GEORGIA DOT RESEARCH PROJECT #19-25
FINAL REPORT

TRANSPORTATION PERFORMANCE MANAGEMENT FOR SYSTEM OPERATIONS: DEVELOPMENT OF PROCESSES, TOOLS, MEASURES AND TARGETS

Georgia Department of Transportation

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16. Abstract
This study identifies effective practices for transportation systems management and operations (TSMO) at the strategic, programmatic and tactical level, assesses Georgia Department of Transportation's status using the TSMO Capability Maturity Model (CMM), and offers recommendations to move the agency to the next level. The study develops a tool for calculating transportation system performance metrics using the National Performance Management Research Data Set (NMPRDS) and other databases. We conduct a literature review to characterize effective strategic, programmatic and tactical TSMO practices; administer a survey to characterize the status of GDOT using the TSMO CMM, and offer recommendations to move GDOT to the next level. Subsequently, we develop a tool to analyze and report on transportation system performance using the MAP-21 PM3 measures. The PM3 Tool calculates metrics for travel time reliability on interstate and non-interstate routes on the National Highway System (NHS), truck travel time reliability, and annual hours of peak-hour excessive delay per capita, and reports on percent of non-SOV travel, and total emission reductions. It uses data from the NPMRDS, GDOT, the U.S. National Census and the Congestion Mitigation and Air Quality (CMAQ) Public Access Database. The study highlights the importance of developing TSMO at the tactical, programmatic and strategic levels simultaneously, integrating TSMO activities with strategic and long range planning and asset management functions within state DOTs. Using the PM3 tool, state DOTs can calculate PM3 measures and use them in setting future performance targets, while working at the strategic, programmatic and tactical levels to improve transportation system performance.

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GDOT Research Project 19-25

Final Report

TRANSPORTATION PREFORMANCE MANAGEMENT FOR SYSTEM OPERATIONS: DEVELOPMENT OF PROCESSES, TOOLS, MEASURES AND TARGETS

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Executive Summary

MAP-21 (Moving Ahead for Progress in the 21st Century) and FAST (Fixing America's Surface Transportation) legislation formally introduced a performance-based approach to decision making on the nation's surface transportation system, adopting seven national performance goals. The Federal Highway Administration (FHWA) defines Transportation Performance Management (TPM) as a strategic approach that uses system information to make investment and policy decisions to achieve national performance goals. The FHWA released rules establishing TPM measures in June 2017. All states, metropolitan planning organizations (MPOs), and public transportation agencies must develop plans to document strategies and investments to address performance needs, incorporate these into the transportation planning and decision-making process, establish and report on targets for each measure, and make significant progress toward achieving these targets.

This report presents key findings of a project sponsored by the Georgia Department of Transportation (GDOT) to accomplish the following: (1) identify best practices for transportation system management and operations (TSMO) in the U.S; (2) assess where GDOT stands using the TSMO capability maturity model (CMM); (3) develop recommendations to move the agency to the next level of TSMO; (4) develop a tool for calculating transportation system performance measures (PM3) for MAP-21 reporting, and, (5) implement the PM3 Analysis and Reporting Tool (i.e., PM3 Tool, for short) in the GDOT environment. The report presents TSMO effective practices at the strategic, programmatic and tactical levels, outlines the results of a survey conducted to characterize the status of TSMO at GDOT, and, offers recommendations to move GDOT to the next level using the TSMO CMM. The report also presents key elements for the development of the PM3 Tool and provides a manual for operating the tool and generating transportation system performance measures to meet the MAP-21 reporting requirements. The PM3 Tool calculates and reports on transportation system performance measures and targets using the data from the National Performance Management Research Data Set (NPMRDS) and other sources.

The first section of the report summarizes effective TSMO practices in U.S. State Departments of Transportation (DOTs) and MPOs. The effective practices are categorized according to the three critical planning elements of TSMO: strategic, programmatic and tactical, and the six dimensions of a successful TSMO plan: (1) Business Processes, (2) Systems and Technology, (3) Performance Metrics, (4) Culture, (5) Organization and Workforce, and (6) Collaborations. The effective practices are drawn from a wide range of state Departments of Transportation (DOTs) across the country. The second section presents the results of a survey conducted to characterize the nature TSMO within GDOT and recommendations to move from the existing to the next level of TSMO. The third and final section of the report provides key details on the development of the GDOT PM3 Tool. Developed using Python and based on equations developed or endorsed by the FHWA, the tool calculates and reports on six performance measures. It calculates metrics for travel time reliability on interstate and non-interstate routes on the National Highway System (NHS). It also calculates truck travel time reliability, and annual hours of peak-hour excessive delay per capita, and, reports on percent of non-SOV travel, and total emission reductions. The PM3 Tool uses data sources from the NPMRDS, GDOT, the U.S. National Census, and, the Congestion Mitigation and Air Quality (CMAQ) Public Access Database.

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PART I: EFFECTIVE TSMO PRACTICES

Overview

The objectives of the project are to:

(1) Identify effective practices, including business processes, institutional arrangement, and TSMO strategies for transportation performance management at the agency;

(2) Determine the current status (i.e., existing) and establish the desired status (i.e., next level) of GDOT on the Operations Performance Management Capability Maturity Model (OPMCMM) (**Figure 1**);

(3) Develop an analytic tool for calculating transportation system performance metrics and targets using the NPMRDS and other data sets, and,

(4) Implement the tools within the OPMCMM framework for GDOT for TSMO.

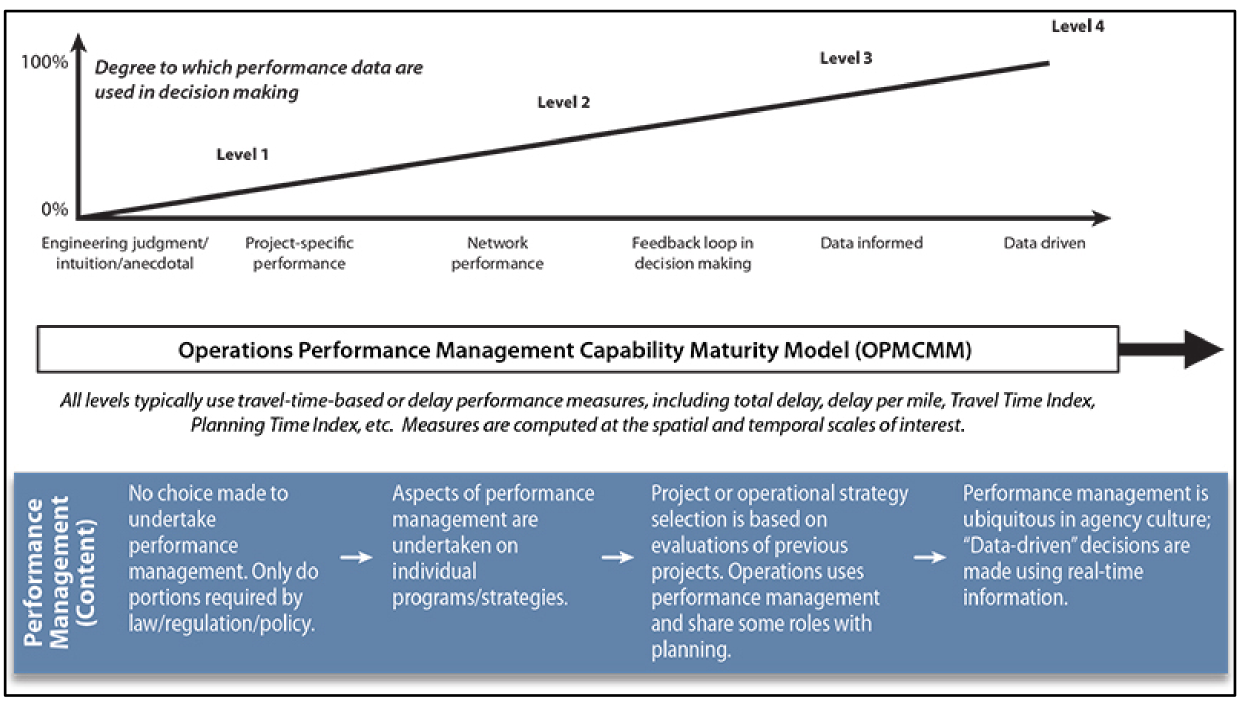

Figure 1: Operations Performance Management Capability Maturity Model (FHWA 2017a)

TSMO Classifications

Transportation System Operations and Management (TSMO) may be classified according to three critical planning elements: (1) Strategic, (2) Programmatic, and, (3) Tactical. In addition, a successful TSMO plan will include the following dimensions: (1) Business Processes, (2) Systems and Technology, (3) Performance Measures, (4) Culture, (5) Organization and Workforce, and (6) Collaborations. We conducted a literature review on effective TSMO practices categorized according to the three critical planning elements of TSMO and the six dimensions of a successful TSMO plan, reviewing practices from a wide range of State Departments of Transportation (DOTs) across the country.

With respect to the three critical elements of TSMO planning, strategic elements relate to the business case for TSMO, vision and program mission, strategic goals and performance objectives, and strategic focus area or priority functions. Programmatic elements relate to leadership and organizational structure, programmatic objectives, staffing and workforce needs, business process and management strategies, TSMO culture in the agency, and financial resource management. Tactical elements relate to prioritized services, activities and projects, implementation policies and guidelines, a multi-year investment plan, and, performance assessment (FHWA 2017a).

With respect to the six key dimensions of TSMO, Business Processes include formal scoping planning, programming and budgeting. Systems and Technology include systems architecture, standards, interoperability, standardization, and, documentation. Performance Measurement includes measures definition, data acquisition, analysis and utilization – the main focus of this study. Culture includes technical understanding, leadership, policy commitment, outreach, and program authority. Organization and Workforce includes organizational structure, staff capacity, development, and retention. And, collaboration includes relationships with public safety agencies, local governments, MPOs, and the private sectors.

TSMO Effective Practices

A total of 31 effective practices, distributed across over 20 states, were identified and characterized first by TSMO critical planning elements and then by the dimensions of a successful TSMO plan. **Appendix A: Effective TSMO Practices** presents the range of effective practices identified. The review results reflect the importance of pursuing an integrated approach to TSMO planning: one that includes well-aligned strategic, programmatic, and tactical elements, for superior outcomes.

PART II: TSMO at GDOT

Overview

This section of the report characterizes key features of the existing decision-making process for transportation system operation and management (TSMO) at GDOT and makes recommendations for enhanced next-level decision-making processes.

