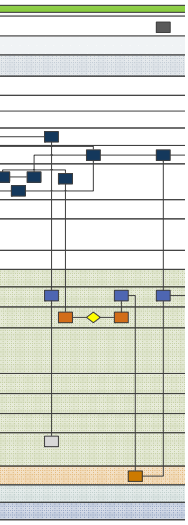
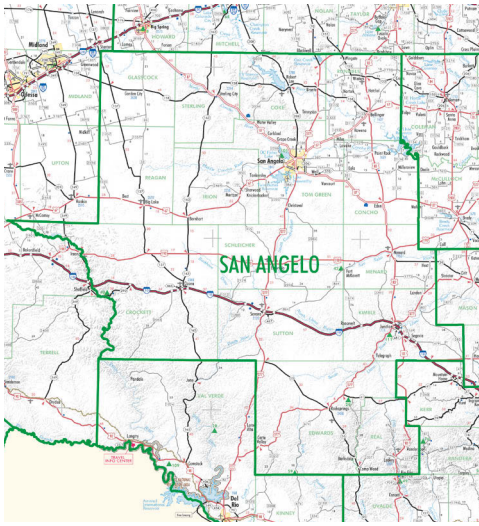
Transportation Systems Management and Operations (TSMO)





San Angelo District Program Plan

January 2024

Texas Department of Transportation

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ACRONYMS AND ABBREVIATIONS

ARC-IT	Architecture Reference for Cooperative and Intelligent Transportation
ATMS	Advanced Traffic Management System
ATSPM	Automated Traffic Signal Performance Measures
BCR	Benefit-Cost Ratio
BP	Business Processes
SA-MPO	San Angelo Metropolitan Planning Organization
CCTV	Closed-Circuit Television
CMF	Capability Maturity Framework
CMM	Capability Maturity Model
CO	Collaboration
Con-Ops	Concept of Operations
CRIS	Crash Records Information System
SJT	San Angelo District
CU	Culture
DE	District Engineer
DMS	Dynamic Message Sign
DOT	Department/s of Transportation
DSRT	District Safety Review Team
DFRT	District Fatality Review Team
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
ITS	Intelligent Transportation Systems
OW	Organization & Workforce
PDO	Property Damage Only
PDP	Project Development Process
PM	Performance Measurement
SEA	Systems Engineering Analysis
SHRP2	Second Strategic Highway Research Program
ST	Systems and Technology
STR	Strategic Initiatives and Innovation
SWZ	Smart Work Zone
TIM	Traffic Incident Management
TM	Traffic Management
TMC	Traffic Management Center
TMS	Traffic Management Systems
TP&D	Transportation Planning & Development
TRF	Traffic Safety Division
TSM	Traffic Signal Management

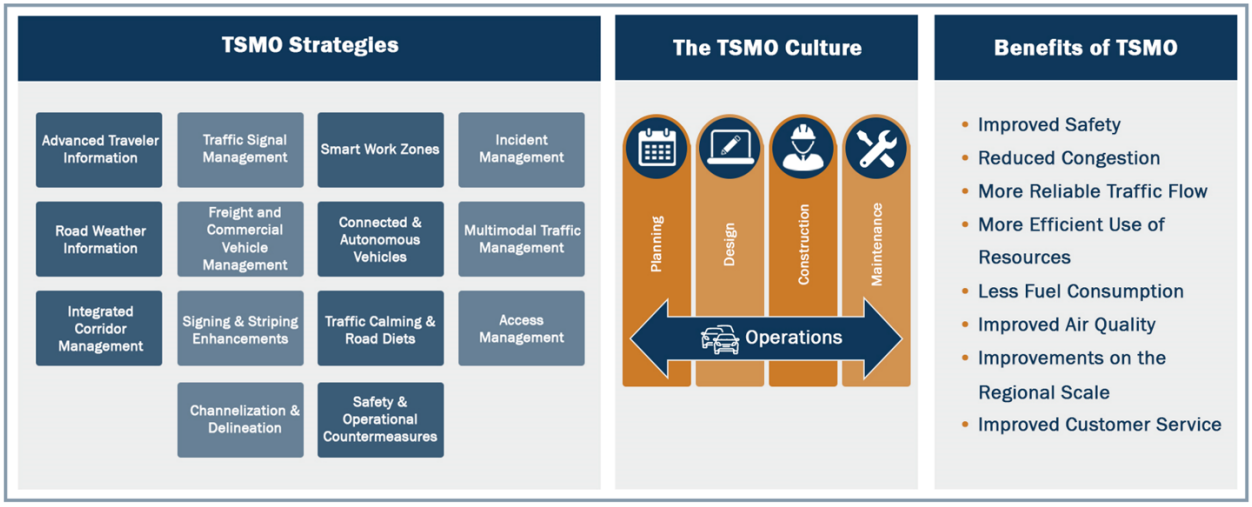
TSMO	Transportation Systems Management and Operations
TTI	Texas A&M Transportation Institute
TxDOT	Texas Department of Transportation
UTP	Unified Transportation Program
WZ	Work Zone
WZM	Work Zone Management

EXECUTIVE SUMMARY

What is TSMO?

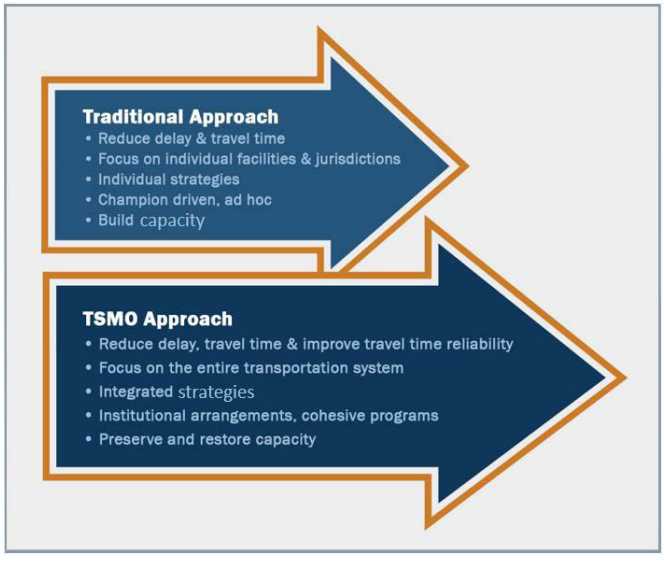
Transportation Systems Management and Operations, also known as TSMO, is a set of strategies that focus on operational improvements that can maintain and even restore the performance of the existing transportation system before additional capacity is needed. The goal of TSMO is to get the most performance out of the existing transportation system, allowing departments of transportation to stretch their funding to benefit more areas and customers.

Successful TSMO programs have adopted TSMO as a core function of the transportation agency and developed institutional arrangements and processes that promote inclusion of TSMO strategies throughout the project lifecycle of planning, design, construction, and maintenance.



The TSMO Difference

The Texas Department of Transportation (TxDOT) San Angelo District (SJT; District) implements many of the above-listed TSMO solutions. However, TSMO is more than implementation of isolated, champion-driven Intelligent Transportation Systems (ITS) solutions. TSMO involves a mindset change to determine the best way to optimize the safety, mobility, and reliability of the existing transportation system with limited resources. This graphic highlights the paradigm shift that will sustain and grow TSMO within the district.



TxDOT TSMO Planning Initiative

Executive Director Marc Williams issued a memo highlighting the importance of traffic management systems (TMS) as cost-effective and efficient means to address safety, mobility, connectivity, maintenance, and emergency response across the state.

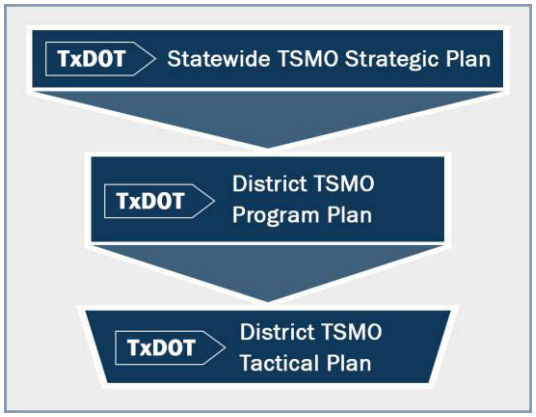
"…it is imperative that Traffic Management Systems (TMS) and operational improvements complement construction and maintenance program efforts. This includes ensuring that TMS is considered throughout the project lifecycle from inception through construction…."

Marc Williams, June 29, 2022

"Each district will be expected to ensure (1) TMS is included in each project's planning, development, design, construction, maintenance and operation, and (2) provide specific TMS projects where gaps exist between typical road and bridge projects."

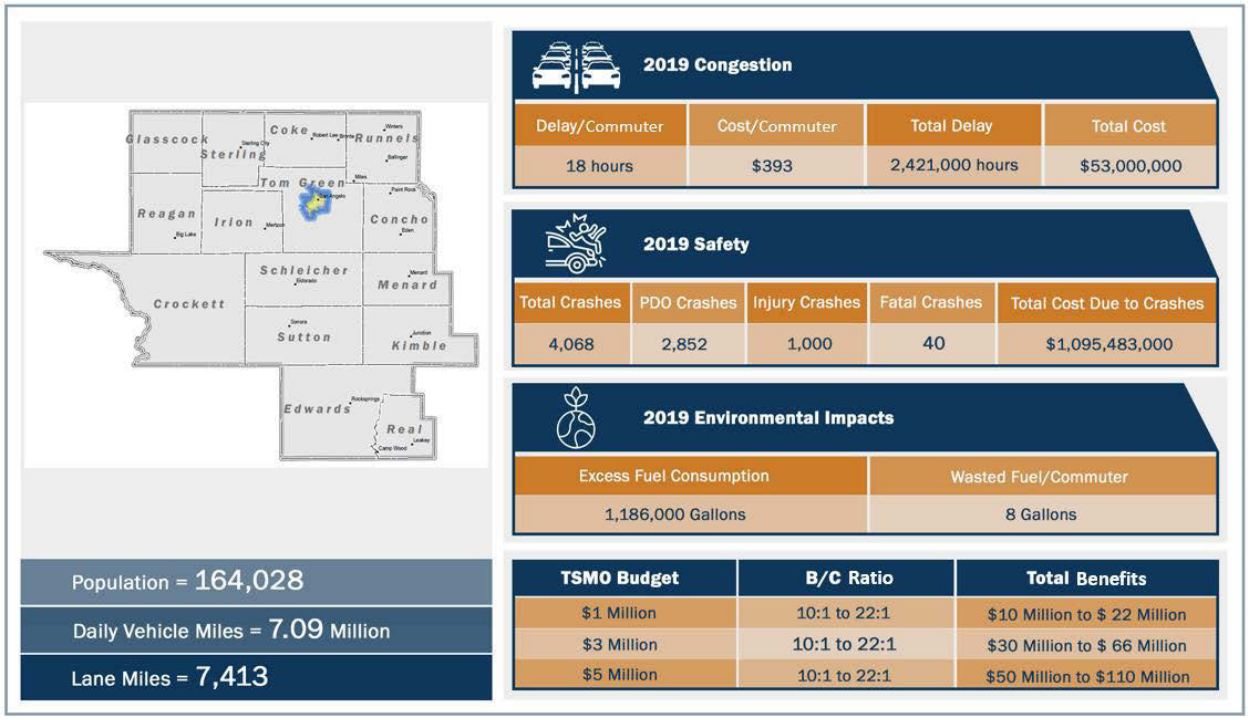
Marc Williams, June 29, 2022

TxDOT's Traffic Safety Division (TRF) developed a three-stage approach to TSMO adoption across the state. As part of the first stage, TRF rolled out the Statewide TSMO Strategic Plan in 2017. As part of the second stage, all TxDOT districts, including TxDOT-SJT, are developing TSMO Program Plans. Subsequently, the districts will develop TSMO Tactical Plans as necessary to address specific operational issues within each district.



Business Case For TSMO

Studies around the country have shown that TSMO deployments provide benefit-to-cost ratios (BCR) between 10:1 to 22:1. The business case summary presented here illustrates the impacts and costs associated with congestion, safety, and the environment within the San Angelo region and highlights the potential benefits from TSMO deployments. The graphic on the following page highlights how hypothetical TSMO investments of $1 to $5 million would result in benefits to congestion and safety of $10 to $110 million.



TSMO Implementation

The process illustrated below was utilized to develop the TSMO actions. The three program areas selected by the District for the development of TSMO actions included traffic signal management (TSM), traffic incident management (TIM), and traffic management (TM). The process, beginning with the District Engineer's (DE's) endorsement, included extensive engagement with District leadership, partner agencies, and a project steering committee to obtain input on existing TSMO practices, complete Capability Maturity Model (CMM) and Capability Maturity Framework (CMF) assessments, develop District-specific TSMO goals and objectives, and cocreate the TSMO actions included in this Program Plan. Twelve representative actions were picked in the categories of early win recommended action items, low cost and high impact recommended action items, and last but not least, high cost and high impact recommended action items.

The key actions are summarized below.

