SANDAG

Regional Transportation System Management and Operations (TSMO) Plan

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Prepared by:

Kimley»Horn
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System Metrics Group

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1 INTRODUCTION

The Transportation Systems Management and Operations (TSMO) Plan for San Diego County provides a roadmap for governance and institutional actions to help advance and facilitate increased cross agency collaboration to promote and achieve support for an integrated management of existing and future transportation technologies and operational strategies.

Historically, transportation systems have been operated and managed as independent systems. This approach has resulted in inefficiencies and ad hoc planning and implementation of projects, which often only addresses project and location-specific needs. Transportation agencies across the United States have been organized to deliver capacity-based infrastructure improvements. As a result, their processes for project development, planning, project prioritization, funding and programming have also been structured to focus on transportation investments that generally placed emphasis on capacity improvements.

Today, agencies are shifting their focus from solving mobility challenges by expanding roadway capacity to increasing transit ridership, managing demand, and utilizing the existing transportation system more efficiently. Because transportation customers travel on roads that cross many jurisdictions and might require multiple modes of travel during their trips, the transportation system must be managed across jurisdictions and across modes. This shift in focus is called TSMO, which emphasizes the user experience and using people, processes, and tools to develop strategies for enhanced transportation utilization.

> *TSMO offers integrated strategies to "improve system performance through multimodal, intermodal, and cross-jurisdictional systems, services, and projects that preserve capacity, enhance public safety and security, enhance seamless connections between modes, and improve reliability" (FHWA, 2017)[1]."*

Effective TSMO strategies need to consider the full range of transportation interactions, whether it is cross-jurisdictional corridor operations, transit routes, and how traffic management systems can safely accommodate bicycles and pedestrians. The strategies are designed to improve safety and reliability by managing multi-modal mobility and minimizing any unpredictable delays to the transportation system. To implement strategies through this TSMO lens, agencies often need to evaluate the institutional, operational, and technical aspects of its day-to-day processes for planning, programming, designing, constructing, and maintaining projects.

The SANDAG Regional TSMO Plan provides a framework for transportation agencies in the San Diego region to carry out, integrate, and mainstream this TSMO philosophy into agencies' mission and fundamental organizational business processes in coordination with its partner agencies. It provides recommendations for actions specific to the San Diego Region to further TSMO strategies and integrate TSMO into day-to-day business processes. It was developed for the San Diego region by San Diego Association of Governments (SANDAG), with input from California Department of Transportation (Caltrans), the Cities and County Transportation Advisory Committee among other stakeholders that included the participation of regional and local agency transportation partners.

1.1 Purpose of the Document

The purpose of this document is **to provide a framework for the San Diego region to promote how people, processes, and tools can facilitate increased cross agency collaboration during the planning, development, and operations of technology-based multi-modal strategies**. By incorporating these strategies into agency activities, local and regional agencies can collaboratively improve the performance of the multi-modal transportation system.

The TSMO Plan supplements and supports the Five Big Moves initiatives, which represent the foundation of SANDAG's 2021 Regional Transportation Plan/Sustainable Communities Strategy (2021 Regional Plan). This plan focuses on specific actions required to leverage existing and emerging technologies to optimize existing and proposed transportation improvements through a systems management and the multi-modal transportation philosophy. Proposed TSMO plan components will supplement planned cross agency collaboration that will be carried out during the development of the Next Operating System (Next OS). In addition, proposed TSMO plan components are also intended to serve as fundamental guiding elements to help increase cross agency collaboration during the development and implementation of future technology-based solutions planned under the other Four Big Move concepts.

Purpose of TSMO Plan is to provide a framework for the San Diego region to promote how people, process, and tools can facilitate increased cross agency collaboration during the planning, development, and operations…"

TSMO is viewed through three different, but overlapping lenses – Institutional (People), Organizational (Processes), and Performance Management (Tools). The institutional provides the collaboration necessary to implement TSMO across modes and agencies. It focuses on the changes that need to happen within the agency's mission to focus on the transportation user experience. The organizational focuses on the processes and procedures that are implemented at the staff level to support TSMO. The tools are used to support both the institutional and organizational by providing data, examples, agreements, and other examples to facilitate TSMO implementation.

Key sections of the TSMO Plan include:

- Business Case for TSMO – this section provides a brief description of transportation strategies that generally fall within the TSMO transportation project designation, why TSMO strategies are needed, and benefits that San Diego area agencies will gain by implementing TSMO strategies.
- Regional TSMO Needs - this section presents the region's needs related to TSMO institutional governance, processes, and tools in order to effectively to plan, program, implement, and operate TSMO strategies.
- TSMO Vision, Guiding Principles, and Goals – this section presents the critical principles needed to properly implement the 2021 Regional Plan and its Five Big Moves as they relate to leveraging existing and emerging technologies.
- TSMO in support of the Five Big Moves – this section illustrates how TSMO complements and supports the Five Big Moves.
- Action Plan – which presents actions required to properly implement TSMO strategies in support of implementing the 2021 Regional Plan and its Five Big Moves.

- TSMO Toolkit – several tools and resources are provided for agencies to use when planning, evaluating, implementing, and assessing TSMO strategies. Sample charter documents, checklists, best practices, and other resources are included and will support consistent planning and implementation processes throughout the region. As new tools and resources are developed for agencies, they will be added to the toolkit.

2 BUILDING THE BUSINESS CASE FOR TSMO

Traditionally, transportation agency processes have been structured around project development, construction, and maintenance. The measure of a project's success was often tied to budget, schedule, and capacity enhancements. TSMO puts the focus on the customer experience and operating systems to achieve optimum performance. When agencies shift to a TSMO perspective, the emphasis becomes:

- Integrating systems and data to operate the various modes seamlessly across jurisdictions
- Agreement on common operating philosophies across the entire transportation network
- Common transportation performance goals that agencies are working toward and that guide all aspects of project selection, development, planning, implementation and operations
- Multimodal collaboration to ensure the complete trip is considered as part of any transportation improvements.

Reshaping well-established processes and implementing cultural shifts can be challenging. Communicating the business case for TSMO strategies is critical to building support from decision-makers and setting local communities up for the benefits of successful deployments. This section draws a business case for TSMO in general. Sub-regional and local stakeholder groups should prepare a business case for the specific strategies that they would like to explore further.

The "TSMO Benefit Cost Compendium" document and the link to the "California Life-Cycle B-C Analysis Model"

Table 1 provides a helpful comparison of key activities carried out under transportation planning project development process under the traditional process and under the TSMO lens.

Table 1. Project Development Through TSMO[1]

	Traditional Approach	TSMO Approach
Goals	▶ Focus on **capital infrastructure investments** to relieve congestion	▶ Multiple agencies align for **common operational and management unity** of the whole system to address multiple goals
Strategies	▶ Adding lanes ▶ Standalone projects	▶ Multimodal operational philosophy ▶ Performance-based
Performance Accountability	▶ Schedule ▶ Budget ▶ Compliance with standards	▶ **Customer-focused** on door-to-door complete trip ▶ **Performance monitoring** after implementation
Time Scale	▶ Defined – Project begins and ends	▶ Ongoing – real-time **active management and operations**
Business Processes	▶ Siloed implementation, operations, and maintenance management	▶ **Cross-agency collaboration** to integrate management of the transportation system

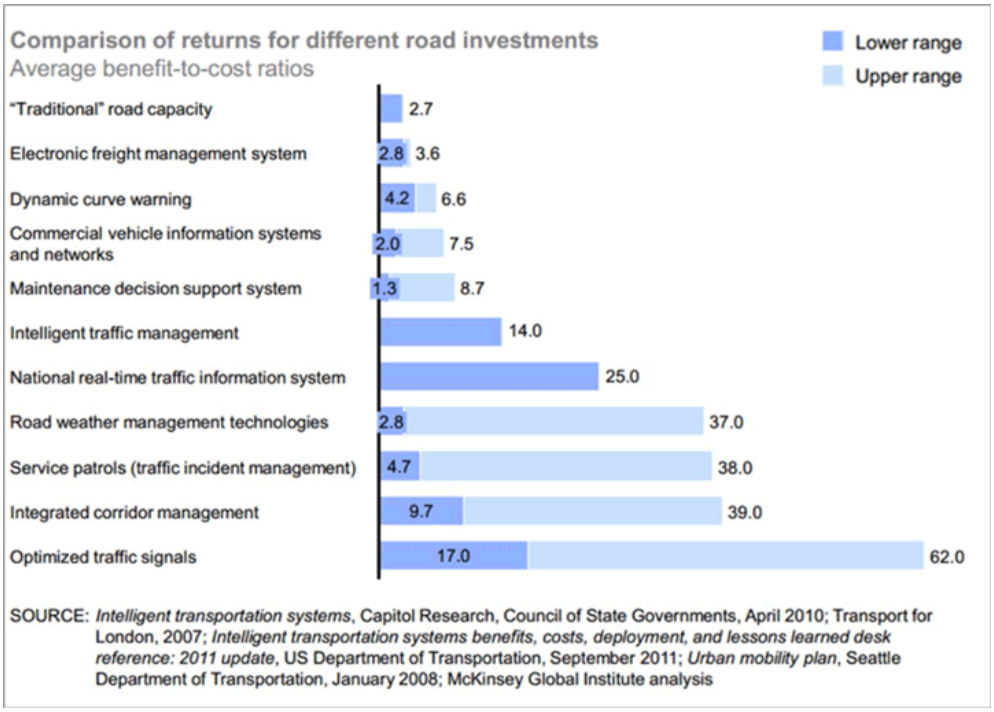
[1] FHWA. *Integrating Operations into Planning and Programming.* https://ops.fhwa.dot.gov/plan4ops/focus_areas/planning_prog.htm

Transportation agencies within the San Diego Region have been implementing and operating various transportation technologies and systems for several decades. Cities and counties have traditionally used technology to facilitate traffic flows on their streets by implementing optimized signal timing plans.

More recently, some agencies have also implemented technologies to implement signal prioritization for transit and pedestrians. Caltrans operates ramp metering to improve mobility and safety on the freeways, provides traveler information on Changeable Message Signs (CMS), and uses closed-circuit television (CCTV) cameras to view and respond to incidents and accidents. Transit also uses technologies for fare collection, Automatic Passenger Counting (APC) and Automatic Vehicle Location (AVL) technologies on some of their transit fleets. Well established research on traditional TSMO strategies identified the following overarching benefits:

- Given their relatively low cost, the return on investment of TSMO strategies is significantly higher than traditional investments due to the minimal physical improvements that are required. Moreover, based on FHWA's Transportation Systems Management and Operations in Smart Connected Communities report[2], TSMO strategies can improve safety by 15 to 50 percent, reduce emissions, and improve livability and economic vitality. To get the most out of limited funding, TSMO strategies should be funded, especially in the early years of the 2021 Regional Plan timeframe. Figure 1 shows a comparison of returns for different road investments.

Figure 1 Comparison of Returns for Different Road Investments



- TSMO strategies are generally low cost and can be implemented relatively faster than traditional expansion projects. Significant expansion projects take several years to complete the planning, environmental, and design processes. Then, they take more years for construction activities. TSMO strategies can be implemented much faster because they are generally categorically exempt under the environmental process[3], and require less time consuming and intensive construction.

[2] FHWA, 2018. Transportation Systems Management and Operations in Smart Connected Communities. https://ops.fhwa.dot.gov/publications/fhwahop19017

[3] Caltrans, 2021. Local Assistance Procedures Manual (LAPM). https://dot.ca.gov/programs/local-assistance/guidelines-and-procedures/local-assistance-procedures-manual-lapm

TSMO has the potential to provide benefits to both agencies and transportation system users. Figure 2 provides an overview of the range of potential benefits of TSMO strategies and collaboration.

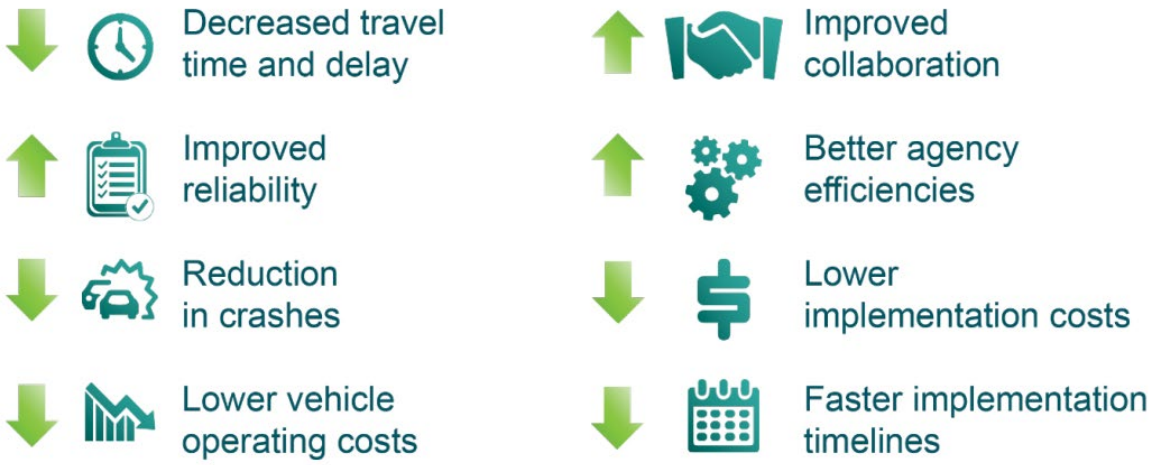


Figure 2 Benefits Associated with TSMO (source: FHWA)

Although previous deployment of individual TSMO technologies helped (e.g., ramp metering, transit AVL), they focused on the part of the transportation system for which a particular agency is responsible. In most cases such strategies are not integrated with other strategic improvements or across agencies. Historically, the implementation and operations of these technologies were carried out independently and only addressed project-specific needs; rarely were these systems designed and operated to meet the needs multi-modal networks and travelers.

Technology advancements from the private sector, such as crowdsourced transportation data and technological mobility innovations, provide agencies in the San Diego region with opportunities to expand on multi-modal transportation solutions. These factors have compelled transportation agencies to look beyond simply deploying the next ramp metering, traffic signal systems, or regional transit priority systems and has cultivated a need to shift how transportation technologies are managed and operated in an integrated manner. This shift in transportation system management and operations marks an important institutional culture shift that focuses on multi-modal and multi-agency coordination.

This TSMO shift has fostered a new way of thinking among federal and state initiatives that reflect the planning and implementation of integrated multimodal performance-based management strategies. TSMO places focus on meeting the needs of its transportation customers for a complete trip regardless of who owns and manages the transportation system. TSMO intends to knit together the numerous stove-pipe transportation strategies and enables transportation jurisdictions to provide transportation solutions and services in an integrated and coordinated manner.

For more information on building a business case for TSMO, see FHWA's "Advancing TSMO: Making the Case for Institutional, Organizational, and Procedural Changes" document in the Toolkit.

This TSMO theme is referenced in key statewide initiatives including the California Transportation Plan (CTP) 2050 and the Caltrans Corridor Planning Guidelines. At the federal level, the U.S. Department of Transportation (U. S. DOT) established the Organizing and Planning for Operations Program and the Integrated Corridor

Management (ICM) Pilot Program Initiative. These initiatives emphasize the importance of developing transportation solutions through several factors, including but not limited to; strengthening strategic partnerships, integrated multi-modal solutions, and cross cutting and innovative technological solutions through the application of cross agency collaboration and coordination.

Under the ICM initiative, the San Diego region served as a national example were a TSMO philosophy was applied by local, state, and regional agencies. In 2014, SANDAG deployed the Interstate 15 (I-15) ICM, which allowed state, regional, and local agencies to interconnect their respective transportation management systems in order to jointly operate those systems as a coordinated and unified system. Furthermore, SANDAG, in partnership with Caltrans District 11 used a chartering process to establish a framework for joint corridor management consisting of agency Directors. This joint agency responsibility is the first in the state of California and is premised on a set of established operating objectives that the partners agreed to and that drive an integrated approach to system management.

Figure 3 Estimated Annual ICM Benefits of Pioneer Sites

PERFORMANCE MEASURE AREAS	San Diego	Dallas	Minneapolis
Annual Travel Time Savings (Person-Hours)	246,000	740,000	132,000
Improvement in Travel-Time Reliability (Reduction in Travel-Time Variance)	10.6%	3%	4.4%
Fuel Saved Annually (in Gallons)	323,000	981,000	17,600
Tons of Mobile Emissions Saved Annually (in Tons)	3,100	9,400	175

Source: U.S DOT, Research and Innovative Technology Administration: 2012 ICM Modeling Results Report

Agencies at the federal, state, and regional levels recognized the importance of TSMO as attested by several funding opportunities.

- **Federal and State Programs** – TSMO philosophy aligns particularly well with evaluation criteria for competitive grants. Because the TSMO approach integrates policy, operating procedures, and technology to improve operations on existing facilities, the return on investment is high compared to traditional capital improvements.

  For instance, the U.S. DOT has provided significant grant funding under the Advance Transportation and Congestion Management Technologies Deployment (ATCMTD) initiative which provides funding for the development and deployment of advance multi-modal and integrated transportation technologies to improve safety, efficiency, and overall system management performance. Also, the Complete Trip – ITS4US initiative provides funding for the implementation of innovative business partnerships and transportation solutions and services to address the challenges of planning and taking a complete trip with specific focus on providing such mobility solutions to the underserved communities and people disabilities and the elderly.

  The California Senate Bill 1 (SB-1) which focuses funding on transit and congested trade and commuter corridors aim to improve mobility and encourage collaboration between the State and regional/agencies and guidelines for these programs discourage roadway capacity investments.

SB-1 provides significant funding for maintaining and upgrading the technology components on the State Highway System (SHS) and set a target of 90 percent of transportation management systems (TMS) elements to be in good condition.[4] TMS elements include detection sensors, ramp meters, changeable message signs, closed circuit television and others. SB-1 also includes competitive programs such as the Solutions for Congested Corridors Program (SCCP) and the Trade Corridor Enhancement Program.

There are also companion documents that provide additional technical details to support local agency implementation of TSMO. These include the Regional Intelligent Transportation System (ITS) Architecture Plan, the Curb Management and Smart Intersections Concepts of Operations Reports. The Regional Border Management System, which includes systems engineering and implementation of various technologies, is also being developed through a recent federal technology grant. Other strategic initiatives include:

The Toolkit contains federal and state resources and links including on the TSMO funding sources.

- Given **Senate Bill 743** (and its focus on reducing vehicular travel demand or vehicle miles traveled), TSMO can complement other modal investments (e.g., active transportation, micromobility, and transit) to significantly improve multi-modal mobility. However, mobility improvements need more than just technology; the institutional collaboration and adoption of common operating procedures are key to successful and sustaining mobility-focused initiatives.

  Some of the most significant operational conflicts occur at agency boundaries. Consider signal coordination between freeway interchange signals, local arterials, and commuter rail; or the multi-modal demands for curb space along the interface between private and public right-of-way. Many agencies are already equipped with technologies that can facilitate mobility across jurisdictional boundaries. Often, cross-jurisdictional technology deployment is not pursued or is even avoided due to institutional and operational constraints, such as maintenance agreements and workforce training. Therefore, if these elements are not considered, even the most capable technology systems will not have a strong foundation for success.

- **Comprehensive Multimodal Corridor Plans (CMCP) advance local priorities** - CMCPs are data-driven plans that offer solutions to reduce congestion, support climate action initiatives, generate transportation choices, and increase access for residents, commuters, visitors, and goods movement. A CMCP evaluates all travel modes and transportation facilities in a defined corridor – highways and freeways, parallel and connecting roadways, transit options, pathways, and bikeways. CMCPs are required in order to apply for certain state and federal funds, which can be leveraged to support regional transportation projects.[5]

TSMO has a key focus on the customer experience. People plan their trips from door to door with little or no regard to jurisdictional boundaries. By focusing on the user perspective, the planning process becomes better aligned with system performance and can enable operators to address mobility barriers more effectively. In the San Diego region, there are numerous corridors that span multiple local jurisdictions. Individual transportation silos need to be connected and focus on the transportation system user, whether that user is a driver, transit rider, pedestrian, bicyclist or uses multiple modes during their trip. This transformational change is a shift from

[4] Caltrans; October 9, 2019. *Transportation Asset Management Plan – Annual Benchmark Performance Update Memorandum.* https://catc.ca.gov/-/media/ctc-media/documents/ctc-meetings/2019/2019-10/19-4-5-a11y.pdf

[5] SANDAG, 2020. *Comprehensive Multimodal Corridor Plan Fact Sheet*. https://www.sandag.org/uploads/publicationid/publicationid_4726_28448.pdf

traditional corridor planning and the first-generation CMCPs serve as an important opportunity to reimagine corridor planning processes to include a TSMO philosophy.

SANDAG has identified the following immediate objectives which provide the underpinning for the 2021 Regional TSMO Plan:

- Coordinate with regional partners to develop and maintain a policy, operational governance, and performance-based framework through the completion of a TSMO Plan to help manage mobility and infrastructure across jurisdictional boundaries as a system.

SANDAG recognizes the importance of TSMO and is including it as one of its 2021 Regional Plan Implementation Strategies.

- Develop and maintain a flexible, adaptable approach to working with the private sector so that solutions launch quickly while still complying with regional, state, and federal laws, regulations, and policies. Technology changes quickly, and the Next OS framework will encourage new apps and services to enter the San Diego market to offer innovative services and partnering opportunities.
- Work with regional transportation system operators to develop and maintain a set of common data standards that will allow systems to share data with one another while protecting security and privacy of user information. This seamless data sharing will support planners and policymakers in making decisions.