Approach

To characterize the status of TSMO at GDOT, a survey was developed aimed at characterizing the status of GDOT's performance management, business processes, as well as system and technology practices. We applied the American Association of State Highway and Transportation Officials (AASHTO) TSMO guidance to improve the effectiveness of TSMO programs. This is a web-based self-assessment guidance designed for transportation agency managers responsible for operating and managing the roadway system (AASHTO n.d.). The guidance is based on the Capability Maturity Model (CMM) approach developed for the second Strategic Highway Research Program (SHRP2 Project L06), by a team led by Parsons-Brinkerhoff working closely with the AASHTO Subcommittee on TSMO (Transportation Research Board and National Academies of Sciences 2011). The survey questions are included in the **Appendix B: TSMO Survey Instrument.** The results of the survey were used to determine the maturity levels based on the CMM approach.

The AASHTO guidance recommends the survey be completed by the following positions (AASHTO n.d.):

1. **Agency Senior Executive and Deputies** - in charge of overall jurisdiction-wide transportation activities/programs (of which operations is but a part)

2. **Agency TSMO Program Manager/Director** - in charge of TSMO activities at agency-wide level (note, senior management of operations may be coupled with another agency program such as maintenance)
3. **Agency/Regional Operations Activity Manager** - responsible for all or specific TSMO program features at regional/district level (examples: assistant district engineer for operations, TMC manager, incident response manager, MPO or local government staff person with senior management responsibility)
4. **Agency/Regional Operations Senior Staff** - key individual involved in all or specific day-to-day TSMO program features

The survey was completed by the Assistant State Traffic Engineer, the Traffic Management Central Manager, the Head of Performance-Based Management and Research, and the Asset Project Manager for Performance-Based Management and Research (OPMR), covering the latter three recommended positions. Follow up questions were sent to the Office of Planning (OP) to verify a number of survey questions. The following sections draw from the survey results, and input obtained from the follow up questions on the survey results.

Recommendations for next-level TSMO were then developed based on a review of the TSMO literature conducted as part of this project. These recommendations form the basis for a next-level TSMO map for decision making.

Results

Median values from the 2018 survey suggest the agency is at Level 3 in Business Processes (including formal scoping, planning, programming and budgeting), Level 3 in Systems and Technology (including systems architecture, standards, interoperability, and standardization, and documentation), and Level 4 in Performance Measures (including measures definition, data acquisition, analysis, and utilization). **Table 5** summarizes the median values and ranges reported for CMM levels under Business Processes, System and Technology and Performance Management in the 2018 survey.

Table 1: Summary of Survey Results

CMM Area	**Business Processes**	**System and Technology**	**Performance Management**
CMM Levels: Median (Range)	3 (2-4)	3 (1-4)	4 (2-4)

Explanation of Maturity Levels

- **Level 1** - Activities and relationships largely ad hoc, informal and champion-driven, substantially outside the mainstream of other DOT activities
- **Level 2** - Basic strategy applications understood; key processes support requirements identified and key technology and core capacities under development, but limited internal accountability and uneven alignment with external partners
- **Level 3** - Standardized strategy applications implemented in priority contexts and managed for performance; TSMO technical and business processes developed, documented, and integrated into DOT; partnerships aligned
- **Level 4** – TSMO as full, sustainable core DOT program priority, established on the basis of continuous improvement with top level management status and formal partnerships

The results of a GDOT self-assessment in a 2013 workshop **(Appendix B: TSMO Survey Instrument**) indicate the agency was at Level 2 in Business Processes, Level 3 in System and Technology, and Level 3 in Performance Management.

Follow up information obtained from the Office of Traffic Operations through the Office of Planning indicates that a TSMO Plan is currently under development by the Atlanta Regional Commission. While there is an MPO-directed TSMO plan under development, there is at this time no state TSMO Plan. However, there is an informal and internal living Intelligent

Transportation System (ITS) document, largely used for tactical decision making by the Office of Traffic Operations. It is a continuously evolving document.[1] Budgeting for ITS projects is conducted through the Office of Traffic Operations.

TSMO Decision-Making Map- Current

The TSMO Decision-Making (DM) map shown in **Figure 2** was developed based on the survey results and a review of the ITS Document. It reflects a tactical and evolving TSMO approach being led out the Office of Traffic Operations and involving multiple GDOT offices: the Office of Traffic Operations conducts ITS pilot studies and pilot projects on an annual basis in conjunction with the Office of Performance-based Management and Research, the Office of Planning, and the Office of Transportation Data. Budgeting responsibility for TSMO lies within the Office of Traffic Operations, and public input is included on ITS actionable information on an annual basis to prioritize ITS projects. The Office of Traffic Operations and the Office of Planning conduct data monitoring to identify travel hotspots, discover high accident areas, detect congestion hotspots and map trends of travel during incidents/construction as a basis for identifying appropriate ITS solutions. The current Decision-Making Map reflects strong tactical elements in the existing TSMO process, with opportunities to build on the existing processes by augmenting formal strategic and programmatic elements of TSMO within the agency.

[1] The Living ITS document is an internal GDOT document managed by the Office of Traffic Operations.

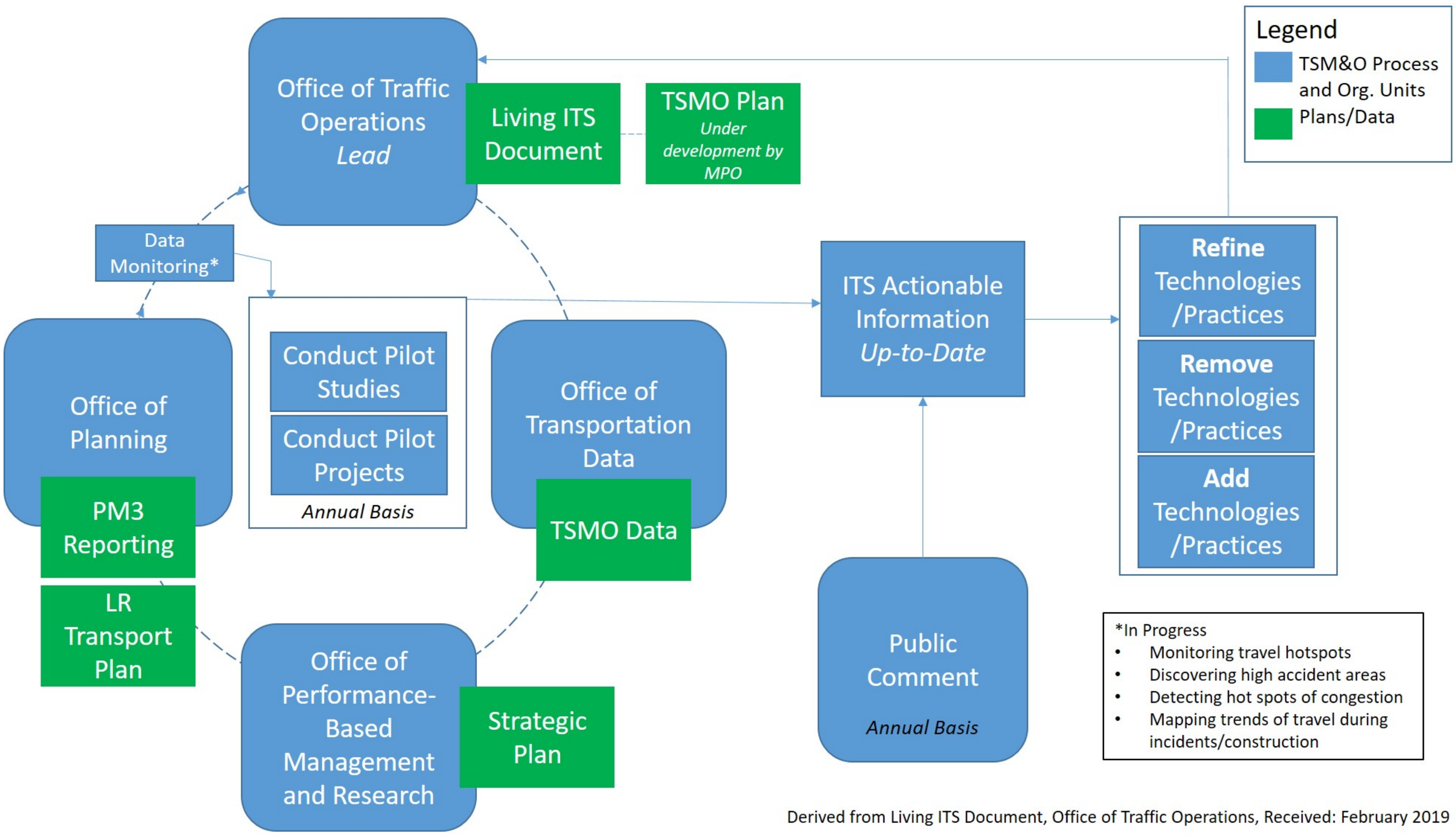

Figure 2: Current TSMO Decision-Making Map

Next-Level TSMO Recommendations/Map

TSMO focuses on actively managing the multimodal transportation network to deliver positive safety and mobility outcomes. The United States Department of Transportation's Office of Operations in the Federal Highway Administration (FHWA) developed the FHWA Primer for Program Planning. The purpose of the primer is to help State DOTs, MPOs, and regional operations organizations understand the rationale for and key elements of successful TSMO program planning. It is intended to help agencies understand (1) Why TSMO planning is important and how it can benefit a transportation agency or region; (2) What are the key elements of TSMO program planning and what steps or activities should be taken; and, (3) What an effective TSMO program plan looks like. It points out a shift from the traditional transportation agency functions - focused on capital project planning, design, construction, and maintenance with limited resources applied to managing and operating transportation systems - to TSMO as part of the core mission of Departments of Transportation (DOTs) and Metropolitan Planning Organizations (MPOs). The Primer notes that this need arises because roadway capacity is largely built out in urban areas and transportation funding is in limited supply. It also notes that in order to be effective, TSMO should be recognized and structured as a core function of a transportation agency – more than simply a strategy or ad hoc set of activities, it must be a pervasive and cohesive program across the agency. Importantly, the Primer acknowledges there is no single approach to TSMO program planning nor is a TSMO Program Plan appropriate for every organization (FHWA 2017b).

TSMO Program Planning involves *strategic*, *programmatic*, and *tactical* elements. It involves the organizational business process and discipline of regular assessing, enhancing and documenting:

1. The relationship of TSMO to the agency mission and the fundamental reasons or business case for organizational commitment to TSMO;
2. The organizational structure and business processes to administer TSMO as a core program area; and,
3. The services, programs, technologies, and infrastructure that an organization or geographic area commits to implement in order to support achievement of performance outcomes.

The process of TSMO program planning identifies the strategic, programmatic, and tactical elements needed to advance TSMO as a critical part of the agency's mission. A TSMO Program Plan is the documented outcome of this process (FHWA 2017b).