Action	Lead	Support	Area
Early Win Recommended Action Items			
Provide communications for 100 percent of District signals, and acquire traffic signal central management system licenses to monitor and control all District signals.	Traffic Operations	TRF	Traffic Signal Management
Establish and attend regular meetings (e.g., quarterly meetings) with partner agencies to collaborate on TSM.	Traffic Operations	City of San Angelo, Tom Green County, SA-MPO	Traffic Signal Management
Collaborate with all TIM partners to develop data-sharing policies, including access to CCTV cameras.	Traffic Operations	City of San Angelo, Tom Green County, SA-MPO	Traffic Incident Management
Update the existing San Angelo Regional ITS Architecture documents to be ARC-IT 9.2 compliant.	Traffic Operations	City of San Angelo, Tom Green County, SA-MPO	Traffic Management
Implement technology for flood detection, warning, and automated road closure in areas that frequently flood.	Traffic Operations	Traffic Operations	Traffic Management
Low Cost, High Impact Recommended Action Items			
Develop a formal process of sharing traffic-signal-related data (e.g., timing data, traffic counts, CCTV video feeds) with partner agencies.	Traffic Operations	City of San Angelo (Fire Department, Police Department)	Traffic Signal Management
Improve TIM Data Collection and performance measures tracking: - Improve incident management related data collection of roadway clearance time, incident clearance time, secondary crash data, and injury contributing factors (e.g., seat belt wearing).	Traffic Operations	TRF	Traffic Incident Management
Increase public awareness of DriveTexas.org for traffic management information.	Operations	City of San Angelo, Tom Green County, SA-MPO	Traffic Management
Establish Standard Protocol for Use of DMS: Develop protocol for when to post and what messages to post on DMS for disseminating information to the traveling public. Develop standard message templates to use for creating messages for various scenarios.	Traffic Operations	TRF	Traffic Management
High Cost, High Impact Recommended Action Items			
Deploy an asset management system for traffic signals (e.g., TxDOTNow).	Traffic Operations	TRF	Traffic Signal Management
Utilize crowdsourced data (e.g., INRIX) to obtain traffic signal performance measures.	Traffic Operations	TRF, TP&D	Traffic Signal Management
Develop a data-driven, needs-based operations and maintenance budgeting process to maintain or replace TSMO (ITS/signals) assets. The process will utilize TSMO asset inventory, asset cost, information on completed/needed maintenance, and assigned asset level of service to determine the operations and maintenance budget.	Traffic Operations	Traffic Operations	Traffic Management

1 INTRODUCTION

Historically, state and local departments of transportation (DOTs) were created to deliver infrastructure capacity for the movement of people and goods. As a result, DOTs have traditionally focused their efforts and resources on the planning, design, construction, and maintenance of capital projects. This focus on delivery of capital projects has generally resulted in limited resources for the management and operations of transportation systems. Further, with capacity building lagging traffic growth in most urban areas and available funding lagging DOT funding needs, DOTs are often required to do more with less. To overcome these challenges, many DOTs are starting to embrace Transportation Systems Management and Operations (TSMO), a strategic approach that provides near-term and cost-effective solutions to improve mobility and safety while addressing customer needs.

1.1 What is TSMO?

In simple terms, TSMO is a set of strategies that focus on operational improvements that can maintain and even restore the performance of the existing transportation system before additional capacity is needed. The goal of TSMO is to get the most performance out of an existing transportation system, allowing DOTs to stretch their funding to benefit more areas and customers.

Successful TSMO programs have adopted TSMO as a core function of the transportation agency and developed institutional arrangements and processes that promote inclusion of TSMO strategies throughout the project lifecycle of planning, design, construction, and maintenance. Figure 1 summarizes the concept of TSMO.

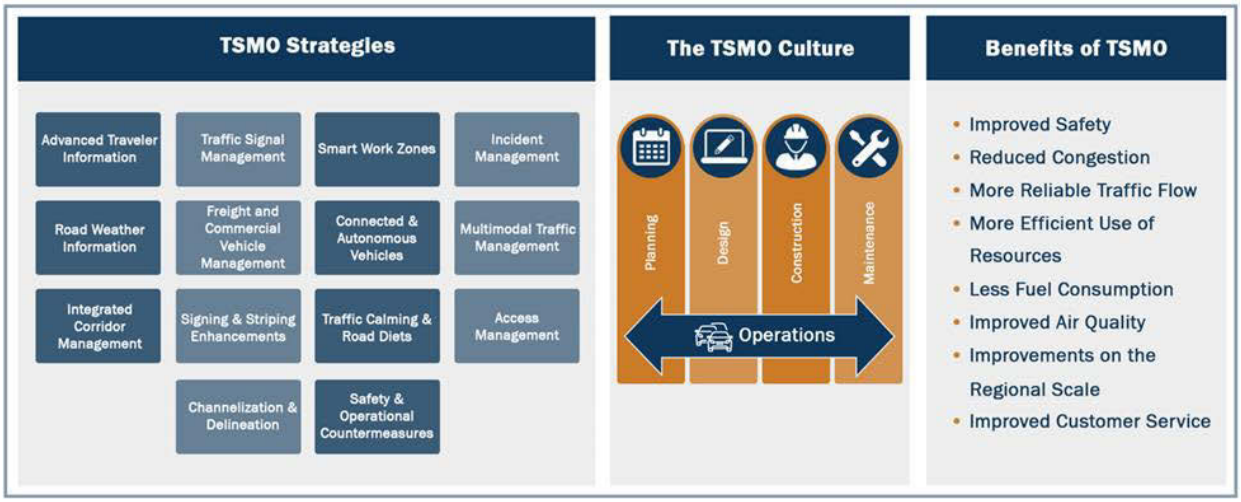


Figure 1: The Concept of TSMO

1.2 Aren't We Already Doing TSMO?

The Texas Department of Transportation (TxDOT) San Angelo District (SJT; District) implements many of the TSMO solutions listed on Figure 1. However, TSMO is more than the implementations of isolated, champion-driven Intelligent Transportation Systems (ITS) solutions. TSMO involves a mindset change to

determine the best way to optimize the safety, mobility, and reliability of the existing transportation system with limited resources.

Figure 2 highlights the paradigm shift that will sustain and grow TSMO within TxDOT-SJT.

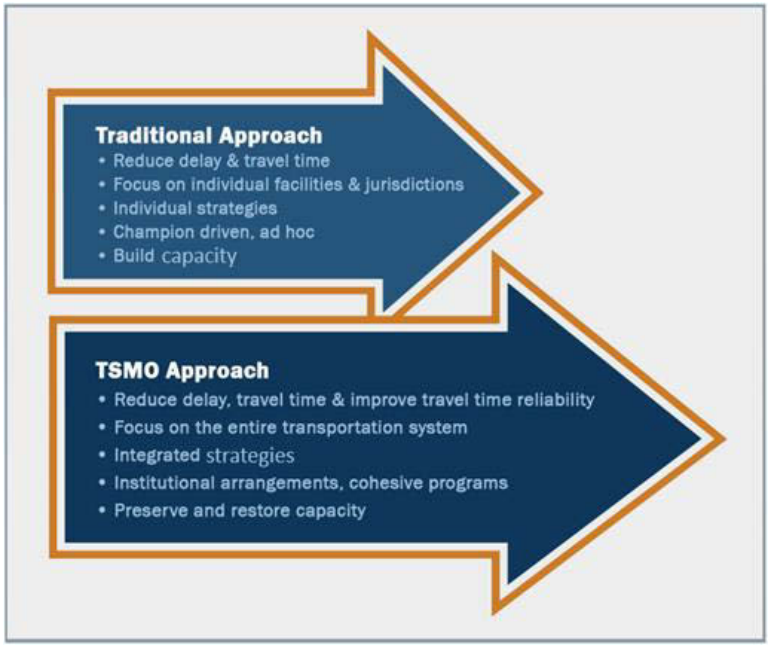


Figure 2: The TSMO Difference

1.3 Need for TSMO Planning

Research conducted as part of the Federal Highway Administration's (FHWA's) Second Strategic Highway Research Program (SHRP2) revealed that in most agencies, TSMO planning and budgeting have been largely limited to specific projects or initiatives and initiatives have been limited based on the availability of funding and a champion to drive those initiatives. The research indicated that agencies with the most effective TSMO activities were differentiated not by budgets or technical skills alone but by the existence of critical processes and institutional arrangements focused on TSMO applications. The research identified the development of a TSMO Program Plan as a key action to guide organizations in advancing the institutional focus on TSMO.

1.3.1 TxDOT Division TSMO Initiative

Executive Director Marc Williams issued a memo highlighting the importance of traffic management systems (TMS) as cost-effective and efficient means to address safety, mobility, connectivity, maintenance, and emergency response across the state. Excerpts from the memo are provided below.

"…it is imperative that Traffic Management Systems (TMS) and operational improvements complement construction and maintenance program efforts. This includes ensuring that TMS is considered throughout the project lifecycle from inception through construction…."

Marc Williams, June 29, 2022

"Each district will be expected to ensure (1) TMS is included in each project's planning, development, design, construction, maintenance and operation, and (2) provide specific TMS projects where gaps exist between typical road and bridge projects."

Marc Williams, June 29, 2022

The TxDOT TSMO initiative (Figure 3) developed a statewide TSMO framework and guidance. The TxDOT TSMO initiative consists of three stages. As part of the first stage, TxDOT's Traffic Safety Division (TRF) rolled out the Statewide TSMO Strategic Plan in 2017. The strategic plan provided the framework and guidelines to mainstream TSMO throughout the state and recommended that each district develop a TSMO program focused on their unique needs. As part of the second stage, the Austin District in 2018 formalized its TSMO program by developing a TSMO Program Plan. In 2019 and 2020, the remaining TxDOT districts began developing their own TSMO Program Plans. As part of the third stage, the districts may develop tactical plans with specific operational focus, such as plans for traffic signal management (TSM), traffic incident management (TIM), traffic management (TM) or ITS implementation.

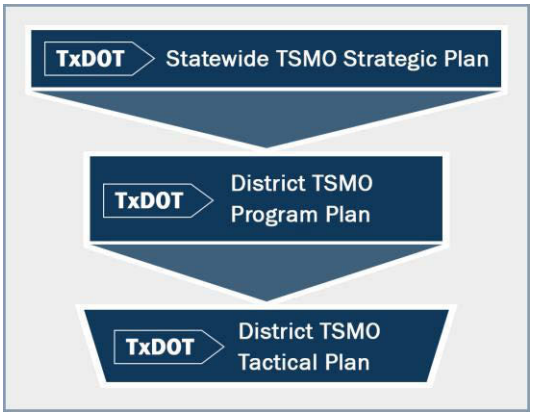


Figure 3: TxDOT TSMO Planning Initiative

1.3.2 TxDOT-SJT TSMO Initiative

In alignment with the statewide TSMO initiative, TxDOT-SJT began developing the District TSMO Program Plan in September 2022. The Program Plan development began with an endorsement from the District Engineer (DE), paving the way to formalizing the District's TSMO program. Subsequently, the leadership and key leads within TxDOT and partner agencies were engaged to seek input on regional operational challenges, capabilities, and ideas for improvements. Leadership engagement within TxDOT focused on gathering input from the DE, the Directors and leads representing Traffic Operations and Maintenance, Transportation Planning & Development (TP&D), and Construction sections, and the area engineers. Partner-agency engagement focused on gathering input from leadership within the City of San Angelo, Tom Green County, San Angelo Metropolitan Planning Organization (SA-MPO), and San Angelo Concho Valley Transit District. A TxDOT steering committee was also established to seek technical input and buy-in at various stages of the project. Appendix A provides a list of TxDOT and partner-agency members that participated during the various engagement efforts. The same TxDOT and partner-agency members were also engaged to conduct the Capability Maturity Model (CMM) and Capability Maturity Framework (CMF) self-assessments for the District. The input received during the leadership engagement and self-assessment stages was combined to develop draft TSMO actions to be included in the District TSMO Program Plan. This District TSMO Program Plan summarizes the District-specific TSMO goals and objectives, institutional arrangements, responsibilities, processes, and implementable action items that were developed collaboratively with the District and partner-agency groups. Figure 4 summarizes the process that was utilized to develop the TxDOT-SJT TSMO Program Plan.

Figure 4: TxDOT-SJT TSMO Planning Process

1.3.3 Program Plan Format

The Program Plan document format follows a process similar to the one utilized to develop TSMO actions for the District and is as follows:

- Introduction: Introduces the concept of TSMO and discusses the need for TSMO planning.
- Business Case for TSMO: Establishes a data-driven business case to support sustained investment in TSMO strategies.
- TSMO Vision, Mission, Goals, and Objectives: Shares the TSMO vision and mission developed as part of the Statewide TSMO Strategic Plan and the District-specific TSMO goals and objectives developed in collaboration with District leadership and the District TSMO steering committee.
- Capability Maturity Model and Frameworks: Discusses the six dimensions of CMM, how TxDOT and partner agencies assessed their capability across each dimension, and opportunities to improve within each dimension. Discussion also includes a summary of CMF assessment across three program areas: TSM, TIM, and TM.
- Five-Year TSMO Implementation Plan: Summarizes TSMO actions developed based on input from District leadership, an understanding of the District's TSMO state of practice, and a review of CMM and CMF self-assessments, and provides an implementation time frame.
- TSMO Tactical Plan Assessment: Evaluates the need for tactical plans, with specific operational focus such as plans for TSM, TIM, TM, and ITS implementation.