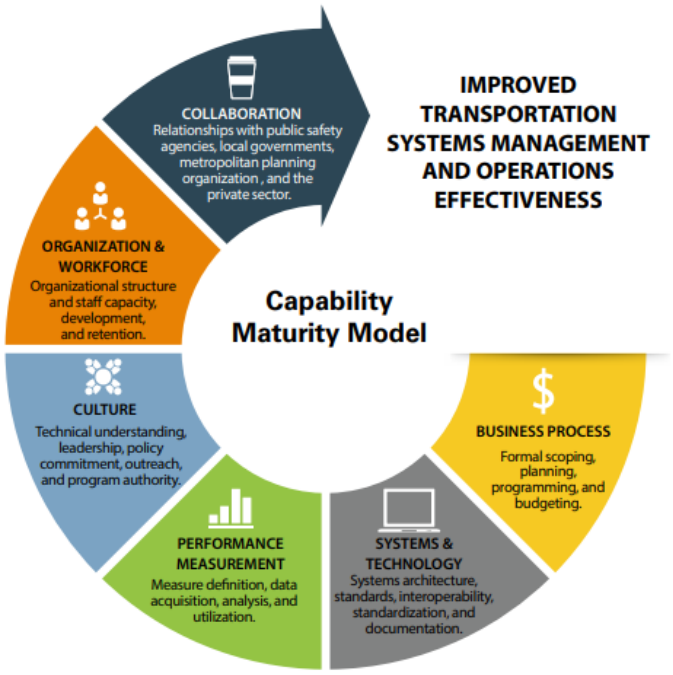
3 REGIONAL TSMO NEEDS

The TSMO needs in the San Diego region are based on a literature review of practices around the country and local stakeholder input through workshops and surveys. Respondents from various jurisdictions and stakeholder groups in the region identified and ranked their priorities. The surveys were organized to identify various needs across a wide range of areas, such as data sharing, technology planning, cross-agency collaboration, performance management, and workforce readiness.

During the development of the TSMO Plan, different institutional approaches were piloted with the North County (SR 78) stakeholders. Coordinating this effort with the onset of the CMCP for the North County Corridor provided the TSMO Plan with local agency feedback on their specific issues, challenges, needs, and priorities. Finally, the TSMO needs also consider an assessment recently conducted efforts to understand of the current readiness of jurisdictional agencies using the FHWA's Capability Maturity Model (CMM) self-assessment tool.

3.1 Current TSMO Readiness Summary

Planning, implementing, and operating transportation strategies under the TSMO philosophy requires stakeholder agencies to be institutionally "ready" to leverage technologies, adopt common operational procedures, and focus on users by managing the multimodal system in real time. To assess this readiness, SANDAG and Caltrans have conducted several CMM workshops (supported by FHWA) to assess the state of agencies related to six dimensions (business processes, systems and technology, performance measurement, culture, organization and workforce, and collaboration) needed to implement TSMO strategies and operate the system in an integrated fashion as depicted in **Figure 4.**



Examples of the surveys, resulting TSMO charter, and presentations are provided in the Toolkit so that other CMCP and corridor teams can integrate these resources into their planning and stakeholder engagement activities.

Figure 4 TSMO Capability Maturity Matrix Dimensions (source: FHWA)

Although there has been good progress by local agencies across many of these dimensions, the general conclusions are that the institutional capabilities are not yet where stakeholders would like them to be**. Figure 5**, developed through the Next OS initiative, shows the results of the latest CMM effort, which was modeled after the

FHWA TSMO approach. The self-assessment required agencies to rate themselves on a scale from 1 (Initial) to 5 (Optimized). These results show that agencies in San Diego, including SANDAG, are in the 2 (Development) or 3 (Defined) stages of maturity in all the dimensions[6].

In the regional stakeholder outreach process, a CMM was conducted for the NCRC corridor. Agency responses to the self-assessment within the NCRC sub-region generally resulted in the Initial and Development stages. These results indicate that SANDAG and its partners need to focus on moving towards the integration and optimization levels in every dimension. This TSMO Plan focuses on the need to move towards the integration and optimizations stages related to people (policy and regulations) and processes (business processes and organization) that can help ensure the successful implementation of the TSMO philosophy (the three dimensions highlighted in the figure).

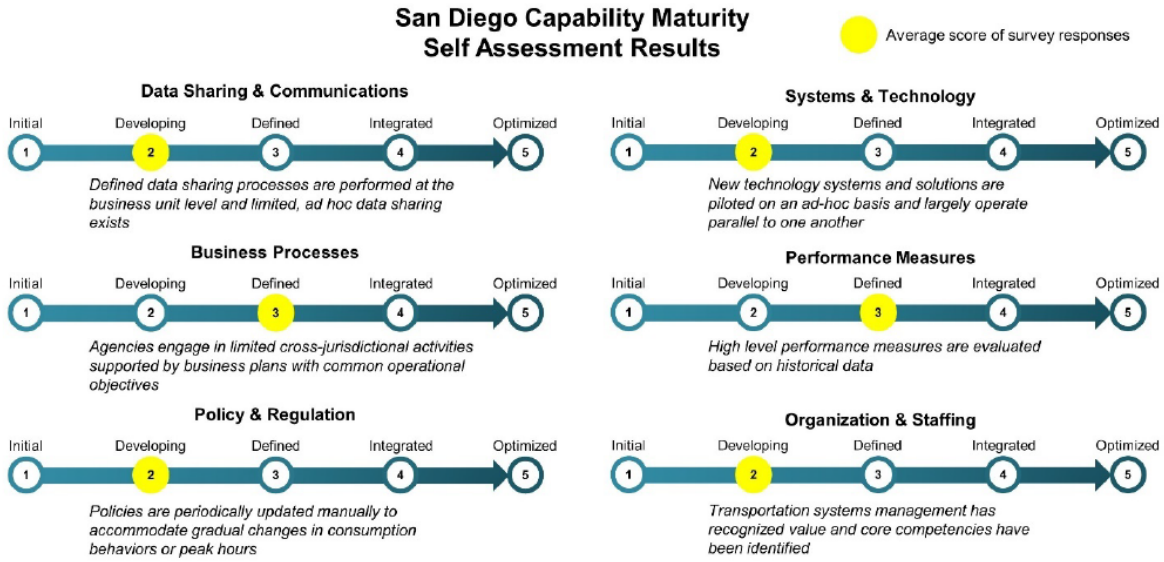


Figure 5 Capability Maturity Self-Assessment Results

3.2 Highlights of Needs Assessments

This section describes the needs to be addressed in three categories: institutional/governance (people), business process/operation (processes), and performance management/tools related needs (tools). Each set of needs is discussed below.

Institutional/Governance (People)

Institutional (People) needs are focused on the policy decisions. Often these needs are implemented from the top of the organizational structure because they set the tone for how the agency implements and integrates TSMO. Although there are many examples of collaboration among transportation agencies in San Diego, TSMO requires special attention, and in some instances will require a shift from how things are done today. The institutional needs for TSMO are:

- Need 1 (N1) - There is a need to establish a collaborative multi-agency forum for TSMO strategy identification, development, implementation, and maintenance.

[6] SANDAG, August 2020. *San Diego Forward Next OS Concept White Paper.*

- N2 - There is a need to develop a decision-making and governance approach to develop policies, approve, prioritize, and fund the various TSMO initiatives proposed, including the use cases of the Next OS, curb management, Smart Intersections, and others.
- N3 - There is a need for agencies to adopt policies that enable multi-jurisdictional initiatives.
- N4 - There is a need for funding for implementing, operating, and maintaining TSMO strategies and associated technologies.
- N5 - There is a need for workforce development to train all levels of staff in TSMO planning and operations.
- N6 - There is a need for training for emerging technologies and technology integration and delivery /implementation (e.g., V2I, connected vehicles, private-public partnerships).
- N7 - There is a need to ensure that TSMO is equitably funded, planned, and deployed.

Operational/Process Needs (Processes)

Operational (Process) needs are focused on the actions and the responsibilities for implementing TSMO. To date, the advancement of establishing a common and agreed upon multi-modal or cross agency operational philosophy have not yet been proactively addressed during the project planning and development stages. For instance, transit planners focused on the transit-specific projects, active transportation planners identified new bike lanes and pedestrian safety, highway planners focused on addressing congestion and addressing bottlenecks. Rarely did these project planning processes go beyond addressing specific modal/and site specific issues and consider operational opportunities from a holistic multi-modal perspective. The Operational (Process) needs for TSMO are:

- N8- There is a need to integrate TSMO into regular planning processes. A corridor plan needs to consider TSMO strategies such signal timing coordination with ramp metering, transit and active transportation prioritization, and traveler information. SANDAG has started this transformation in developing CMCPs, which brings together diverse transportation stakeholders to ensure that the corridor plan considers multimodal, TSMO and operations, as well as real-time management and maintenance. Mainstreaming this approach into future project planning efforts will further integrate TSMO into corridor project decision-making.
- N9 - There is a need to establish common performance based operating and system management procedures once a TSMO strategy has been implemented for consistency among deployments and to streamline the process. Developing these procedures must be collaborative. Modal representatives, traffic engineers from cities and Caltrans, and technology experts need to work together to develop and commit to how TSMO strategies will be operated or adjusted as performance assessment may require.
- N10 - There is a need to understand current TSMO capability maturity within agencies and with partner agencies.
- N11 - There is a need to address existing infrastructure gaps and disparate levels of investment for certain modes and in certain geographic areas across the region.
- N12 - There is a need to establish data sharing standards and guidelines.

Technology/Tools

Tools are needed to assist in planning and operating existing and future transportation improvements and services through a TSMO approach. Even though SANDAG has developed and maintained a sophisticated Activity-Based-Model (ABM) for developing the 2021 Regional Plan and analyzing major investments for CMCPs, the ABM cannot evaluate proposed transportation improvements at the operational and multi-modal system management level. The technical needs for TSMO are:

The toolkit has many examples of tools that have been used successfully for TSMO in the region, including the I-15 ICM Memorandum of Understanding.

- N13 - There is a need to facilitate concept exploration with tools that match user needs with possible multi-modal and innovative transportation strategies and services.
- N14 - There is a need for comprehensive monitoring and reporting of multi-modal, multi-jurisdictional metrics.
- N15 - There is a need for support in evaluating and selecting multi-modal and innovative transportation strategies and prioritizing corridor-level deployments.
- N16 - There is a need to provide procurement support for technology integration and procurement.
- N17 - There is a need for guidance on choosing appropriate performance metrics multi-modal and innovative transportation strategies and services.
- N18 - There is a need to understand existing regional assets and infrastructure gaps.

These needs are meant to guide the implementation of TSMO across the region. The stakeholders shall reassess and reprioritize the needs periodically as part of the continued emphasis on institutional, operational, and technical development.

4 TSMO PLAN GUIDING PRINCIPLES AND GOALS

SANDAG has a proven track record of building consensus in the delivery and advancement of a number of innovative transportation projects and programs among them for example include the development of the 5 Big Moves concepts, on-going development of the CMCPS, on-going major regional project priority projects that include the planned new State Route 11/Otay Mesa East Port of Entry and the I-5 North Coast Corridor Project, and the completion of the I-15 Manage Lanes project. This plan sets forth the foundational components for establishing a regional TSMO Vision, Guiding Principles, and Goals based on the needs noted in Section 3. The vision, guiding principles, and goals complement and support the Five Big Moves and support the implementation of the 2021 Regional Plan.

The TSMO Vision is to establish an institutional and governance platform to help advance and facilitate cross-agency collaboration to ensure existing and proposed transportation strategies are not operated or managed as independent systems but as a multi-modal and unified transportation system.

PRINCIPLES

The guiding principles are tied directly to goals that are used to set the course for TSMO over the short (0-5 years) and medium term (5-10 years). They will be reevaluated on a regular basis as the needs of the stakeholder evolve and the region reaches higher levels of TSMO maturity.

GUIDING PRINCIPLES

- Transportation improvements that include technological advancements in mobility should be designed and operated based on institutional coordination and common operational procedures that places focus on customer needs, regardless of who owns, manages, or operates transportation systems and services.
- Business processes and transportation strategies should emphasize ongoing, coordinated multi-agency and multi-modal management of transportation operations and services.
- Ensure that TSMO initiatives are considered as a core component of local and regional transportation plan project, program, and investment strategies.

Principle 1- Transportation improvements that include technological advancements in mobility should be designed and operated based on institutional coordination and common operational procedures that places focus on customer needs, regardless of who owns, manages, or operates transportation systems and services.

- Goal 1A – Improve safety for all users across all modes utilizing consistent metrics.

- Goal 1B – Improve travel time reliability for all users across all modes.
- Goal 1C – Improve transportation operations using emerging technologies.
- Goal 1D – Improve the equitable access for non-motorized modes of travel.

Principle 2 - Business processes and transportation strategies should emphasize ongoing, coordinated multi-agency and multi-modal management of transportation operations and services.

- Goal 2A – Establish business processes to integrate TSMO into planning, programming, and operations.
- Goal 2B – Implement a common performance measurement framework.
- Goal 2C- Create a data-sharing strategy that promotes equity for all users.
- Goal 2D – Create a TSMO Mobility Policy and Technical Advisory Group to further TSMO collaboration.
- Goal 2E – Provide training on TSMO to improve the working TSMO knowledge across stakeholders and transportation users.

Principle 3 - Ensure that TSMO initiatives are considered as a core component of local and regional transportation plan project, program, and investment strategies.

- Goal 3A – Establish an asset management program that prioritizes TSMO.
- Goal 3B – Establish funding criteria that prioritizes TSMO.
- Goal 3C - Develop an action plan for SANDAG and its partner agencies that addresses the needs identified for governance, process improvements, and goals.
- Goal 3D – Support TSMO integration using standardized tools.

The TSMO goals are used to provide ongoing guidance as the region moves towards a more integrated approach to transportation system management and operations under the proposed Action Items activities discussed in Section 6 of this report. Tables 3, 4, and 6 illustrate the identified TSMO Needs (Section 3) and are mapped back to the TSMO goals.

5 TSMO IN SUPPORT OF THE FIVE BIG MOVES

The SANDAG 2021 Regional Plan introduces a transformative vision for the San Diego region, which revolves around the 5 Big Moves7. The 5 Big Moves are five key mobility strategies for reimagining how people and goods are moved around San Diego County. The Five Big Moves include:

- **Complete Corridors** – Provides a variety of travel choices in a multimodal transportation system that reimagines how highways and major roads are managed and how space is allocated to different modes[8].
- **Transit Leap** – A network of high-speed and high-capacity transit services that connect major residential and employment centers and regional attractions, such that transit is a convenient and attractive alternative to driving[9].
- **Mobility Hubs** – Places of connectivity where different modes of travel converge and are located at concentrations of employment, housing, shopping, and/or recreation[10].

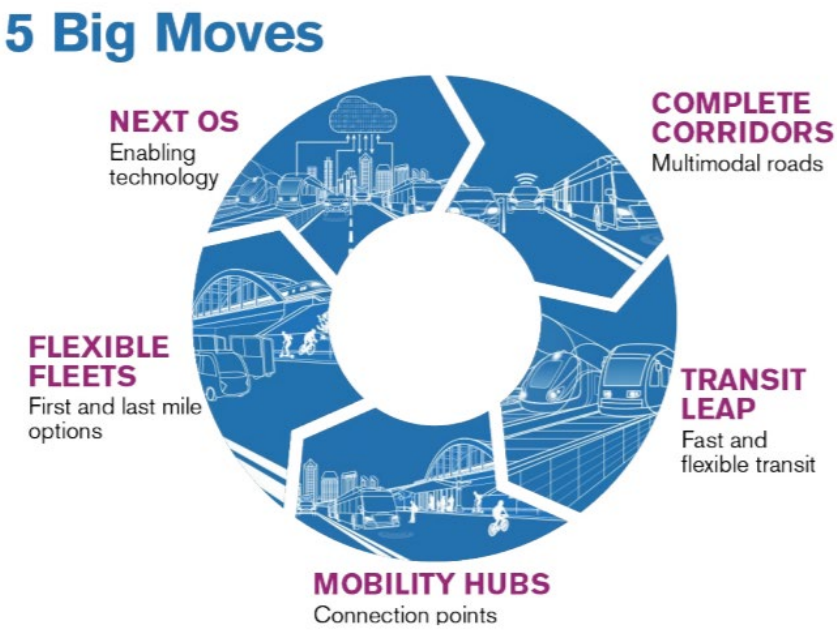


Figure 6 SANDAG 5 Big Moves

- **Flexible Fleets –** Provides flexible options for making first- and last-mile connections to transit or to the user's destination through shared vehicles, such as micro-mobility, ride share, micro-transit, and ride hailing. It also includes last-mile delivery solutions, such as e-bikes, drones, bots, or automated vehicles[11].
- **Next Operating System (Next OS)** – The Next OS is the concept of connecting all devices and vehicles in the transportation system to improve efficiency and accessibility for people and goods to move throughout the region[12].

TSMO complements and supports the implementation of each of the Five Big Moves. The TSMO guiding principles relate directly to the implementation of the 5 Big Moves.

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[7] SANDAG, 2020. *A Bold New Vision in 5 Big Moves.* https://www.sdforward.com/mobility-planning/5-big-moves

[8] SANDAG, 2020. *Complete Corridors.* https://www.sdforward.com/mobility-planning/complete-corridors

[9] SANDAG, 2020. *Transit Leap.* https://www.sdforward.com/mobility-planning/transit-leap

[10] SANDAG, 2020. *Mobility Hubs.* https://www.sdforward.com/mobility-planning/mobilityhubs

[11] SANDAG, 2020. *Flexible Fleets.* https://www.sdforward.com/mobility-planning/flexible-fleets

[12] SANDAG, 2020. *Next OS.* https://www.sdforward.com/mobility-planning/next-os

TSMO activities focus on shifting the planning, development, and implementation of 5 Big Moves strategies to a more comprehensive approach that moves away from considering strategies as independent from jurisdictional silos, to a broader, regional, and systems management approach. For instance, under the Complete Corridors an outcome of the coordinated system management philosophy under TSMO may include coordinating signal timing with ramp metering, dynamic pricing, and improved incident management strategies to improve network travel times and reduce traveling delays for commuters that use such facilities. Similarly, for high-speed transit services under Transit Leap, a TSMO outcome may include improving traveler information services that will inform users of high-speed transit services on schedules, connections, and expected arrival times to provide a holistic and seamless transportation service across all modes. SANDAG will ensure that TSMO initiatives are considered as unified system and support the development of other strategies, such as:

- Providing the institutional and coordinated platform for improved system wide and multi-agency traffic signal coordination
- Allow for the development, integration, and coordination of multi-agency disaster and incident management system that will improve the selection and use of evacuation routes
- Provide high-speed connectivity, real-time data analytics, and advanced decision support systems that will increase effectiveness of existing and future ITS deployments through shared data and situational awareness of regional transportation conditions
- Allow for the integration and coordination of all transportation networks to help advance multimodal congestion management strategies.

6 ACTION PLAN

This section presents the action plan for implementing and managing TSMO initiatives in a manner that supports and complements the Five Big Moves and thereby advance existing and new mobility options by leveraging technologies. SANDAG is already in the process of developing Concepts of Operations for such TSMO strategies such as Curb Management and Smart Intersection. These documents will help significantly, but more coordinated actions are required for the following three categories to address the needs presented in section 5:

- Establish an Institutional and Governance Framework
- Adopt Processes for identifying, prioritizing, and implementing TSMO strategies
- Identify and develop tools to support the implementation of TSMO strategies.

6.1 Institutional and Governance Actions

By all accounts, the I-15 ICM project was the first successful ICM project implemented in California and serves as a national showcase for collaborative transportation system operations. Moving forward, TSMO needs to be embedded into planning and decision-making processes. Three key actions are recommended:

- **Convene a decision-making group** – A body of decision makers/TSMO Advisory Group should be assembled to make decisions on which TSMO initiatives need to be implemented and how they will be funded. This body should represent the various modal and jurisdictional agencies so they can commit their organizations to carry out and consider institutional and governance changes.

  For instance, Caltrans has convened a Managed Lanes Executive Committee to review and approve managed lane projects and policies. The California Transportation Commission is another example. Even though its members are appointed, they do make decisions on State transportation expenditures. A San Diego TSMO decision making body will help emphasize the commitment of the region to embrace existing and emerging technologies and commit their agencies to implement and operate its TSMO strategies cooperatively to improve multi-modal mobility.

- **Technical coordination** – A body of technical experts from SANDAG and its partners should be convened as a technical Mobility TSMO Advisory Group. This body can include multiple-discipline mobility representatives, technology industry experts, and local and regional transportation system operators.

  This body will help guide the implementation of the TSMO Plan and can serve as a regional advisory body to help advance the implementation of the Next OS, help identify and establish enabling operational and technological policies for data sharing, establish cross-agency procedural guidelines for multimodal operations, help provide a forum for mutual technology innovation research, deploy pilot projects, and develop technology standards and assist in developing needed tools needed by planning and reporting processes. This committee will provide recommendations to the decision-making body/TSMO Advisory Group.

- **Review agency project development and local policies** – Each agency should revisit their project development approach and guidelines to determine if there are any changes necessary to integrate and mainstream TSMO. The project development process may be amended to have more oversight with maintenance, to include specific performance metrics, and to have review by other modal agencies, among other prospective changes.

Agencies can conduct their own CMM self-assessments to identify strengths, challenges and areas for improvement for key processes. An example template and guidance on the AASHTO CMM are included in the Toolkit.

- **Workforce development** – The workforce across agencies needs to be trained to understand TSMO analysis and implementation framework and be informed of new and emerging technologies. Some training is already available through FHWA and additional training will need to be developed as the region implements the Five Big Moves and advanced concepts such as through SIS and Curb Management. It is anticipated that the workforce will articulate needs to the Mobility TSMO Advisory Group.

  SANDAG is positioned well to help facilitate training through national courses and peer exchanges with research organizations, which could be offered to participants at relatively low cost. Another option is to organize some vendor-provided training and make it available to regional groups or corridor-level groups as they undertake implementation.

  Within SANDAG, this can be an expansion of the ITS function or across organizations (perhaps within a Mobility and Innovation group or department). In addition, the workforce will manage the operations and maintenance of the technology-based strategies, modify these technologies as conditions change, and report their performance impacts to policy bodies and the public.

Table 2 shows the full list of institutional actions that SANDAG and local agencies should undertake to facilitate the implementation of TSMO.