Based on the current TSMO Decision-Making Map (**Figure 2**) and the review and assessment of TSMO programs in the literature (Amekudzi-Kennedy et al. 2019), we propose the following five recommendations for next steps in strengthening the strategic and planning elements of the agency's TSMO Program, with the attendant benefits:

1. Develop, document and disseminate strategic, programmatic and tactical elements of TSMO Program to integrate TSMO well within the agency. Communicate these appropriately to internal and external stakeholders.
2. Develop and document overarching TSMO vision.
3. Develop and document overarching TSMO strategic goals and objectives.
4. Formally integrate TSMO with other DOT programs, with formal document integration.

5. Develop business case for TSMO applications across project lifecycle and multimodal TSMO applications, particularly including passenger and freight mass transportation.

These recommendations will augment the value of TSMO within the agency and to the users of the transportation system as they will align these activities with strategic priorities and planning activity and guide decision makers to a higher return on investment. The recommendations are discussed individually below.

Recommendation 1: ***Develop and document strategic, programmatic and tactical elements of TSMO Program to integrate TSMO well within the agency. Communicate these appropriately to internal and external stakeholders.***

A review of State DOT TSMO activity reveals clear strategic, programmatic and tactical elements documented as standard practice in evolving TSMO programs in state DOTs (Amekudzi-Kennedy et al. 2019). These elements may be documented separately or in a single, integrated document. **Figure 3** shows Iowa DOT's TSMO Plan which includes a TSMO Strategic Plan for all internal stakeholders, a TSMO Program Plan for agency leadership, and TSMO Service Layer Plans for staff involved with TSMO. The strategic elements situate TSMO explicitly within the agency's strategic goals, mission and vision, and make a business case for the particular version of TSMO the agency has chosen to adopt and advance. Among other things, the Program Plan articulates program objectives, a budget and a multi-year improvement program to achieve program objectives. It also articulates how TSMO is integrated with other DOT programs (Lakeside Engineers, LLC and Pat Noyes & Associates 2016).

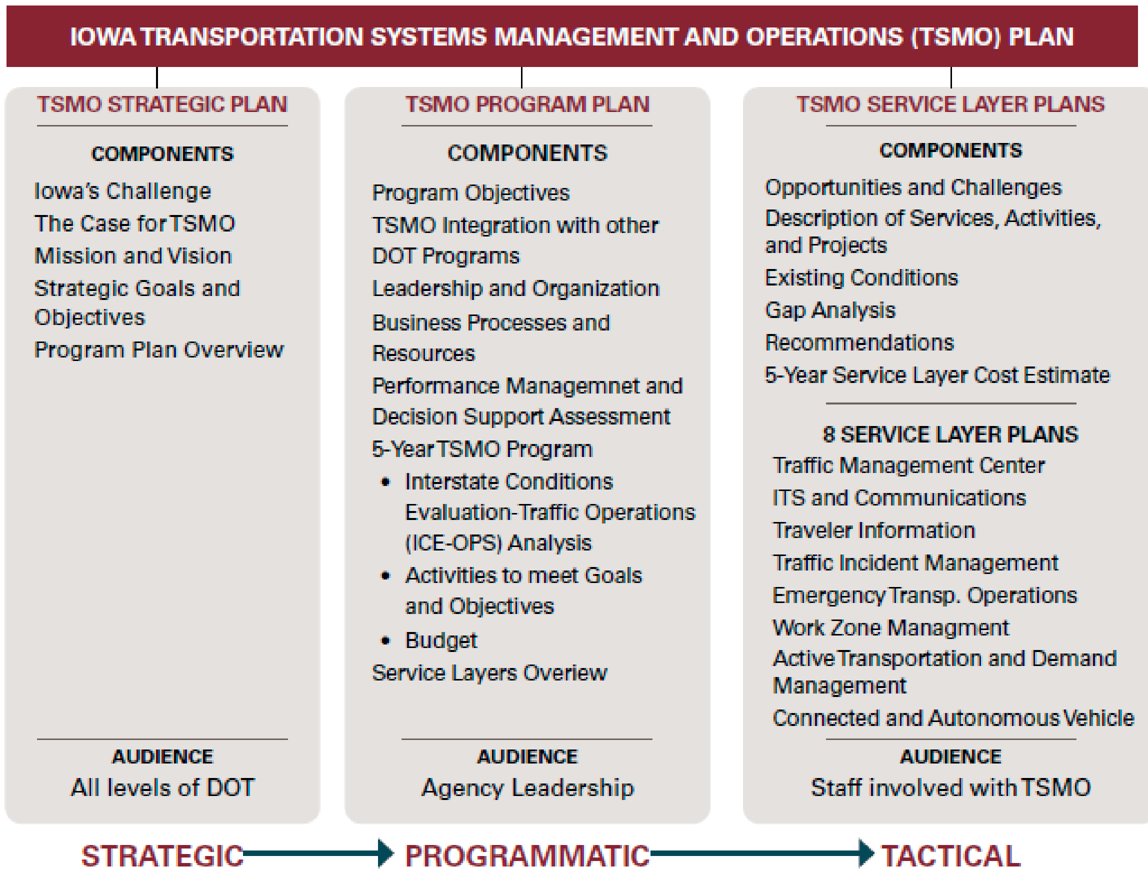

Figure 3: Iowa DOT TSMO Structure
Adapted from **(Lakeside Engineers, LLC and Pat Noyes & Associates 2016)**

In **Figure 4**, TxDOT's TSMO Program components, showcase strategic, programmatic and tactical elements.

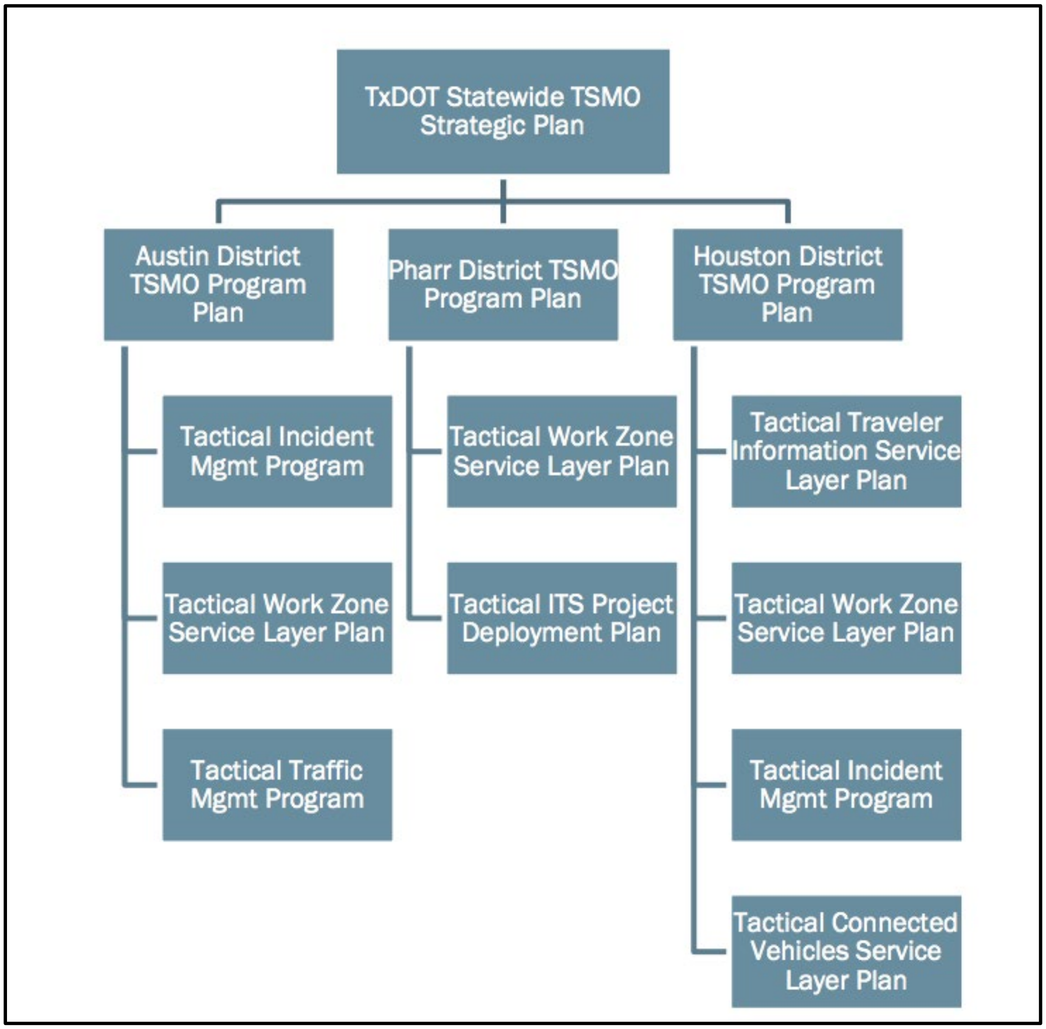

Figure 4: TxDOT TSMO Program Components (Atkins 2017)

Multiple state transportation agencies have documented TSMO strategic, programmatic and tactical elements that are linked with agency strategic goals, including documentation on how TSMO activities are linked with other related formal business processes and plans. Examples include Missouri DOT (Olsson Associate and Cambridge Systematics 2017), Pennsylvania DOT (PennDOT 2018), and Ohio DOT (Gannett Fleming and Burton Planning Services 2017).

Recommendation 2: ***Develop and document overarching TSMO vision for the agency.***

A review of TSMO activity in state DOTs reveals that multiple agencies have adopted and documented TSMO visions in their TSMO plans. The fact that these visions are similar but not identical reflects the importance of a well-thought out vision that aligns well and evolves with the overall strategic vision and priorities of the transportation agency. These visions will shape the kinds of data collected and analytics conducted to support TSMO decision making. **Table 2** shows examples of state DOT TSMO visions. To be effective, these visions must properly align with the overall strategic priorities of the agency in order to guide decision makers to the most appropriate projects to secure the highest return on investment for the agency and the general public.