2 BUSINESS CASE FOR TSMO

Figure 5 summarizes the business case for TSMO within TxDOT-SJT. The figure provides impacts and costs associated with congestion, safety, and the environment within the San Angelo region and highlights potential benefits from TSMO deployments. Studies around the country have shown that TSMO deployments provide benefit-to-cost ratios (BCR) between 10:1 to 22:1. The figure highlights how hypothetical TSMO investments of $1 to $5 million would result in benefits to congestion and safety of $10 to $110 million. A more detailed discussion on the TSMO business case is provided in the paragraphs that follow.

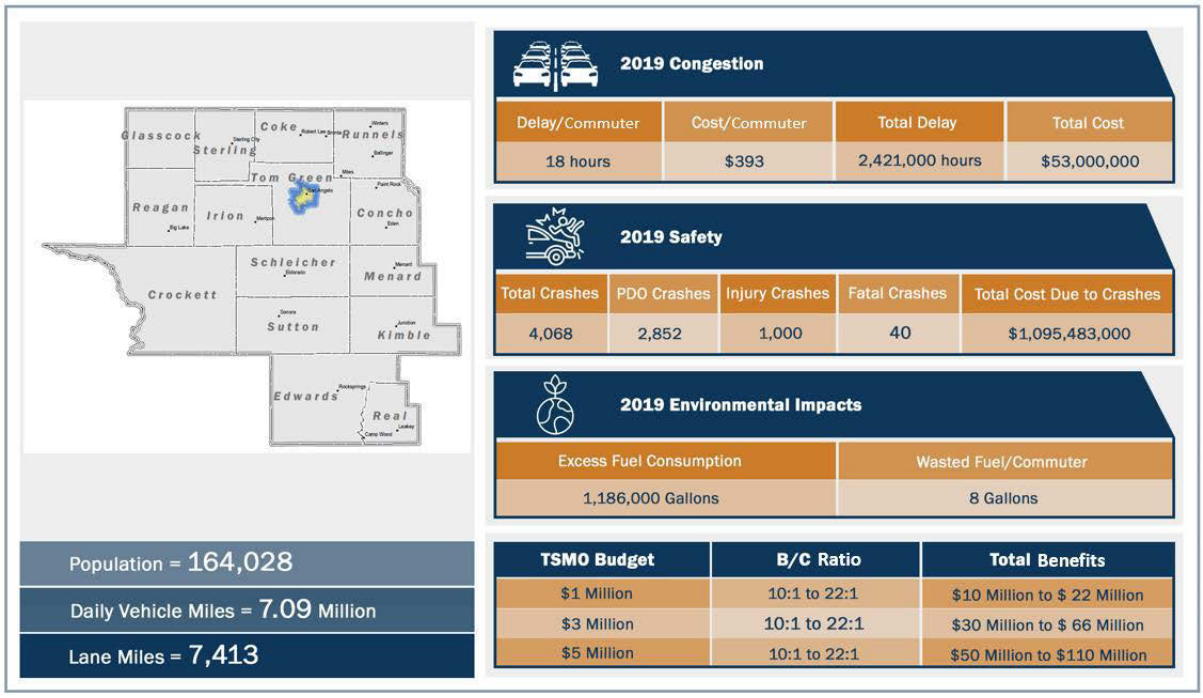


Figure 5: TxDOT-SJT TSMO Business Case Summary*

* Data sources: TxDOT District Profile, TTI Urban Mobility Report, and TxDOT CRIS

2.1 Funding

2.1.1 Challenge

Texas population grew by 16 percent between 2010 and 2020 and is projected to grow by 60 percent between 2020 and 2050. While the state's population continues to grow rapidly, the available transportation system capacity continues to decrease. Additionally, many of the state's congested corridors are fully built out, and the funding necessary to expand the system capacity continues to be constrained. Figure 6 shows the funding deficit at the statewide level and district level based on TxDOT's 2023 Unified Transportation Program (UTP). It is important to note that the actual needs are much greater than what is documented in the fiscally constrained UTP. As a result, the budget shortfall in reality is greater than what is shown.

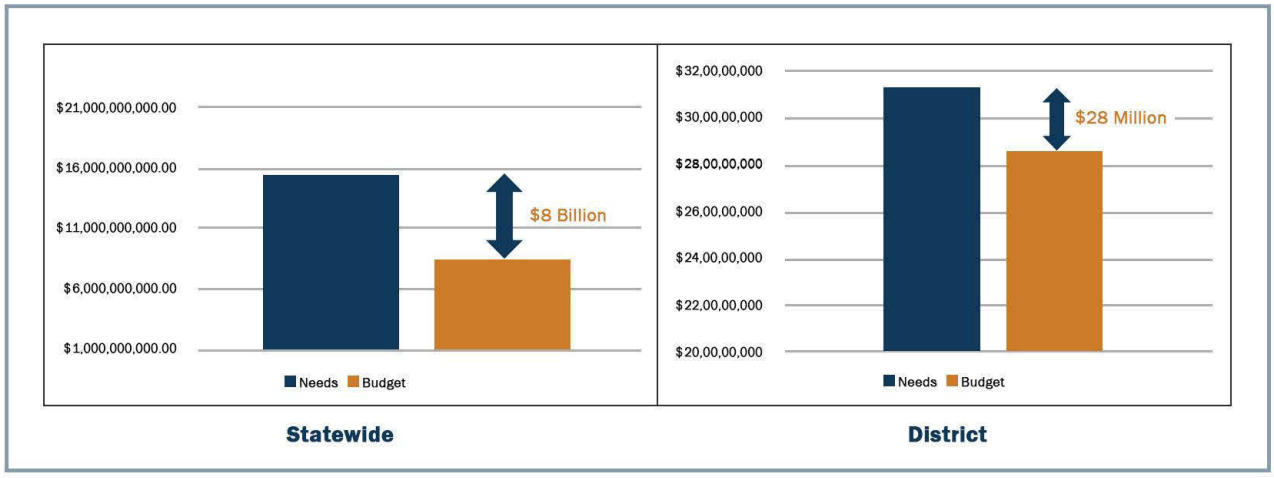


Figure 6: TxDOT Statewide and District-Level Funding Needs Vs. Budget

2.1.2 How TSMO Can Help

To address the growing capacity and funding constraints, TxDOT recommends transitioning a portion of funding and resources from the more expensive, long-range capacity expansion projects to cheaper, near-term TSMO deployments that focus on the management and operation of the existing transportation system. This new TSMO approach also leverages resources among regional partner agencies and the private sector to improve regional mobility at a higher BCR compared to capacity improvement projects.

Placing importance on TSMO strategies in long-range planning, project development, and system operations and maintenance creates a strong basis for devoting funding to these strategies. Applying a TSMO approach in the early stages of project development can help establish procedures that lead to efficient and cost-effective implementation of TSMO strategies. TSMO program planning helps develop institutional arrangements to reserve funds for system management during construction, asset management techniques, upgrades to existing ITS and signal infrastructure, workforce development, and other operational strategies.

2.2 Congestion

2.2.1 Challenge

According to TxDOT's performance dashboard, an average driver experienced more than 31 hours of delay while traveling on Texas roadways in 2019. In the same year, an average urban driver in Texas had to account for 51 percent more travel time to be 95 percent confident in reaching their destination on time.

Figure 5 at the beginning at chapter two summarizes the congestion statistics for the San Angelo region based on the Texas A&M Transportation Institute's (TTI's) Urban Mobility Report. Per the report, an average driver traveling in the region experienced more than 18 hours of delay in 2019. The region also recorded a planning time index of 1.04, indicating that an average driver had to account for 4 percent more travel time during peak

periods to reach their destination on time. The monetary cost of congestion was over $393 per commuter per year and $53 Million overall.

2.2.2 How TSMO Can Help

Figure 5 shows that in San Angelo, on average, one commuter spent 18 more hours and 393 more dollars on the road per year due to congestion. As seen in Figure 7, FHWA estimates that approximately 40 percent of the national congestion is attributable to recurring congestion (bottlenecks), while 60 percent is attributable to non-recurring congestion (e.g., traffic incidents, Work Zones (WZs), special events). TSMO provides robust and near-term strategies such as TIM, work zone management (WZM), TSM, and TM to address the recurring and non-recurring congestion at a fraction of the cost of the capacity expansion projects.

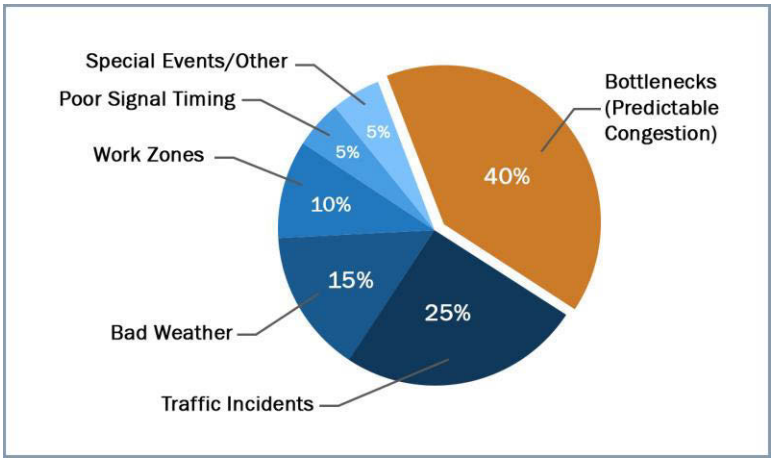


Figure 7: National Causes of Congestion by FHWA

2.3 Safety

2.3.1 Challenge

According to TxDOT's performance dashboard, there were 3,622 fatalities and 15,851 serious injuries on Texas roadways in 2019. According to TxDOT's Crash Records Information System (CRIS), the San Angelo region experienced 47 traffic-related fatalities, 1,000 injury crashes, and 2,852 property-damage-only (PDO) crashes in 2019 (Figure 8). Of the fatal and injury crashes, 310 crashes occurred at intersections and 26 occurred within WZs. Of the overall crashes, 11 percent occurred on freeways and 89 percent on arterials. The total cost of crashes was more than $1 billion.

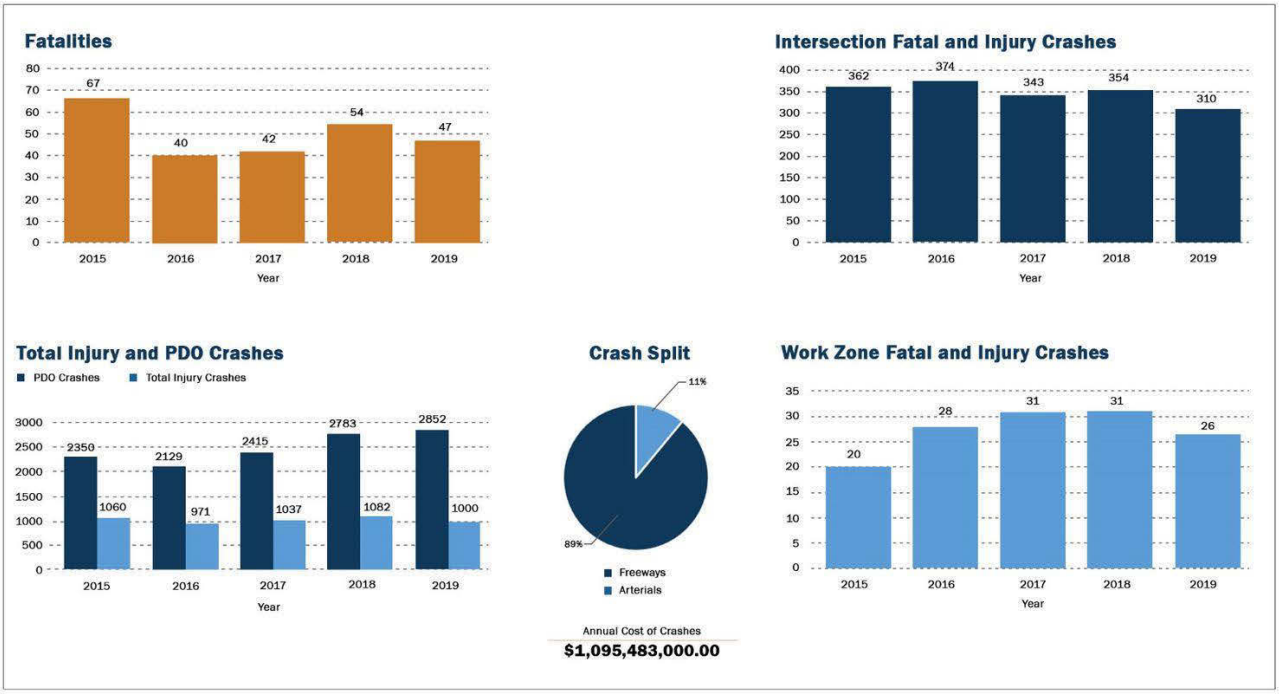


Figure 8: San Angelo Region Crash Summary

2.3.2 How TSMO Can Help

Integrating TSMO principles throughout the project development process (PDP) ensures a collaborative and data-driven approach, consideration of cost-effective alternatives (e.g., conflict reduction, ITS), evaluation of network-wide opportunities, and inclusion of operational elements during and after construction. This holistic approach to project development ensures that solutions to improve safety are evaluated and implemented throughout the project lifecycle and across the transportation network. TSMO strategies aimed at reducing non-recurring congestion and improving traveler information can improve driver expectancy and improve driver awareness of hazardous conditions. Finally, TSMO strategies can help protect those who spend time working on roadways, including TxDOT employees and contractors, public safety officers, and emergency responders.