Table 2 – Regional TSMO Institutional Actions

Institutional Need Statement (N#)	Short-Term Actions (0-5 Years)	Medium-Term Actions (5-10 Years)	TSMO Plan Goal Alignment
N1- There is a need to establish a collaborative multi-agency forum for TSMO strategy identification, development, implementation, and maintenance.	SANDAG to convene a mobility and technology experts to form a Mobility TSMO that includes participation from various transportation modes including transit, active transportation, and other stakeholders. This group will provide recommendations to the decision-making body, including proposed priorities and associated benefits.	Committee should provide ongoing support to local TSMO implementation, deployment, and planning activities. Provide updates on TSMO implementations, ongoing maintenance and operations, lessons learned, findings from performance monitoring.	Goal 1C, 2A, 2D, 3C
N2 - There is a need to develop a decision-making and governance approach to develop policies, approve, prioritize, and fund the various TSMO initiatives proposed, including the use cases of the Next OS, curb management, Smart Intersections, and others.	SANDAG to convene a decision-making /TSMO Policy Advisory body. Members should be able to commit their agencies organizations to carry out and consider institutional and governance changes.	Decision-making committee to address emerging issues reported by the Mobility TSMO group by continually working to optimize deployments and recommending policy changes.	Goal 1C, 1D, 2A, 2C, 2D, 2E, 3A, 3B, 3C, 3D
N3 - There is a need for agencies to adopt policies that enable multi-jurisdictional initiatives.	Sub-regional and local groups to develop the business case for chosen TSMO strategies to build support for local policy enabling initiatives like data sharing, funding mechanisms, operations agreements, and maintenance agreements.	SANDAG to collect the business case for each deployment to streamline future efforts, implement policy changes, and periodically assess new approaches to enable multi-jurisdictional, multi-modal operations and maintenance activities.	Goal 1A, 1B, 1C, 1D, 2A, 2C, 2D, 2E, 3A, 3B, 3C, 3D
N4 - There is a need for funding for implementing, operating, and maintaining TSMO strategies and associated technologies.	Sub-regional and local groups to position for funding opportunities by aligning sub-regional and local goals with TSMO Plan guiding principles.	SANDAG should facilitate a comprehensive approach to strengthen grant applications region-wide through trainings and alignment of strategies with state and federal priorities.	Goal 2A, 2D, 3A, 3B
N5 - There is a need for workforce development to train all levels of staff in TSMO planning and operations.	Sub-regional and local groups should seek out workforce training related to planning and evaluating potential TSMO strategies.	SANDAG should investigate federal training programs or partner with organizations and vendors that can provide trainings to stakeholder groups.	Goal 2A, 2E, 3C
N6 - There is a need for training for emerging technologies and technology integration (e.g., V2I, connected vehicles).	SANDAG, sub-regional, and local groups to seek out training to operate TSMO strategies, analyze performance, and recommend ongoing improvements.	SANDAG, sub-regional, and local groups to provide ongoing staff training opportunities and refresher courses for workforce development related to emerging technologies.	Goal 2A, 2E, 3C, 3D
N7 - There is a need to ensure that TSMO is equitably funded, planned, and deployed.	SANDAG to establish a digital equity and accessibility policy to address the needs of all users.	SANDAG, sub-regional, and local groups to prioritize projects that promote TSMO Plan guiding principles	Goal 1A, 1B, 1C, 1D, 2A, 2C, 2D

6.2 Operation/Process Actions

SANDAG aims to promote and advance the TSMO Plan in daily operations, long-term regional and local transportation-planning initiatives, and project development and implementation processes. This effort will support the implementation of the Next OS and technology components of the Complete Corridors, Transit Leap, Mobility Hubs, and Flexible Fleets. Key TSMO activities include:

- **Planning for TSMO** - SANDAG and its partners engage in many planning activities. For TSMO, planning has generally been confined to individual strategies or projects when funding is available. For the current cycle of the 2021 Regional Plan, SANDAG has committed to the Five Big Moves. Embedding TSMO initiatives into planning and development of these concepts will ensure that TSMO is a core component of local and regional transportation plans, programs, and investment strategies in order to ultimately allow all transportation modes work together as a unified system. Recognizing TSMO as a 2021 Regional Plan Implementation Strategy and development of the CMCPs is a first step in this process. Both activities ensure compliance with regional, state, and federal regulations and maintain consistency with local agency initiatives.
- **Establish common operational philosophy** – SANDAG will utilize partnerships, data, and technology as key enablers to implementing and help advance TSMO activities including:
  - Build consensus on the TSMO goals and objectives for each transportation corridor
    Whether the goals are to improve travel times, reduce congestion, increase person throughput, increase mode share, or reduce collisions and incidents, goals should be performance-based to support continuous improvement. These goals and objectives should be corridor-based and not facility or mode-based – this concept of corridor-based goals is an important shift toward TSMO. This will also help to enhance decision-making and increase accountability.

  - Identify roles and responsibilities for system operations
    Clear roles and responsibilities for the owner, operator, and facilitator, if any, should be identified, particularly with ICM and priced managed lanes projects. Lead agencies should be established and ongoing activities determined, with communication protocols established. Roles and responsibilities are usually identified during the development of a Concept of Operations, part of the system engineering approach. These roles can be further defined and agreed upon through a charter or a more formal agreement.

  - Establish operations within the framework of the regional ITS architecture
    This will ensure interoperability, sustainability, and viable maintenance, as well as consistency and standards are met. This includes data management and decision support systems, as well as research and development. Data is critical in supporting TSMO activities, particularly as the SANDAG region progresses into the future where technology advancements demand more data such as Connected/Autonomous Vehicles, Internet of Things, and Big Data Analytics. How the data are gathered, analyzed, reported, and stored will need to be determined in the framework of common operational philosophy and regional ITS architecture.

  - Identify method of shared resources
    Financial and staff time resources can often be challenging, particularly with local jurisdictions. For multimodal corridors with integrated and shared TSMO, commitments can be complex. Operational and maintenance resources need to be clearly identified and committed for long-term effectiveness. This will also require resources for training and skill development.

- **TSMO in Project Development Process** – The implementation of TSMO activities is complimented by following the systems engineering approach that is applied when planning, designing, and deployment of ITS projects. This approach is shown in **Figure 7**[13]. Once the planning is completed and funding secured, the steps shown allow for systematic implementation. This too requires training and workforce development.

  SANDAG and its partners should also consider public private partnerships (PPP) for implementing TSMO.

  Also, there may be opportunities to consider adopt region-wide procurement opportunities to facilitate the efficient delivery of TSMO strategies such as SIS or curb management since they will likely be deployed in various jurisdictions.

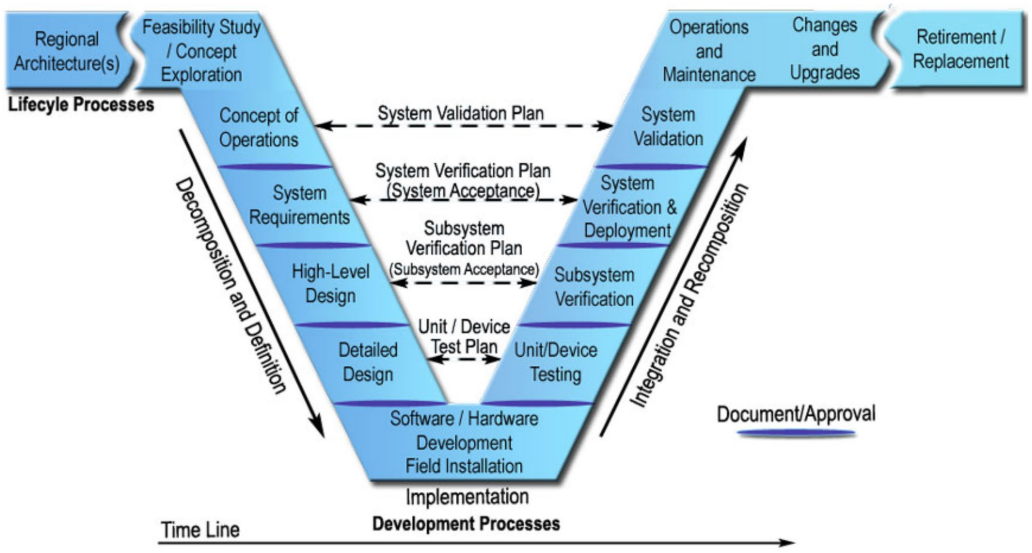


Figure 7 Systems Engineering Diagram

After confirming the feasibility of the project concept (top left of the figure), the Regional ITS Architecture needs to reflect the components needed for implementation. Next, the Concept of Operations defines the purpose of the project, the overall concept and functionality, the operational scenarios, interactions with other systems, agency roles and responsibilities, and expected performance. It is important to engage a wide range of perspectives in the Concept development, to be sure that the system development considers needs from various stakeholder and agency department perspectives.

Following stakeholder agreement on the Concept of Operations, system design, hardware and software installation and development, and validation occurs. Some elements such as the Concept of Operations can occur before funding is secured since it may help convince decision makers to fund the project/initiative. It can also help to better estimate potential funding needs based on the range of functions and level of functionality stakeholders expect that are described in the Concept of Operations.

Also note to expect changes and upgrades over time. As results, the systems are monitored and as new technologies evolve, changes and upgrades are almost certain. Technology evolves at a fast pace, and there

[13] US DOT, 2007. *Systems Engineering for Intelligent Transportation Systems: An Introduction for Transportation Professionals.* https://ops.fhwa.dot.gov/publications/seitsguide/section3.htm?cf03380E65=11102CC57!MjA0MDY3MDUzOmNvcnByYWRpdXNzc286Xe2LeHbcHM6hiXiTi6uULw==

could be some important functions or system efficiencies that agencies will want to implement to improve system operations.

- **Ongoing operations and performance-based management** - Once a project is completed and operations starts, system managers from the various stakeholder agencies must work together to ensure that it is having the desired or expected impact on performance. This means they need access to real-time data (which should be part of the project) to continuously monitor and analyze system performance, and work together to adjust or identify courses of action due to potential performance impacts or changes in transportation conditions.

  Often, at the start of operation, different jurisdictions are involved in the final decision until there is enough confidence in the tools used. Over time, as the confidence increases, some actions can be automated.

  Also critical for effective operations is that the technologies deployed in the field are fully functional and automated field data is accurate. This puts an increased emphasis on maintaining equipment. For the workforce to lead this effort, significant training will be required, tailored to the individual strategy the staff will operate.

- **Monitoring TSMO initiatives/projects** - TSMO initiatives require stakeholders to monitor how well they are performing. For instance, the I-15 ICM stakeholders held regular meetings to evaluate asset conditions, actions taken, and impacts of these actions.

  These evaluations help adjust the strategies and tools as appropriate. As traffic patterns and modal services evolve/change, such adjustments will likely be required. In addition, new technologies such as connected vehicles and autonomous vehicles become reality, TSMO will have to incorporate them into their data, analysis, and tools.

  SANDAG and its partner agencies have developed and maintained several tools to evaluate individual projects (e.g., new transit projects), strategies (e.g., land use, demand management), and the combination of these included in the 2021 Regional Plan. SANDAG's activity-based model (ABM) is a sophisticated regional model that evaluates how the planned investments perform, whether they meet federal air quality attainment goals, vehicle miles traveled (VMT), and greenhouse gas (GHG) emissions.

Table 3 shows the full list of operational actions that SANDAG and local agencies should undertake to facilitate corridor-level concept development, deployment, and ongoing operations and maintenance.

Table 3 – Regional TSMO Operational Actions

Institutional Need Statement (N#)	Short-Term Actions (0-5 Years)	Medium-Term Actions (5-10 Years)	TSMO Plan Goal Alignment
N8 -There is a need to integrate TSMO into regular planning processes.	SANDAG, sub-regional, and local groups to integrate TSMO into current planning processes, including the 2021 Regional Plan and CMCPs.	Sub-regional and local groups to integrate TSMO into planning documents such as general plan updates, active transportation, climate action, etc.	Goal 2A, 2D, 3B, 3C
N9 -There is a need to establish common performance based system management operating procedures once a TSMO strategy has been implemented for consistency among deployments and to streamline the process.	Advance the implementation of the TSMO Plan to help build consensus on TSMO goals and objectives, identify roles and responsibilities, and identify methods of shared resources.	SANDAG to compile a library of previous deployments, sample documents such as MOU and ConOps, and make them available for other agencies to reference through a regional dashboard.	Goal 1A, 1B, 1D, 2A, 2B, 3C
N10 -There is a need to understand current TSMO capability maturity within agencies and with partner agencies	Sub-regional and local groups to perform maturity analyses and needs assessments within local agencies and sub-regional stakeholder groups to identify needs, goals, and priorities	Sub-regional and local groups to continue to evaluate agency maturity through CMM to identify specific actions to advance to higher levels of capability.	Goal 2B, 2D, 3C
N11- There is a need to address existing infrastructure gaps and disparate levels of investments for certain modes in certain geographic areas across the region	SANDAG, sub-regional, and local groups to prioritize existing infrastructure gaps and equity considerations in the process of prioritizing TSMO deployments	SANDAG, sub-regional, and local groups to inform future development and refinement of digital equity and accessibility policies	Goal 2D, 3A, 3C, 3D
N12 - There is a need to establish data sharing standards and guidelines.	SANDAG to assess existing data sharing processes and perform a review and assessment of agencies that are operating at a high level of TSMO maturity.	SANDAG, sub-regional, and local groups to recommend updates to data sharing processes after TSMO deployments.	Goal 2D, 3A, 3D

6.3 Technical/Tools Actions

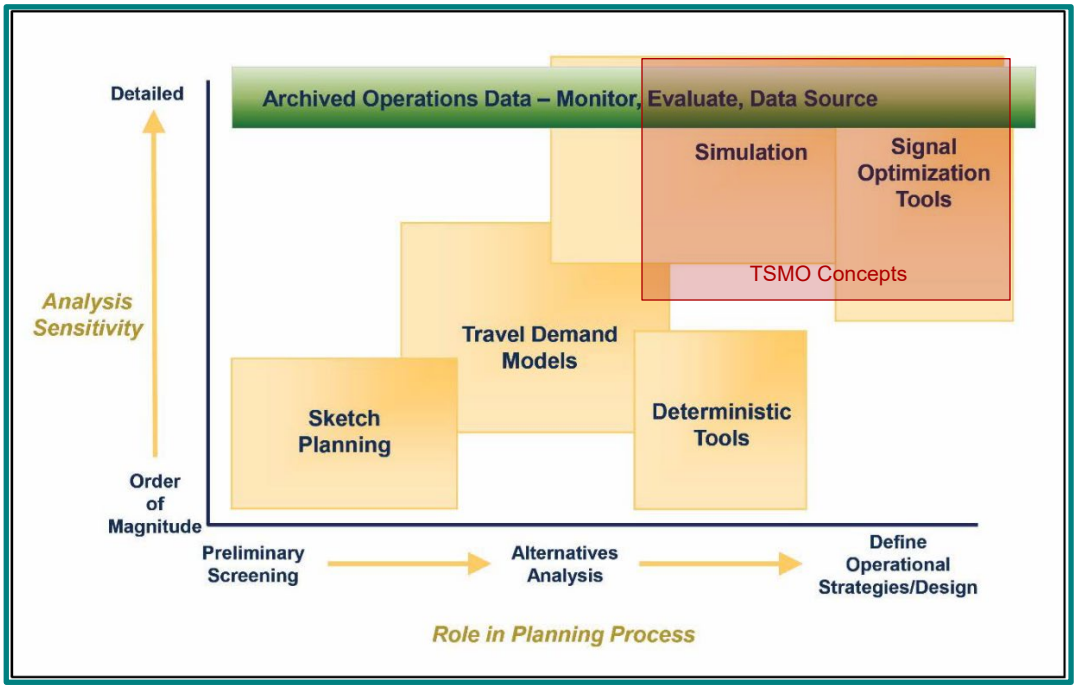
The ability to apply a systematic process for analyzing data to in order to understand how to best maximize the performance of the existing and future transportation system across all modes and networks is a basic and fundamental tenet of TSMO. TSMO relies on a collaborative process to establish measurable operational performance based system management objectives through the application of analytical tools that facilitate cross agency coordination during the planning and implementation of multi-modal strategies.

While the use of transportation analysis tools has been a long-standing practice in the transportation planning process, such tools have mainly focused on helping analyze and evaluate long-term transportation strategies with regard to policy and regional level goals. Currently there is not a single tool or method that can be applied for TSMO. The types of analysis tools currently applied in the transportation planning process have different uses ranging from initial sketch-level planning (early stages of the transportation planning process) to the more intensive and complex tools which are more in line with TSMO application (simulation tools). **Figure 8** shows the various levels of analysis tools as they relate to the transportation planning process and relationship to TSMO and level of analytical sensitivity.

Because TSMO reflects a performance based driven approach it requires analytical tools that focus on near-term measurable outcomes and multi-modal operational level strategies which can be reassessed and monitored over time. Such tools are generally characterized as resource-intensive in terms of staff expertise and require significant set up/integration with the more traditional tools. Key TSMO activities are focused on the advancement of the Next OS to include developing and deploying analytical TSMO tools that:

- Help identify and assess operational coordination strategies between transportation system operators and public safety organizations that include major event and emergency evacuation strategies
- Help identify and develop performance measures of proposed multi-modal technology and mobility transportation strategies
- Help evaluate the supply of services to match demand across all transportation technology and mobility strategies to assess potential impacts for short or long term operational actions
- Help assess operational strategies and determine performance outcomes of proposed multi-modal technology and mobility transportation strategies
- Help visualize TSMO coordinated strategies for use by transportation system operators and transportation planners to help convey improved transportation performance conditions and visually depict expected benefits that will be achieved with multi-modal transportation strategies. The tool will serve as a feedback mechanism to monitor, evaluate, and document the effectiveness of TSMO.
- Develop TSMO maintenance forum or guidelines to pool maintenance resources or expertise of TSMO tools

Figure 8 Comparison of Analysis Tool Capabilities



Source: Applying Analysis Tools in Planning for Operations Participant Workbook, FHWA Workshop Series.

Table 4 shows the full list of technical actions that SANDAG and local agencies should undertake to facilitate corridor-level concept development, deployment, and ongoing operations and maintenance.

Table 4 - Regional TSMO Technical Actions

Institutional Need Statement (N#)	Short-Term Actions (0-5 Years)	Medium-Term Actions (5-10 Years)	TSMO Plan Goal Alignment
N13 -There is a need to facilitate concept exploration with tools that match user needs with possible multi-modal and innovative transportation strategies and services.	SANDAG to develop tools to match user needs, modal priorities, regional goals, and infrastructure gaps with possible TSMO strategies.	Sub-regional and local groups to advance selected TSMO strategies to Concepts of Operations on the corridor level or sub-regional level. Develop corridor-level implementation plans.	Goal 1A, 1B, 1C, 1D, 2B, 3C
N14 -There is a need for comprehensive monitoring and reporting of multi-modal, multi-jurisdictional metrics.	SANDAG to develop a regional dashboard for planners and system operators to view multi-modal operations and safety performance within intersections, corridors, and the region.	SANDAG, sub-regional, and local groups to identify gaps in the data set and implement monitoring methods to make a more complete representation of users, modes, and safety data.	Goal 1A, 1B, 1C, 1D, 2B, 2D, 3C
N15 -There is a need for support in evaluating and selecting multi-modal and innovative strategies and prioritizing corridor-level deployments.	Sub-regional and local groups to utilize existing tools to estimate the benefits and costs of TSMO strategies.	SANDAG to collect data on life-cycle costs of deployments and historical measures of effectiveness. Identify and develop new tools as needed.	Goal 2B, 2D, 3B
N16 -There is a need to provide procurement support for technology integration and procurement.	SANDAG to develop procurement guidelines to support user needs and interoperability among agencies, devices, and data sets.	SANDAG, sub-regional, and local groups to refine the guidelines as challenges emerge.	2D, 3A, 3B, 3C
N17 -There is a need for guidance on choosing appropriate performance metrics multi-modal and innovative transportation strategies and services.	SANDAG, sub-regional, and local groups to develop performance metrics that tie to regional goals.	SANDAG, sub-regional, and local groups to incorporate these guidelines into TSMO training courses.	Goal 1A, 1B, 1C, 1D, 2C, 3C, 2E
N18 - There is a need to understand existing regional assets and infrastructure gaps.	Sub-regional and local groups to perform local asset inventories of equipment, systems, and communications infrastructure. Identify gaps and develop a list of critical corridors, such as key evacuation routes.	SANDAG to develop and maintain an asset inventory database and continue proactive asset management strategies and programming.	2D, 3A, 3C

7 TSMO TOOLKIT AND RESOURCES

A Regional TSMO Toolkit has been developed to provide stakeholders with reference documents, guidelines, and tools as they begin the process to implement each of the three dimensions of TSMO – institutional, operational, and technical. The toolkit, summarized in Table 5, provides a description of how to use each document and how each links to the action plan. The Toolkit includes insight on the following TSMO themes:

- Convene a decision-making body and technology and mobility expert group
- Develop the business case for TSMO strategies
- Position for funding opportunities
- Establish a regional TSMO Dashboard
- Seek out workforce training.
- Perform maturity analyses and needs assessments
- Advance and implementation of TSMO strategies
- Utilize existing tools to estimate the benefits and costs of TSMO strategies
- Develop performance metrics and monitoring
- Advancing TSMO in the Transportation Planning Process

It is important to note that the action plan and toolkit are not intended as a cookie cutter approach to TSMO deployment. Rather, these tools are intended to support local agencies in examining their internal processes for project selection and development and provide guidance on potential best practices that could be applied to their TSMO projects. Agencies will need to tailor the process to specific circumstances and issues within their study area.

Several tools are examples and templates, which can help to provide a starting point for institutional collaboration through charters and other agreements. SANDAG envisions the toolkit and resources to evolve over time, and as new tools and examples are developed, they will be made available to agencies throughout the region to support their agency TSMO efforts. The toolkit provides these resources via publicly accessible web links, or as supporting toolkit documents attached at the end of the toolkit table.