Table 2: State DOT TSMO Visions/Missions and Strategic Plan Priorities - Examples

TSMO Visions and Missions/Source Documents	**Strategic Plan Visions/Missions**	**State**
Improve *safety* and *mobility* for all modes of transportation by *integrating* planning, operations, and maintenance activities. (Vision, TxDOT TSMO Statewide Strategic Plan, July 2018)(TxDOT n.d.)	Through collaboration and leadership, we deliver a *safe*, *reliable*, and *integrated* transportation system that enables the movement of people and goods. (Mission, TxDOT 2017-2021 Strategic Plan)(TxDOT 2016)	Texas
Iowa's transportation system is *safe*, *efficient* and *reliable*, supporting the state's *environmental* and *economic health* as a result of TSMO. (Vision, Iowa DOT TSMO Program Plan, Feb 2016)(Lakeside Engineers, LLC and Pat Noyes & Associates 2016)	Getting you there *safely*, *efficiently* and *conveniently*. (Mission, Iowa DOT 2018-2020 Strategic Plan)(Iowa DOT n.d.)	Iowa

TSMO strategies and principles guide the efficient management of a *safe* and *reliable* transportation system that supports Ohio's *economic vitality*. (Vision, Ohio DOT TSMO Plan)(Gannett Fleming and Burton Planning Services 2017)	To provide easy movement of people and goods from place to place, we will: (1) Take care of what we have; (2) Make our system work better; (3) improve *safety*, and (4) Enhance *capacity*. (Mission, Ohio DOT Strategic Plan) (ODOT n.d.)	Ohio
PennDOT's vision is a *less congested*, *more reliable* network. The PennDOT TSMO mission is to move people and goods, from Point A to Point B, as *efficiently*, *safely* and *reliably* as possible. (TSMO Plan for Pennsylvania) (PennDOT 2018)	A better quality of life built on transportation excellence (Mission). To provide a sustainable transportation system and quality services that are embraced by our communities and add value to our customers. (Vision, 20/20 Strategic Direction Pennsylvania DOT). (PennDOT n.d.)	Pennsylvania
MoDOT's TSMO Program applies integrated strategies to optimize infrastructure through the implementation of systems, services, real-time information and programs designed to preserve *capacity* and improve *safety* and *reliability* of transportation systems. MoDOT's TSMO program helps get people safely where they want to go. (Mission, Missouri DOT TSMO. Program and Action Plan) (Olsson Associate and Cambridge Systematics 2017)	MoDOT's core values remain *safety*, *service* and *stability*. The department will promote and provide for the safe operation of a 21st century transportation system in Missouri while also keeping MoDOT employees safe in the field. (Focus, Strategic Initiatives for Continuous Improvement) ("The Case for Change | Missouri Department of Transportation" n.d.)	Missouri

Recommendation 3: ***Develop overarching TSMO strategic goals and objectives that are explicitly linked to agency strategic priorities***

Developing TSMO strategic goals and objectives designed to achieve the TSMO vision is important to guide the development of the most appropriate projects. Several agencies have articulated and documented TSMO strategic objectives that guide program activity. Some have articulated how these objectives advance the overall strategic objectives of the agency. **Tables 3 to 6** show examples of TSMO strategic goals and objectives from Iowa DOT, Missouri DOT, and Ohio DOT.

Table 3: Iowa DOT's TSMO Strategic Goals and Objectives
Adapted from ***(Lakeside Engineers, LLC and Pat Noyes & Associates 2016)***

Strategic Goal		Strategic Objective
(1)	Safety	Reduce crash frequency and severity
(2)	Reliability	Improve transportation system reliability, increase system resiliency, and add highway capacity in critical corridors
(3)	Efficiency	Minimize traffic delay and maximize transportation system efficiency to keep traffic moving
(4)	Convenience	Provide ease of access and mobility choices to customers
(5)	Coordination	Engage all DOT disciplines, and external agencies and jurisdictions to proactively manage and operate the transportation system
(6)	Integration	Incorporate TSMO strategies throughout DOT's planning, design, construction, maintenance, and operations activities

Table 4: Missouri DOT TSMO Goals and Objectives
(Olsson Associate and Cambridge Systematics 2017)

Goals	Objectives
Operate MoDOT's existing system efficiently, reliably and effectively through the application of TSMO strategies and programs	Provide for TSMO deployments statewide
Consider TSMO solutions and strategies in every MoDOT project	Include TSMO proactively rather than opportunistically/reactively
Include TSMO in the planning stages of projects and programs	Include planning for operations principles in MoDOT planning process documents
Strengthen TSMO related education and workforce development	Provide new and supplement existing TSMO outreach, training, and recruitment resources for MoDOT staff and partners
Document progress toward meeting each goal and MoDOT's stated tangible results.	Quantify and document TSMO performance measures

Table 5: Ohio DOT TSMO Goals and Objectives
(Gannett Fleming and Burton Planning Services 2017)

Strategic Goal	Strategic Objective
1. Safety	Reduce crash frequency and severity.
2. Reliability	Improve transportation system reliability, increase system resiliency, and improve highway capacity in critical corridors.
3. Efficiency	Minimize traffic delay and maximize transportation system efficiency to keep traffic moving.
4. Access	Provide ease of access and mobility choices to customers.
5. Coordination	Engage all ODOT disciplines and external partners to proactively manage and operate the transportation system.
6. Integration	Incorporate TSMO strategies throughout ODOT's transportation planning, design, construction, maintenance, and operations activities.
7. Security	Leverage TSMO strategies to provide a safe and secure transportation network.

Table 6: TSMO and Access Ohio Goals
(Gannett Fleming and Burton Planning Services, 2017)

TSMO Strategic Goal	Access Ohio Goal					
	Preservation	Mobility & Efficiency	Accessibility & Connectivity	Safety	Stewardship	Economic Development
1. Safety				■		
2. Reliability		■				■
3. Efficiency	■	■			■	■
4. Access			■			
5. Coordination					■	■
6. Integration					■	
7. Security				■		

Recommendation 4: ***Formally integrate TSMO with other DOT programs, with formal document integration***

TSMO, when integrated with agency strategic priorities, can add to return on investment at every stage of the project lifecycle. PennDOT articulates this need to move from the status quo where operations are considered more or less separately from other elements of the project lifecycle to one where it is considered throughout the project life cycle (**Figure 5**). Developing the formal business processes to leverage TSMO in planning, design, construction, maintenance and operations can lead to identifying and taking advantage of existing synergies and augmenting return on investment. MoDOT reflects this intent in their strategic goals: Include TSMO in the planning stages of projects and programs (**Table 4**) and articulates explicitly TSMO actions and responsibilities aligned with various agency units (**Table 7**).

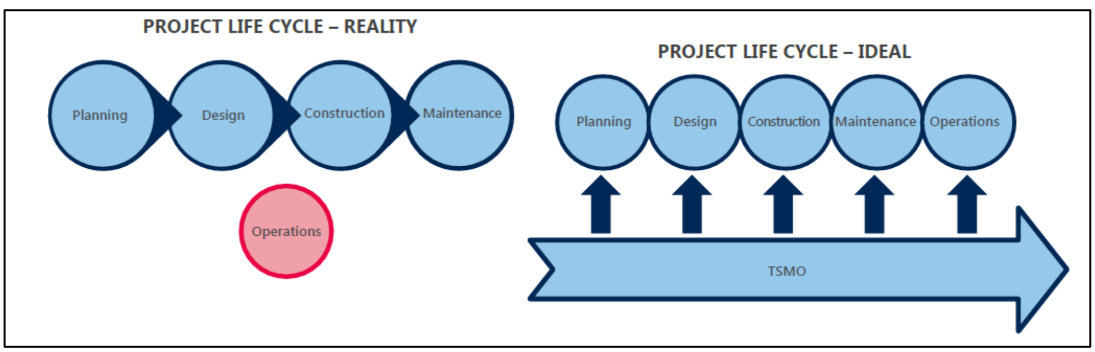

Figure 5: Importance of Considering Operations throughout Project Lifecycle (PennDOT 2018)

Table 7: TSMO Actions and Responsibilities Aligned with various Agency Units (Olsson Associate and Cambridge Systematics 2017)

Action	Responsibilities
TMC	Execute and oversee real-time transportation operational support and dissemination of traveler information
Maintenance	Implement maintenance-related TSM&O strategies; provide feedback and effort for continual improvement of these strategies and tools
Traffic Operations	Implement traffic operations-related TSM&O strategies; provide feedback and effort for continual improvement of these strategies and tools
Transportation Planning	Include TSM&O along with other traditional transportation improvement strategies in all planning efforts
Design	Consider TSM&O as an essential element of design, either as a direct improvement for the specific application or as an opportunity for the continuation of existing TSM&O strategies
Construction	Consult personnel with the appropriate expertise when modifying a design or during construction inspection of TSM&O support infrastructure
Information Systems	Provide oversight and management of field and central communications systems, computer and software, and other information systems resources
Human Resources	Incorporate relevant related skills and experience into position descriptions where TSM&O expertise is needed; assist with training programs to improve the knowledge, skills, and abilities of existing operations personnel

With respect to planning, the MoDOT TSMO Program and Action Plan notes the following: "Planning for operations places focus on how TSMO strategies and solutions are incorporated into the planning process in support of improving transportation system reliability and efficiency. The planning process can be defined quite broadly in this context, and it includes the formal planning processes with DOTs and MPOs, and the process that individual projects and programs go through in their executions. It also includes elements of the ITS architecture design and the use of the systems engineering process. Areas of detail in this section include (Olsson Associate and Cambridge Systematics 2017):

- Integrating TSMO into the planning and programming processes
  - STIPs and TIPs
  - Congestion management processes
  - Regional concepts of transportation operations (often owned by MPOs)
  - Performance measurement and management programs

- Statewide and regional ITS architecture development and maintenance
- Application of the systems engineering process
- Advancing operations through the application on CMM.

Recommendation 5: ***Develop business case for TSMO applications across project lifecycle and multimodal initiatives of regional significance***

For several U.S. metropolitan areas, traffic congestion has become something that is managed to reduce the rate of worsening system conditions on the highway network, rather than to reverse directions and actually improve system conditions, because of the relentless growth in metropolitan populations and travel demand. Tactical and reactive TSMO approaches, important because of their urgency in dissipating bottlenecks, are in the critical business of monitoring travel hotspots, discovering high accident areas, detecting hot spots of congestion and developing and delivering TSMO solutions as rapidly as possible. At the same time, there are other opportunities to adopt TSMO as a core business process over the project lifecycle and envision bold, creative and transformative projects of regional significance, involving mass movement of people and freight, which will shift the needle on transportation system performance in notable ways. Such longer-term, creative and strategic initiatives stand to increase the return on investment to transportation agencies and transportation system users in non-incremental and transformative ways.

Intentional innovation and explicit searches for such multimodal solutions, with the development of a business case for pursuing them, will involve leadership from within state transportation and other agencies, and collective efforts from Planning, Operations, Strategic Management and other units. The agencies that recognize the value of these kinds of transformational projects and lead in identifying and implementing them will position themselves to gain competitive advantages over others that are singularly focused on managing toward a slower rate of worsening congestion. It is, therefore, imperative that a business case is developed for TSMO applications across the project lifecycle and to multimodal initiatives of regional significance. It is also important that this kind of innovative thinking becomes a routine part of agency decision making with the intent to reverse the slowly decaying performance of highway systems in several metropolitan areas. A heavily tactical approach to TSMO may not capture strategic-level and planning-level opportunities for augmenting return on investment.