2.4 Mainstreaming TSMO

FHWA research has shown that agencies with the most effective TSMO activities are differentiated not by budgets or technical skills alone but by the existence of critical processes and institutional arrangements focused on TSMO applications. Therefore, mainstreaming TSMO through the modification of existing business and technical processes is an important step toward building a sustainable TSMO program. The TxDOT-SJT District currently implements numerous processes, projects, and programs with TSMO elements, including ITS, traveler information, WZM, over-height vehicle detection, 4-year safety planning, and 4-year-maintenance planning. The TxDOT-SJT District aims to incorporate additional TSMO strategies into its operations by improving the understanding of TSMO and its benefits.

Mainstreaming TSMO through integration within the PDP (Figure 9), creation of institutional arrangements, and documentation of critical processes will ensure that TSMO is fully adopted within the District. Taking full advantage of TSMO will require the following:

Figure 9: Integrating TSMO within PDP

1. A commitment from the DE to integrate the TSMO mission and vision within the District's project development and business processes.
2. A commitment from District leadership (DE, and Directors) to embrace a TSMO mindset in which processes are formalized and programs and projects are developed in a data-driven, collaborative, and cost-effective manner.
3. A performance-based approach to budgeting, selecting projects, assessing project/program performance, and tracking and enhancing system performance.
4. Consistent funding, staffing, and training to sustain the TSMO program.
5. Utilization of a systems engineering process during TMS project planning and deployment.
6. Leveraging existing touchpoints with partner agencies to collaborate on regionally significant TSMO implementation opportunities.

The institutional commitments to TSMO— including reorganization, staffing, and changes in processes to accommodate TSMO— are outside the control of the staff who manage the TSMO functions. Implementing these changes will require the DE's support and authorization. There will need to be high-level direction to all staff that the changes needed to deploy and implement TSMO strategies are necessary and that those strategies should apply across all sections of the District.

3 TSMO VISION, MISSION, GOALS, AND OBJECTIVES

The San Angelo District has adopted the statewide TSMO vision, mission, and goals as well as specific objectives to address District-specific mobility and safety challenges.

3.1 Statewide TSMO Vision

The statewide TSMO Vision is as follows: Improve safety and mobility for all modes of transportation by integrating planning, design, operations, construction, and maintenance activities and acknowledging all opportunities for innovation.

3.2 Statewide TSMO Mission

The statewide TSMO Mission is as follows: Through innovation, collaboration, and performance-based decision-making, transportation facilities are developed, constructed, maintained, and operated cost-effectively with the end user in mind.

3.3 District-Specific TSMO Goals and Objectives

TxDOT-SJT has adopted each of the six statewide TSMO goals of safety, reliability, efficiency, customer service, collaboration, and integration. For each of these goals, the District has developed objectives in order to monitor the District's progress toward implementing the TSMO Program Plan. Measurable objectives have been set where baseline data are available to track performance. Non-measurable objectives for which baseline data are not available should be revisited with future Program Plan updates once the District has established more performance metrics. TxDOT goals and objectives are listed in Table 1.

Table 1: TxDOT-SJT TSMO Goals and Objectives

Goal	TxDOT Statewide TSMO Objectives	TxDOT SJT TSMO Objectives
Safety 	• Reduce crashes and fatalities through continuous improvement of TMS and procedures.	• Continually develop and track safety performance measures for the transportation system. • Utilize safety performance measures to document the benefits of TSMO deployments and to prioritize projects. • Periodically review safety data to develop systemwide safety improvements and package the improvements for implementation. • Reduce WZ-related crashes.

Goal	TxDOT Statewide TSMO Objectives	TxDOT SJT TSMO Objectives
Reliability 		
Efficiency 	Implement projects that optimize existing transportation system capacity and vehicular throughput.	
Customer Service 		
Collaboration 	Proactively manage and operate an integrated transportation system through multi-jurisdictional coordination, internal collaboration, and cooperation between various transportation disciplines and partner agencies.	• Discuss TxDOT TSMO initiatives and collaboration opportunities during District Director's meetings. • Promote data sharing across TxDOT sections and TSMO stakeholders. • Participate in periodic meetings with TSMO stakeholders to collaborate on TSMO initiatives.
Integration 	Prioritize TSMO as a core objective in the agency's planning, design, construction, operations, and maintenance activities.	• Integrate TSMO within the existing District policies, plans, and procedures. • Discuss TSMO opportunities during Design Concept Conference, Design Review, and District Safety Review Team meetings. • Leverage regional stakeholder partnerships, including with the SA-MPO, to identify funding opportunities for TSMO. • Deploy TMS assets as part of new construction projects. • Achieve 100 percent monitoring capabilities for all existing and proposed TMS deployments. • Conduct joint TSMO training exercises in the region.

4 CAPABILITY MATURITY MODEL AND FRAMEWORKS

4.1 Capability Maturity Model

CMM is a concept adopted from the information technology industry during the FHWA's SHRP2 research. CMM assessment aims to allow agencies to identify, build consensus around, and prioritize institutional and process improvements that further TSMO objectives within the agency and region. The CMM framework, laid out as a matrix, consists of six improvement areas (often referred to as the CMM dimensions) that are evaluated across four levels of capability (Level 1 being the lowest and Level 4 being the highest). Illustrated below (Figure 10) are the six CMM dimensions, the four levels of capability, and the FHWA-recommended process of CMM assessment. The CMM assessment is not meant to be a scorecard. Its purpose is to identify opportunities for improvement and support setting achievable goals.

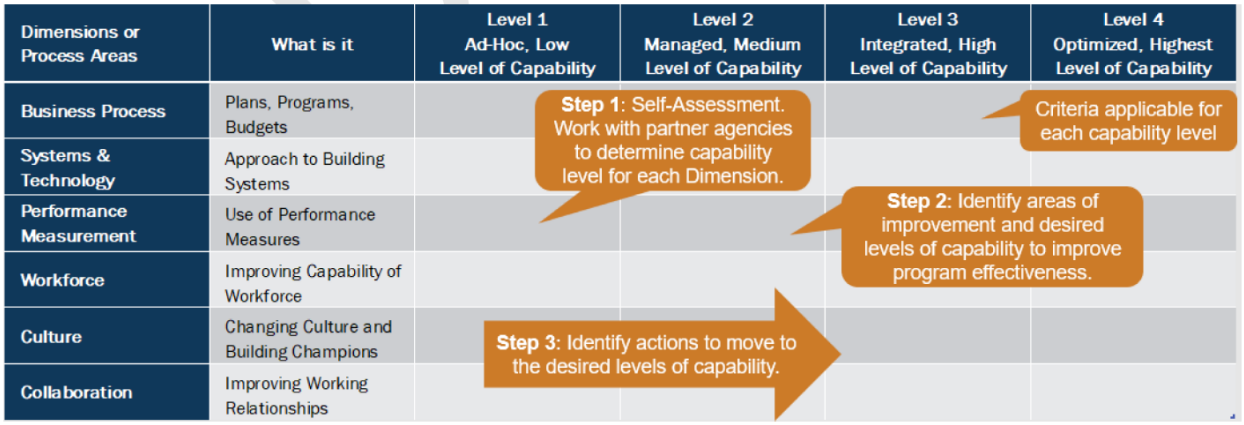


Figure 10: CMM Assessment Process

TxDOT, along with partner agencies, conducted a CMM assessment workshop to identify TSMO-related gaps and needs for TxDOT-SJT and the region. CMM assessment results from the workshop are discussed below.

4.1.1 Business Processes

The Business Process dimension relates to the planning, programming, budgeting, and implementation of TSMO programs. Table 2 summarizes the FHWA-provided criteria for each Business Process capability level.

Table 2: Capability-Level Descriptions for Business Process

Dimension				Level 4
Business Processes (Planning, programming, budgeting, implementation)				**Processes streamlined** and subject to **continuous improvement**

Figure 11 summarizes the results of the capability assessment for the Business Process dimension. As seen in the figure, most of participants ranked themselves at Level 1, and all participants ranked themselves between Level 1 and Level 3. The results indicate the participants' desire for a shift from ad-hoc implementation of TSMO projects/programs toward institutionalizing TSMO as a core function of regional agencies.

The following needs related to Business Process were discussed through TSMO meetings and discussion:

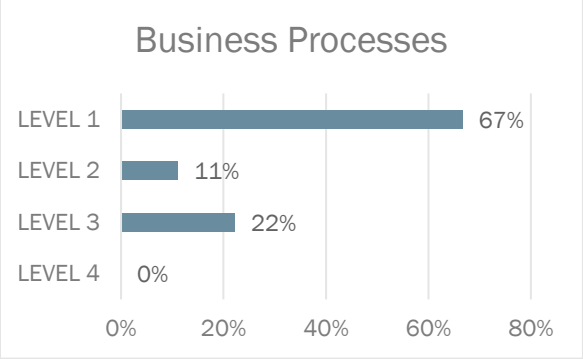


Figure 11: Business Process Assessment Results

Revised Project Delivery Process:

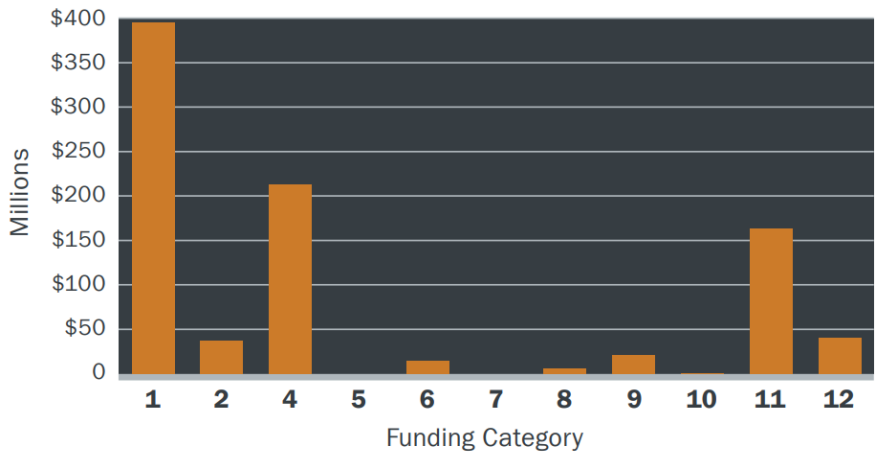
The PDP at TxDOT-SJT comprises six steps: Planning, Programming, Design, Construction, Operations, and Maintenance. While this process has successfully been used to develop capital projects over the years, the process also supports development of new or retrofit TSMO projects. During the meeting, TxDOT identified the opportunity to integrate operations- or technology-oriented strategies throughout the existing PDP. This can be accomplished by enhancing Construction Portfolio Review, Design Review, District Safety Review Team (DSRT), District Fatality Review Team (DFRT) and meeting agendas to include broader TSMO topics.

TSMO Planning:

TxDOT-SJT currently develops several multi-year plans that address aspects of TSMO. These plans include the ITS Master Plan, Maintenance Plan (e.g., striping, seal coat, pavement rehabilitation) and Safety Plan. The TxDOT team discussed that these plans can be further enhanced through interdepartmental data sharing to include data-driven analysis and project prioritization and map-based dashboards for performance measurement and tracking. Additionally, improving the understanding of TSMO across sections and developing a TSMO strategy toolbox will allow for incorporation of TSMO strategies at the project schematic stage and through long-range planning.

Programming, Budgeting, and Funding:

Figure 12 shows TxDOT-SJT funding allocations based on the 2023 UTP. Although there is no dedicated funding for TSMO, the projects in Categories 1, 2, 4, and 10 can be good candidates in which to incorporate TSMO strategies. Adding cost-effective and near-term TSMO strategies to projects in these categories presents an opportunity to address the TxDOT-SJT funding deficit shown on Figure 6.



TXDOT FUNDING CATEGORIES:

1 Preventive Maintenance & Rehabilitation
2 Metropolitan & Urban Area Corridor Projects
3 Non-Traditionally Funded Transportation Projects
4 Statewide Connectivity Corridor Projects
5 Congestion Mitigation & Air Quality Improvement
6 Structures Replacement & Rehabilitation
7 Metropolitan Mobility & Rehabilitation
8 Safety
9 Transportation Alternatives Program
10 Supplemental Transportation Projects
11 District Discretionary
12 Strategic Priority

Figure 12: TxDOT-SJT Funding Allocations from 2023 UTP

Continuous Improvement:

TxDOT's top statewide TSMO objective is to "reduce crashes and fatalities through continuous improvement of Traffic Management (TM) systems and procedures." During the TSMO Leadership Engagement process, the TxDOT-SJT District discussed the need to incorporate TSMO strategies, such as Smart Work Zones during the PS&E development when creating the traffic control plans. The District is also interested in exploring flood warning technologies as part of its ITS Master Plan to provide a pipeline of ITS needs to support mobility and safety.