Table 5 - Regional TSMO Toolkit Summary

Action	Toolkit Document	Description and Background	How To Use This Document
Convene a decision-making body and a technology and mobility expert group.	NCRC Management Team Charter (Attached as a Toolkit Supporting Document below)	During the TSMO needs assessment workshops, the NCRC stakeholder group drafted a Corridor Management Team (CMT) Charter document. This charter's purpose was to establish a CMT to collaborate on operations, identify and prioritize strategies, and position for future funding opportunities.	This is an example of an institutional charter that establishes an agreement to develop and implement TSMO principles to maximize network performance within a corridor or sub-region.
	I-15 ICM Charter (Attached as a Toolkit Supporting Document below)	In August 2016, the I-15 Corridor Management Team developed a Team Charter. This charter's purpose was to establish stakeholder roles and responsibilities to implement Integrated Corridor Management and support on-going operations.	This is an example of a charter that speaks to a specific TSMO strategy.
	Planning for TSMO Within Corridors: A Desk Reference – Chapter 4 (web link)	FHWA created a reference to plan and implement TSMO on a corridor level. Chapter 4 was extracted and included in the toolkit, which covers the implementation phase and the three major categories of interagency agreements.	Stakeholder groups can reference this chapter of the desk reference when determining what type of interagency agreement suits their needs. The full document is included in the "Further Reading – State and Federal Guidance" section of the Toolkit.
Develop the business case for TSMO strategies to build support for local policy enabling initiatives like data sharing, funding mechanisms, operations agreements, and maintenance agreements.	Advancing TSMO: Making the Business Case for Institutional, Organizational, and Procedural Changes (web link)	FHWA developed a guide to communicate the business case for TSMO to agency leaders, staff, external partners, and the general public.	Stakeholder groups can reference the business case primer to build support for TSMO by tailoring the approach to the specific audience. This guide assists with communicating the benefits of proposed TSMO strategies for institutional, operational, and technical changes to agency assets and procedures.
Position for funding opportunities by aligning sub-regional and local goals with TSMO strategies that are eligible for state and federal funding.	Fixing America's Surface Transportation Act (FAST Act): • Advance Transportation and Congestion Management Technologies Deployment (ATCMTD) (web link)	Summary of key USDOT funding opportunities that place focus or advance and promote the implementation of technologies.	This is a starting point for agencies to determine possible funding sources for TSMO.

Action	Toolkit Document	Description and Background	How To Use This Document
	• INFRA Grants (Nationally Significant Freight and Highway Projects) (web link) • Intelligent Transportation Systems (ITS) Program (web link) • Technology and Innovation Deployment Program (TIDP) (web link) US DOT - Rebuilding American Infrastructure with Sustainability and Equity (RAISE) (web link)		
	California Transportation Commission – Road Repair and Accountability Act of 2017 (Senate Bill 1) – Solutions for Congested Corridors Program (SCCP) (web link)	In 2019, the CTC published an update to the 2017 Implementation Plan for Senate Bill 1.	This is a starting point for agencies to determine possible funding sources for TSMO.
Seek out workforce training.	NCHRP TSMO Workforce Guidebook (web link)	NCHRP developed a guide to TSMO workforce development of 19 model position descriptions for TSMO-related positions and a framework for recruiting, developing, and retaining TSMO personnel.	Agencies can use this guide to identify positions, skills, and strategies for developing staff so they can plan, implement, monitor, and evaluate the effectiveness of TSMO deployments.
Perform maturity analyses and needs assessments within local agencies and sub-regional stakeholder groups to identify needs, goals, and priorities.	Regional TSMO Needs Survey (Attached as a Toolkit Supporting Document below)	Building upon the needs identified by the NCRC stakeholder group, the project team solicited feedback from stakeholders across the San Diego Region to scale the needs up and include needs relevant to other corridors. This outreach included all five CMCP (Central Mobility Hub; Coast, Canyons, and Trails; North County, San Vicente, and South Bay to Sorrento), CTAC/SANTEC, SSTAC, and CBOs. This survey was used to verify the needs and begin to identify priorities.	Stakeholder groups can use these example needs as a starting point for determining local priorities. It is important to consider that some needs may be over or under-represented depending on the professional background of staff members that receive and fill out the survey. For example, if an agency has a robust traffic management team but does not have a staffer dedicated to freight management, then freight will likely score significantly lower than others despite being a significant driver of the local and regional economy. These effects must be considered before assigning final priorities.

Action	Toolkit Document	Description and Background	How To Use This Document
Perform maturity analyses and needs assessments within local agencies and sub-regional stakeholder groups to identify needs, goals, and priorities.	NCRC TSMO Capability Maturity Model (Attached as a Toolkit Supporting Document below)	During the TSMO needs assessment workshops, the NCRC stakeholder group participated in a Capability Maturity Model (CMM) Analysis. The CMM helps agencies understand their existing processes and barriers to TSMO implementation and identifies steps to advance to the next maturity level.	This is an example CMM which stakeholder groups can use as a reference while performing their local needs assessments.
	Example Needs Assessment Survey and Interview Questions (Attached as a Toolkit Supporting Document below)	Survey questions were developed to determine existing TSMO processes and capabilities during the Needs Assessment for the NCRC. The survey was administered through a web-based platform which collected stakeholder responses. Follow-up questions were developed to discuss over conference call for further context behind agency responses.	Stakeholder groups can use these example questions as a reference while performing their local needs assessments.
	Systems Engineering Guidebook for ITS (web link)	FHWA and Caltrans developed a guidebook to provide standardized approach to multi-agency coordination, participation, operations, and maintenance of ITS projects. The systems engineering model of project development connects activities in the early planning stages to the end results of the project. The process addresses challenges and barriers among partner agencies to align user needs with the proposed system.	Agencies should review this document and align their TSMO project development process with the systems engineering approach.
	TSMO Program Planning – Experiences from the SHRP 2 Implementation Assistance Program (web link)	NCHRP developed a TSMO Program Planning Framework to help agencies implement TSMO effectively, regardless of their existing level of maturity.	Stakeholder groups can use this guide to understand existing capability maturity levels and create a plan to implement strategies to advance TSMO in their study area.

Action	Toolkit Document	Description and Background	How To Use This Document
	CMM One Minute Guidance Evaluation (web link)	AASHTO created online guidance in the form of a one-minute evaluation and a more comprehensive evaluation of existing agency programs. Based on responses to the evaluation, specific recommendations are provided for advancing to the next maturity level.	Agencies can use this guidance to evaluate agency capabilities for each dimension of TSMO.
Advance and implement TSMO strategies - Concepts of Operations on the corridor level or sub-regional level. Develop corridor-level implementation plans.	SANDAG Curb Management ConOps (web link)	The verified needs, goals, and objectives formed the foundation of the regional Curb Management ConOps. The purpose of this ConOps was to develop a consistent regional approach to one of the six use cases of the Next OS. Ultimately, the curb management concept described in this document will be tailored to specific corridors when implemented locally.	This is an example ConOps which stakeholder groups can use as a reference while developing their local TSMO ConOps.
	SANDAG Smart Intersection Systems ConOps (web link)	The verified needs, goals, and objectives formed the foundation of the regional SIS ConOps. The purpose of this ConOps was to develop a consistent regional approach to one of the six use cases of the Next OS. Ultimately, the SIS concept described in this document will be tailored to specific corridors when implemented locally.	This is an example ConOps which stakeholder groups can use as a reference while developing their local TSMO ConOps.
	I-15 ICM ConOps (web link)	In 2009, SANDAG developed a ConOps for the I-15 ICM. The purpose of this ConOps was to develop a concept for operating a specific TSMO strategy within a given study area.	This is an example ConOps which stakeholder groups can use as a reference while developing their local TSMO ConOps.
	I-210 ICM ConOps (web link)	Caltrans developed a ConOps for the I-210 ICM. The purpose of this ConOps was to develop a concept for operating a specific TSMO strategy within a given study area.	This is an example ConOps which stakeholder groups can use as a reference while developing their local TSMO ConOps.
	NCRC Implementation Roadmap Outline (Attached as a Toolkit Supporting Document below)	The NCRC TSMO Roadmap to Implementation Outline attachment to the North County Regional Corridor Management Team Charter identifies near, medium, and	This is an example action plan with tangible steps to implement TSMO strategies within a given study area.

Action	Toolkit Document	Description and Background	How To Use This Document
		long-term actions to achieve the CMT purpose.	
Utilize existing tools to estimate the benefits and costs of TSMO strategies.	Planning-Level ATDM Strategies and Cost Matrix (Attached as a Toolkit Supporting Document below)	This matrix was developed in support of SANDAG's Complete Corridors visioning activities. Planning-level unit costs were assigned to ATDM strategies for three unique corridor typologies: freeways, arterials, and rural corridors.	Agencies can use these planning-level costs as a starting point while programming future budgets and pursuing TSMO funding opportunities.
	Planning-Level ATDM Strategies and Cost Memorandum (Attached as a Toolkit Supporting Document below)	This matrix was developed in support of SANDAG's Complete Corridors visioning activities. This memorandum states the assumptions behind the ATDM strategy planning-level unit costs.	This document provides context on the assumptions behind the planning-level ATDM strategy costs. Agencies can use these costs and assumptions as a starting point and tailor them to local conditions.
	Example Needs Matrix – NCRC Needs, Goals, and Supporting Actions (Attached as a Toolkit Supporting Document below)	Stakeholder input from the NCRC workshops, surveys, and interviews, were distilled into underlying need statements. These needs statements were broken down into goals, objectives, and actions.	This is an example of how to turn each problem statement into a need statement and continue breaking it down to establish goals and supporting objectives and actions. This exercise can be used to develop a roadmap to implement the overarching goals.
	TSMO Benefit-Cost Analysis Compendium (web link)	Justifying TSMO expenditures can be a challenge because many tools for conducting benefit cost analyses are best suited for traditional infrastructure projects. FHWA collected cases across the country where benefit cost analyses were applied to TSMO strategies and created a spreadsheet tool available online at:	Agencies can use this guide to help in prioritizing strategies, programming investment strategies, and pursuing TSMO funding opportunities.

Action	Toolkit Document	Description and Background	How To Use This Document
		https://ops.fhwa.dot.gov/plan4ops/topsbctool/index.htm	
	California Life-Cycle B-C Analysis Model (web link)	Caltrans has created a variety of downloadable B/C tools that focus on different types of transportation improvements, including active transportation, transit, freight, commuter parking and ride-share, and physical improvements. The website also features an emissions calculator and modules for federal discretionary grants.	Agencies can use these resources to help them select, prioritize, and build a business case for strategies that are covered in the spreadsheet tools.
Develop performance metrics and monitoring techniques that tie to regional goals.	Organizing for TSMO - Case Study 3: Performance Measurement – Making Data-driven Transportation Decisions Using Performance Measures (web link)	FHWA gathered case studies of agencies that have a high level of maturity in the performance measurement dimension of TSMO. This document provides examples of best practices and lessons learned.	Agencies can reference these case studies when considering performance metrics data collection, storage, and analysis processes.
Advancing TSMO in the Transportation Planning Process	AASHTO Operations Guide Development Plan (web link) Advancing TSMO Through Scenario Planning (web link) Developing and Sustaining a TSMO Mission for Your Organization (web link) Developing and Using the ConOps in Transportation (web link) Connecting TSMO and Environment (web link) Connecting TSMO and Maintenance (web link)	Agencies like AASHTO, Caltrans, and FHWA have developed many documents over the years to assist in TSMO planning and cultural shift. The selected documents are provided to help agencies gain a deeper understanding of the benefits of TSMO, how to program and implement institutional change, how to communicate TSMO, and how to develop concepts in greater detail.	Agencies can reference these additional resources to find more information. A few examples of topics covered in these resources include: • Developing concepts of operations for specific strategies on the corridor level, such as arterial traffic management and smart connected communities • Developing operational scenarios • Following the systems engineering process • Connecting TSMO to maintenance, environment, and safety • Program planning and lessons learned.

Action	Toolkit Document	Description and Background	How To Use This Document
Advancing TSMO in the Transportation Planning Process	Connecting TSMO and Safety (web link) Organizing and Planning for Operations (web link) ITS Concept of Operations for Arterial Traffic Management (web link) The Planning for TSMO Guidebook (web link) Planning for TSMO Within Corridors: A Desk Reference (web link) TSMO Caltrans Statewide Perspective (web link) TSMO in Smart Connected Communities (web link) TSMO Program Planning–Experiences from the SHRP2 Implementation Assistance Program (web link)		

Regional TSMO Toolkit

Supporting Documents to
Convene a Decision-Making Body and a Technology Expert Committee

North County Regional Corridor Management Team Charter

1. Charter Purpose

The purpose of the North County Regional Corridor (NCRC) Charter is to establish an on-going Corridor Management Team (CMT) to define a state-of-the-art multi-modal, multi-agency, and performance-based approach to active systems management along the SR-78 corridor. This partnership will promote collaboration for operations and system integration, prioritize systems-level operational strategies, and continue to position the corridor for funding opportunities that will maximize mobility on SR-78 and its adjacent arterials, active transportation, and transit systems. The charter will help the agencies identify a path to addressing the mobility needs of all users and form a foundation to further Transportation Systems Management and Operations (TSMO) within the North County area.

2. Background

In 2020, a series of stakeholder workshops was held to determine the TSMO capability maturity level of agencies operating on or adjacent to the NCRC. Throughout this process, agencies partnered together to determine needs, challenges, and opportunities for enhanced collaboration and TSMO deployment within the corridor. The NCRC agencies expressed a desire and need for a more formalized partnership structure among the agencies co-operating the corridor. This Charter establishes a formal communications framework among stakeholder agencies.

The San Diego region is implementing the “5 Big Moves” innovations – Complete Corridors, Transit Leap, Mobility Hubs, Flexible Fleets, and Next OS – through its 2021 Regional Transportation Plan. These data-driven strategies support a vision that strives to enhance connectivity, increase sustainability, and improve quality of life. The Charter is a necessary step towards structuring the region to be ready to implement these concepts. The 5 Big Moves will rely on regional cross collaborations between agencies in activities such as sharing data and working as a regional team to provide connected, diverse transportation services across the county. The Charter establishes a framework for agencies to develop a culture of collaboration in the context of the SR-78 corridor.

3. Goals and Objectives of the Corridor Management Team

a. Create an engaging and collaborative environment for information sharing and TSMO project development.
    i. Develop an Implementation Plan of institutional, operational, and technical strategies and related projects to support performance-based management of the transportation system with a focus on the user experience by early 2021.
    ii. Collaboratively implement strategies and projects that result from the Implementation Plan and regularly revisit the Plan to verify its relevance to the region’s goals.

iii. Create actions with a timeline to implement the Road Map to Implementation tied to regional planning initiatives such as the CMCP and RTP.
iv. Share experiences, lessons learned, and best practices in the development and implementation of new technologies for transportation management.
v. Position the corridor for funding opportunities; identify and collaboratively pursue these funding opportunities.

b. Utilize cooperative operations to improve mobility and efficiency for all modes.
   i. Establish common performance measures and targets.
   ii. Address safety measures by analyzing hot spots.
   iii. Utilize a systems approach to maximize person throughput and minimize delay.
   iv. Make performance-based operational decisions.
   v. Develop a ConOps for integrated NCRC management by mid-2021.

c. Promote regional TSMO approach through improved data sharing and technology integration.
   i. Develop common data standards and architecture.
   ii. Address adaptation to evolving technology.
   iii. Address multi-agency communications and infrastructure needs.

4. Schedule/Key Milestones

a. CMT meetings will be held on a regular basis, at least quarterly.
b. Action items will include responsible parties who will endeavor to complete tasks by the scheduled date.
c. All signatories to this Charter will work cooperatively to ensure that reviews, approvals, and input are received in a timely manner.
d. Agencies will begin meeting within one month after Charter is executed.
e. Implementation Plan shall be tied to the Road Map timelines and developed in accordance with a schedule that adheres to regional plan timelines to provide input into the CMCP and RTP.

5. Approvals

Caltrans District 11	**Date:**
City of Carlsbad	**Date:**
City of Escondido	**Date:**
City of San Marcos	**Date:**
City of Oceanside	**Date:**
City of Vista	**Date:**
NCTD	**Date:**
SANDAG	**Date:**

6. Attachment

a. NCRC TSMO Roadmap to Implementation Outline

Team Charter: Interstate 15 (I-15) Corridor Management Team (CMT)

Charter Purpose:

The purpose of the Team Charter is to establish an agreement concerning the roles and responsibilities of SANDAG, San Diego Metropolitan Transit System, and Caltrans for undertaking the data collection and reporting activities including establishing common transportation performance measures for on-going management and operations and idetinfying near and long term performance monitoring targets to support on-going Corridor Management and Operations and maximize the use of existing and proposed transportation improvements.

Background	In 2014, SANDAG's Executive Director (Gary Gallegos) and Caltrans District 11 Director (Laurie Berman) established the I-15 Corridor Management Steering Committee. The primary objective of the Steering Committee was to develop coordinated strategies to maximize overall performance on the I-15 Corridor. Key efforts focused on trying to understand, document, and quantify the benefits and impacts associated with the application of changes to the configuration of the barrier and FasTrak/pricing algorithm. The Steering Committee formed a cross agency I-15 Corridor Management Technical Team which concluded its work in February 2015. The results of the Technical Team's efforts included: • identified corridor level goals, objectives, and performance measures • identified steps to be considered when deploying corridor management strategies • identified a set of initial strategies to be further examined for implementation including conducting a public awareness campaign; modifying the existing CMS signs, making a change to the tolling algorithm, and changing the configuration of the barrier system to support peak period travel conditions • the team also recommended the establishment of an on-going multi-agency team, including SANDAG, SDMTS and Caltrans to carry out the implementation, monitoring, management and operations for proposed corridor management strategies This charter establishes of the ongoing multi-agency team, known as the Interstate 15 (I-15) Corridor Management Team (CMT); defines the Purpose of the CMT; identifies Goals; and sets a Schedule for key deliverables.

Purpose	The CMT will: • Conduct on-going data collection, analysis, and reporting to optimize multi-modal and multi-agency transportation system management and operations • Provide a forum for information sharing; the exchange of ideas and recommendations to continuously improve and optimize system operations

Goals	• Develop common data collection and reporting procedures • Report on the initial agreed upon performance measures including: <u>Quantity of Travel</u> Number of FasTrak Transponders Number of FasTrak Users - Active Accounts Number of FasTrak Users - During the Peak Periods Average FasTrak User Trip Length - During the Peak Periods FasTrak Cost Recovery Express Lanes Violation Rates Peak Period Express Lanes Volumes and VMT GP Lane Volumes and VMT Transit Ridership Corridor Vanpool Use <u>Quality of Travel</u> Peak Period Corridor Speeds (GPs and Express Lanes) Peak Period Person Delay (35 and 60) Peak Period Average Corridor Travel Times Transit - On-time performance/or Peak Load Factor • Track, prioritize, quantify and summarize performance findings for initial agreed upon corridor strategies that may include, but are not limited to: o Changes to information distribution/traveler related strategies (modify existing Express Lanes signs) o Enhancements to system operations (adjusting ramp meters) o Modifications to FasTrak algorithm o Move Barrier to 3+1 configurational changes o Public Awareness Campaigns • Provide recommendations on possible operational changes to CMT Steering Committee. • Exploring additional performance measures to consider over time and documenting best practices for on-going performance management activities

Schedule/Key Milestones	• Team members will meet on an on-going basis to summarize performance findings and prepare monthly and quarterly reports to the Steering Committee. • Team members will review the CMT Charter annually for progress updates and possible amendments as appropriate • 2015-2016 Deliverables: o Develop baseline performance management and reporting procedures (On-going 2016) o Develop CMT Decision Process and Procedural Guidelines (Fall 2016)

Team Members	CMT Steering Committee: • Cory Binns, Chief Deputy District Director, Caltrans District 11 • Gustavo Dallarda, Corridor Director, Caltrans District 11 • Ray Traynor, Department Director of Operations, SANDAG • Sharon Cooney, Chief of Staff, San Diego Metropolitan Transit System (MTS) CMT Co-Chairs • Gary Vettese, Caltrans Team Sponsor, Traffic Operations D11 • Marcelo Peinado, Caltrans Team Sponsor, Freeway Operations D11 • Alex Estrella, SANDAG Team Sponsor, Performance Management and Operations CMT Technical Team • Ryan Ross, FasTrak PM, SANDAG • Ellison Alegre, Performance Monitoring, SANDAG • MTS Staff (Staff TBD), Transit Operations and Performance Reporting, MTS • Carlos Mendoza and Joshua Reese, Performance Monitoring, Caltrans D11 • Michael Powers, Performance Management and Operations, Caltrans D11 • Julie Jacinto, Performance Reporting, Caltrans D11

Sponsor: _____ Date: 9/26/16
Laurie Berman
District Director
Caltrans District 11

Sponsor: Gary L. Gallegos Date: 10-3-16
Gary Gallegos
Executive Director
San Diego Association of Governments

Sponsor: _____ Date: 8/23/16
(MTS Sponsor)
San Diego Metropolitan Transit System

Regional TSMO Toolkit

Supporting Documents to
Perform Maturity Analyses and Needs Assessments within Local Agencies and
Sub-regional Stakeholder Groups to Identify Needs, Goals, and Priorities

Regional TSMO Needs Survey		
	Needs Statement	**Rank how relevant the statement is to your agency (1 being most important and 5 being least important)**
Safety	Need more monitoring of bike and pedestrian safety metrics	
	Need more accurate crash data portal	
	Need near-miss monitoring and analysis in key corridors	
	Need more accountability for effectiveness of safety improvement projects with better before and after data	
	Need transportation infrastructure that improves support for emergency evacuations and emergency vehicle access	
	Need public traveler information features that improves support for emergency evacuations like real-time evacuation orders, road closures, and emergency shelter locations	
	Need real-time information sharing with emergency management personnel, first responders, and public safety personnel	
	Need to improve after-incident review	
	Need improved personal safety at transit stations and park-n-ride lots	
	Need emergency call buttons at mobility hubs	
	Other (write-in)	
Signal Operations and Interconnectivity	Need complete and resilient communications network infrastructure	
	Need consistent approach to adaptive signals deployments	
	Need better coordination of transit operations with local signals	
	Need a consistent approach to transit priority signals	
	Need infrastructure support for vehicle-to-infrastructure communications on transit	
	Need infrastructure support for vehicle-to-infrastructure communications in connected vehicles	
	Need updated processes for interchange signal coordination	
	Need walk time extension for low mobility users and active transportation modes	
	Other (write-in)	
ent	Need online reservations for on-street parking, parking structures, park-n-rides, and at border crossings	
	Need real-time commercial delivery loading zone information	
	Need to designate ridehail pick-up/drop-off zones to make it easier for riders and drivers to find each other in high-demand destinations (such as stadiums and venues)	
	Need for urban consolidation centers to utilize smaller vehicles for last-mile delivery	
	Need demand-based street parking prices	