Figure 6 captures these recommendations in a next-level TSMO Decision-Making Map reflecting enhanced strategic and programmatic elements, building upon existing tactical elements, and with formal linkages to related business processes and plans within the agency.

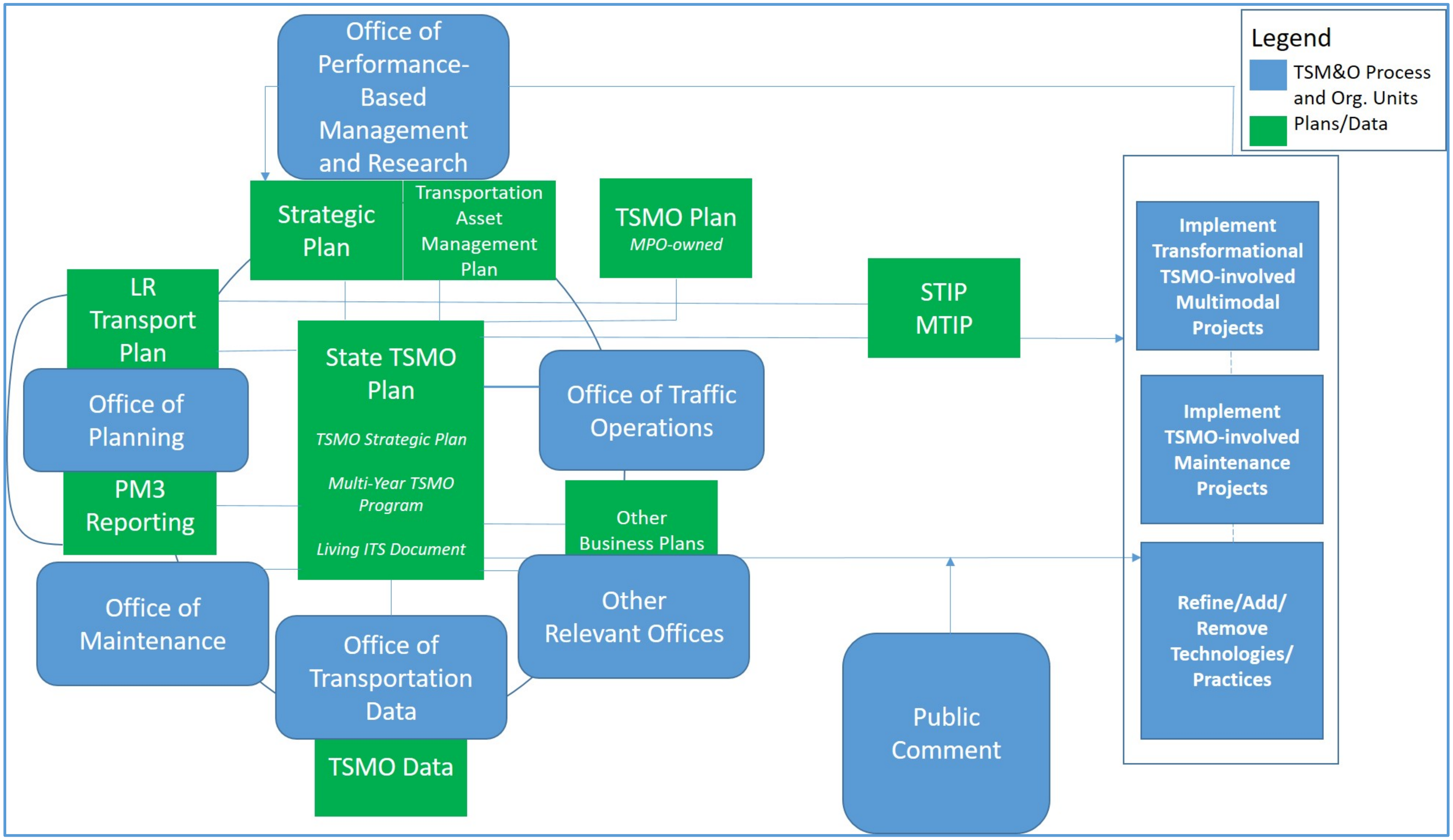

Figure 6: Next-Level TSMO Map

PART III: GDOT PM3 TOOL

In 2012, MAP-21 legislation introduced a performance-based approach to decision making for the nation's transportation system. Transportation Performance Management (TPM) is defined by the Federal Highway Administration (FHWA) as a strategic approach that uses system information to make investment and policy decisions to achieve national performance goals. The FHWA released rules establishing TPM measures in June 2017, requiring all states, metropolitan planning organizations, and public transportation agencies to develop plans to document strategies and investments to address performance needs, incorporate these into the transportation planning and decision-making process, establish and report on targets for each measure, and make significant progress toward achieving these targets.

Performance Metrics

Under Section 1203 of MAP-21, as amended by the FAST Act, Congress established seven national goals and directed the FHWA to establish national performance measures for the Federal-aid highway program, promulgated through rulemaking, in support of six out of the seven goals established in MAP21. To meet the new statutory requirements, FHWA pursued a number of significant rulemakings. Collectively, the rules establish performance management requirements that address safety (PM1), infrastructure condition (PM2), system performance, traffic congestion, on-road mobile source emissions, and freight movement (PM3) (FHWA 2018a). This study focuses on the reporting of PM3 metrics, which is the responsibility of the Office of Planning. Per MAP-21, GDOT and other state DOTs are required to set targets for the six performance measures shown in **Table 8** (FHWA 2018a).

Table 8: Summary of PM3 Metrics and Targets for GDOT

Performance Measure	Geographic Extent	Applicable Roadways	Timeframe
Percent of person-miles traveled on the Interstate that are reliable	Statewide	Interstate	2-year and 4-year targets
Percent of person-miles traveled on the non-Interstate NHS that are reliable	Statewide	Non-Interstate	4-year target
Truck Travel Time Reliability (TTTR) Index	Statewide	Interstate	2-year and 4-year targets
Annual Hours of Peak Hour Excessive Delay (PHED) Per Capita*	Atlanta Urbanized Area	Entire NHS	4-year target
Percent of Non-Single Occupancy Vehicle (SOV) Travel*	Atlanta Urbanized Area	All Roads	2-year and 4-year targets
Total Emissions Reduction	Statewide	All Roads	2-year and 4-year targets

*: GDOT, Atlanta Regional Commission and Cartersville-Bartow Metropolitan Planning Organization are required to establish and report single targets for Annual Hours of Peak Hour Excessive Delay (PHED) Per Capita and Percent of Non-Single Occupancy Vehicle (SOV) Travel for Atlanta urbanized area.

The following section describes the six PM3 measures in more detail and explains how they are calculated (FHWA 2018b) .

(1) Percent of person-miles traveled on the interstate that are reliable

See (2) below.

(2) Percent of person-miles traveled on the non-interstate National Highway System (NHS) that are reliable

The above two performance measures assess the percent of person-miles traveled on the interstate or non-interstate NHS that are reliable. Level of Travel Time Reliability (LOTTR) is defined as the ratio of the longer travel times (80^{th} percentile) to a normal travel time (50^{th} percentile) over segments of all applicable roads, between the hours of 6am and 8pm each day. The measures are expressed as the percent of person-miles traveled on the interstate or non-interstate NHS that are reliable. Person-miles account for people traveling in buses, cars, and trucks over these roadway segments.

(3) Truck Travel Time Reliability (TTTR) Index

The TTTR performance measure assess the reliability index for trucks traveling on the interstate. A TTTR ratio is generated by dividing the 95th percentile travel time by a normal travel time (50th percentile) for each segment of the interstate system over specific time period throughout weekdays and weekends. This is averaged across the length of all interstate segments in the state or MPO planning area to determine the TTTR Index.

(4) Annual Hours of Peak Hour Excessive Delay (PHED) Per Capita

This measure quantifies traffic congestion per capita on the NHS. The threshold for excessive delay is based on the travel time at 20 miles per hour or 60% of the posted speed limit travel time, whichever is greater. The total excessive delay metric is developed using weekday morning (6am – 10am) and afternoon (3pm to 7pm) periods, weighted by vehicle volumes and occupancy.

(5) Percent of Non-Single Occupancy Vehicle (SOV) travel

This measure quantifies non-SOV travel in specific urbanized areas. This may include travel via carpool, van, public transportation, commuter rail, walking, or bicycling as well as telecommuting.

(6) Total Emissions Reduction

Total emissions reduction is calculated by summing the 2-year and 4-year totals of emissions reductions of applicable criteria pollutants and precursors, in kilograms per day, for all projects funded with CMAQ funds.

Data Sources

The data for the tool was obtained from NPMRDS, GDOT, the American Community Survey, and the CMAQ Public Access Database (**Table 9**).

Table 9: PM3 Tool – Data Sources

23 CRF 490	Performance Measures	Metric	Data Sources
*NHPP	Travel Time Reliability (Interstate)	Level of Travel Time Reliability (LOTTR)	• NPMRDS • GDOT
	Travel Time Reliability (Interstate)		
+NHFP	Truck Travel Time Reliability	TTTR Index	• NPMRDS
CMAQ	Annual Hours of Peak-Hour Excessive Delay Per Capita	Peak Hour Excessive Delay (PHED)	• NPMRDS • GDOT • American Community Survey
	Percent of Non SOV Travel	Non-Single Occupancy Vehicle Travel (SOV)	• American Community Survey
	Total Emission Reductions	N/A	• CMAQ Public Access Database

*NHPP: National Highway Performance Program

+NHFP: National Highway Freight Program

Architecture and Technical Issues

Table 10 provides a brief description of the architecture of the PM3 tool.

Table 10: PM3 Tool – Architecture

Element	**Description**
Language	Python 3.7 with libraries: numpy, pandas and heapq
Input Data Format	GUI with drop down menus
Output Data Format	Text (CSV) output – multiple files
Run Time	24 to 48 hours for 12 months of data
Need for Internet Access (Y/N)	Y – to obtain input data, but not to run the tool
Required IT Support	Provide workstation and install dependencies

The PM3 tool has large file storage (at least 500 GB) and long processing time requirements, which makes a dedicated workstation, or server, ideal for running. The tool relies on file caching for storing intermediate processed data, which is helpful for managing re-run times.

Data Acquisition

Table 11 summarizes the data acquisition process for the tool. In each performance metric category, once the data identified in the first row is downloaded from the Internet, all the other data in that category are also downloaded.