4.1.2 Systems and Technology

The Systems and Technology dimension relates to the use of systems engineering, systems architecture standards, interoperability, and standardization in TSMO activities. Table 3 summarizes the FHWA-provided criteria for each Systems and Technology capability level.

Table 3: Capability-Level Descriptions for Systems and Technology

Dimension	Level 1	Level 2	Level 3	Level 4
Systems and Technology (Systems engineering, ITS standards, technology interoperability)	**Ad-hoc** approaches outside systematic systems engineering	**Systems engineering employed** and consistently used for **Concept of Operations, architecture,** and systems development	**Systems and technology standardized,** documented, and trained, and new technology incorporated	**Systems and technology routinely upgraded** and utilized to improve efficiency performance

Figure 13 summarizes the results of the capability assessment for the Systems and Technology dimension. As seen in the figure, all of the participants ranked themselves between Level 1 to Level 3, and mostly at Level 1. To reach the next level, TxDOT is aiming for more consistent use of systems engineering and Regional ITS Architecture in developing TSMO projects to ensure that systems and technology tools are routinely being upgraded and utilized to address project and stakeholder needs. The following needs related to Systems and Technology were discussed during the CMM meeting.

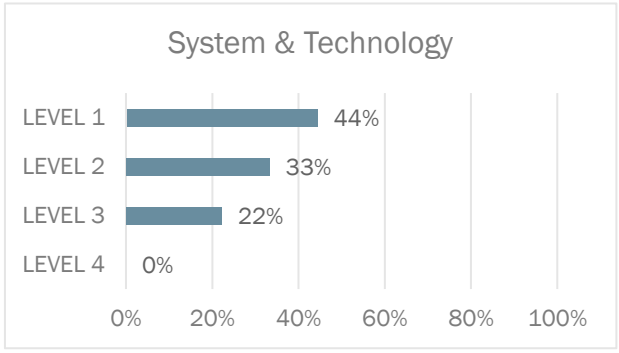


Figure 13: Systems and Technology Assessment Results

Systems Engineering Analysis Process

Systems engineering analysis (SEA) provides a systematic method for ITS and Operations project developers to design their systems to achieve the desired operations objectives while also providing an assessment of alternative physical solutions. SEA allows developers to establish the concept of operations (Con-Ops) and perform alternatives analysis, cost analysis, technical risks analysis, and effectiveness analysis. SEA is required for all ITS projects using federal funds per Title 23 Code of Federal Regulations 940.11. All projects, not necessarily limited to federally funded projects, borrow components from the systems engineering process shown on Figure 14. This figure also highlights the key stages of TxDOT PDP and how they relate to the systems engineering process.

TxDOT projects apply a few components from the systems engineering process but generally begin with high-level system requirements and go straight to the Plans, Specifications, & Estimates stage. TxDOT engineers have an idea of the system requirements, but the requirements are generally not documented in Con-Ops and ITS architecture is seldom referenced during project development. Factors such as critical timelines to spend available funding cause engineers to expedite project design and advertise the project for construction. As a result, the SEA is often omitted during the PDP.

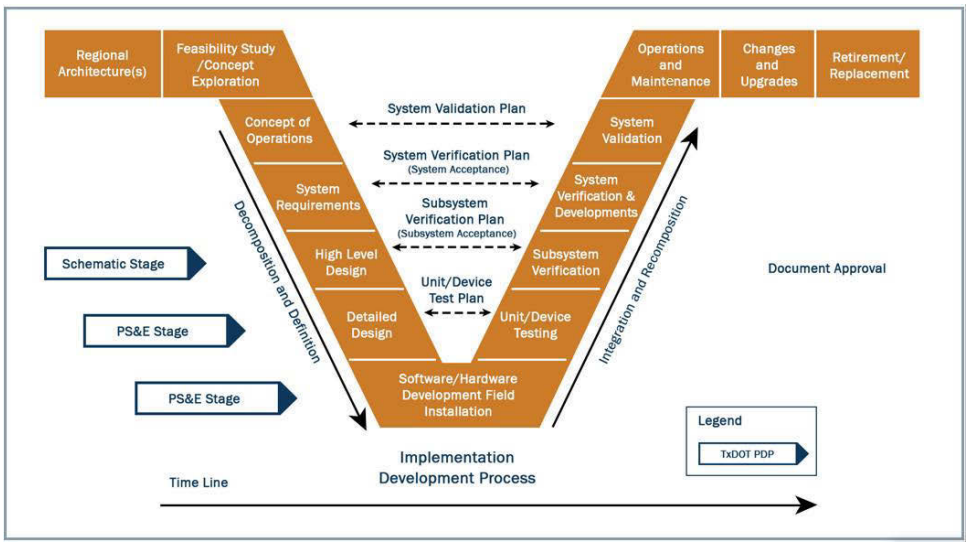


Figure 14: Systems Engineering Process

TSMO, which incorporates the "Plan to Operate" concept, encourages integration of the "Feasibility Study/Concept Exploration" phase (SEA) shown in Figure 14 within the PDP. This ensures consideration of a range of alternatives, incorporation of stakeholder needs, incorporation of operations and maintenance costs within planning-level costs, and selection of an alternative that addresses most system needs.

Innovative Technology Vetting Process

The transportation industry is currently going through a phase of rapid innovation. New types of detection, communication, software, and connected vehicle technology, as well as probe-based data, are becoming available each day, putting the onus of vetting and accepting the technologies on DOT staff. Vendors market the products based on case studies that are limited in scope, and many of these technologies employ "black box" algorithms that are challenging to validate. It also becomes challenging to compare multiple technology products with similar features due to the absence of technical specifications for those applications. To mitigate these challenges, the District, in collaboration with the TRF as well as the Strategic Initiatives and Innovation (STR), should develop a technology vetting process and apply it in conjunction with an SEA to evaluate a range of options and select the technology application that most closely and cost effectively meets the system requirements. The vetting process should also take into account maintenance considerations in order to address potential system impacts caused by equipment downtime required for repairs.

Regional ITS Architecture

The existing San Angelo Regional ITS Architecture was developed back in 2004 and planning is currently underway to update the information contained in the document. The ITS Regional Architecture document needs to be updated to systematically identify transportation needs for the region through stakeholder workshops. Additionally, Regional ITS Architecture provides a framework to support project planning and the systems engineering process reflecting the regional transportation priorities and needs. It provides a systematic approach to integrate TMS and ITS in project planning. The architecture fosters stakeholder coordination and reflects the current state and priorities of ITS for the region. It ensures that the region is in conformation with the Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) and meets FHWA Final Rule 940 and Federal Transit Administration (FTA) Final Policy on ITS Architecture and Standards. ITS architecture also supports initial identification and scoping of an ITS project—the initial steps of the systems engineering process represented by the "V" model. Regional ITS Architecture identifies many agency interfaces, information exchanges, and formal agreements among the associated stakeholders in addition to their roles and responsibilities in providing ITS services for the region.

ITS technologies and projects to support TxDOT-SJT TSMO strategy action item implementation will need to be referenced in the TxDOT-SJT Regional ITS Architecture and meet FHWA Final Rule 940 and/or FTA Final Policy on ITS Architecture and Standards if the Highway Trust Fund is used for their deployment. It is recommended that the TxDOT-SJT architecture be updated approximately every 5 years to accommodate changes in technology, to reflect the region's ITS status as new projects are being deployed, and to ensure that TxDOT-SJT's operational needs are met.

Existing and Planned Tools

All sections within TxDOT-SJT utilize some level of technology to assist staff with their daily work activities. TxDOT's Lonestar Advanced Traffic Management System (ATMS) is the foundational platform from which applications are launched, including accessing closed-circuit television (CCTV) camera video and providing dynamic message sign (DMS) messages. TxDOT utilizes Centracs and ATMS.now central systems to remotely monitor and control traffic signal operations and is planning to adopt Automated Traffic Signal Performance Measures (ATSPM) to improve the maintenance and operations of traffic signals. Additionally, TxDOT recently launched their asset and network management tool, TxDOTNow, to track assets (e.g., CCTV, DMS), monitor traffic along the communication network, and identify locations where the network is bogged down. TxDOT has also instituted cybersecurity measures to combat unauthorized access to the network.

During leadership engagement, TxDOT expressed interest in sharing tools and data across groups and utilizing them to improve technical and business processes. Table 4 summarizes the tools and data utilized by TxDOT sections that could be of interest to other groups. Partner agencies and TxDOT expressed the desire to share data such as camera feeds, signal operations data, traffic counts, public concerns, lane closures, and performance measures.

Table 4: Tools and Data Used by TxDOT-SJT

Tool or Data	Purpose
Probe Data (e.g., INRIX, Streetlight)	Traffic analysis (travel time, speed, origin-destination)
Traffic Counts	Traffic analysis (capacity analysis, prioritization)
Performance Measures (delay, travel time)	System performance tracking
Travel Demand Models	Traffic projections
Lonestar ATMS	Active traffic management
TxDOTNow	Ticketing, network monitoring, and asset management
Pavement Analyst (PMIS ratings, visual condition, ride data, maps)	Identify pavement segments in need of maintenance/rehabilitation and prioritize them
TxTAP and TxMAP	Evaluate traffic control devices and determine needs and maintenance priorities
TxDOTCONNECT	Portfolio management, project development, letting management, project execution
Project data in spreadsheets	Countermeasure development, cost estimation
GIS apps and dashboards	Identify hotspots, develop countermeasures, prioritize projects, budgeting
Tablet/phone	Field documentation
SiteManager	Information on project (work diary, payment, measurements)
Primavera P6	Scheduling
ProjectWise	File storage

Tool or Data	Purpose
Veoci	Cloud-based emergency management system

4.1.3 Performance Measurement

The Performance Measurement dimension relates to the identification of performance measures, consistent use of data and analytics, and use of performance measures throughout a project lifecycle for decision-making. Table 5 summarizes the FHWA-provided criteria for each Performance Measurement capability level.

Table 5: Capability-Level Descriptions for Performance Measurement

Dimension	Level 1	Level 2	Level 3	Level 4
Performance Measurement (Measures data, analytics, and utilization)	**No regular performance measurement** related to TSMO	TSMO strategies measurement largely via **outputs**, with **limited after-action analyses**	**Outcome measures identified and consistently used** for TSMO strategies improvement	**Mission-related outputs data routinely utilized** for management, reported internally and externally, and archived

Figure 15 summarizes the results of the capability assessment for the Performance Measurement dimension. As seen in the figure, all of the participants ranked themselves evenly between Level 1 and Level 3. The results indicate TxDOT's desire for greater use of data and data-driven insights throughout the project lifecycle and enhanced data sharing both within and across partner agencies.

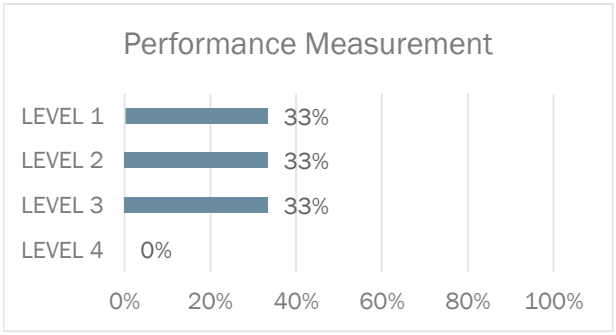


Figure 15: Performance Measurement Assessment Results

Agency Performance-Based Initiatives

TxDOT's Performance Dashboard (Link) provides insights to the public on how TxDOT is doing in relation to its seven strategic goals. Table 6 summarizes the TxDOT strategic goals and performance measures available on the statewide dashboard. TxDOT has also adopted a statewide "Road to Zero" initiative to reduce fatalities on all Texas roadways by half by 2035 and to zero by 2050. The TxDOT strategic goals and Performance Dashboard serve as a guide for districts to develop their own performance measures to track projects and assets starting from planning through operations and maintenance.

Table 6: TxDOT Strategic Goals and Statewide Performance Measures

TxDOT Strategic Goal	Performance Measures Include
Promote Safety	Annual fatalities and fatality rate, annual serious injuries and serious injury rate, fatality emphasis areas (e.g., run off road, DUI, intersections, pedestrians, bicyclists).
Optimize System Performance	Congestion and reliability indices (urban, rural, and truck), vehicle miles traveled, delay per person.
Preserve Our Assets	Bridge condition scores (statewide, national highways, non-national highways), percentage of lane miles in good or better condition.
Deliver the Right Projects	Percentage of construction contracts completed on time and on budget, savings due to innovative contracting usage (e.g., A+B bidding).
Focus on the Customer	Customer complaints closed on time, complaint type, customer service through social media.
Foster Stewardship	Transportation expenditures, Disadvantaged Business Enterprise/Underutilized Business goal attainment.
Value Our Employees	Employee engagement score.

District-Wide Performance Measures

Executive Director Marc Williams's memo from June 2022 placed an emphasis on utilizing TMS performance measures to track and improve transportation system performance. The memo also required districts to submit their TMS status with an implementation plan for the next 12 months to TRF semiannually. As a result, TxDOT-SJT has been developing biannual TMS Status Reports with documentation of performance measures such as asset operation uptime, incident clearance times, and TMS system coverage.