Curb Managem	Need car-free living incentive programs such as a monthly stipend for transit and shared mobility services, where desirable	
	Need shorter parking time limits to increase parking turnover, where desirable	
	Need automated enforcement of dedicated curb space	
	Need an established process for selecting curb management treatments	
	Need a baseline of shared mobility trip data	
	Need a baseline of delivery vehicle turnover data	
	Need a baseline of parking turnover data	
	Need improved access to up-to-date curb data	
	Need an existing inventory of curb usage regulations and parking policy	
	Other (write-in)	
Equity and Accessibility	Need access to mobility, payment options, and information for unbanked or underbanked individuals	
	Need access to mobility, payment options, and information for those who do not own smartphones, do not have access to home internet, or who have low technological literacy	
	Need interfaces that support users with low English proficiency, low vision, and the hard of hearing	
	Need to ensure that emerging modes provide equitable and accessible transportation services	
	Need data processing techniques that mitigate for bias based on race, gender, socioeconomic status, etc.	
	Need equity metrics to be a major component in project planning and prioritization	
	Need to communicate outcomes of community engagement and performance metrics back to public, especially to those who participated in outreach	
	Need to prioritize accessibility in curb management	
	Need accommodations for mobility devices, service animals, and personal care attendants in transit and shared mobility services	
	Need travel training for seniors and disadvantaged groups	
	Need technology training for seniors and disadvantaged groups	
	Need trip planning assistance for seniors and disadvantaged groups	
	Need bus driver training refreshers on protocols for curb pull-up, bus kneeling, and securing mobility devices	
	Need bus driver training refreshers on courteous interactions with disabled riders, including those with cognitive or behavioral disabilities	
	Need to prioritize projects that improve air quality in areas with existing environmental health challenges	
	Need to incorporate mitigation of gentrification into planning process	
	Need to fill existing gaps in transportation and communications infrastructure that may make it more difficult for some areas to benefit from technology improvements	

	Need to prioritize improvements in areas that have historically received less robust infrastructure investment	
	Other (write-in)	
Performance Metrics	Need metrics for access to mobility and transit services for people with disabilities	
	Need metrics for connectivity of low income housing to employment, education, services, and recreation	
	Need air quality metrics	
	Need person-throughput metrics	
	Need mode usage monitoring and mode shift metrics	
	Need vehicle-miles-traveled metrics	
	Need congestion and vehicle travel time metrics	
	Need first responder accessibility and emergency evacuation metrics	
	Need metrics for length of transportation service disruptions during maintenance operations and disasters	
	Need economic opportunity metrics	
	Need travel time reliability metrics across transportation modes	
	Need traffic signal efficiency performance metrics for vehicles	
	Need traffic signal efficiency performance metrics for active transportation modes	
	Need a consistent approach to performance reporting processes	
	Need user satisfaction surveys	
	Need truck travel time metrics	
	Need truck travel stop/idle time metrics	
	Need truck fuel consumption metrics	
	Need to integrate multimodal data into corridor performance metrics	
	Need to monitor the number of households near transit	
	Other (write-in)	
Mulitmodal and Transit Optimization	Need more mode choice options	
	Need to improve attractiveness and viability of alternate modes	
	Need interactive kiosks at mobility hubs and transit stations to plan and schedule entire trips using any combination of modes, including shared mobility services	
	Need improved first and last mile connectivity	
	Need wireless internet connectivity and charging ports for users of mobility hubs	
	Need increased transit ridership	
	Need dynamic transit routes to complement traditional fixed routes	
	Need for smaller capacity vehicles such as personal rapid transit or neighborhood electric vehicles (NEV)	
	Need for rider satisfaction surveys	
	Need infrastructure to support faster bus loading times such as queue jump lanes and bus boarding islands	
	Need increased travel time reliability	
	Need on-demand microtransit such as neighborhood electric vehicle shuttles between homes and transit stops	

	Need improved transit on time performance	
	Need enhanced coordination between transit operators and signal operators	
	Other (write-in)	
Incident Corridor Management and Regional Partnerships	Need more proactive system monitoring and response to network impacts	
	Need to provide alerts to agency representatives when conditions prompt a predetermined action	
	Need to coordinate ramp operations with arterial operations	
	Need to reduce incident clearance time	
	Need to identify the origin and destination of trips to track diversion and cut-through	
	Need to improve coordination between agencies during major incidents	
	Other (write-in)	
Mobility Services and Traveler Information	Need ability to plan trips based on travel time	
	Need ability to plan trips with multiple modes	
	Need ability to plan trips based on bike rack/bike box locations	
	Need ability to plan trips based on amount of walking and/or ADA accessible routes	
	Need to incorporate paratransit into trip planners	
	Need for paratransit trip reminders and real-time arrival notifications	
	Need a database of mobility service providers to facilitate matching with individuals based on accessibility needs	
	Need traveler information on EV charging station availability and type	
	Need traveler information of trip duration using managed lanes versus general purpose lanes	
	Need resources for businesses to implement telecommuting effectively	
	Need planned lane closure information to enable proactive route planning	
	Need real-time arrival information at mobility hubs and transit stations	
	Need public notifications when conditions affect route or mode choice	
	Need to maintain equitable access to request Motorist Aid Service (roadside assistance) during peak hours	
	Need to encourage/incentivize mode shift from single occupant vehicles to HOV, active transportation, micromobility, and transit services	
	Other (write-in)	
nal Border agement	Need binational agency coordination to achieve border system objectives: enhance safety, security, efficiency, reliability, and reduce greehouse gas emissions through reduced wait times	
	Need wait time detection	
	Need toll collection system and customer service	
	Need real-time border crossing information for passenger vehicles: READY lanes and regular lanes	

Regio Mar	Need real-time border crossing information for freight: READY lanes, laden, and empty	
	Need greater transit frequency and improved reliability at border crossing	
	Need real-time border crossing information for pedestrians	
	Other (write-in)	
Freight	Need ability to dynamically route freight traffic during incidents	
	Need to reduce truck congestion during peak travel times	
	Need to utilize urban consolidation centers to improve last-mile delivery operations using smaller vehicles	
	Need improved coordination between port and local freight operators for improved schedule optimization	
	Need freight-specific information on route restrictions, road closures, lane restrictions, dynamic loading zones, bridge heights, and truck parking availability	
	Need to optimize scheduling for trucks based on stop times, travel times, terminal wait times, and other constraints to spread out arrivals at the intermodal terminal and reduce wait/idle times	
	Need to optimize container load matching and freight information exchange systems to reduce dry runs and wasted miles	
	Other (write-in)	
Data Collection and Management	Need to establish a common data exchange that is interoperable across locations, mode types, and operators	
	Need regional resources to support data analysis	
	Need robust cybersecurity protocol for regional data hub	
	Need data user access management protocol to limit who can view or modify data	
	Need to sanitize and/or encrypt data of a sensitive nature	
	Need to collect, manage, maintain, and analyze data in adherence with applicable laws, regulations, policies, and procedures	
	Need to share relevant corridor performance measures with adjacent or impacted agencies	
	Need to share real-time traffic signal timing plans with adjacent or impacted agencies	
	Need to share real-time video of key corridors to improve operations with adjacent or impacted agencies	
	Need to detect incidents and share the detection with partner agencies that may be impacted	
	Need to collect real-time speed and travel time information	
	Need data output that is easier for local decision makers, planners, and operators to interpret and act on	
	Need access to historic travel times to help inform operations and policy decisions	
	Need flight arrival and departure information available on an open data portal	
	Need rideshare and vanpool service information on an open data portal	
	Need transit schedule information available on an open data portal	

	Need vehicle travel time information available on an open data portal	
	Other (write-in)	
Systems Management	Need an integrated revenue management system - Express lanes, border tolls, transit, shared mobility services, etc.	
	Need an asset management system to track maintenance and guide planning	
	Need a systematic process for evaluating effectiveness of signal timing plans and ramp metering rates	
	Need a more cohesive network of managed lanes (HOV, transit only, tolling, etc)	
	Need legal agreements with mobility providers	
	Need procurement guidelines, performance requirements, and data sharing requirements	
	Need CV/AV testing and evaluation guidelines	
	Need ongoing analysis of system effectiveness and public acceptance of technology	
	Need guidelines for interoperability of technological devices and data sets	
	Other (write-in)	
Back-Office System Maintenance	Need a coordinated back-office environment to support the integrated revenue management system	
	Need ongoing forum for back-office coordination across department and agency silos	
	Need IT support personnel to maintain data hub interface, public mobile app interface, and perform data QA	
	Need experienced data analysts to turn data into meaningful information relevant to each use case	
	Need responsive IT support personnel to solve system issues and update time-sensitive information	
	Need timely ongoing maintenance of hardware and software, such as licensing and operating system updates according to vendor software support cycles	
	Need to follow best practices to protect customer information	
	Need data-secure backups and recovery plans	
	Other (write-in)	

TSMO Capability Maturity Model

Introduction

The Regional Transportation System Management and Operations (TSMO) Plan provides San Diego Association of Governments (SANDAG) 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.

Part of implementing TSMO strategies requires transportation agencies to evaluate the policies, processes, and institutional practices in place such that they can identify gaps and achieve a more effective program. This is accomplished by focusing on identifying opportunities for continuous improvements to the transportation system by improving capabilities within the agency.

The Capability Maturity Model (CMM) is a management tool that provides a framework for agencies to use when evaluating their business processes to better manage projects and programs. The CMM framework was developed by Federal Highway Administration (FHWA) for the TSMO program. The CMM framework defines agencies' capabilities in different "process areas," which are defined by FHWA as:

- Business Process;
- Systems and Technology;
- Performance Measurement;
- Workforce;
- Culture; and
- Collaboration.

Agencies evaluate their capabilities within these process areas, grouped into levels ranging from Level 1, defined as "ad-hoc, low level of capability" to Level 4, defined as "optimized, highest level of capability." The CMM matrix from FHWA is shown in **Figure 1**.

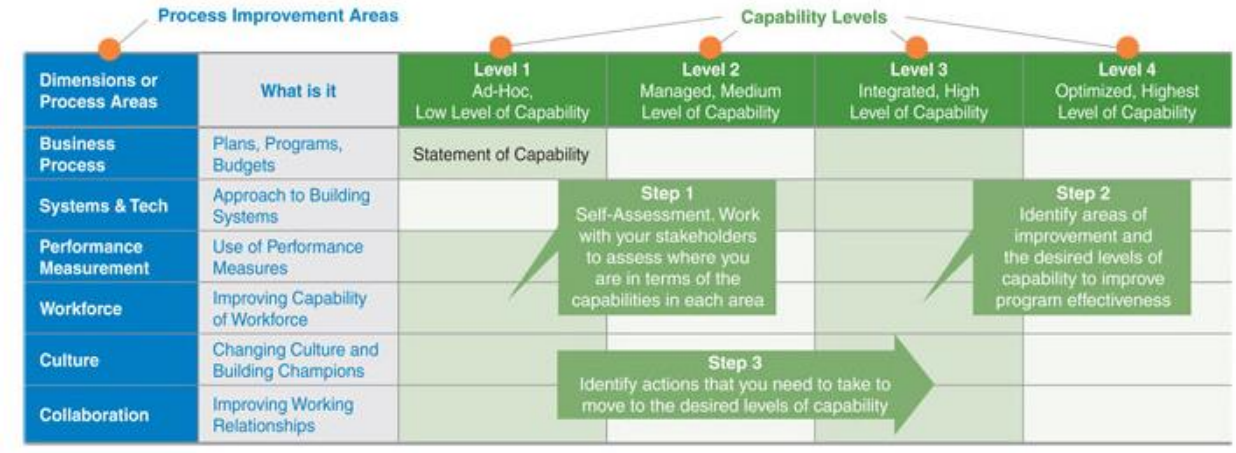


Figure 1 – Capability Maturity Model

Purpose and Background

This document provides an assessment of the existing operational, institutional, and technical conditions based on the TSMO CMM for state, regional, and local agencies. It provides a baseline of the existing TSMO capabilities of California Department of Transportation (Caltrans), SANDAG, North County Transit District (NCTD), and local cities, which were gleaned from surveys and interviews with representatives from each agency. Then, it identifies gaps, constraints, and opportunities for advancing institutional, operational, and technical capabilities for all agencies. Finally, it will discuss recommendations of specific actions agencies can take to achieve continuous growth towards higher levels of capabilities.

For the purpose of evaluating existing TSMO capabilities, the project team used SR-78 as a case study corridor to guide conversations. The SR-78 corridor is a regionally significant corridor that has several TSMO elements established or in development. To operate SR-78, agencies need to collaborate institutionally, operationally, and technically to coordinate corridor management. Thus, it is a corridor that allows agencies to speak specifically on the level of maturity and capability of each process area. Agency interviews and surveys to drive this evaluation uses SR-78 as a specific case study to establish a baseline, but the identification of improvements in capabilities applies to agencies' TSMO operations as a whole.

Participating agencies are listed as follows:

- Caltrans
- SANDAG
- NCTD
- City of Carlsbad
- City of Escondido
- City of Oceanside
- City of San Marcos
- City of Vista

Capability Maturity Model Evaluation

This section documents the existing conditions of agencies' capabilities against the CMM process areas. These outputs are the result of many individual and group conversations and surveys that involved each of the participating agencies. It provides overall strengths and challenges identified by the agencies, establishes the level of capability for each process area, and summarizes opportunities for improvements to advance to the next level. The intent of this assessment is to provide an overview CMM evaluation. Many of the dimensions were only discussed with the agencies in general terms.

Business Processes

Strengths Cited	Challenges Cited
• SANDAG is leading the Regional TSMO Plan to define the common vision for transportation system operations. • Agencies have invested in TSMO related infrastructure, such as communications lines and traffic control systems. • Agencies have identified creative solutions for projects, such as requiring developers to pay for TSMO improvements as a mitigation measure. • Some agencies have corridor prioritization plans that help determine the locations of projects for programming. • There are existing TSMO partnerships in the region to collaboratively operate specific corridors, including I-15, I-805, and SR-78. • All agencies have participated in data sharing through the Regional Arterial Management System (RAMS) data hub. • SANDAG established the San Diego Forward: 2021 Regional Plan, which establishes a regional action plan that includes transformative strategies to reimagine the transportation system through alternative transportation and technology connectivity.	• Funding resources for TSMO is ad hoc, with some agencies relying on private developments to fund communications and ITS device infrastructure, which results in patchwork system of improvements. • Tendency for agencies to fund for capital improvements for TSMO, but not funding staffing, operations, and maintenance. • Planning is needed within agencies and regionally to prioritize corridors for signal operations enhancements (e.g. installing adaptive). • There is a need for procurements to scope equipment that uses standards that allow interoperability with other agencies in the region. • Project programming typically prioritizes "fix-it-first" and "state-of-good-repair" projects. • Process for field equipment upgrades for some agencies requires 3-5 years to construct and implement, which risks projects to be obsolete soon after it is built.

Level	1 — Performed	2 — Managed	3 — Integrated	4 — Optimized
Criteria	Each jurisdiction with its own planning/programming budgeting according to individual priorities and capabilities	Consensus regional approach developed regarding TSMO/ICM goals, deficiencies, B/C, networks, strategies and common priorities	Regional program integrated into jurisdictions' overall multimodal transportation plans with related staged program, sustainable funding identified	TSMO integrated into jurisdictions' multi-sectoral plans, programs, budgets based on formal continuing planning processes
Consensus		2		

Opportunity Actions to Advance to the Next Level

- Use the Regional TSMO Plan to establish the regional vision for TSMO and provide recommendations for agency business processes to more efficiently deploy and operate transportation systems.
- Create a San Diego regional TSMO Business Plan to identify order of magnitude cost estimates for capital, operating, and maintenance costs for at least the next five years and perform a preliminary cost-benefit analysis for project prioritization.
- Initiate a process that creates consensus among agencies on the improvements desired for the region, their priorities, and document them in a Regional ITS Architecture or similar document.
- Identify how TSMO concepts fit into San Diego's regional programs and initiatives, such as San Diego Forward: 2021 Regional Plan. Identify regional projects to make the business case to Councilmembers to support funding.
- Establish a TSMO Steering Committee that meets regularly (monthly to quarterly) that has at least one member from each agency. This group of stakeholders will use the forum to coordinate projects and interconnectivity, identify funding opportunities for identified projects, and use a regionally coordinated approach to obtaining competitive funding.
- Create a plan to identify sustainable funding sources that can be used for TSMO projects on a yearly basis and is not tied to any specific project or technology. Regional agency to disburse yearly TSMO funds to local agencies based upon need and regional performance improvements.

Systems and Technology

Strengths Cited	Challenges Cited
• Caltrans is installing advanced V2I equipment. • Existing communications infrastructure is fairly extensive. • All local agencies have a TMC, and some are in the process of upgrading for enhanced remote capabilities. • Many agencies are taking steps to bring signals online by upgrading antiquated field equipment, converting serial communications to fiber, and taking leveraging adjacent construction projects to fill gaps in the network. • SANDAG installed the RAMS hub, which is a regional traffic signal management software for local agencies. • Caltrans is replacing their ATMS and adding capability to notify other agencies of incident or travel time alerts based on geographic region. • Caltrans has a data warehouse in API format that can be integrated into other agencies' systems to show incidents in real-time.	• Some cities operate traffic signal systems that are not open source and will need to invest in integration projects to share data and control of devices with other agencies and achieve interoperability. • There is a lack of automated system monitoring that is shared between agencies, so agencies are often late to respond to growing congestion on adjacent jurisdictions (such as freeway congestion spilling onto streets). • Some agencies have old equipment that does not have capabilities for interoperability. • Interoperable technology specifications are not standardized and prioritized. • Escondido has communications bandwidth challenges. • Cities do not have real-time information from NCTD, which makes challenges for signal timing at at-grade railroad crossings. • Some agencies no longer use RAMS or have left the RAMS system. • Caltrans' ramp metering system relies on loop detection, which does not provide much data.

Level	1 — Performed	2 — Managed	3 — Integrated	4 — Optimized
Criteria	Ad hoc approaches to system implementation without consideration of systems engineering and appropriate procurement processes	Regional/corridor ConOps, architectures, DSS developed and documented with costs included; appropriate procurement process employed	Systems, technology standardized and integrated on a regional/corridor basis and DSS utilized in real time – with related processes and training as appropriate	Architectures and technology routinely upgraded to improve performance; systems integration/interoperability maintained on continuing basis
Consensus	1.5			

Opportunity Actions to Advance to the Next Level

- Develop Concept of Operations documents for TSMO applications to be developed for the region, which identifies roles and responsibilities of partners in the region to develop and operate TSMO projects (including arterial signal timing, transit coordination, and freeway management).
- Request Systems Engineering training sessions from Caltrans Headquarters and allow all agencies to participate.
- Consider making policy changes within agencies to follow a standardized Systems Engineering process through the lifecycle of a project, from planning to maintenance.
- Update the Regional ITS Architecture to reflect existing and planned systems and technologies in the near-term (including planned TMC and ITS device upgrades) and long-term (including V2I and other connected vehicles concepts).
- Within the Regional ITS Architecture, update ITS Standards that can be used by local agencies in procurements.
- Develop training session to introduce their new ATMS features, API availability, and requirements for interoperability to local agencies.
- Document and map ITS assets deployed across the region, including communications lines, traffic signals and associated equipment, CCTV cameras and video management systems, TMC equipment, and others. Identify gaps across the region and use analysis to prioritize projects that promote connectivity, interoperability and data sharing.
- Build in automated alerts based on operational thresholds that can be sent to select people inside and outside of an agency, such that incidents and outages are automatically communicated to key regional stakeholders.

Performance Measurement

Strengths Cited	Challenges Cited
• Several cities collect and store high volumes of data using Bluetoad and Blyncsy, detection loops, and CCTV cameras. • City of Carlsbad uses performance measure data to prioritize projects and shares some data with the public. • NCTD outfits all transit routes with GPS and shares real-time arrival information with the public. • All have participated in data sharing through the RAMS data hub. • SANDAG is developing the Privacy Impact Assessment to understand data gathering implications and data security. • SANDAG is developing mobility data governance guidelines and micromobility data as a pilot for data management. • SANDAG is developing a performance measurement framework. • NCTD collects extensive transit performance data and meets with SANDAG and other regional transit agencies to discuss performance and scheduling. • Travel time maps are available for the public. • Some agencies have dashboard displays that show performance metrics data in real time.	• Even in agencies where devices are collecting large amounts of data, agency staff lacks knowledge on how to use data collected. • Oceanside has detectors installed, but a power outage has taken them down indefinitely. • Some agencies do not collect enough data throughout its jurisdiction to determine performance metrics for analysis and prioritizations. • Agency staff is overloaded with day-to-day duties and do not have time to analyze data collected • There is a need for guidance on identifying what data to collect based on agency's goals of optimizing the system and how to integrate the use of data into critical programming and project decision-making • Data collected are not shared with other agencies to form a coordinated regional understanding of traffic conditions. • Data sharing is limited due to concerns for liability and security • Some agencies no longer use RAMS or have left the RAMS system.

Level	1 — Performed	2 — Managed	3 — Integrated	4 — Optimized
Criteria	Some outputs measured and reported by some jurisdictions	Output data consistently used directly for after-action debriefings and improvements; data easily available and displayed on a dashboard	Outcome measures identified (networks, modes, impacts) and routinely utilized for objective-based program improvements and performance measured in real time	Performance measures reported internally for utilization and externally for accountability and program justification
Consensus		2		

Opportunity Actions to Advance to the Next Level

- A regional agency to lead in conducting technical training sessions for staff at local and regional agencies for education on best practices for data gathering, monitoring, and usage such that agencies are managing corridors based on performance outcomes and objectives.
- Regular training sessions to be held to help agencies understand the types of data collected and how to utilize the data to make planning and programming decisions on the local and regional level.
- Workshop-style training sessions to be held for agencies that focus on understanding FHWA performance measure requirements and applicable State and regional MPO targets. Within these training sessions, guide agencies to create action plans to utilize the data they have to regularly report on these performance measures and establish a schedule for agencies to report performance to the applicable regional or State agency.
- SANDAG to share Privacy Impact Assessment with agencies and conduct training webinars to educate agencies on data security.
- Develop a regional strategy for collecting and reporting performance measures data that are related to the outcomes supporting agencies' objectives.
- A focus on performance metric data availability and automated compiling through a dashboard interface for future ITS procurements (such as for an ICM Decision Support System) may help with having readily available data for use in making future decisions.
- Develop performance measure targets that must be met to initiate actions and projects.
- Establish a list of performance measures to be collected and reported on a regular basis by all agencies. Establish a standard data format for each performance measure that is used throughout the region.