Table 11: Data Acquisition Process for PM3 Tool

Performance Measure	Data Requirements	Source	Acquisition Process
Percent of person-miles traveled on the interstate (& Non –interstate NHS) that are reliable	Travel time for all traffic	NPMRDS	Web download
	Segment lengths	NPMRDS	Web download
	Annual traffic volume data	NPMRDS	Web download
	Average vehicle occupancy	GDOT/FHWA	Built in source code
Truck Travel Time Reliability Index	Travel time for trucks	NPMRDS	Web download
	Segment lengths	NPMRDS	Web download
Annual Hours of Peak-Hour Excessive Delay per Capita	Travel time for all traffic	NPMRDS	Web download
	Segment lengths	NPMRDS	Web download
	Annual vehicle classification data	NPMRDS	Web download
	Average vehicle occupancy	GDOT	Built in source code
	Hourly volume estimates	GDOT	Manual formatting
	Posted speed limits	GDOT	Web download
	Urbanized area population	Census	Web download
Percentage Non-SOV Travel	Total commuting population	Census	Web download
	Population driving alone	Census	Web download
Total Emission Reduction	Emission reduction for each pollutant for each applicable project	CMAQ public access system	Web download

Running the Tool

The PM3 Manual in **Appendix C** provides detailed directions on how to run the tool. It presents details on obtaining the data, operating the tool, and generating performance metrics for PM3 reporting.

SUMMARY

MAP-21 and the FAST Act have formalized a performance-based planning and decision-making paradigm for transportation, introducing seven national transportation performance goals. This study reviews the literature to identify best practices for Transportation System Management and Operations (TSMO) – categorized by the three critical planning elements for TSMO – (1) Strategic, (2) Programmatic, and, (3) Tactical, and the six dimensions for a successful TSMO plan - (1) Business Processes, (2) Systems and Technology, (3) Performance Measures, (4) Culture, (5) Organization and Workforce, and (6) Collaborations. TSMO practices of State Departments of Transportation (DOTs) across the country highlight the importance of engaging in well integrated strategic, programmatic and tactical TSMO, for effective transportation system performance management.

To this end, the following recommendations were offered to enhance TSMO at GDOT: (1) Develop and document strategic, programmatic and tactical elements of TSMO Program to integrate TSMO well within the agency. Communicate these appropriately to internal and external stakeholders; (2) Develop and document overarching TSMO vision for the agency; (3) Develop overarching TSMO strategic goals and objectives that are explicitly linked to agency strategic priorities; (4) Formally integrate TSMO with other DOT programs, with formal document integration; and, (5) Develop business case for TSMO applications across project lifecycle and multimodal initiatives of regional significance.

A performance management tool, the PM3 Tool, was developed to support PM3 reporting. The PM3 tool, an analytic and reporting tool, takes data from the National Performance Management Research Data Set (NPMRDS), GDOT, the U.S. National Census and the Congestion Mitigation and Air Quality (CMAQ) Public Access Database to calculate six performance metrics. The

PM3 tool calculates travel time reliability on interstate and non-interstate routes on the National Highway System (NHS), truck travel time reliability, and annual hours of peak-hour excessive delay per capita, and reports on percent of non-SOV travel, and total emission reductions.

Using the PM3 tool, state DOTs can calculate PM3 measures and use them in setting future performance targets, while working strategically, programmatically and tactically to improve transportation system performance.

GLOSSARY OF TERMS

CMM: Capability Maturity Model

CMAQ: Congestion Mitigation and Air Quality

DOT: Department of Transportation

FHWA: Federal Highway Administration

FAST: Fixing America's Transportation System

GDOT: Georgia Department of Transportation

MAP-21: Moving Ahead for Progress in the 21st Century

MPO: Metropolitan Planning Organization

NHS: National Highway System

NHFP: National Highway Freight Program

NHPP: National Highway Performance Program

NPRMDS: National Performance Research Management Dataset

TPM: Transportation Performance Management

TSMO: Transportation Systems Management and Operations

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Appendix

Appendix A: Effective TSMO Practices

RP 18-29

Transportation Performance Management for System Operations: Development of Processes, Tools, Measures & Targets

Effective Practices Map

Prepared for: **Georgia Department of Transportation**
TIM: Sarah Lamothe/Habte Kassa | PM: Trang Mai | RIM: Binh Bui
Prepared by: **Georgia Institute of Technology**
PI: Adjo Amekudzi-Kennedy, Ph.D. | Co-PI: Russell Clark, Ph.D. | GRA: Prerna Singh

January 2019

Introduction

Three critical elements of TSMO planning:

Strategic

Programmatic

Tactical

Six dimensions of a successful TSMO plan:

Business Processes

System and Technology

Performance Measures

Culture

Organization & Workforce

Collaborations

31 Best Practices identified in the field of TSMO

Effective Practices Distribution

Strategic	Programmatic	Tactical
12	6	13

Business Processes	System and Technology	Performance Measures	Culture	Organization & Workforce	Collaborations
18	6	6	10	2	8

Three Key Elements of TSMO Planning

Strategic elements

- The business case for TSMO
- Vision and Program Mission
- Strategic Goals and Performance Objectives
- Strategic Focus Area or Priority Functions

Programmatic elements

- Leadership and Organizational structure
- Programmatic Objectives
- Staffing and Workforce Needs
- Business Process and Management Strategies
- TSMO Culture in the Agency
- Financial Resource Management

Tactical elements

- Prioritized Services, Activities and Projects
- Implementation Policies and Guidelines
- Multi-year Investment Plan
- Performance Assessment

[FHWA, Developing and Sustaining a Transportation Systems Management & Operations Mission for Your Organization A Primer for Program Planning. September 2017]

Six Key Dimensions of TSMO

Business Processes – including formal scoping planning, programming, and budgeting;

Systems and Technology – including systems architecture, standards, interoperability, and standardization and documentation;

Performance Measurement – including measures definition, data acquisition, analysis, and utilization;

Culture – including technical understanding, leadership, policy commitment, outreach, and program authority;

Organization and **Workforce** – including organizational structure, staff capacity, development, and retention;

Collaboration – including relationships with public safety agencies, local governments, MPOs, and the private sector.

Effective Practices by TSMO Planning Element

Figure 1: Distribution of the Effective Practices by State based on the Three Critical Elements of TSM&O planning

Effective Practices by TSMO Dimension

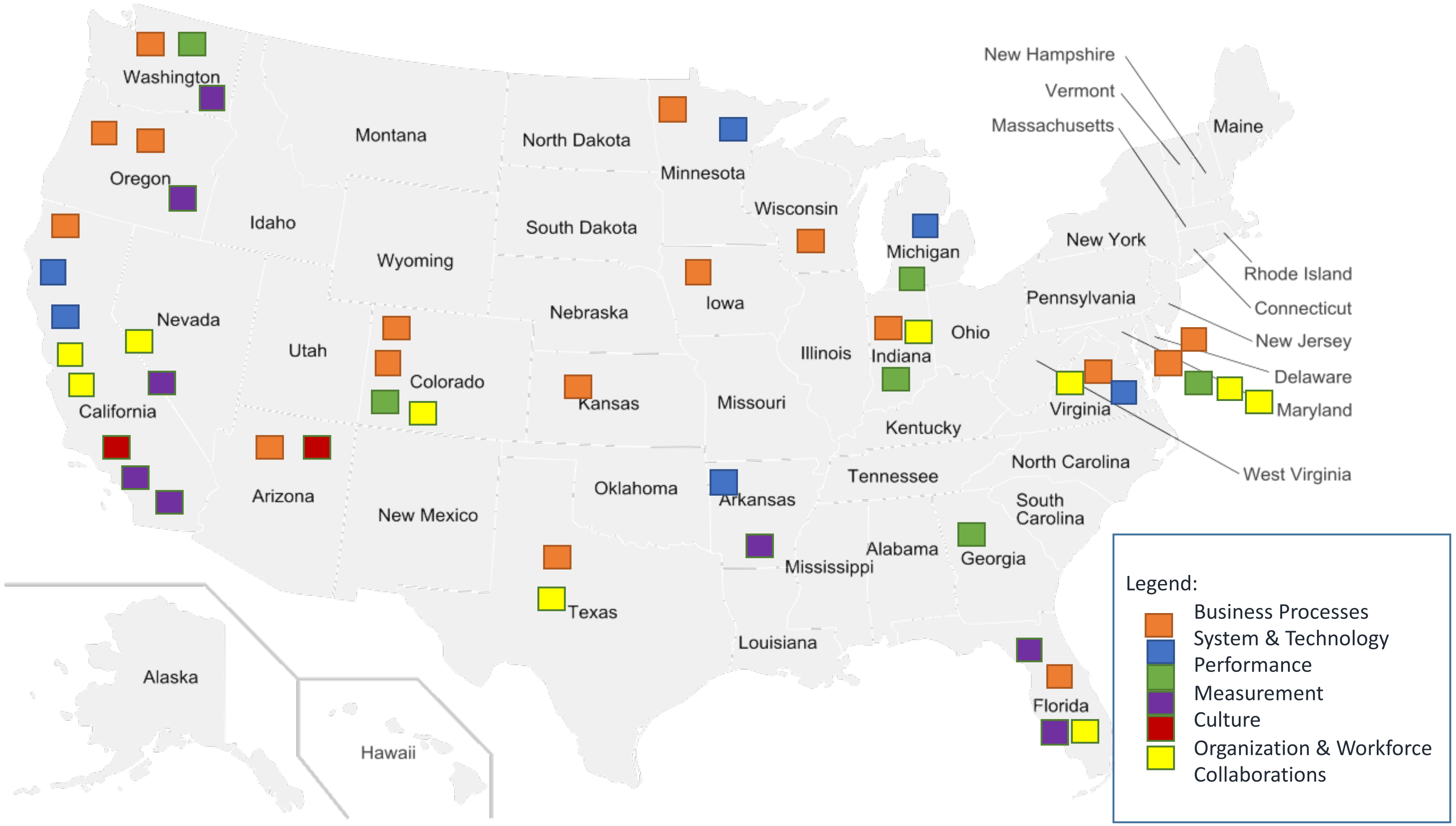

Figure 2: Distribution of the Effective Practices by State based on the Six Key Dimensions of TSM&O Planning

Effective Practices

Arizona DOT TSMO Division

Key Element: Programmatic

Key Dimension: Organization & Workforce

Source Document:

- Developing and Sustaining a Transportation Systems Management & Operations Mission for Your Organization A Primer for Program Planning

Focus Points:

- Developed a new TSMO division in 2015
- Shifted core functions such as roadway safety improvements, ITS operations, traffic signal systems, pavement conditions, traffic operations center, incident management, emergency management, and innovative technologies under the TSMO division

Reference Documents:

- Latest ADOT Organizational chart
- Related Press Release: *ADOT division focuses on efficiencies in operating, sustaining a reliable transportation system for Arizona, Jan 2016*

Arkansas-Northwest Arkansas regional ITS architecture

Key Element: Tactical

Key Dimensions: System and Technology; Collaborations

Source Document:

- Applying a Regional ITS Architecture to Support Planning for Operations: A Primer, FHWA, Feb 2012

Focus Points:

- Fayetteville-Springdale, Arkansas (Northwest Arkansas) regional ITS architecture
- The information from this regional ITS architecture could be used to support the identification of current and future data sources for tracking operations objectives.
- The MPO is potentially collecting data from more than 20 different planned data sources

Reference Documents:

- Northwest Arkansas Regional Planning Council, “Final Northwest Arkansas Regional ITS Architecture” Web Site, March 2007

California- Special Event Cost Management Strategy, Los Angeles

Key Element: Tactical

Key Dimension: Business Processes; Culture; Collaboration

Source Document:

- Improving Business Processes for More Effective Transportation Systems Management and Operations

Focus Points:

- Case Study: Special Event Cost Management Strategy Results in Improved Cost Tracking and Asset Allocation in LA
- Careful documentation of costs during special events in LA used to justify increase in budget allocation
- Contracts with special event venues with recurring events to improve the efficiency of the budget process

Reference Documents:

- LADOT Special Events Webpage

California-Caltrans Organizational Integration for TSMO

Key Element: Programmatic

Key Dimensions: Culture, Organization & Workforce

Source Document:

- Developing and Sustaining a Transportation Systems Management & Operations Mission for Your Organization A Primer for Program Planning

Focus Points:

- Focus on developing a TSMO program on organizational integration
- Conducting regional operations forums to get planners, operations staff and their partners to work better together

Reference Documents:

- Caltrans TSMO webpage
- Caltrans regional operations forum

California-Caltrans Corridor System Management Plan

Key Element: Strategic

Key Dimensions: System and Technology; Collaborations

Source Document:

- Developing and Sustaining a Transportation Systems Management & Operations Mission for Your Organization A Primer for Program Planning

Focus Points:

- The corridor system management plan is unique in its ability to analyze existing corridor conditions, to forecast corridor performance through scenario testing utilizing complex traffic simulation models on a corridor-wide scope, and to recommend consensus-driven long-range implementation strategies.

Reference Documents:

- Caltrans, Corridor System Management Plans

California and Nevada - Coordination on Interstate during winter closures

Key Element: Tactical

Key Dimensions: Collaborations; Culture

Source Document:

- Improving Business Processes for More Effective Transportation Systems Management and Operations

Focus Points:

- Case Study: Improved Coordination on I-80 - Provides More Advanced Notice to Travelers and Freight Movers of Winter Closures in Nevada and California
- Study addresses the following business processes: 1) Defined roles and responsibilities, 2) Framework or agreements for multiagency coordination

Reference Documents:

- Interstate 80 Winter Operations Coalition webpage

Colorado DOT integration of TSMO evaluations in its Project Development Process

Key Element: Programmatic

Key Dimensions: Business Processes; Culture

Source Document:

- Developing and Sustaining a Transportation Systems Management & Operations Mission for Your Organization A Primer for Program Planning

Focus Points:

- Focus is on improved traffic operations and on continual process improvements
- Developed an operations evaluation process as an essential element of the project development process for new infrastructure projects.
- Evaluation consists of 1) a safety analysis, 2) an operations analysis, and 3) an ITS analysis.

Reference Documents:

- CDOT TSMO Evaluation webpage
- Case Study in Report FHWA-HOP-16-018

Dallas Region Annual Evaluation of ITS Priorities

Key Element: Tactical

Key Dimensions: Business Process; Culture

Source Document:

- Developing and Sustaining a Transportation Systems Management & Operations Mission for Your Organization A Primer for Program Planning

Focus Points:

- The North Central Texas Council of Governments (NCTCOG) reviews its ITS plan annually
- A stakeholder task force uses performance measurement data to make decisions about whether to add or remove regional ITS projects and proposed deployments from the plan

Reference Documents:

- North Central Texas Council of Governments, North Central Texas Intelligent Transportation System (ITS) Strategic Deployment Plan, May 2016

Delaware- Identification of Strategies to Support TSMO Goals and Objectives

Key Element: Tactical

Key Dimension: Business Processes

Source Document:

- Developing and Sustaining a Transportation Systems Management & Operations Mission for Your Organization A Primer for Program Planning

Focus Points:

- DVRPC, the metropolitan planning organization (MPO) for the Philadelphia region, developed a *Transportation Operations Master Plan* outlining a long-range vision for transportation operations for the region.
- The plan includes goals, objectives, and strategies to accomplish the regional goals and vision. A financial analysis is conducted to estimate the costs to construct, operate, and maintain these initiatives.

Reference Documents:

- DVRPC, *Transportation Operations Master Plan*, 2009.

Denver Regional Council of Governments- Regional Concept of Transportation Operations

Key Element: Strategic

Key Dimensions: Business Processes; Performance Measures

Source Document:

- Developing and Sustaining a Transportation Systems Management & Operations Mission for Your Organization A Primer for Program Planning

Focus Points:

- Within the regional concept of transportation operations, strategic goals and associated performance objectives for TSMO are identified
- Program initiatives and performance measures are identified to link the objectives with the goals

Reference Documents:

- Denver Regional Council of Governments, *Regional Concept of Transportation Operations*, Adopted August 15, 2012

Florida TSMO Strategic Plan

Key Element: Strategic

Key Dimensions: Business Processes; Culture

Source Document:

- Developing and Sustaining a Transportation Systems Management & Operations Mission for Your Organization A Primer for Program Planning

Focus Points:

- The Plan describes Florida's challenges, including population growth, traffic fatalities, and safety for older drivers
- Describes the value of TSMO in terms of benefit-cost ratios of intelligent technologies, and the economic benefits associated with ITS and operations investments

Reference Documents:

- Florida's Statewide Strategic TSMO Plan. August 2017

Florida DOT Rapid Incident Scene Clearance (RISC)

Key Element: Tactical

Key Dimension: Collaborations

Source Document:

- Creating an Effective Program to Advance Transportation System Management and Operations

Focus Points:

- Public-private partnership that utilizes both incentive payments and disincentive liquidated damages to ensure shortened clearance times for heavy vehicle wrecks.
- Program is an implementation of TSM&O strategies and have reduced the average clearance times by 100 percent.

Reference Documents:

- FDOT RISC webpage

Florida Road Ranger Program Expansion

Key Element: Tactical

Key Dimensions: Business Processes; Collaborations

Source Document:

- Improving Business Processes for More Effective Transportation Systems Management and Operations

Focus Points:

- Case Study: Florida Road Ranger Program Expands Using Alternative Funding Sources
- Business Processes involved: 1) Funding for program and strategies, 2) Contracting and procurement processes to support programs and strategies.

Reference Documents:

- Press Release: FDOT expands Road Ranger service on I-10 in Northeast Florida
- FDOT Road Rangers Webpage

Georgia DOT Towing and Recovery Incentive Program (TRIP)

Key Element: Tactical

Key Dimension: Collaborations

Source Document:

- Creating an Effective Program to Advance Transportation System Management and Operations

Focus Points:

- Public-private partnership that utilizes both incentive payments and disincentive liquidated damages to ensure shortened clearance times for heavy vehicle wrecks.
- Program is an implementation of TSM&O strategies and has reduced the average clearance times by 100 percent.

Reference Documents:

- GDOT TRIP webpage
- GDOT TRIP Evaluation, 2011

Indiana Maintenance decision support system

Key Element: Tactical

Key Dimensions: Business Processes; Performance Measures; Culture

Source Document:

- Improving Business Processes for More Effective Transportation Systems Management and Operations

Focus Points:

- Case Study: Maintenance Decision Support System helps in the development of Winter Maintenance Budget in Indiana
- Business Processes focused on: 1) Funding and resource needs identified as part of program budget, 2) Performance outcomes informing program needs.

Reference Documents:

- Indiana DOT Research Documentation: Implementing a winter maintenance decision support system, 2009
- Indiana DOT Maintenance Decision Support System Final Report, 2009

Iowa TSMO Program Plan

Key Element: Strategic

Key Dimension: Business Processes

Source Document:

- Developing and Sustaining a Transportation Systems Management & Operations Mission for Your Organization A Primer for Program Planning

Focus Points:

- A three-tiered approach by Iowa DOT for TSMO program planning served as key basis for recommendations for FHWA TSMO Program Planning primer
- The three segments include 1)Strategic Plan, 2) Program Plan, and 3) service layer plans, mirroring the Strategic, Programmatic, and Tactical elements from FHWA primer

Reference Documents:

- Iowa Department of Transportation, *Iowa Transportation Systems Management and Operations Program Plan*, February 2016.

Kansas Speedway Special-Event Traffic Management Planning

Key Element: Tactical

Key Dimension: Business Processes

Source Document:

- Improving Business Processes for More Effective Transportation Systems Management and Operations

Focus Points:

- Case Study: Kansas Speedway Special-Event Traffic Management Planning Reduces Patrol Resource Requirements for On-Scene Traffic Management
- Business Processes focused on: 1) Planning and program plan, 2) Resource management, 3) Lessons learned to inform programing and resource needs.

Reference Documents:

- Volz, M.A. and B.J. Nicholson, "Kansas Speedway Event Management Using ITS, 2002
- FHWA, Managing Travel for Planned Special Events: First National Conference Proceedings, 2005

Maricopa Association of Governments (MAG) Procedures for ITS Project Prioritization

Key Element: Programmatic

Key Dimension: Business Processes

Source Document:

- Developing and Sustaining a Transportation Systems Management & Operations Mission for Your Organization A Primer for Program Planning

Focus Points:

- MAG's ITS project selection process includes extensive involvement of various policy and technical committees as well as the public
- The ITS committee and the transportation review committee review projects for funding and inclusion in the transportation improvement program

Reference Documents:

- FHWA, *Programming for Operations: MPO Examples of Prioritizing and Funding Transportation Systems Management & Operations Strategies*, FHWA-HOP-13-050 (Washington, DC: September 2013).
- MAG Regional ITS Architecture webpage

Maryland TSMO Strategic Implementation Plan

Key Element: Strategic

Key Dimension: Culture

Source Document:

- Developing and Sustaining a Transportation Systems Management & Operations Mission for Your Organization A Primer for Program Planning

Focus Points:

- In developing a TSMO program, Maryland DOT SHA clearly defined its TSMO program vision and mission, along with associated goals and objectives to support attainment of that vision.