Additionally, TP&D develops project-specific planning-level performance measures related to traffic operations and safety (e.g., delay, volume-to-capacity ratio, level of service, travel time, queue length, crash rate) that are used to develop transportation system improvements. The data used to develop these performance measures are usually collected on a single day during the school year. Usually, no follow-up studies (before vs. after) are conducted after the improvements are constructed to validate the planning-level performance measures.

During the CMM meeting, TxDOT participants recognized that a lot of data are being collected across sections in an ad-hoc manner. Streamlining data collection and sharing data and performance measures across sections will improve system efficiency and save data collection costs. Also, many types of operational, safety, and maintenance data (e.g., probe data, CRIS data, Lonestar data, Centracs data, Pavement Analyst, and lane closures) are available at all times. But specific training is needed for the utilization of those data. These data can be brought into a single GIS-based platform and overlayed to provide insights that could improve various TxDOT processes, including project analyses, selection, prioritization, and TM. TxDOT-SJT also aims to improve TIM data collection and performance measures tracking, including improving incident management-related

data collection of roadway clearance time, incident clearance time, secondary crash data, and injury contributing factors (e.g., seat belt wearing). Meeting participants, including partner agencies, recognized the need to report TSMO performance measures and quantify benefits and costs associated with TSMO projects. Doing so will allow TSMO projects to compete well with capacity improvement projects. All agencies recognized that sharing data and performance measures across agencies will contribute to overall system performance.

4.1.4 Organization and Workforce

The Organization and Workforce dimension relates to the programmatic status, organizational structure, staff development, and recruitment and retention related to TSMO. Table 7 summarizes the FHWA-provided criteria for each Organization and Workforce capability level.

Table 7: Capability-Level Descriptions for Organization and Workforce

Dimension	Level 1	Level 2	Level 3	Level 4
Organization and Workforce (Organizational structure and workforce capability development)	**Fragmented roles** based on legacy organization and available skills	Relationship among roles and units rationalized and **core staff capacities identified**	**Top-level management position and core staff for TSMO established** in central office and districts	**Professionalization and certification of Operations** core capacity positions including performance incentives

Figure 16 summarizes the results of the capability assessment for the Organization and Workforce dimension. As seen in the figure, all participants ranked themselves at Level 1 and Level 2, and mostly at Level 1. The results indicate TxDOT's desire to evaluate staff capabilities and roles and responsibilities to better integrate TSMO within the District. To reach Level 3 and above, TxDOT is aiming to identify core staff capacities, as well as to establish regular training opportunities for existing staff to support the facilitation of TSMO activities in the District. Some of the training needs that were discussed during the TSMO meetings include: analyzing available data (e.g. probe data), conducting performance measures, and utilizing tools to help TxDOT staff to perform their daily job activities.

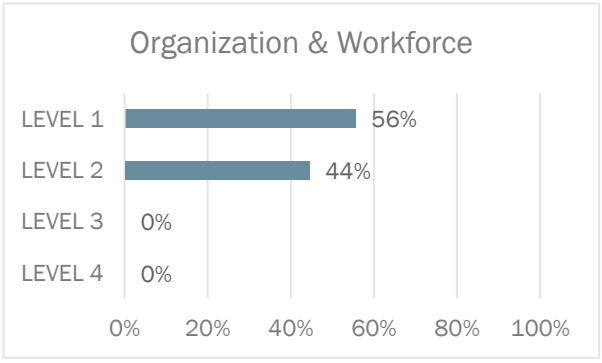


Figure 16: Organization and Workforce Assessment Results

Organization Structure to Accommodate TSMO

During TxDOT SJT leadership engagement meetings and the CMM meeting, TxDOT SJT leadership was supportive of integrating TSMO within their organizational structure.

Although District leadership recognizes the benefits of having TSMO as part of their organizational structure, current resource constraints make it challenging to have existing staff take on additional responsibilities to focus on integrating TSMO within the district. As a result, the TxDOT San Angelo District is planning to incorporate new positions including a TSMO Champion, a TSMO Coordinator, and several TSMO Liaisons to lead district's TSMO integration activities in the future. Figure 17 below describes where these new TSMO positions (highlighted in orange) would fit into the existing organizational structure and collaborate with the other existing staff positions (highlighted in blue) to implement TSMO integration. It is also important to note that the existing staff positions as shown in the organization structure are expected to assist/support the dedicated TSMO personnel for TSMO integration activities in their respective roles.

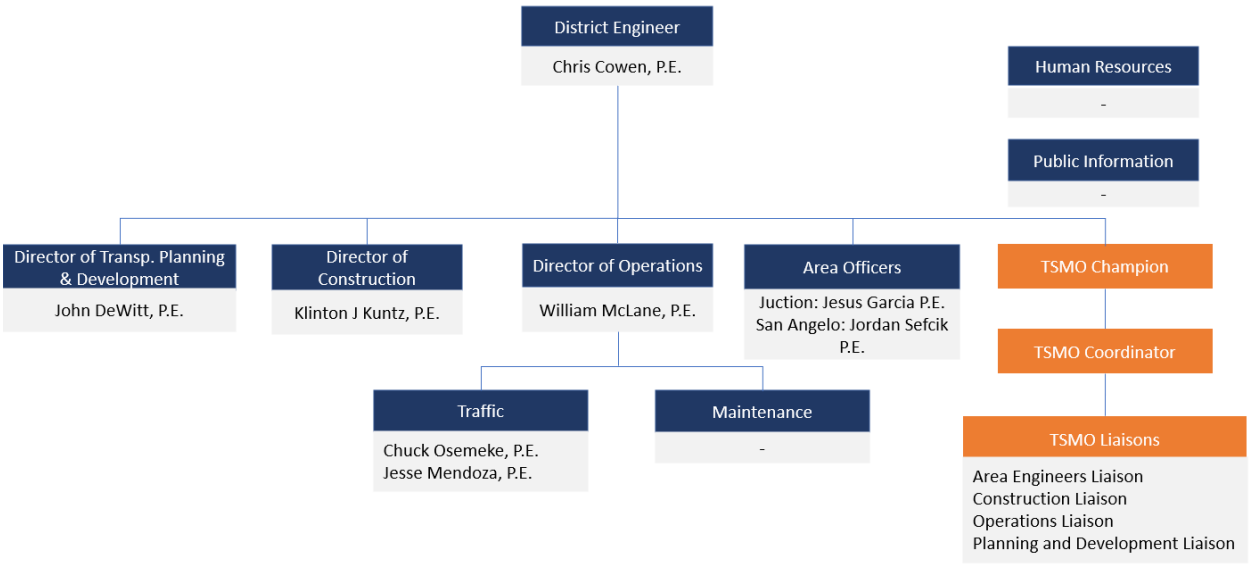


Figure 17: Organization Structure with TSMO Integration

Key TSMO Roles

As TSMO matures within the organization, key TSMO roles will need to be formalized to ensure continuous implementation of TSMO. This section describes how key roles in the region could support TSMO:

TSMO Champion:

This designation is currently held by the Director of Operations. Key responsibilities will include:

- Representing TSMO activities during leadership meetings.
- Advocating for funding and resources.
- Promoting the value of TSMO activities and the high-benefit cost.

TSMO Coordinator:

This designation is currently held by the District Traffic Engineer. Key responsibilities will include:

- Acting as the point of contact for TSMO questions and activities internally and among partner agencies.
- Managing the development and continuous improvement of the TSMO Program Plan.

TSMO Liaisons:

This designation will be held by a key lead from each section and a lead representing all area offices. Key responsibilities will include:

- Embracing a TSMO mindset and identifying TSMO-related opportunities while performing functions critical to their department.
- Collaborating with the TSMO Coordinator and liaisons from other sections to advance TSMO ideas to actionable strategies.

Staffing Plan for Recruitment and Retention

The transportation industry is evolving rapidly. As a result, many agencies are having difficulties recruiting and retaining qualified personnel. Having trained staff to carry out critical TMS, traffic engineering, and planning functions is critical to the success of TSMO within the District. Therefore, a staffing plan detailing strategies to fill immediate needs in the workforce such as positions carrying out critical TSMO functions becomes necessary. The plan should consider how TSMO can help prepare the District for the advancement of technology. Additionally, the staffing plan should consider the following strategies:

- Cross-train employees to ensure staff can transition into TSMO roles quicker.
- Provide professional development opportunities related to TSMO.
- Establish a TSMO career path, with established training requirements and goals.

4.1.5 Culture

The Culture dimension relates to the technical understanding, leadership, outreach, and program legal authority related to TSMO. Table 8 summarizes the FHWA-provided criteria for each Culture capability level.

Table 8: Capability-Level Descriptions for Culture

Dimension				Level 4
Culture (Technical understanding, leadership, outreach, program authority)				**Explicit agency commitment to TSMO** as key strategy to achieve full range of mobility, safety, and livability

Figure 18 summarizes the results of the capability assessment for the Culture dimension. As seen on the figure, all participants ranked themselves between Level 1 and Level 2, and mostly at Level 2. The results indicate TxDOT and partner agencies' desire to improve the technical understanding of TSMO and agency-wide appreciation of the role TSMO can play in improving regional traffic mobility and safety.

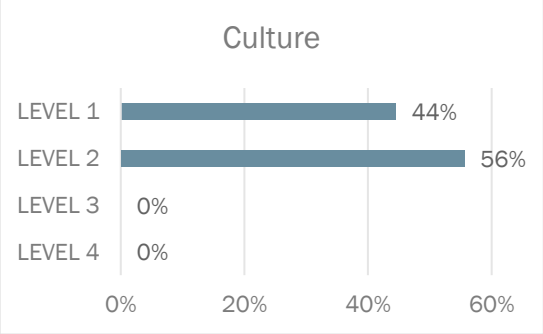


Figure 18: Culture Assessment Results

TSMO culture within the District can be enhanced in a similar way to how the District has enhanced the safety culture. The TSMO program within the District is endorsed by the DE and is currently being led by the Director of Operations (TSMO Champion) and the District Traffic Engineer (TSMO Coordinator). These leaders can encourage every District staff member to review the TSMO Program Plan and attend TSMO outreach events within the District and at TxDOT-sponsored conferences to improve their understanding of TSMO.

The District leadership and staff can consider the following strategies to enhance TSMO culture within the District:

- Share TSMO opportunities, accomplishments, and lessons learned within meetings.
- Include TSMO discussions within existing Director's meetings, Construction Portfolio Review, Design Review, DSRT and DFRT meetings.
- Continue distribution of the monthly TSMO Voice newsletter with TSMO case studies.
- Develop an annual report, sharing advancement of TSMO within the District and highlighting key staff members for their TSMO-related successes.

4.1.6 Collaboration

The Collaboration dimension relates to the working relationships and partnerships between TxDOT and partner agencies, public safety agencies, and the private sector in relation to TSMO. Table 9 summarizes the FHWA-provided criteria for each Collaboration capability level.

Table 9: Capability-Level Descriptions for Collaboration

Dimension	Level 1	Level 2	Level 3	Level 4
Collaboration (Partnerships among levels of government and with public safety agencies and private sector)	**Relationships on informal**, infrequent, and personal basis	**Regular collaboration** at regional level	Collaborative interagency adjustment of roles/ responsibilities by **formal interagency agreements**	High level of operations **coordination institutionalized among key players**—public and private

Figure 19 summarizes the results of the capability assessment for the Collaboration dimension. As seen on the figure, all participants ranked evenly between Level 1 and Level 3. The results reflect TxDOT's desire to build stronger and longstanding working relationships that streamline collaboration across agencies.

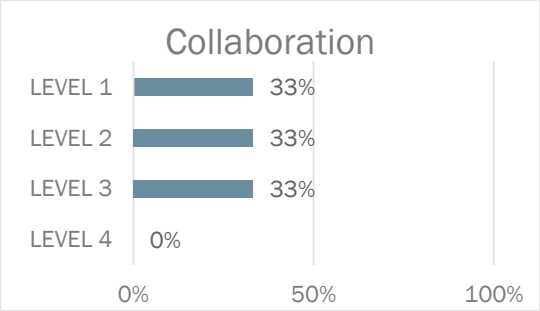


Figure 19: Collaboration Assessment Results

Internal Partnerships

Many of the senior leadership within TxDOT-SJT have been with the District for a long time and have established strong working relationships with each other. These relationships, along with some institutionalized activities such as monthly Director's meetings and Construction Portfolio Review, Design Review, DSRT and DFRT meetings, form the basis for strong collaboration throughout traditional project development. However, the District is staff constrained with existing workload, and it can sometimes be a challenge for staff to attend every meeting. For this reason, the opportunity to provide input on TSMO opportunities can be missed. Additionally, most of the collaboration beyond the project development, including collaboration within the sections, occurs on an ad-hoc basis.