Culture

Strengths Cited	Challenges Cited
• Multiple agencies reported that their City Council has identified traffic congestion as among its top priorities in recent years. • Multiple agencies have prior TSMO experience through projects such as I-15 ICM, I-805 Bus on Shoulder, I-805 TSMO Plan, and Mobility Hubs. • The San Diego Forward: 2021 Regional Plan focuses on the 5 Big Moves, including Complete Corridors, Transit Leap, Mobility Hubs, Flexible Fleets, and Next OS, which are all related to TSMO. • Agencies in the region have experience with operating ICM corridors with other agencies. • Agencies are generally open to data sharing and partnership with other jurisdictions. • All agencies in the region have expressed interest in participating in a monthly or quarterly regional TSMO meeting to discuss and align TSMO objectives and activities. • SANDAG has initiated and funded several programs and projects focused on TSMO to organize and educate local partners on TSMO and ITS Planning.	• There lacks formal agreements between agencies to operate systems collaboratively. • Some agencies do not prioritize TSMO projects and TSMO focused operations due to lack of staffing resources. • There is not a clear understanding within individual agencies of what the TSMO concept is and who is responsible for performing it. • Some efforts for regional collaboration have fell short of signed agreements and agency buy-in, which causes the collaboration efforts to be ad-hoc on an as-needed basis, rather than regular and sustained. • There is a need for a clear regional champion of TSMO activities that is responsible for scheduling meetings, initiating TSMO-related studies, and organizing local agencies in collaboration to fill regional gaps. • Caltrans HQ has initiated a focus on TSMO, but the current project prioritization method is "Fix-it First," which has been a barrier in procuring funding for TSMO projects. • The TSMO acronym and concept is not widely known by the public, including senior management at agencies and agency Councilmembers. There needs to be a regional educational initiative to inform decisionmakers on TSMO.

Level	1 — Performed	2 — Managed	3 — Integrated	4 — Optimized
Criteria	Individual staff champions promote TSMO – varying among jurisdictions	All Jurisdictions' senior management understands TSMO business case and educates decision makers/public	All Jurisdictions' mission identifies TSMO and benefits with formal program and achieves wide public visibility/understanding, credibility	Customer mobility service commitment accountability accepted as formal, top level core program of all jurisdictions
Consensus	1			

Workshop Actions to Advance to the Next Level

- Create an educational and branding program for TSMO, similar to the outreach effort for the 5 Big Moves, making the concept recognizable and desired by agency staff when planning and programming projects.
- Identify and write down the business case for TSMO through development of the TSMO Business Plan, which establishes the cost-benefit analyses of TSMO related projects in relation to overall agency goals, such as mobility, safety, livability, and sustainability. Provide evidence from TSMO efforts within and outside of the region that have assisted in managing congestion, incidents, and major emergencies.
- Identify likely TSMO champions in the region (elected officials or management) and have them present to Councilmembers and Board Members on the importance of TSMO. Have opportunities for ribbon-cutting and press releases for TSMO projects that show collaboration across the region.
- Identify TSMO-related conferences, courses, and trainings and promote investment to send key staff members to improve their technical backgrounds.
- Prepare educational material to be released as an after-action incident/emergency report. When emergencies occur within the region, prepare description of agency partnerships in response to the emergency and make the case to the public and decision makers on the importance of routine preparedness to mitigate major disruptions during emergencies.
- Identify constraints within each agency that may prevent the implementation or funding of TSMO efforts and create an approach to resolving them.

Organization/Workforce

Strengths Cited	Challenges Cited
• Agencies generally have understanding on how to operate and maintain their own traffic signal systems and related ITS devices. • There are ad-hoc communications between some agencies and staff generally have a contact that they can call to coordinate for incident management. • There is recognition of the need for further training and staff skills/knowledge development within most agencies. • The San Diego Regional Traffic Engineers Council (SANTEC) includes local cities, regional transit agencies, SANDAG, and Caltrans. The group meets monthly to discuss regional partnerships and regionally significant projects.	• Staff resources to operate TSMO are currently very limited. Some cities only have 2-3 staff members that are responsible for transportation, and thus have shared duties • Agencies lack and desire training for data analysis, data utilization, and technical knowledge on TSMO concepts. • There is not a clear understanding of the knowledge and skills needed by staff to perform TSMO. There is a need to understand what capabilities currently exist in organizations and what gaps need to be filled. • Agencies typically have small staff dedicated to traffic and transportation within cities, and do not have dedicated staff that have the training/knowledge required to operate and maintain complicated ITS projects and data analysis. • When staff at agencies move to different positions or leave the agency, other agencies in the region typically do not know who to contact for coordination.

Level	1 — Performed	2 — Managed	3 — Integrated	4 — Optimized
Criteria	TSMO/ICM added on to units within existing structure and staffing – dependent on technical champions	TSMO/ICM-specific organizational concept developed within/among jurisdictions with core capacity needs identified, collaboration takes place	Corridor Management established: TSMO Managers have direct report to top management; Job specs, certification and training for core positions developed	TSMO senior managers at equivalent level with other jurisdiction services and staff professionalized
Consensus		2		

Workshop Actions to Advance to the Next Level

- Identify and document staffing needs across each agency for TSMO (number of staff and knowledge, skills, and abilities) and compare these needs to what is currently available in existing staff. With identified gaps, agencies can consider different options for filling these gaps, including reorganizing and training existing staff, hiring new staff, and contracting out maintenance or operations responsibilities.
- Identify a clear transition plan for TSMO duties and knowledge when agency staff is reorganized. The transition plan should involve notifying other local agencies of the staff change, updating the group on the contact information for the new staff member, and inviting the new responsible staff member to regional forums and meetings.
- Clarify the TSMO chain of command for performance accountability on TSMO program implementation. Review relationship from local agency to regional agency to state agency such that each agency understands its roles and responsibilities in funding, planning, and implementing TSMO-related activities.
- Within each agency, encourage staff responsible for TSMO related activities to engage in conferences and trainings that continue to develop their skill set.
- Examine each agency's organizational and career advancement structure and develop performance criteria tied to TSMO KSAs.

Collaboration

Strengths Cited	Challenges Cited
• Agencies overwhelmingly support an ongoing collaborative approach to corridor management and operations. • Agencies coordinate individually for projects, planning studies, and maintenance issues near jurisdictional boundaries as needed. • Escondido, Caltrans, and SANDAG have previously partnered on the I-15 ICM and have coordinated well as partners, showing a level of buy-in between agencies. • Caltrans has an API portal and a TOC phone line reserved for local agencies. • Carlsbad had success with coordinating evacuation response to wildfire emergency by coordinating with Caltrans over the phone • Caltrans currently has agreement with San Diego and Chula Vista to take control of their signals and flush traffic west of I-15. • Operations and maintenance staff	• Communications between agencies is ad-hoc between individuals, which is challenging when individuals are unavailable or moves to a different position. • No existing standardized process to initiate requests to implement signal timing changes and coordination projects between agencies. • There lacks formal agreements between agencies to work together as a corridor and region. • Sharing device control is limited due to liability concerns. • There are reservations within some agencies that are understaffed to participate in regular collaboration that can help congestion problems along major corridors in the region. • There are no standard operating procedures for agencies to notify each other when incidents or outages occur that will affect the adjacent agency's traffic signal network.

Level	1 — Performed	2 — Managed	3 — Integrated	4 — Optimized
Criteria	Relationships ad hoc, and on personal basis (public-public, public-private)	Objectives, strategies and performance measures formally aligned (MOUs) among organized key players (transportation, public safety) with after-action debriefing	Rationalization/ sharing/ formalization of responsibilities among key players through co-training, formal agreements and incentives	High level of TSM&O coordination among owner/operators (state, local, private)
Consensus	1.5			

Workshop Actions to Advance to the Next Level

- Establish a formal process to initiate and maintain coordination between agencies (e.g. a bi-monthly coordination meeting between all agencies).
- Sign interagency agreements (MOUs) to establish roles and responsibilities of each agency in sharing data and potentially sharing control of traffic signals for specific use cases, such as for priority corridors that experience recurring and incident-caused congestion, which would require agencies to communicate for incident response.
- Identify high-priority corridors to begin agency collaboration efforts and bring key stakeholders (Caltrans, SANDAG, local cities, emergency response, and public safety) together to establish TSMO strategies to help manage the corridor. Using these corridor management meetings, establish a culture of consensus building and buy-in to improve partnerships and relationships across the region.
- Identify a lead regional agency and identify the staff within the agency to champion regional collaboration and manage collaboration activities, such as hosting regular meetings, creating and maintaining a list of key contact staff from each agency, lead discussions.

Summary of Recommendations

From the CMM evaluation, there are many potential activities for the region to undertake to improve its TSMO capabilities and reach the next level of each TSMO dimension. A summary of the activities is provided below, organized into People (Institutional Governance), Processes (Operational Management), and Tools (Technical Strategies).

People – Institutional Governance

1. **Gather institutional support and normalize TSMO in the region.**
   - Create an educational and branding program for TSMO, similar to the outreach effort for the 5 Big Moves, making the concept recognizable and desired by agency staff when planning and programming projects.
   - Identify TSMO Champions (elected officials or management) who make presentations to Councilmembers and Board Members on the importance of TSMO. Allow opportunities for ribbon-cutting and press releases for TSMO projects showing collaboration across the region.
   - Identify constraints within each agency that may prevent the implementation or funding of TSMO efforts and create an approach to resolving them.
   - Create a plan to identify sustainable funding sources that can be used for TSMO projects on a yearly basis and is not tied to any specific project or technology. Regional agency to disburse yearly TSMO funds to local agencies based upon need and regional performance improvements.
2. **Present the business case to justify a focus on TSMO.**
   - Identify and write down the business case for TSMO through development of the TSMO Business Plan, which establishes the cost-benefit analyses of TSMO related projects in relation to overall agency goals, such as mobility, safety, livability, and sustainability. Provide evidence from TSMO efforts within and outside of the region that have assisted in managing congestion, incidents, and major emergencies.
   - Prepare educational material to be released as an after-action incident/emergency report. When emergencies occur within the region, prepare description of agency partnerships in response to the emergency and make the case to the public and decision makers on the importance of routine preparedness to mitigate major disruptions during emergencies.
3. **Determine knowledge, skills, and abilities (KSAs) required within each agency to implement TSMO and identify available resources to fill gaps in KSAs.**
   - Identify and document staffing needs across each agency for TSMO (number of staff and KSAs) and compare these needs to what is currently available in existing staff. With identified gaps, agencies can consider different options for filling these gaps, including reorganizing and training existing staff, hiring new staff, and contracting out maintenance or operations responsibilities.
   - Identify TSMO-related conferences, courses, and trainings and promote investment to send key staff members to improve their technical backgrounds.
   - Within each agency, encourage staff responsible for TSMO related activities to engage in conferences and trainings that continue to develop their skill set.
   - Examine each agency's organizational and career advancement structure and develop performance criteria tied to TSMO KSAs.

Processes – Operational Management

1. **Establish an accountability chain of command between State, regional, and local agencies.**
   - Clarify the TSMO chain of command for performance accountability on TSMO program implementation. Review relationship from local agency to regional agency to state agency such that each agency understands its roles and responsibilities in funding, planning, and implementing TSMO-related activities.

- Identify a clear transition plan for TSMO duties and knowledge when agency staff is reorganized. The transition plan should involve notifying other local agencies of the staff change, updating the group on the contact information for the new staff member, and inviting the new responsible staff member to regional forums and meetings.

2. **Formalize expectations and roles and responsibilities for each agency in corridor partnerships.**
   - Sign interagency agreements (MOUs) to establish roles and responsibilities of each agency in sharing data and potentially sharing control of traffic signals for specific use cases, such as for priority corridors that experience recurring and incident-caused congestion, which would require agencies to communicate for incident response.
   - Identify high-priority corridors to begin agency collaboration efforts and bring key stakeholders (Caltrans, SANDAG, local cities, emergency response, and public safety) together to establish TSMO strategies to help manage the corridor. Using these corridor management meetings, establish a culture of consensus building and buy-in to improve partnerships and relationships across the region.
   - Establish a formal process to initiate and maintain coordination between agencies (e.g. a bi-monthly coordination meeting between all agencies.
   - Use experience from Corridor Management Partnerships to create a TSMO Steering Committee that meets regularly (monthly to quarterly) that has at least one member from each agency. This group of stakeholders will use the forum to coordinate projects and interconnectivity, identify funding opportunities for identified projects, and use a regionally coordinated approach to obtaining competitive funding.
3. **Identify TSMO strategies and projects to fit within regional planning documents.**
   - Use the Regional TSMO Plan to establish the regional vision for TSMO and provide recommendations for agency business processes to more efficiently deploy and operate transportation systems.
   - Create a San Diego regional TSMO Business Plan to identify order of magnitude cost estimates for capital, operating, and maintenance costs for at least the next five years and perform a preliminary cost-benefit analysis for project prioritization.
   - Initiate a process that creates consensus among agencies on the improvements desired for the region, their priorities, and document them in a Regional ITS Architecture or similar document.
   - Identify how TSMO concepts fit into San Diego's regional programs and initiatives, such as San Diego Forward: 2021 Regional Plan. Identify regional projects to make the business case to Councilmembers to support funding.
4. **Seek or develop TSMO training modules.**
   - A regional agency to lead in conducting technical training sessions for staff at local and regional agencies for education on best practices for data gathering, monitoring, and usage such that agencies are managing corridors based on performance outcomes and objectives.
   - Regular training sessions to be held to help agencies understand the types of data collected and how to utilize the data to make planning and programming decisions on the local and regional level.
   - Workshop-style training sessions to be held for agencies that focus on understanding FHWA MAP-21 performance measure requirements and applicable State and regional MPO targets. Within these training sessions, guide agencies to create action plans to utilize the data they have to regularly report on these performance measures and establish a schedule for agencies to report performance to the applicable regional or State agency.
   - SANDAG to share Privacy Impact Assessment with agencies and conduct training webinars to educate agencies on data security.
   - Request Systems Engineering training sessions from Caltrans Headquarters and allow all agencies to participate.
5. **Identify performance measures for regular reporting, which will be used to make regional decisions on planning, programming, and operations.**
   - Develop a regional strategy for collecting and reporting performance measures data that are related to the outcomes supporting agencies' objectives.

- A focus on performance metric data availability and automated compiling through a dashboard interface for future ITS procurements (such as for an ICM Decision Support System) may help with having readily available data for use in making future decisions.

Tools – Technical Strategies

1. **Require the usage of the Systems Engineering process to plan and design projects.**
   - Consider making policy changes within agencies to follow a standardized Systems Engineering process through the lifecycle of a project, from planning to maintenance.
   - Develop Concept of Operations documents for TSMO applications to be developed for the region, which identifies roles and responsibilities of partners in the region to develop and operate TSMO projects (including arterial signal timing, transit coordination, and freeway management).
2. **Perform an inventory of existing ITS assets in the region.**
   - Document and map ITS assets deployed across the region, including communications lines, traffic signals and associated equipment, CCTV cameras and video management systems, TMC equipment, and others. Identify gaps across the region and use analysis to prioritize projects that promote connectivity, interoperability and data sharing.
   - Request training session from Caltrans to introduce their new ATMS features, API availability, and requirements for interoperability to local agencies.
3. **Perform an update to the ITS Architecture and designate an agency staff member or team to keep it updated.**
   - Update the Regional ITS Architecture to reflect existing and planned systems and technologies in the near-term (including planned TMC and ITS device upgrades) and long-term (including V2I and other connected vehicles concepts).
   - Designate an agency as the regional lead for ITS Architecture maintenance and designate a staff position within that agency to be responsible for updates and performing ITS Architecture training sessions for local agencies.
4. **Establish ITS Standards for uniformity and interoperability.**
   - Within the Regional ITS Architecture, update ITS Standards that can be used by local agencies in procurements.
   - Establish a list of performance measures to be collected and reported on a regular basis by all agencies. Establish a standard data format for each performance measure that is used throughout the region.
5. **Use automated alerts based on operational thresholds to pre-emptively address issues.**
   - Build in automated alerts based on operational thresholds that can be sent to select people inside and outside of an agency, such that incidents and outages are automatically communicated to key regional stakeholders.
   - Develop performance measure targets that must be met to initiate actions and projects.

REGIONAL TSMO ASSESSMENT SURVEY

Thank you for taking the time to fill out the Transportation Systems Management and Operations (TSMO) survey. The objective of this survey is to provide a baseline to obtain an understanding of your agency's current TSMO capabilities, strengths, and challenges. Please answer these questions from your agency's perspective with input from other staff as needed.

People

1. How does your agency assign staff to TSMO project development and operations?
    - TSMO project responsibilities are assigned to available staff who existing role most closely fits the project.
    - TSMO project responsibilities are assigned to TSMO champions.
    - Organization structure contains TSMO technical staff and leadership positions who manage TSMO projects.
    - TSMO responsibilities are assigned to available staff who are provided training to align with TSMO roles.

2. What do you think is the level of interest or support within your agency for developing a collaborative TSMO approach to the corridor? Check all that apply.
    - Very supportive, likely to champion ongoing efforts.
    - Moderately supportive, likely to participate in ongoing efforts.
    - Willing to participate in development activities, but not ready to commit to ongoing involvement.
    - Not likely to champion TSMO, would prefer to manage assets within jurisdictional boundaries.
    - Not sure.

3. How would your agency benefit from a collaborative TSMO approach for the corridor? Check all that apply.
    - More staffing for operations
    - Improved performance metrics
    - Greater access to funding
    - Greater visibility to Executive-level staff
    - Other

Processes

4. How does your agency account for long-term operations and maintenance for TSMO projects?
    - My agency generally allocates funding for long-term operations and maintenance during project planning.
    - My agency's planning process generally allocates funding for operations and maintenance in a collaborative process with partner agencies.
    - My agency takes an ad hoc approach to operations and maintenance funding.

- My agency does not account for long-term operations and maintenance funding.
- Other.

5. How does your agency identify and prioritize TSMO projects? Check all that apply.
    - Projects are identified and prioritized based on local knowledge of local system performance needs.
    - Projects are identified and prioritized based on community or political involvement.
    - Projects are identified and prioritized based on collaboration with partner agencies.
    - Projects go through a data-driven assessment process to be included in a priority list.
    - Projects are identified as mitigation for development projects.
    - Other.

6. What would improve the way TSMO solutions are planned and funded? Check all that apply.
    - A clear TSMO project development process to gather stakeholders and attain consensus on TSMO priorities.
    - Tools to understand the true cost of TSMO implementation and ongoing operations.
    - Guidance on funding sources and strategies for securing funding.
    - A streamlined stakeholder engagement process that minimizes the time from project inception to implementation.
    - Policy supporting the adoption of technology interoperability.
    - A TSMO champion at my agency.
    - Dedicated funding for TSMO projects and improvements.
    - Methods for evaluating TSMO projects against other projects my agency is planning.
    - Other

Tools

7. What performance measures are being collected?
   Fill in the blank.

8. How are performance measures being used to manage the system in your jurisdiction? Check all that apply.
    - Performance measures are used to help operate systems in real-time.
    - Performance measures are used for analysis to help identify system management changes that are needed.
    - Performance measures are used to maintain systems in real-time.
    - Performance measures used to guide future decision making and project priorities.
    - Performance measures are not widely used for system operations and management.
    - Not sure.
    - Other.

9. Are performance measures being shared and reviewed with partner agencies?
    - Yes

- No
- They are shared, but there are no reviews or subsequent action.

10. On a scale of 1 to 10, please indicate your agency's relative priority to enhance each of the elements "people, processes, and tools" with 1 being the lowest priority and 10 being the highest.
    - People (choose 1-10)
        i. Additional staff support
        ii. Additional training on specific TSMO-related strategies
        iii. A TSMO champion
    - Processes (choose 1-10)
        i. Improved operational framework across agencies
        ii. Improved operations and maintenance within my agency
        iii. Shared TSMO vision
    - Tools (choose 1-10)
        i. Performance measurement analysis
        ii. Standards or tools for TSMO cost and benefit analysis
        iii. Technology interoperability

11. Which of the following possible benefits of TSMO are most important to your agency?
    - Access to funding or regional grant resources
    - Enhanced inter-agency communication structure
    - Planning guidelines for consistent TSMO strategy deployment
    - Regional data sharing initiatives
    - Other

12. Is there anything else you would like to share?

Individualized Discussion Questions

Follow-up questions with individual stakeholders can be tailored to suit the discussion based on initial survey results.

People

- Who ultimately has decision-making authority at your agency to prioritize and advance projects?
- What other groups/divisions are involved in these processes?
- What is your agency's approach or willingness to share data with other agencies?
- What is your agency's approach or willingness to coordinate operations with other agencies?
- What would you like to see happen to help advance agency collaboration for TSMO on the corridor?

Processes

- How much does project cost weigh in to decision-making on projects? What other project 'metrics' are considered? (Are safety metrics considered? Does mobility/delay/congestion even factor in to the process?)
- Are there policies/existing processes/guidelines in place in your agency for maintaining certain performance thresholds including practices/procedures for data collection, analysis, and reporting requirements along your local roadways/intersections?
- Are there policies/existing agency guidelines that allow, limit, establish guidance on data sharing across agency departments or across other agencies?
- What policies or existing agency guidelines allow, limit, or establish processes on data sharing across agency departments or across other agencies?
- Are you currently working with other agencies for any system operations?
- What systems do you currently have in place that would benefit from coordination with other agencies?
- How are operations strategies or new technology tested and selected?
- Do you currently have an TSMO projects funded or planned?

Tools

- How does your agency fund TSMO projects or enhancements?
- What performance measures are you currently measuring?
- What tools/processes/operational procedures does your agency carry out including frequency (real time or post processing) for addressing changes in operations and management of your local roadways/intersections.

