource requirements may limit network size and number of analysis scenarios. Calibration may be time consuming. Extensive outputs may require development of separate post processing tools. Static network assignment.

ACTIVITY-BASED MODELS

Activity-based models are increasingly being used as a region's travel demand model and may be useful in evaluating TSMO strategies within corridors. 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, transportation demand management programs, and many other TSMO strategies.

DYNAMIC TRAFFIC ASSIGNMENT

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, used primarily in conjunction with travel demand forecasting procedures for planning applications, with traffic simulation models, 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.

CATEGORY	DYNAMIC TRAFFIC ASSIGNMENT INFORMATION
DESCRIPTION	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: • 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	*DYNASMART-P*. *DynusT*. *DynaMIT*. *Dynameq*.
PLANNING FOR OPERATIONS USES FOR CORRIDORS	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, integrated corridor management (ICM) strategies, managed lanes, congestion pricing, etc.

CATEGORY	DYNAMIC TRAFFIC ASSIGNMENT INFORMATION
ADVANTAGES	More realism in estimating traveler response and therefore operations. Wider range of strategies can be more accurately tested.
CHALLENGES	Is resource intensive. Requires skill sets of both travel demand modeling and simulation modeling.