Some opportunities to formalize the internal collaboration in the TSMO context include:

- Adding a discussion of TSMO opportunities to the existing Director's meeting, Construction Portfolio Review, Design Review, DSRT and DFRT meetings.
- Obtaining input from Traffic Operations staff during planning, design, construction, and maintenance phases to ensure TSMO opportunities are considered.
- Collaborating with Operations and TP&D to develop performance measures for comprehensive TSMO projects to allow them to integrate TSMO with traditional project types during project selection.
- Collaborating with Operations and Maintenance, exploring the use of technology to make the maintenance process more effective and efficient.
- Collaborating with Operations and Construction, ensuring the consideration of appropriate smart work zone (SWZ) technology and detour signal timing within regionally significant projects.
- Collaborating with Operations, establishing funding needs for proactive management of traffic signals through a data-driven process.

External Partnerships

Partner agencies have been working in considerable capacity within the San Angelo region for a long time and have established strong working relationships with each other. Collaboration across agencies typically occurs in an ad-hoc manner. Some examples of interagency collaboration include collaboration between TxDOT, City of San Angelo, Tom Green County on Highway Safety Improvement Program projects to improve roadways and signals. Some opportunities to formalize the internal collaboration in the TSMO context include:

- Establishing and attending regular meetings (e.g., quarterly meetings) with partner agencies to collaborate on TSMO.
- Developing a formal process of sharing traffic-signal-related data (e.g., timing data, traffic counts, CCTV video feeds) with partner agencies.
- Collaborating with all TIM partners to develop data-sharing policies, including access to CCTV cameras.
- Formalizing the process of collaboration during incident responses and special events.
- Formalizing the process of collaboration during day-to-day TM activities.

4.2 Capability Maturity Framework

Based on the success of CMM across the country, the FHWA adapted the CMM approach to develop specific CMFs for individual TSMO applications (also called program areas), including TSM, TIM, and TM. Tailored capability frameworks allow agencies and stakeholders to focus on specific capability improvement needs within each program area.

TxDOT-SJT determined the three program areas discussed in paragraphs below to be the most critical for regional mobility and safety. Discussed below is the existing state of practice for TxDOT-SJT in these program areas and case studies that were discussed in conjunction with CMF self-assessments to develop actions for the program areas. The actions are detailed in the Five-Year TSMO Implementation Plan section (Section 5).

4.2.1 Traffic Signal Management

TSM involves the planning, design, integration, maintenance, and proactive operation of a traffic signal system. It is one of the most cost-effective TSMO strategies to improve movement of people and goods while making the streets safer and trips more reliable.

TxDOT-SJT currently operates approximately 34 traffic signals. All 34 signals utilize the Iteris system communicating with Cisco cell modems, and 20 signals have Axis cameras. Most of the signal detection devices are in the San Angelo area on SH-306 and US-67. Cell modems for intersection traffic signal systems are the sole ITS components in the San Angelo District. They are made up of a grid smart system or Cisco cell modems with Axis cameras and Iteris video detection. Signal timing and coordination are managed by District staff. The signal timing adjustments or equipment repairs are conducted once the issue is observed in the field or a request is received from the public. The request is tracked through completion by using the ticketing system TxDOTNow.

TxDOT is in the process of modernizing the signal system by implementing cabinet upgrades and communication at signals. The San Angelo District will be using Econolite's central software, Centracs, to communicate with traffic signal controllers. Once completed, all 34 and any future traffic signals will have Econolite's Cobalt controllers and networked cabinet devices (detection system, video, controller, and battery back-up system) connected to Centracs. Centracs will allow signal technicians to remotely monitor (view traffic

behavior) and access traffic signals to optimize timings. The District also plans to increase the usage of Centracs and adopt ATSPM to proactively maintain and operate signals. Additionally, the TxDOTNow program will incorporate features to track assets and inventory performance and perform asset management. Table 10 provides examples of how agencies across the country have utilized TSMO principles to enhance traffic signal/arterial management. These examples, along with CMF assessment results and discussions with TxDOT leadership, were utilized to develop the TSM program-area recommendations presented in Table 14.

Table 10: TSMO Applications for Traffic Signal Management

Case Study 1: GDOT ATSPM Implementation and Dashboard Development (LINK) Extent: Statewide Program Components: GDOT in partnership with local and consultant partners: 1. Used open-sourced technologies to implement ATSPM. 2. Developed an automated, near-real-time public-facing web application for performance reporting—quarterly/monthly reports and detailed corridor-level and signal–level reports. Benefits: Approximately $250,000 in annual savings.
Case Study 2: GDOT RITIS Data-Driven Screening and Project Selection (LINK) Extent: Statewide Need: Intersection project identification and prioritization Project Components: GDOT in collocation with consultants: 1. Reviewed the RITIS platform to identify which tools will be the most effective for intersection prioritization. 2. Used the bottleneck prioritization tool and delay to prioritize intersection approaches. 3. Developed a spatial dashboard for easy review of intersection ranking. Benefits: Proactive identification of bottleneck intersections and better communication with the public concerning funding priorities.
Case Study 3: Traffic Signal Retiming Program, North Central Texas Council of Governments (LINK) Extent: 400+ signals retimed as part of Phase 1 Project Components: 1. Collect and analyze traffic data, develop and optimize traffic models, create signal timing plans, and field deploy the signal timing plans. 2. Collect and report before-after performance measures. Funding: CMAQ Benefits: 7.3 percent reduction in travel time, 31.1 percent reduction in number of stops, 14.3 percent reduction in fuel consumption, and 4.9 percent reduction in emissions; approximately $25.7 million in annual savings.

4.2.2 Traffic Incident Management

TIM is a planned and coordinated program to detect, respond to, and remove traffic incidents and restore traffic capacity as safely and quickly as possible. TIM reduces travel delay and non-recurring congestion and improves responder and traveler safety. Effective incident management helps address approximately 25 percent of all traffic congestion and reduces secondary incidents, which account for approximately 20 percent of all incidents.

TxDOT-SJT generally conducts TIM activities on an ad-hoc basis as no formal TIM program exists. TxDOT and stakeholders recognize the importance of a coordinated response to traffic incidents and therefore plan to develop a TIM program for the region to identify ways to enhance the District's capability for incident management. As part of the program, the District will coordinate with key stakeholders, including representatives from partner agencies, to discuss TIM collaboration needs and ways to improve safety and mobility during TIM events. For example, the District would like to develop data-sharing policies as well as sharing access to CCTV cameras. TxDOT also plans to utilize probe data sources (such as RITIS/INRIX) for incident detection, tracking, and reporting. Table 11 provides examples of how agencies across the country have utilized TSMO principles to enhance TIM. These examples, along with CMF assessment results and discussions with TxDOT leadership, were utilized to develop the TIM program-area recommendations presented in Table 14.

Table 11: TSMO Applications for Traffic Incident Management

Case Study 1: Waycare Incident Management Platform Deployment at Southern Nevada Traffic Management Center (TMC) Extent: Southern Nevada region Project Components: 1. Real-time sharing of incident information across four agencies housed at the TMC and with the public. The information used to be siloed across various software platforms used by the agencies. 2. Live map showing active incidents, congestion, queues, construction zones, road closures, location of highway patrol, service patrol, and maintenance drivers. 3. Incident alerts on all devices, including incident location, a 20-second looped GIF, geofenced CCTV footage, insights on current road conditions, as well as relevant notes. Benefits: 12-minute reduction in incident response time; greater context of incident details prior to arriving on the scene; reduction in secondary crashes.
Case Study 2: TMC-based Active Incident Monitoring and Management, Denver, CO Extent: Metro Denver area including Colorado Department of Transportation (CDOT) roadways Project Components: 1. The City uses "live" travel time and vehicular volume data and CCTV cameras to detect and verify incidents as well as bottlenecks, queuing, and diversion routes. 2. The City and CDOT work together to activate incident-related messaging on DMS signs and deploy signal timing changes to address congestion and travel time increase due to congestion. 3. The City and CDOT actively monitor and manage the incident through the TMC, which includes use of cameras and travel time/volume data to iteratively adjust signal timing on diversion routes. Benefits: 67 percent reduction in travel time on diversion routes.

Case Study 3: Real-Time Incident Management Dashboard, Bellevue, Washington

Extent: City of Bellevue

Project Components:

1. The City developed a map-based dashboard integrating real-time 911 dispatch data (incident location, type, time) and CCTV cameras at traffic signals.
2. The dashboard map displays incident alerts near traffic signals, allows filtering of calls and viewing and archiving of CCTV footage.
3. The engineers utilize the dashboard to verify, monitor, and respond to incidents. Incident response includes signal timing adjustments, public notifications, incident analysis, and countermeasures development.

Benefits: Up to 50 percent reduction in incident clearance time; reduced travel delays and improved safety of the traveling public and responders.

4.2.3 Traffic Management

TM is the efficient management of traffic by application of the appropriate policies, strategies, and actions to mitigate any potential impacts resulting from the intensity, timing, and/or location of travel and to enhance mobility on transportation facilities. Effective TM reduces travel delay, reduces recurring and non-recurring congestion, and improves safety.

TM within the district is provided by a combination of services from TxDOT and local jurisdiction. Some of these activities include providing traveler information through DMSs, utilizing CCTVs for traffic monitoring, and coordinating special events, incidents, and emergency response. There are currently 8 active CCTV cameras for traffic monitoring and 14 active DMSs which are primarily used to alert travelers of information regarding weather and/or roadway conditions.

San Angelo District has a basic TMC, built in 2019 and measuring approximately 100 square feet. This location is not permanently staffed, but is used on an as-needed basis by TxDOT engineers. At this location, available District staff can monitor all 34 signal locations in the District, school zones, DMSs, CCTV cameras, and any other technology which has cell modem connectivity. Additionally, automated incident detection systems can supplement incident monitoring at the TMC. San Antonio District's TransGuide TMC serves as San Angelo's backup to help operate the district's ITS assets.

TxDOT-SJT first developed the San Angelo Regional ITS Architecture in 2004. It was developed through a cooperative effort by the Region's transportation agencies, covering multiple modes of transportation in the Region. It reflects stakeholder input received at workshops conducted in December 2003 and February 2004. The document was finalized in September 2004. Since then, the architecture has not been updated. The National ITS Architecture v7.0 utilized during the 2015 update has been updated to ARC-IT v9.2. Therefore, TxDOT plans to update the San Angelo Regional ITS Architecture to be ARC IT v9.2 compliant.

TxDOT-SJT's most recent ITS Master Plan was developed in 2021, providing a 5-year roadmap for developing the on-system ITS for major corridors within the San Angelo region. Flood detection system, CCTV deployment, and DMSs are among some of the proposed ITS deployments outlined in the document.

Table 12 provides examples of how agencies across the country have utilized TSMO principles to enhance TM. These examples, along with CMF assessment results and discussions with TxDOT leadership, were utilized to develop the TM program-area recommendations presented in Table 14.

Table 12: TSMO Applications for Traffic Management

Case Study 1: FDOT District 5 Integrated Corridor Management (LINK) **Extent:** Florida Department of Transportation District 5 **Project Components:** 1. FDOT District 5 freeway personnel and Active Arterial Management personnel work side-by-side to ensure an integrated approach to operations throughout the region. 2. ICM includes a wide variety of strategies such as traffic signal management through remote control and ATSPM, signal preemption and priority, ramp metering, traveler information (511, DMS, WAZE), incident management, dynamic shoulder running, information management, etc. **Benefits:** up to 10:1.
Case Study 2: Arizona DOT Needs Based Maintenance Budget **Extent:** All of ADOT **Project Components:** 1. Determination of TSMO (CCTV, DMS, signals, lighting, ITS, signing, striping, etc.) maintenance needs based on a data-driven, performance centered approach as opposed to the one based on historical perspective (budget allocation based on what was accomplished last year). 2. ADOT staff collects inventories, assigns Level of Service grades, and enters data into a Needs Based Budget model for analysis and budget allocation. 3. Real-time Tableau-based performance measures and dashboards are available to make decisions based on the most recent data and to track progress towards targets. **Benefits:** Limited maintenance funds are allocated more efficiently.
Case Study 3: Georgia DOT Connected Data Platform (LINK) **Extent:** All GDOT **Project Components:** 1. The project will build a platform that aggregates data from multiple departments and eliminates the need to use multiple software. 2. The map-based platform will aggregate, quality check and develop performance measures for data such as crashes, incidents, ITS/signal devices, traffic, weather, fleet, etc. 3. The platform will provide automated alerts, on-screen monitoring, performance 4. measure dashboards and reports. **Benefits:** Improve decision making accuracy and efficiency.

5 FIVE-YEAR TSMO IMPLEMENTATION PLAN

This section includes a prioritized implementation plan for advancing TSMO in the San Angelo District over the next five years. The action items included in Tables 13 and 14 are the outcome of the comprehensive TxDOT and partner-agency engagement process discussed earlier, through which the leadership and key leads from TxDOT and partner agencies were engaged multiple times over the course of the project to cocreate the TSMO actions. This approach ensures that the action items listed below are properly vetted and that there is TxDOT support for them, making the actions implementable. Table 13 provides program-level CMM-based TSMO actions, and Table 14 provides program-area-level CMF-based TSMO actions. These tables provide the following information for each action item.