Regional TSMO Toolkit

Supporting Documents to
Utilize Existing Tools to Estimate the Benefits and Costs of TSMO Strategies

Planning-Level ATDM Strategies and Cost Matrix

	ATDM Elements	Description	Unit Price	Unit	Assumptions/ Inclusions	Deployment Considerations
Freeway Management	Ramp Metering	Regulate traffic platoons entering freeway	$ 150,000	per ramp	One-mile spacing between interchanges; one ramp each direction; lane configuration agnostic; detection, cabling, cabinet, controller	Ramp widening will increase cost; multilane metering will increase cost
	CCTV Cameras	Pole-mounted video monitoring of traffic conditions	$ 40,000	per location	One-mile spacing; 45-55' pole and foundation; cabinet; cabling	Non-standard foundations increase cost; installation on sign structure can decrease cost
	Vehicle Detection	Data collection equipment for monitoring traffic flow	$ 60,000	per location	1/3-mile spacing; all new detection; technology agnostic	New poles for non-intrusive detection would increase cost
	Changeable Message Signs	Model 500 electronic sign for displaying traveler information (sign and cabling - no structure)	$ 250,000	per sign	Two in each direction over 10 miles; full-color, full-matrix; similar size to Model 500s	
	Overhead/Cantilever Structure	Structure for supporting electronic signs	$ 500,000	per structure	New structure for each new CMS; includes structure, foundation, cabinet, cabinet equipment; cabling; no additional structures for other electronic signs	Additional structure for overhead lane use signs will significantly increase cost
	Dynamic Lane Use	Electronic signs to change lane configuration of mainline and/or ramps	$ 80,000	per sign	One set of signs every 1/2 mile; 4 signs per structure; sign, cabling, conduit, cabinet	
	Queue Warning System/ Variable Advisory Speed Limit System	Alert drivers of downstream stopped/slowed conditions; display suggested maximum speed	$ 350,000	per location	Enhanced vehicle detection, signage, cabling, cabinet and equipment; assumes no gantries costs	Technology could impact cost up or down; gantry/ cantilever costs will increase cost
	Fiber Communications	Fiber communication backbone and lateral connection for transmitting data and video to central server	$ 500,000	linear mile	One 3" conduit; 30" depth; no slurry fill or concrete encasement; directional drill or trenching typically same price	Rock wheeling could reduce cost; conduit depth, number of conduit, sidewalk replacement, and increased number of pull boxes will increase cost
	Bus-on-Shoulder / Hard Shoulder Running	Part-time allowed use of shoulder by transit vehicles	$ 1,000,000	linear mile (one direction)	On-board equipment; DSRC on ramps; shoulder improvements; ramp meter	
	Virtual Changeable Message Signs	Use DSRC or 5G to disseminate traveler information into vehicles or smartphones within a geo-fenced area	$ 20,000	per location	One unit per mile; mounting on an existing structure	
	Electric Charging Lane	Enhanced pavement for charging transit vehicles, trucks, or personal vehicles	$ 2,500,000	linear mile (one direction)	Pavement replacement, installation of embedded charging equipment. Based on Sweden deployment.	Detailed costs should be further developed and evaluated as this concept moves forward
	Parking Management Infrustructure	Infrastructure for collection of parking availability info at park-and-ride lots - detection and CMS signs	$ 500,000	per lot	Equipment at parking facilities; does not include central equipment or database	Number of parking facilities and type of data collection equipment will impact cost
	Smart Work Zone Technology	Infrastructure for disseminating work zone information to vehicles or smartphones - portable CMS signs and radio technology	$ 300,000	per work zone (portable setup)	Database and enhanced traffic control equipment for capturing real-time work zone information; does not include staff time for traffic control setup	Extent of elements equipped with advanced technology will impact cost
Smart Intersections/ Arterial Management	Traffic Signal Upgrades	Upgraded controller, cabinet, wiring	$ 40,000	per intersection	Three per mile on main parallel route, additional 10 for connector routes; upgrade controller to 2070 or ATC; cabinet to remain; additional accessory equipment; traffic signal heads, mast arms, and other traffic signal mods are not included	New cabinet/foundation will increase cost
	Enhanced Vehicle Detection	Video, fisheye, or third party collection of intersection data	$ 35,000	per intersection	New detection per signalized intersection; non-intrusive technology; cabling, cabinet equipment in existing cabinet	Loops will require traffic control that increases cost
	Transit Signal Priority (and EVP)	Infrared or GPS-based system to grant transit preemption or emergency vehicle priority under certain conditions	$ 10,000	per intersection	Assume major approaches only; applicable to infrared or GPS-based	Include additional $7,500/vehicle for on-board equipment
	Active Arterial Management Signs	Local street electronic signs for disseminating traffic conditions or route guidance. This includes arterial changeable message signs, trailblazer signs, or dynamic lane assignment signs that can be mounted to existing posts	$ 75,000	per sign	Estimate 2 per intersection - one for each direction; sign, structure, foundation, cabling, power	Additional routes beyond 1 at each intersection will increase cost; could save costs by implementing a virtual messaging system
	Active Arterial Management Signs and Overhead Cantilever Structure	Local street electronic signs for disseminating traffic conditions or route guidance. This includes arterial changeable message signs, or dynamic lane assignment signs mounted to an overhead cantilever structure	$ 250,000	per structure	Estimate 1 sign with structure between each intersection - sign, structure, foundation, cabling, power	Additional routes beyond 1 between each intersection will increase cost; could save costs by implementing a virtual messaging system
	Transit Queue Jump Lanes	Right turn lane or shoulder use by transit vehicles to bypass incident	$ 75,000	per queue jump lane	1/4 of intersections; includes signs, signal, minor restriping, cabling to existing cabinet, detection	Cost increases with major widening or approach restriping
	Traffic Signal Timing Optimization	Development and implementation of signal timing coordination	$ 4,500	per intersection	AM, midday, PM; data collection included	Additional time periods will increase cost
	Traffic Signal Flush Plans	Development and implementation of incident timing plans for use during incidents	$ 3,000	per corridor	3 flush plans per intersection; one direction	Additional plans or additional routes will require additional effort
	Adaptive Signal Control	Field upgrades to enable signal timing adjustments based on actual conditions, such as additional detection	$ 20,000	per corridor	Additional detection for adaptive operations; soft costs for installation and configuration; cabinet, controller, basic detection, and other equipment are captured elsewhere	Detection technology will impact cost - video will decrease, loops will increase
	Arterial Fiber Communications	Fiber communication backbone and lateral connections for transmitting data and video to central server	$ 500,000	per linear mile	One 3" conduit; 30" depth; no slurry fill or concrete encasement; directional drill or trenching typically same price	May be able to reduce costs if parallel freeway section also has fiber; may be able to reduce lateral length.
	Arterial Capital Improvements	Ancillary improvements required to support ITS and ICM pedestrian and bike elements (e.g., ADA ramps, bike boxes, sidewalk replacement at pole installation sites)	$ 200,000	per intersection	Generally a placeholder for improvements associated with lane geometry, median modifications, ADA ramps, etc.	Cost significantly impacted by extent of improvements
	DSRC/5G Communications	Localized communication between vehicles and intersections (V2I)	$ 20,000	per location	One radio/antenna per intersection	
	Enhanced Bicycle and Pedestrian Signalization and Detection	Bike/ped signal heads, possible upgrades to cabinet and wiring, technology to detect bicycles as they approach and intersection	$ 40,000	per intersection	Cabling, antenna, and ancillary equipment for detecting presence of bicycles and pedestrians	Costs should continue to be evaluated as details of this concept are further advanced
Rural Corridor Typologies	Directional Lane Management	Local street electronic sign on mast arms to change lane direction during major events and evacuations	$ 250,000	per sign/structure	Estimate 1 sign with structure per mile per direction - sign, structure, foundation, cabling, power	Additional routes beyond 1 between each intersection will increase cost; could save costs by implementing a virtual messaging system
	Wireless Communications	Wireless communication drops from field equipment to TMC	$ 25,000	per location	One per mile - Includes modem, wireless radio, and recurring yearly cost for data plan	Varies based on terrain
	Traffic Signal Upgrades	Upgraded controller, cabinet, wiring	$ 40,000	per intersection	One per mile on main route; upgrade controller to 2070 or ATC; cabinet to remain; additional accessory equipment; traffic signal heads, mast arms, and other traffic signal mods are not included	New cabinet/foundation will increase cost
	Traffic Signal Timing Optimization	Development and implementation of signal timing coordination	$ 4,500	per intersection	AM, midday, PM; data collection included	Additional time periods will increase cost
	Traffic Signal Flush Plans	Development and implementation of incident timing plans for use during incidents	$ 3,000	per corridor	3 flush plans per intersection; one direction	Additional plans or additional routes will require additional effort

TECHNICAL MEMORANDUM

To: Alex Estrella – Senior Transportation Planner, SANDAG

From: Caralee Jaeckels, P.E. – Kimley-Horn and Associates, Inc.
Randy Durrenberger, P.E. – Kimley-Horn and Associates, Inc.

Date: November 1, 2019

Subject: Support Information for ATDM Cost Estimating

Introduction and Background

As part of the San Diego Regional TSMO Plan, we developed a sketch-level estimate of Active Travel Demand Management (ATDM) elements for enhanced traffic management on corridors throughout the San Diego region. This memorandum provides additional detail supporting the unit prices, quantities, and design assumptions that contributed to the estimate. Many of these values are based on Kimley-Horn project design and delivery experience over the last 25 years, both within California and nationally, supplemented by additional research of the more advanced elements.

SANDAG is developing a network of "Connected Corridors" consisting of freeways, expressways, highways, and arterials which serve different purposes and will likewise benefit from certain ATDM strategies over others. Five corridor typologies have been identified, three of which are included in this memorandum. Corridor Typology A consists of the most heavily traveled urban freeways and expressways which primarily serve regional commuters traveling distances of more than 20 miles. Corridor Typology B consists of freeways and expressways that primarily serve regional commuters traveling between 5 miles and 20 miles. Some segments of Corridor Typology B exist in rural parts of the region but most are in urban areas. Corridor Typology C consists of highways that serve regional and sub-regional travel in primarily rural areas, with typical travel distances between 5 miles and 20 miles.

Unit Pricing

Unit prices for freeway, urban arterial, and rural arterial management system elements (also known as ITS elements) are estimated based on recent projects with similar scopes of work, including the I-805 / SR-94 Bus On Shoulder (BOS) project, I-15 and I-80 Integrated Corridor Mobility (ICM) projects, I-880 Express Lane, and I-680 Express Lane and Backhaul. We have also considered planning-level projects that have recently been completed, including the Caltrans District 10 ICM Plan, Metropolitan Transportation Commission (MTC) Regional Communications Plan, and the Sacramento Area Council of Governments (SACOG) Smart Region Future Technology Plan. Details of each element are descried below:

> *Ramp Metering* – This unit price assumes that each ramp will have two metered lanes. This could be 2 general purpose lanes or one general purpose and one HOV preferential lane. Either way, the infrastructure needs are generally the same, including 1B poles, meter foundation, advanced meter-on sign, cabinet, foundation, controller, cabinet equipment, pull boxes, conduit, power cables, communications cables, vehicle detection, and striping. The unit price of $150,000 per ramp can be reduced by the presence of existing infrastructure or

single lane ramps; it would be increased by the need for ramp widening to accommodate more lanes.

CCTV Cameras – This unit price assumes that pan-tilt-zoom cameras are installed on 45-55' poles on a new foundation. Unit price also assumes new controller cabinet, infrastructure between camera pole and cabinet, and cabinet equipment. Installation on an existing sign structure can reduce cost; installation that requires a non-standard pole or foundation can decrease cost.

Vehicle Detection – Vehicle detection stations are generally installed at 1/3-mile spacing along the freeway, based on one-mile spacing between interchanges. One-third mile spacing results from one vehicle detection station placed adjacent to an on-ramp, one station placed adjacent to an off-ramp, and one station between interchanges. One installation assumes two loops per lane or one non-intrusive device, cabinet, controller, infrastructure between equipment and cabinet, and cabinet equipment. The cost of a new pole and foundation for a non-intrusive device would increase the unit price by about $25,000.

Changeable Message Signs – This only assumes the cost of the electronic sign, cabinet, and cabinet equipment. Structure cost is captured separately. This generally reflects the cost of a full-color, full-matrix sign for similar projects and applications, with a size relative to an existing Model 500 sign (approximately 7' x 25').

Overhead/Cantilever Structure – This captures overhead sign structure for CMS and dynamic lane use signs. Price includes foundations, cabinet, cabinet equipment, cabling, and infrastructure between structure and cabinet. The price will vary based on structure span, foundation requirements, foundation footing depth, and other customized elements to fit the structure into the surroundings.

Freeway Dynamic Lane Use – Installation of dynamic lane use signs primarily focuses on placement of an electronic sign above the lanes that will be changed. For freeways, this would typically be directly over each lane, in which case each sign would be installed on an overhead gantry structure and connected to a ground-mounted cabinet. The unit price of $80,000 represents the cost of each electronic sign mounted on a structure, cabling through the sign structure and to the cabinet, and the cabinet and internal equipment. This is based on actual costs from the I-80 ICM project. This cost can be significantly affected by the length of conduit and cabling that needs to be installed between the structure and cabinet, especially if it is separate from a trunkline conduit.

Queue Warning System/Variable Advisor Speed System – There are several ways to implement a queue warning system. As a standalone system of roadside signs, one installed between each interchange, each sign could cost as much as $175,000 depending on the extent of power conduit and cabling. With 10 signs in each direction of a 10-mile segment, this would amount to 20 signs, totaling $3,500,000.

Freeway Fiber Communications – Represents "last-mile" communications as a backbone running along the project corridor. This item includes one 3" conduit, 30" conduit depth, open trench or directional boring, no concrete slurry fill or encasement. Fiber strand count does not have a major impact on price per mile.Extent of fiber splicing and slack should be considered as price impacts as the project is further developed.

Bus-on-Shoulder/Hard Shoulder Running – Assumes $1,000,000 per mile based on I-805 bus-on-shoulder project. Price will be dependent on the specific elements required to provide bus-on-shoulder or hard shoulder running operations, This could include reconstructing the roadway cross-section to accommodate more and heavier vehicles, connected vehicle equipment to communicate with ramp metering, video monitoring, and signage for use constraints.

Traffic Signal Upgrades – This item includes upgrade of controllers, signal heads, wiring, and cabinet equipment. It does not include replacement of cabinets, mast arms, luminaires, sidewalk, ADA ramps, detection, and other ancillary equipment.

Enhanced Vehicle Detection – This item includes additional detection such as advanced detection, video detection, fisheye camera, or other technology for collecting high-resolution data for future connected vehicle operations.

Arterial CCTV Cameras – Pan-tilt-zoom, fixed, or fisheye cameras mounted on an existing mast arm extension. Each of these camera types results in roughly the same unit price. Unit price includes camera, cabling in existing mast arm and in new conduit to cabinet, and installation of camera equipment in existing cabinet. Unit price does not include a new pole and foundation, or new cabinet, which will increase cost.

Transit Signal Priority (and EVP) – Infrared or GPS-based receiver at intersection; infrared assumes 2 major approaches. Unit price includes equipment mounted on existing mast arm or cabinet, and cabling to existing cabinet. New cabinet will increase cost. On-board equipment is not included.

Active Arterial Management Signs – Unit price includes sign, structure, foundation, cabling, and power based on typical installation in a dirt area or with minor concrete replacement. Sign would include small CMS, trailblazer signs, or dynamic lane use signs.

Transit Queue Jump Lanes – Unit price reflects the cost of restriping, queue jump signal head mounted on an existing mast arm, cabling to existing conduit, signage, and additional detection in the turn lane or shoulder. Cost can vary based on existing conditions of the traffic signal equipment, roadway striping, and lane configuration.

Traffic Signal Timing Optimization – This unit price is based on developing timing for a typical intersection. Cost includes counts and development of AM, midday, and PM timing plans.

Traffic Signal Flush Plans – This unit price is similar to developing time-of-day plans. Counts are typically not required as this process is a modeling exercise to develop timing plans during incidents. Cost is based on flush plan development.

Adaptive Signal Control – This unit price is based on typical costs seen in the industry across multiple solution providers. The cost includes installation and configuration of software. Other capital costs such as controllers and cabinets are captured elsewhere. The cost of deploying an adaptive system can be very dependent on the additional detection that is required. More detection provides better results but can be costly.

Arterial Fiber Communications – Represents “last-mile” arterial communications as a backbone running along the project arterial corridor. This item includes one 3” conduit, 30” conduit depth, open trench or directional boring, no concrete slurry fill or encasement. Fiber

strand count does not have a major impact on price per mile. Extent of fiber splicing and slack should be considered as price impacts as the project is further developed.

Center-to-Field Communications – The unit price considers conduit and cable backbone infrastructure to connect a central facility to a field network. This include one 3" conduit, 30" conduit depth, open trench or directional boring, no concrete slurry fill or encasement (which would increase cost). This item could apply to connecting to the freeway segment or arterial segment, but not both. Cost could be reduced if there is an opportunity to connect to an adjacent corridor.

Central Signal System – This unit price reflects a typical installation for a central system that includes central servers and workstations, and configuration of intersections. This cost does not include infrastructure (captured elsewhere) or upgrades to field equipment. The unit price reflects a one-time cost for initial deployment; but future budgeting should include costs to add additional signals and other functionality to the system (estimate a budget of $400,000 per additional corridor).

Arterial Capital Improvements – Other intersection improvements often impact other intersection operations that require additional capital improvements. This can include new sidewalk or curb-and-gutter, removal of median islands, ADA ramps, and restriping. Costs can vary significantly depending on the impacts, so this unit price reflects a placeholder.

Unit prices for some of the newer advanced technologies have fewer data points for estimating the costs, so a conservative planning-level estimate is used for budgetary purposes. The actual cost of these items will vary as the project elements are further defined in terms of the ancillary items that will influence the cost, as well as advancing technology.

Virtual Changeable Message Signs – This is an advanced approach to disseminating traveler information that utilizes geo-fenced areas to send messages to subscribed recipients, such as an in-vehicle infotainment system or a smartphone. The hardware installation cost reflects the use of a DSRC radio or 5G small cell site within the corridor, estimated at $20,000. This includes the radio or antenna connected to an existing controller in an existing cabinet. There will be additional software costs not captured here that will be required to enable an Active Traffic Management System (ATMS) to disseminate messages over DSRC or 5G.

Electric Charging Lane – Sweden is developing a pilot program for this technology. They estimate a cost of $3B to equip 2,000 km with an electric vehicle charging lane. This equates to approximately $2,500,000 per mile, totaling $50,000,000 to equip both directions of a 10-mile segment. This cost should be further detailed and updated to reflect specific project elements, extent of improvements, and advancing technology.

Parking Management Infrastructure – This unit price includes data collection equipment at a park-and-ride or transit station parking facility. This cost is a placeholder representing the cost of space counters or entrance counters to detect and track available spaces, and an electronic sign to display availability. This price may include initial central software costs, which would decline as this system is deployed at additional facilities.

Smart Work Zone Technology – This unit price includes a placeholder for an estimated cost of technology embedded on a portable CMS or other traffic control device that would convey location and other work zone information to vehicles equipped with technology to receive messages. This solution would include one or more DSRC radios or other communication

device. The intent of this solution is to have the ability to move this equipment from one work zone to another, so overall cost will be influenced by the number of devices equipped with this technology.

DSRC/5G Communications – This unit price includes the installation of a radio or small cell device used to communicated in a Connected Vehicle environment. Equipment is assumed to be installed or mounted on existing structures.

Enhanced Bicycle and Pedestrian Detection – This unit price includes devices mounted on existing poles or structures to detect bicycle or pedestrian activity at an intersection. This could include GPS-based, acoustical, or other detection equipment; the price will vary based on the technology implemented and extent of detection coverage.

The cost extended to each corridor is factored by applying the per-mile average cost to the length of each corridor.

Quantities

The quantities presented in the spreadsheet are based on a 10-mile freeway segment (both directions) since some elements are expected to have fewer than one per mile. The number of units per 10-miles is based on rules-of-thumb for Bus On Shoulder, traffic signals and communications, ICM, freeway management systems, and arterial management systems implemented over the last 25 years. The most recent project references are the I-805/SR-94 Bus On Shoulders, I-15 ICM, I-80 ICM, Caltrans District 10 ICM, Main Street Chula Vista Interconnect, Uptown Bikeway Bike/Ped Corridor, South Bay BRT. Quantities will certainly vary by corridor and can be adjusted accordingly based on actual conditions. Specific assumptions are described below:

Ramp Metering – This quantity assumes ramp spacing of one interchange per mile in each direction. This is a typically frequency in a grid network configuration, but certainly varies based on specific network development.

CCTV Cameras – One camera per mile is the typical freeway spacing for CCTV cameras. This is based on a ½-mile visibility in each direction for a pan-tilt-zoom (PTZ) camera, typically mounted on a 45-55' pole.

Vehicle Detection – One-third mile spacing is used for vehicle detection. Historically this has been based on placing detection adjacent to an on-ramp, adjacent to an off-ramp, and in between interchanges (with one mile spacing between interchanges). In a 10-mile section, this is 30 stations per direction, totaling 60 detection stations. With the need for higher resolution data, some agencies are planning for ¼-mile spacing, while others looking evaluating the use of third-party data, eliminating the need to install and maintain agency-owned equipment.

Changeable Message Signs – CMS are placed in advance of major interchanges at key decision points along the freeway, generally no more than 5 miles apart in urban settings. Therefore, a 10-mile segment will generally have 2 CMS in each direction, totaling 4.

Overhead/Cantilever Structure – This quantity assumes the need for new overhead or cantilever sign structures for each CMS and Dynamic Lane Use application. This represents 4 CMS and 40 Dynamic Lane Use installations per 10-mile segment. This quantity could change depending on the extent of installing dynamic lane use signs, and opportunities to install the CMS and Dynamic Lane Use signs on the same structure.

Queue Warning System/Variable Advisory Speed System – The quantity is reflected as a single line item, since there are a variety of ways that a queue warning system or variable advisory speed system can be deployed. This system could be accomplished through the installation of roadside signs to display queue or speed warnings, a series of flashing beacons with static signs, or implemented in conjunction with other sign applications. Specific detailed quantities will be developed as project development progresses.

Fiber Communications – A fiber backbone is assumed for the entire length of the 10-mile segment along one side of the road. A conservative estimate is to include 2 additional miles of fiber for lateral connections from the backbone to a cabinet or hub. Cost will vary based on existing infrastructure.

Bus-on-Shoulder/Hard Shoulder Running – This quantity assumes that bus-on-shoulder or hard shoulder running operations are installed along the entire 10-mile segment in both directions. The specific length per corridor would be adjusted based on the actual length of bus on shoulder operations.

Freeway Dynamic Lane Use – For full coverage of dynamic lane use signs, a ½-mile spacing is recommended to provide drivers the ability to see the next downstream sign when traveling along the corridor. For budgetary purposes, 4 lanes are assumed at each freeway location. For a 10-mile section this results in 20 sets of sign installation, totaling 40 locations. With 4 signs per location, there are 160 signs in a 10-mile section.

Virtual Changeable Message Signs – This technology utilizes DSRC or 5G small cell installations to provide connected communications along the corridor. For planning purposes, one is placed every other mile, totaling 20 in both directions of a 10-mile segment.

Electric Charging Lane – This quantity is shown as a single item for an entire corridor. Further detailed quantities should be developed as this element moves into project delivery.

Parking Information – This assumes installing parking data collection equipment at 2 park-and-ride facilities within a 10-mile segment. Further details on locations on each corridor should be further detailed as this strategy moves into development.

Smart Work Zone Technology – This is reflected as a single line item representing one set-up of traffic control devices equipped with technology for disseminating location and extent of a work zone. This item should be further detailed as this element is developed to reflect the number of traffic control devices equipped with technology. This is likely not a cost or quantity that is fixed to a specific route; rather, a collection of traffic control devices that could move from one location to another.

Traffic Signal Upgrades – In a 10-mile segment, assume one signal every ½ mile along the major corridor, with 3 signals along each connecting arterial. Connecting arterials are assumed to be one mile apart. Actual number will vary based on signalized intersection spacing and number of connecting arterials. In rural areas, assume one signal every other mile.

Enhanced Vehicle Detection – This assumes that each signalized intersection will have enhanced vehicle detection to provide high-resolution data. Actual number will vary based on number of signalized intersections and whether intersections need enhanced detection.

Arterial CCTV Cameras – This assumes cameras are installed at each major intersection along a parallel route, and assuming one major intersection per mile. Actual number will vary based on final determination of CCTV camera placement. Freeway cameras near interchanges will be covered in the freeway section.

Transit Signal Priority (and EVP) – Assumes that TSP/EVP are installed at each signalized intersection. This quantity will vary based on number of signalized intersections, and number of intersections along each transit and emergency route. Some routes will not need to be equipped with TSP or EVP.

Active Arterial Management Signs – Electronic signs placed at or in advance of decision points and would consist of arterial changeable message signs, trailblazer signs, or dynamic lane use signs. Quantity assumes that ¼ of the intersections will have 2 signs representing each direction or two different purposes (e.g., CMS and a dynamic lane use sign).

Transit Queue Jump Lanes – Assume that one transit queue jump lane is installed at ¼ of the intersections along the parallel corridor. This could be in one direction or the other depending on where it is needed. The frequency will be based on actual transit routes and the need (based on intersection queuing) for queue jump lanes.

Traffic Signal Timing Optimization – This assumes signal timing modifications are made to each traffic signal.

Traffic Signal Flush Plans – This assumes one set of flush plans is developed for each traffic signal.

Adaptive Signal Control – This assumes that each intersection is equipped with adaptive traffic signal control functionality. Equipping an entire corridor including connector arterials may not always be cost effective or practical, so the quantity should be adjusted based on actual number of intersections as this element is further developed.

Center-to-Field Communications – This assumes additional infrastructure installed between a central facility (e.g., Traffic Management Center) and a field hub or corridor backbone infrastructure. Distance could be affected by extent of existing infrastructure or an adjacent corridor equipped with communications infrastructure.

Central Signal System – This reflects one line item for central hardware (e.g., servers, workstations) to house software that processes and disseminates data, routes data and video, and provides the interface to control field devices. Each additional corridor added to a system will require less central hardware since previous corridors will install the required equipment.

Arterial Capital Improvements – This assumes that ¼ of the signalized intersections will require some type of capital improvements to accommodate technology installations. Actual quantity will be based on the extent of required improvements.

DSRC/5G Communications – This assumes that a radio or antenna is installed at each signalized intersection.

Enhanced Bicycle and Pedestrian Detection – This assumes that bicycle and pedestrian detection technology is installed at each signalized intersection.

Directional Lane Management – This assumes one overhead cantilever with changeable message sign per direction on rural corridors.

Wireless Communications – In rural areas where a fiber backbone does not exist and is cost prohibitive, a wireless communication repeater is assumed every mile of the corridor. Increased cost is expected in areas with difficult terrain where more communication drops are needed to achieve a continuous line of sight.

Additional Administrative Costs

Beyond the capital improvements described above, there are additional administrative costs that are part of developing and implementing an ICM system. For budgetary purposes, the following administrative items and costs can be assumed (percentages based on construction cost):

- Project Development - PSR, PR, ED, Systems Engineering 15%
- Design and Construction Support 15%
- System Integration and Testing 10%
- System Manager 8%
- Program Contingency 20%

These can be adjusted based on SANDAG's experience.

NCRC TSMO Needs Matrix

Needs Category	Problem Statement	Need Statement	→	Goal	→	Objectives and Supporting Actions
Operations	System monitoring is currently ad hoc/reactive in nature, often dependent on reports from the public to notify when systems are suboptimal or malfunctioning	Need more proactive system monitoring and response to network impacts	→	Updates to local agency SOPs	→	Review existing SOPs and make consistent revisions across stakeholder agencies through the NCRC CMT meetings
			→	Establish automated alert system (to alert D11 TMC and local agency TMCs)	→	Determine performance thresholds that will trigger a request for a specific response or action from local agencies
					→	Develop mutually agreed-upon actions that local agencies will implement under certain performance conditions (i.e. implement alternate timing plans, deploy field technicians, dispatch enforcement to detour traffic, etc.)
	Communication between across is currently based on individual relationships or project-specific	Need more streamlined communication processes	→	Develop formal interagency communications structure and contact information for D11 TMC and local agency TMCs	→	Determine how local agencies will always be able to find the most current information (i.e. set up a NCRC web portal or shared document that will be updated consistently)
					→	Determine if/how/when local agencies will be alerted to changes
			→	After hours notification protocol	→	Identify protocol for after-hours issues and secondary chain of command in case the primary contact is unavailable
					→	Clearly establish what actions will be expected of the secondary contacts, limitations, and communication expectations for when the primary contact becomes available
			→	Establish CMT	→	Identify representatives within local agencies to participate in corridor management activities
			→	Finalize corridor charter	→	Get input from local decision-makers
					→	Obtain necessary signatures from agency representatives
	Interchanges can be seen as barriers within a coordinated corridor due to differing agency priorities	Update/refresh processes for interchange coordination	→	Need ongoing and incident-specific interchange processes	→	Develop mutually agreed-upon actions that local agencies will implement under certain stress conditions such as unplanned partial or full closure
					→	Implement alternate coordinated timing plans on adjacent arterials under certain stress conditions such as unplanned partial or full closure
					→	Develop plan of modified operations for acute v. longer term stress incidents, those that occur inside PH, outside PH, etc.
		Need a fiber maintenance strategy	→	Document priority fiber maintenance needs	→	Compile existing fiber network, plans for expansion, plans for repair/upgrades
					→	Develop prioritization criteria (i.e. benefit to operations, mode shift potential, potential for connecting peer-to-peer comm with the overall system, access to funding, state of good repair, etc.)

Maintenance	Fiber maintenance is currently ad-hoc per individual agency with a "fix-it first" approach	Need a strategic maintenance program	→	Provide maintenance staff with training and resources on new and emerging technologies	→	Consider training requirements during procurement
				Explore options for sharing local resources or regional/CT resources with local agencies on key corridors	→	Develop a maintenance labor agreement with partner agencies to share technical expertise
				Establish regular schedule of replacing equipment based on life cycle	→	Program funding for ongoing fiber maintenance
					→	Document age and state of repair of existing communications
	Agencies have a variety of equipment in the field with varying degrees of data collection capabilities	Develop a current inventory of roadside devices and assets	→	Identify gaps in infrastructure (physical or technological)	→	Perform an inventory of existing communications and ITS assets
		Develop guidance for consistent procurement	→	Develop technology specifications	→	Develop approved products list
					→	Consider training requirements during procurement
Systems Management	Funding for TSMO projects is often lower priority than traditional capital improvements, is added on to other projects, or is added as a condition to mitigate impacts of private development	Position for TSMO-specific funding	→	Develop NCRC TSMO Implementation Plan based on Road Map	→	Review scoring criteria for competitive funding opportunities and revise detailed Implementation Plan elements to align
			→	Develop a Business Case for TSMO for the corridor to share with local decision-makers	→	Tie performance measures to local and regional goals.
					→	Identify champions who will present the business case for TSMO to elected officials and other decision makers.
			→	Identify regional, state and national funding programs that could support TSMO in the SANDAG region	→	Document potential/available grant funding opportunities and map potential projects from implementation plan that could align with those
					→	Maintain list/calendar of grant initiative timelines to promote better readiness to respond to opportunities when they are released
					→	Identify grant requirements/objectives early to potentially integrate key focus areas into corridor operations (demonstrate early adoption or alignment of grant goals/priorities)
			→	Develop a joint fund to allocate funds strategically (rather than on relying on developers' frontage area)	→	Develop a joint fund to allocate funds strategically (rather than on relying on developers' frontage area)
	Internal policies of project prioritization, funding, and project life cycle can be a barrier to TSMO	Revise internal policies to support TSMO	→	Modify project prioritization methods to program standalone TSMO projects	→	Present Business Case for TSMO to local decision-makers and executives
			→	Allocate annual funding for TSMO without requiring technical specifics	→	Present Business Case for TSMO to local decision-makers and executives
				Develop operating agreements to	→	Develop sample MOU language for agency operating agreements

			→	streamline work across departments and agency boundaries	→	Develop sample MOU / contract language for cities/vendors
	Establish corridor-wide ops/mgmt priority list for key arterials/interchanges	Establish corridor-wide ops/mgmt priority list for key arterials/interchanges	→	Identify corridors with timing and coordination needs	→	Develop prioritization criteria (i.e. benefit to operations, mode shift potential, potential for connecting peer-to-peer comm with the overall system, access to funding, state of good repair, etc.)
			→	Develop mini concepts/studies to be ready for project funding opportunities	→	Consider high mobility locations surrounding college campuses and local business districts and connectivity to transit, potential for mode shift
			→	Identify potential regional funding sources for high priority study locations	→	Align priority study locations and mini concepts with identified needs and regional initiatives like NextOS, SIS, CMCP
		Establish/update process for evaluating metering rates	→	Perform state-of-the-practice assessment and literature review	→	Develop performance criteria and schedule for periodically analyzing effectiveness by location
	Communications network is filled in based on the funding available, which doesn't always match up the funding needed for comm on high priority arterials	Need a communications infrastructure master plan to strategically fill gaps	→	Identify critical communications and technology gaps	→	Compile existing fiber network, plans for expansion, plans for repair/upgrades
					→	Develop prioritization criteria (i.e. benefit to operations, mode shift potential, potential for connecting peer-to-peer comm with the overall system, access to funding, state of good repair, etc.)
			→	Program specific funding for fiber network expansion	→	Establish a joint transportation fund for developers to contribute to in lieu of providing connectivity strictly along their frontage
Data Collection and Management	Agencies have a variety of equipment in the field with varying degrees of data collection capabilities	Need guidance on using different data collection technologies	→	Identify priority data needs for performance analysis	→	Build from performance metrics identified in NCRC CMT workshops (person throughput, safety, travel time reliability) and align with those in the RTP, CMCP, Vision Zero, competitive funding criteria, etc.
			→	Identify priority data needs for operations	→	Inventory existing data and data collection capabilities
			→	Identify priority data needs for system maintenance	→	Build from inventory of existing communications and ITS assets
			→	Identify priority data needs for long-term planning	→	Build from Business Case for TSMO document
	Data analysis can be time consuming and difficult to convert into a simple format that results in specific actions	Identify regional resources to support data analysis	→	Develop agreement and/or database to share regional reports showing data or performance affecting local corridors such as cut-through traffic, OD studies, micromobility/shared mobility data, etc	→	Establish procedures for reviewing such information (as-needed, monthly, quarterly) - how will agencies know when something is uploaded that is of particular relevance to them?
	Regional data hub has limited uses for local agencies	Update processes for RAMS usage	→	Assess what information local agencies are interested in downloading	→	Refresh training for local agencies on how to use RAMS (or training for NextGen RAMS)
					→	Identify what info local cities can access/use
					→	Assess system compatibility with evolving operating system updates, patches, software company support, and cybersecurity best practices

	Data sharing has hit barriers due to security and liability limitations	Need to develop data sharing agreements	→	Address liability and security concerns	→	Establish requirements for restricted access to view/download/edit/implement changes and cybersecurity best practices,
					→	Identify roles/responsibilities for how data is to be shared, stored, accessed
					→	Identify local procedural requirements such as internal approval prior to action being taken
					→	Identify local procedural requirements during and after alternate operations such as field personnel presence and/or active monitoring practices
			→	Establish consistent language for data sharing/usage	→	Perform state-of-the-practice assessment and literature review and tailor to local needs
					→	Clearly delineate data sharing for operations versus analysis or maintenance purposes
Multi-Modal Coordination	Transit can be disruptive to vehicle traffic (and vice versa)	Need consistent approaches to transit priority	→	Identify priority corridors for maximum benefit to throughput	→	Align priority locations with local transit studies, regional initiatives, and last-mile options
		Need to coordinate on Sprinter operations and local intersections	→	Explore alerting system for local agency TMCs when Sprinter is approaching intersections	→	Explore technology options to expand controller capabilities to modify operations when Sprinter is approaching intersections without needing intervention at TMC
	Path to funding for safety improvements can be reactive in nature	Need to integrate multimodal data into corridor performance data	→	Need strategies for obtaining data on bikes, peds, micromobility, shared mobility	→	Identify ways to analyze non-vehicular safety hazards, near misses, and crashes that may not always be captured in traditional vehicular collision data
					→	Explore technology options/alternatives for obtaining this data
			→	Identify ways to clearly identify safety issues and crashes in a more timely way	→	Elevate recurring safety issues/locations
	Limited last-mile connections results in cruising and reduced HOV/transit usage	Need a strategy for shared mobility	→	Collect data: community characteristics, parking/curb space inventory, occupancy, turnover	→	Identify problem areas
			→	Incorporate curb management analysis into overall TSMO/smart intersections/ITS reporting	→	Align curb management strategies with regional planning initiatives such as Complete Corridors and RTP
					→	Develop list of pilot locations for early action
	An overabundance of technology options can be overwhelming and	Need for ITS and technology training	→	Establish recurring technology training program for local agencies and new staffers	→	Schedule training sessions for existing technologies, upcoming deployments such as Transparity/Bluetoad/etc
			→	Identify national training resources (CITE, NOCoE)	→	Periodically schedule training opportunities for agencies to keep up with new technology and analytics options that have not been deployed locally
			→	Establish technology resource pool	→	Identify champions/experts with various technologies

Technology	time-consuming to boil down to what agencies really need - and what they don't	Consistent approach to data collection technology	→	Document capabilities of different data collection technologies	→	Develop checklist of features/capabilities to aid in technology decision-making
					→	Document and gather lessons learned from local agency operating experiences
					→	Identify operating and management needs for different technologies
		Need guidance on evaluating new technologies	→	Develop processes for evaluating new technologies capabilities, trade-offs, legacy system integration issues, analytics and management requirements	→	Align evaluation criteria with performance metrics and regional initiatives
					→	Develop consistent approach (with stakeholder input) for how to handle technology companies approaching agencies with unsolicited proposals to test technologies
	Agencies deploy smart intersection technology and adaptive signals on an ad-hoc basis, which can result in technological barriers between systems	Need consistent approach to smart intersections and adaptive signals deployments	→	Fill gaps in communications infrastructure	→	Consider flexibility for future expansion of V2X management capabilities during procurement of traffic management systems
			→	Improve network redundancies in critical corridors	→	Consider backup technologies and resilient infrastructure practices to safeguard against unplanned outages and accidental damage to communications network
			→	Develop consistent processes for software systems	→	Document operational parameters for adaptive
					→	Identify 'ideal' corridor operating environment that would be well suited for adaptive technology
					→	Develop baseline requirements for adaptive that can be tailored to agency, corridor (FHWA Model Sys Engineering document for Adaptive is a good starting point)
Performance Monitoring	There is a lack of clarity on what performance metrics will be most beneficial for active arterial management versus long-term planning exercises	Identify preliminary corridor performance metrics based on regional priorities	→	Develop baseline performance data	→	Align preliminary performance metrics with regional initiatives
			→	Develop performance targets for 78 corridor	→	Obtain consensus from all operating agencies
		Define specific metrics for different audiences	→	Identify key metrics needed by operations staff	→	Define procedures for periodically reviewing this data and how to determine appropriate actions
			→	Identify key metrics needed by maintenance staff	→	Define procedures for periodically reviewing this data and how to determine appropriate actions
			→	Identify key metrics needed to inform longer-term corridor performance needs/issues	→	Define procedures for periodically reviewing this data and how to determine appropriate actions
	Agencies have a variety of reporting processes with varying levels of detail	Consistent approach to performance reporting	→	Need to establish a strategy for performance reporting	→	Identify roles/responsibilities for performance reporting
					→	Establish format for dashboard that can be accessed by all agencies

Regional TSMO Toolkit

Supporting Documents to
Advance and Implement TSMO Strategies - Concepts of Operations
on the Corridor or Sub-Regional Level

North County Regional Corridor
TSMO Roadmap to Implementation Outline

The Roadmap outline is intended to be a starting point to guide the direction of the CMT on a general timeline. This roadmap will be updated over time and will be included in the Implementation Plan and Concept of Operations to be developed by the CMT and their stakeholders. The Implementation Plan will contain more specific details about the steps and actions to complete this roadmap.

1. Near-Term Actions (0 - 6 months)

a. People – Institutional Governance

i. Establish list of stakeholders who will participate in the on-going corridor management team (CMT).
ii. Finalize the SR-78 Corridor Charter with input from executives and gather the required signatures.
iii. Begin recurring Corridor Management Team meetings.
iv. Coordinate and provide input into CMCP.

b. Processes – Operational Management

i. Develop an inter-agency communications structure for TSMO planning, operations, and system maintenance activities.
    1. Identify the method by which that agencies should use to coordinate on planning, operations, and maintenance activities such as timing changes, equipment malfunctions, emergency/incident management, etc.
    2. Identify how communications will proceed if staff are unavailable or change due to turnover.
ii. Identify preliminary performance measures to be used to make decisions regarding corridor planning, operations, and system maintenance.
    1. Build from performance metrics identified in the North County Regional Corridor (NCRC) workshops (person throughput, safety, travel time reliability) in alignment with the RTP and CMCP.
    2. Consider existing data and data collection capabilities.

c. Tools – Technical Strategies

i. Perform an inventory of existing assets.
    1. Map communications network, inventory field data collection devices.
    2. Identify existing data sharing capabilities and limitations.
    3. Develop a gap assessment.
ii. Develop and approve an Implementation Plan as a part of the Comprehensive Multimodal Corridor Plan (CMCP).
    1. Develop a prioritized list of projects and TSMO strategies to be implemented in the region.
    2. Identify current and likely future funding opportunities for projects or “bundles” of projects.
iii. Develop a Concept of Operations that builds on the needs gathered by the stakeholder group and the strategies developed in the Implementation Plan.

2. Medium-Term Actions (6 months – 2 years)

a. People – Institutional Governance

i. Continue recurring Corridor Management Team meetings.
ii. Ongoing participation with CMCP development.
iii. Pursue TSMO funding opportunities identified in the Implementation Plan.
    1. Determine competitive grant application criteria.
    2. Develop a plan to incorporate this information into performance metrics, reporting, project prioritization, etc. to increase competitiveness.

iv. Establish standards for data exchange and architecture to enhance and encourage integration and data sharing.
v. Develop and make the business case for TSMO.
    1. Tie performance measures to regional goals.
    2. Identify regional champions who will present the business case for TSMO to elected officials and other decision makers.

b. Processes – Operational Management

i. Define the conditions under which agencies are comfortable sharing data and sharing systems management responsibilities.
    1. Identify cybersecurity and legal needs for shared management.
ii. Seek out or develop TSMO training modules.
    1. Performance measures
    2. Data analytics
    3. Technology / ITS
    4. TSMO competitive grant opportunities / grant writing
iii. Develop guidelines for procurement, including standards and specifications.

c. Tools – Technical Strategies

i. Develop targets for the identified performance measures.
ii. Develop operational thresholds that must be met to initiate an action.
iii. Establish standards for data uniformity.

3. Long-Term Actions (2 years and beyond)

a. People – Institutional Governance

i. Continue recurring Corridor Management Team meetings.
ii. Continue pursuing TSMO funding opportunities.
iii. Continue coordination with CMCP implementation
iv. Implement policy changes in planning and prioritization of projects to support a system-wide approach to TSMO projects, for example:
    1. Prioritize TSMO instead of the "fix-it first" approach.
    2. Set up joint funds to implement TSMO in the places that need it most instead of relying on developers to fund/build TSMO projects along their frontage.
    3. Allocate yearly TSMO funding without specifying the technology, instead of deploying aging technology due to the time lapse in planning, funding, and implementation.

b. Processes – Operational Management

i. On-going performance-based decision making in operations and maintenance.

c. Tools – Technical Strategies

i. On-going data collection and reporting.
ii. Expand or automate alerts and/or actions when operational thresholds are met, within the boundaries set by policy and technical capability.
iii. Develop and implement an Incident Management Plan.
    1. Establish how the region will collaboratively respond to different types and severities of incidents.
    2. Develop a Concept of Operations for regional Incident Management.
    3. Update Implementation Plan with strategies and projects from the Incident Management Plan.