- **ID**: An identifier for each recommended action item, organized by CMM capability dimension: Business Processes (BP), Systems and Technology (ST), Performance Measurement (PM), Culture (CU), Organization and Workforce (OW), and Collaboration (CO).
- **Action:** Brief description of the action and associated steps.
- **Lead:** Identification of the department or agency that will take ownership of the action and lead its implementation.
- **Support:** Identification of the department or agency that will support the implementation of the action.
- **Cost:** An estimate of the level of fiscal resources TxDOT would need to commit to implement the action.
- **Impact:** An estimate of the magnitude of improvement as a result of implementing the action.
- **Time Frame:** The time frame in which an action is likely to be implemented.
- **Measure of Success:** Identification of how the progress and completion of an action will be tracked.

While all action items listed below could potentially be implemented within the next five years, no funding is currently allocated for any of these action items unless otherwise specifically stated in this plan. Action items will be implemented as District resources permit.

Table 13: TxDOT-SJT Program-Level TSMO Action Items

ID	Action	Lead	Support	Cost	Impact	Time Frame	Measure of Success
Year 1 - 2 Actions							
BP-01	Consider incorporating TSMO/ITS strategies during planning.	TP&D	Traffic Operations	$	★★★★	1-2 years	Yes/No
BP-02	Develop a formal process that institutionalizes how project development and funding needs for TSMO projects are coordinated between TP&D, Construction, and Operations and Maintenance.	TP&D	All	$	★★★	1-2 years	Yes/No
PM-01	Continuously analyze mobility (speeds and travel times) and safety data (crashes) to develop mobility- and safety-based performance measures.	TP&D/Traffic Operations	Area Engineers	$$	★★★	1-2 years	% Complete
ST-01	Monitor ongoing system developments and update the ITS Regional Architecture to reflect changing needs.	Traffic Operations	TP&D	$$	★★★	1-2 years	% Complete
ST-02	Implement ITS Field Devices Identified in the ITS Master Plan. Phase 1: Deploy ITS infrastructure identified in Phase 1 of the TxDOT San Angelo District ITS Master Plan to support improved traffic management and operations in the District.	TP&D/Traffic Operations	Area Engineers	$$	★★★	1-2 years	Yes/No
CU-01	Perform outreach efforts to inform staff on how TSMO will better help them do their jobs.	Deputy DE	All	$	★★★	1-2 years	Yes/No
OW-01	Evaluate training and development of existing staff to perform specialized functions related to data and technology to enhance TxDOT business processes.	Deputy DE	All	$	★★★	1-2 years	% Complete
Year 3 - 5 Actions							
BP-03	Enhance maintenance planning and tracking activities by utilizing systematic processes.	Maintenance	Maintenance	$$$	★★★★	3-5 years	% Complete
BP-04	Identify ways to incorporate TSMO priorities into existing and planned projects within the District's annual budget.	TP&D	Traffic Operations	$	★★★	3-5 years	Yes/No
PM-02	Share use cases of various TSMO strategies to help better understand their benefits and justify future deployments.	TP&D/Traffic Operations	Area Engineers	$	★★★	3-5 years	Yes/No

Table 14: TxDOT-SJT Program-Area-Level TSMO Action Items

ID	Action	Lead	Support	Cost	Impact	Time Frame	Measure of Success
Traffic Signal Management							
Year 1 - 2 Actions							
ST-01	Provide communications for 100 percent of District signals, and acquire traffic signal central management system licenses to monitor and control all District signals.	Traffic Operations	TRF	$$	★★★★	1-2 years	% Complete
ST-02	Plan and Implement Surveillance Technology for Signals: Identify implementation priority for cameras and necessary software enhancement to allow remote surveillance of District traffic signals from a single software platform.	Traffic Operations	TRF	$$	★★★★	1-2 years	% Complete
CU-01	Identify ways to communicate benefits, outcomes, and needs to various internal and external stakeholders, including policy makers, the media, and others. - Share benefits from signal timing at Directors' and supervisors' meetings. - Leverage social media to share information (e.g., Twitter, Facebook).	Traffic Operations	TRF	$	★★	1-2 years	Yes/No
CO-01	Establish and attend regular meetings (e.g., quarterly meetings) with partner agencies to collaborate on TSM.	Traffic Operations	City of San Angelo, Tom Green County, SA-MPO	$	★★	1-2 years	Yes/No
CO-02	Develop a formal process of sharing traffic-signal-related data (e.g., timing data, traffic counts, CCTV video feeds) with partner agencies.	Traffic Operations	City of San Angelo (Fire Department, Police Department)	$	★★★	1-2 years	% Complete
Year 3 - 5 Actions							
BP-1	Develop a TSM plan that identifies needs and strategies to operate, maintain, and upgrade the traffic signal system. - Establish goals that are aligned to TxDOT and the region. - Formalize/develop traffic signal timing and maintenance programs. - Determine funding streams, the level of collaboration, and training requirements.	Traffic Operations	City of San Angelo	$	★★★	3-5 years	% Complete
PM-01	Utilize crowdsourced data (e.g., INRIX) to obtain traffic signal performance measures. - Participant in training for probe data analytic tools - Conduct before/after performance measure comparison	Traffic Operations	TRF, TP&D	$$	★★★	3-5 years	Yes/No
ST-03	Implement technologies to improve traffic signal operations (ATSPM, traffic responsive signals, adaptive systems, connected vehicles).	Traffic Operations	TRF	$$	★★★	3-5 years	Yes/No
ST-04	Deploy an asset management system for traffic signals (e.g., TxDOTNow). - Have information on existing assets. - Ensure traffic signal assets are maintained in good condition.	Traffic Operations	TRF	$$$	★★★★	3-5 years	Yes/No
OW-01	Develop a recurring staff training program. - Create staff redundancy by cross-training on skills and job functions. - Trainings should include existing and emerging technology relating to traffic signal system (detection, diamond intersections, troubleshooting signals, fiber-optics management, and ITS assets).	Traffic Operations	Traffic Operations	$$	★★★	3-5 years	Yes/No

ID	Action	Lead	Support	Cost	Impact	Time Frame	Measure of Success
Traffic Incident Management							
Year 1 – 2 Actions							
PM-01	Improve TIM Data Collection and performance measures tracking: - Improve incident management related data collection of roadway clearance time, incident clearance time, secondary crash data, and injury contributing factors (e.g., seat belt wearing).	Traffic Operations	TRF	$	★★★★	1-2 years	Yes/No
CU-01	Share lessons learned, benefits, and outcomes from traffic incident responses with stakeholders and TxDOT leadership.	Traffic Operations	Traffic Operations	$	★★	1-2 years	Yes/No
CO-01	Collaborate with all TIM partners to develop data-sharing policies, including access to CCTV cameras.	Traffic Operations	City of San Angelo, Tom Green County, SA-MPO	$	★★★	1-2 years	Yes/No
Year 3 – 5 Actions							
PM-02	Utilize probe data sources (such as RITIS/INRIX) for incident detection, tracking, and reporting.	TRF	Traffic Operations	$$	★★★	3-5 years	Yes/No
OW-01	Participate in reoccurring, consistent and evolving TIM training for all stakeholders: - to train new staff and develop redundancy in existing staff, - for multidisciplinary TIM program participants to understand the incident command structure, roles of involved agencies, and applicable standards (e.g., Texas Manual on Uniform Traffic Control Devices). - to improve TIM practices based on lessons learned.	Traffic Operations	Traffic Operations	$	★★★	3-5 years	Yes/No
Traffic Management							
Year 1 – 2 Actions							
BP-01	Establish Standard Protocol for Use of DMS: Develop protocol for when to post and what messages to post on DMS for disseminating information to the traveling public. Develop standard message templates to use for creating messages for various scenarios.	Traffic Operations	TRF	$	★★★★	1-2 years	% Complete
PM-01	Continuously track asset performance (e.g., percentage uptime, asset reliability, asset age vs. service life, work-order tracking) against goals.	Traffic Operations	TRF	$$	★★★	1-2 years	% Complete
ST-01	Develop a Regional Traffic Management Center Con-Ops.	Traffic Operations	Traffic Operations	$	★★★	1-2 years	Yes/No
ST-02	Update the existing San Angelo Regional ITS Architecture documents to be ARC-IT 9.2 compliant.	Traffic Operations	City of San Angelo, Tom Green County, SA-MPO	$$	★★★	1-2 years	Yes/No
ST-03	Implement technology for flood detection, warning, and automated road closure in areas that frequently flood.	Traffic Operations	Traffic Operations	$$	★★★	1-2 years	Yes/No

ID	Action	Lead	Support	Cost	Impact	Time Frame	Measure of Success
OW-01	Evaluate training and development of existing staff and new staff to continue to leverage data and technology in traffic management activities.	Traffic Operations	Traffic Operations	$$	★★★	1-2 years	% Complete
CO-01	Identify ways to collaborate with partner agencies from the inception of a project.	Traffic Operations	City of San Angelo, Tom Green County, SA-MPO	$	★★★	1-2 years	Yes/No
CU-02	Increase public awareness of DriveTexas.org for traffic management information.	Operations	City of San Angelo, Tom Green County, SA-MPO	$	★★★★	1-2 years	Yes/No
Year 3 - 5 Actions							
BP-02	Develop a data-driven, needs-based operations and maintenance budgeting process to maintain or replace TSMO (ITS/signals) assets. The process will utilize TSMO asset inventory, asset cost, information on completed/needed maintenance, and assigned asset level of service to determine the operations and maintenance budget.	Traffic Operations	Traffic Operations	$$$	★★★★	3-5 years	% Complete
BP-03	Evaluate the need for a performance-driven preventive maintenance and inspection program that would complement the statewide ITS/signals network monitoring contract.	Traffic Operations	TRF	$$	★★★	3-5 years	Yes/No
ST-04	Explore the use of technology to address issues determined in the District Safety Plan.	Traffic Operations	Traffic Operations	$$	★★★	3-5 years	Yes/No
CU-01	Document and share lessons learned from TSMO projects district-wide and throughout the region.	Traffic Operations	City of San Angelo, Tom Green County, SA-MPO	$	★★★	3-5 years	Yes/No

6 TSMO TACTICAL PLAN ASSESSMENT

Tactical plans build upon the higher-level recommendations provided in a TSMO Program Plan related to specific services, projects, and programs, and provide more detailed recommendations and actions to operationalize them. Tactical plans include discussion and analysis of existing conditions, needs and gaps, opportunities and challenges, recommendations including responsibilities and staffing, and a more detailed cost estimate for implementation. The purpose of this chapter is to provide a framework for future development of tactical planning activities as part of TSMO implementation.

6.1 Tactical Plan Criteria

Tactical criteria were developed by the TRF using qualitative descriptors, with the intent that, as tactical plans advance to implementation, quantitative analyses will be performed (e.g., cost estimates, BCR, funding sources, detailed schedules). Criteria for tactical plans applied at the strategic plan level are as follows:

- Alignment with TxDOT-SJT TSMO goals.
- Stakeholder partnerships necessary for implementation.
- Anticipated initial and ongoing costs.
- Level of District staff effort.
- Expected return on investment.

6.2 Tactical Plan Components

The following components will be included in each tactical plan:

- Documentation, discussion, and analysis of existing conditions, including existing processes, systems, roles, and responsibilities.
- Identification of gaps and development of needs based on tactical plan objectives.
- Discussion of institutional and technical challenges in addition to opportunities to support TSMO advancement developed in conjunction with stakeholders.
- Recommendations related to enhancement of activities or addition of new activities to advance TSMO elements.
- Budgetary requirements and schedule for implementation.
- Performance measures to track progress of the proposed activities.

6.3 Recommended Tactical Plans

Based on current projected needs, TSMO tactical plans recommended for TxDOT-SJT are summarized in Table 15. Additional tactical plans as identified during the TSMO implementation process will be included in future TSMO Program Plan updates.

Table 15: TxDOT-SJT TSMO Tactical Plan Recommendations

Tactical Plan	Supported District TSMO Goals						Lead	Support	Cost	Impact
	Safety	Reliability	Efficiency	Customer Service	Collaboration	Integration				
Regional ITS Architecture Update					X	X	Operations	City of San Angelo, Tom Green County, SA-MPO, Concho Valley Transit District	$$	★★★
TSM Plan	X	X	X	X	X	X	Operations	City of San Angelo, Tom Green County, SA-MPO	$$	★★★
TIM Handbook	X	X	X	X	X	X	Operations	City of San Angelo, Tom Green County, SA-MPO	$$	★★
Regional Traffic Management Center Con-Ops	X	X	X	X	X	X	Operations	City of San Angelo, Tom Green County, SA-MPO	$	★★★★

7 REFERENCES

- Texas Transportation Plan 2050
- TxDOT Transportation Systems Management & Operations
- TxDOT (2018) Transportation Systems Management and Operations (TSMO) Statewide Strategic Plan
- TTI Urban Mobility Report San Angelo 2019
- TxDOT Performance Dashboard
- TxDOT (2023) Unified Transportation Program
- San Angelo (2004) Regional ITS Architecture
- Federal Highway Administration (2017) Developing and Sustaining a Transportation Systems Management & Operations Mission for Your Organization: A Primer for Program Planning (FHWA-HOP-17-017)
- FHWA (2020) Capability Maturity Frameworks Overview
- US DOT (2021) Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT)
- FHWA (2015) Transportation Systems Management and Operations Benefit-Cost Analysis Compendium

APPENDIX A

List of TxDOT and Partner-Agency Members

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