Reference Documents:

- Maryland DOT, *Maryland Transportation Systems Management and Operations Strategic Implementation Plan*, August 2016.

Maryland's Coordinated Highways Action Response Team (CHART)

Key Element: Strategic

Key Dimensions: Business Processes; Performance Measures; Collaborations, Culture

Source Document:

- Improving Business Processes for More Effective Transportation Systems Management and Operations

Focus Points:

- Case Study: Maryland's Coordinated Highways Action Response Team Business Plan and Business Processes Emphasize Implementation-Ready Projects to Improve Freeway Operations
- Business Processes focused on: 1) Program plan and priorities, 2) Budget and programming to support program needs, 3) Program alignment to agency mission, goals, and objectives, 4) Coordination among program planning to other key planning activities (that is, long-range plan), 5) Performance outcomes that influence planning and programming

Reference Documents:

- Maryland SHA TSMO Strategic Implementation Plan, Aug 2016
- Maryland SHA Coordinated Highways Action Response Team (CHART) webpage

Maryland Work Zone Performance Management Program

Key Element: Tactical

Key Dimension: Performance Measures

Source Document:

- Improving Business Processes for More Effective Transportation Systems Management and Operations

Focus Points:

- Case Study: Maryland Work Zone Performance Management Program Uses New Data Sources to Monitor and Analyze Work Zone Impacts
- Business Processes addressed: 1) Coordination involving multiple divisions and groups, 2) Program plan and review processes, 3) Performance measures, metrics, and data informing practices and procedures

Reference Documents:

- Maryland DOT, Work Zone Analysis Guide, 2008
- NCHRP, Best Practices in Work Zone Assessment, Data Collection and Performance Evaluation, 2010

Michigan DOT- Work Zone Traffic Control Modeling

Key Element: Tactical

Key Dimensions: Performance Measures; System and Technology

Source Document:

- Improving Business Processes for More Effective Transportation Systems Management and Operations

Focus Points:

- Case Study: Work Zone Traffic Control Modeling provides valuable insight to Construction Staging and Scheduling in Michigan
- Established processes for using modeling to evaluate the impacts of upcoming work zones and to develop work zone traffic control plan alternatives

Reference Documents:

- FHWA, Traffic Analysis Tools Volume IX: Work Zone Modeling and Simulation A Guide for Analysts webpage

Minnesota Statewide Regional ITS Architecture

Key Element: Strategic

Key Dimensions: Business Process; System and Technology

Source Document:

- Applying a Regional ITS Architecture to Support Planning for Operations: A Primer, FHWA, Feb 2012

Focus Points:

- Incorporates operations objectives from the transportation planning process into the regional ITS architecture
- Minnesota views ITS as a tool to implement the goals and policies of the statewide plan and updates the architecture in coordination with the plan.

Reference Documents:

- Minnesota Department of Transportation, Minnesota Statewide Regional ITS Architecture, 2018
- Minnesota DOT Regional ITS Architecture update webpage

Oregon DOT Transportation System Planning Guide

Key Element: Programmatic

Key Dimensions: Business Processes; Collaborations

Source Document:

- Developing and Sustaining a Transportation Systems Management & Operations Mission for Your Organization A Primer for Program Planning

Focus Points:

- Jurisdictions throughout Oregon are required to prepare and adopt regional or local transportation plans that serve as the transportation element for their comprehensive plans
- Developed Transportation System Planning Guidelines, which include best planning practices to strengthen their plans

Reference Documents:

- ODOT planning and technical guidance webpage

Portland Metro, Regional TSMO Plan, 2010-2020

Key Element: Strategic

Key Dimension: Business Processes

Source Document:

- Developing and Sustaining a Transportation Systems Management & Operations Mission for Your Organization A Primer for Program Planning

Focus Points:

- The plan identifies four key functional area priorities: 1) Multimodal traffic management. 2)Traveler information. 3) Traffic incident management. 4)Transportation demand management.
- For each functional area, the plan identifies strategies and projects that improve the operation of the existing infrastructure and manage demand on the transportation system using a 10-year planning horizon.

Reference Documents:

- Regional Transportation System Management and Operations 2010-2020, Portland

San Diego Association of Governments (SANDAG) ITS Architecture

Key Element: Strategic

Key Dimensions: System and Technology; Business Process

Source Document:

- Applying a Regional ITS Architecture to Support Planning for Operations: A Primer, FHWA, Feb 2012

Focus Points:

- SANDAG used its architecture to support the initial definition and development of its Integrated Corridor Management (ICM) program.
- The decision support system defined for the ICM program helped the regional ITS architecture better reflect its use to support regional traffic management.

Reference Documents:

- California PATH Research Report: San Diego I-15 Integrated Corridor Management (ICM) System: Phase I, 2008

Southeast Wisconsin- Regional Transportation Operations Plan for Short-Range Priorities

Key Element: Tactical

Key Dimension: Business Processes

Source Document:

- Developing and Sustaining a Transportation Systems Management & Operations Mission for Your Organization A Primer for Program Planning

Focus Points:

- The MPO developed a Regional Transportation Operations Plan (RTOP) as a short-range plan identifying system operations measures and actions recommended for implementation over a five-year period.

Reference Documents:

- Southeastern Wisconsin Regional Planning Commission, *Regional Transportation Operations Plan for Southeastern Wisconsin: 2012-2016.*

Virginia VDOT Statewide Operations Program Plan (SOPP)

Key Element: Strategic

Key Dimension: Business Process

Source Document:

- Creating an Effective Program to Advance Transportation System Management and Operations

Focus Points:

- Used the CMM model to develop the new SOPP
- It provided the framework for both VDOTs Central Office and regional evaluations – and the development of specific actions that are being embodied in both ongoing technical and policy development.

Reference Documents:

- VDOT Operations Program webpage
- VDOT Statewide Systems Operations Program, 2009

Washington DOT Gray Notebook

Key Element: Strategic

Key Dimensions: Business Processes, Performance measures

Source Document:

- Creating an Effective Program to Advance Transportation System Management and Operations

Focus Points:

- The quarterly Gray Notebook tracks performance based on five legislative goals for the Washington State DOT, including mobility/congestion.
- Includes regular updates on progress in the application of operations strategies such as incident management and High-Occupancy Toll (HOT) lanes.

Reference Documents:

- WSDOT Navigating Grey Notebook webpage

Washington DOT Joint Operations Policy Statement

Key Element: Strategic

Key Dimension: Collaborations

Source Document:

- Improving Business Processes for More Effective Transportation Systems Management and Operations

Focus Points:

- Case Study: Joint Operations Policy Statement Encourages Innovative Approaches to Collaborating on Effective Incident Management Strategies in Washington State
- The joint agreement between WSDOT and Washington State Police formalized each agency's roles and responsibilities for freeway operations, including incident response
- Enhancement of collaboration and accountability for achieving a set of standard, consistent objectives

Reference Documents:

- WSDOT & WSP, A Joint Operations Policy Statement (JOPS), 2016

For questions and comments, email:
prerna.singh@gatech.edu

Thank you.

Appendix B: TSMO Survey Instrument

TSM&O Survey

This survey is administered by Georgia Institute of Technology (PIs: Adjo Amekudzi-Kennedy, PhD and Russell Clark, PhD | Graduate Research Assistant: Prerna Singh) under the auspices of Georgia Department of Transportation Project RP 18-29: Transportation Performance Management for System Operations: Development of Processes, Tools Measures and Targets. The objective is to characterize the current status of GDOT's business processes, system and technology, and performance management practices using the Capability Maturity Model (CMM) generated by the SHRP II Project. Each of the three survey sections has three levels of questioning. The survey may be completed in 15 to 20 minutes. The results will be used to update GDOT's 2014 CMM Transportation Systems Management and Operations (TSM&O) self-assessment.

* Required

General Information

This section gathers identification information from the survey participant.

1. **Name** *

2. **Unit within GDOT** *

3. **Position within GDOT** *

4. **Number of years at GDOT** *

Business Processes Section 1

The key elements of business processes in TSM&O (Transportation Systems Management and Operations) are:
1) TSM&O Planning Process
2) Programming/Budgeting
3) Project Development/Procurement
The following few sections assess the current level of the agency in these key elements.

5. **Is there a state TSM&O plan?** ***Mark only one oval.***

- Yes
- No *After the last question in this section, skip to question 19.*
- Under Development

6. **Are there district level multiyear budgets for TSM&O?** ***Mark only one oval.***

- Yes
- No *After the last question in this section, skip to question 19.*
- Under Development

7. **Is there a state ITS (Intelligent Transportation Systems) plan?** ***Mark only one oval.***

- Yes
- No *Skip to question 19.*
- Under Development

Business Processes Section 1- Evidence

8. **Select all the areas that have documentation for TSM&O and ITS planning** ***Check all that apply.***

	TSM&O Plan	ITS Plan
1. Freeway Management	☐	☐
2. Arterial Management	☐	☐
3. Traffic Incident Management	☐	☐
4. Road Weather Management	☐	☐
5. Planned Special Event Management	☐	☐
6. Emergency Transportation Operations	☐	☐
7. Parking Management	☐	☐
8. Work Zone Management	☐	☐

Business Processes Section 2

9. **Is the TSM&O plan mentioned in previous section a multiyear plan?** ***Mark only one oval.***

- Yes
- No *After the last question in this section, skip to question 19.*

10. **Does the TSM&O plan include the following dimensions? (Select all that apply)** ***Check all that apply.***

- [ ] Capital
- [ ] Operating
- [ ] Maintenance

11. **Does the plan include improvements and analysis of TSM&O and ITS plans? Select all that apply.**
Check all that apply.

- [ ] TSM&O improvements and analysis included
- [ ] ITS improvements and analysis included

12. **Are sustainable funding sources available for the plans and programs?** ***Mark only one oval.***

- ( ) Yes
- ( ) No ***After the last question in this section, skip to question 19.***

13. **Is a collaboration among state DOT, local governments and MPOs/RTPAs in place?** ***Mark only one oval.***

- ( ) Yes
- ( ) No ***After the last question in this section, skip to question 19.***
- ( ) Under Development

14. **Does a multiyear statewide TSM&O/ITS itemized program budget exist? (Select all that apply)** ***Check all that apply.***

- [ ] TSM&O itemized program budget exists
- [ ] ITS itemized program budget exists
- [ ] TSM&O program budget under development
- [ ] ITS program budget under development
- [ ] None of the above

15. **Are there TSM&O and ITS programs in place/operation?** ***Mark only one oval.***

- ( ) TSM&O programs in place
- ( ) ITS programs in place
- ( ) ITS/TSM&O programs not in operation ***Skip to question 19.***

Business Processes Section 2 - Evidence

16. **Select all areas that have TSM&O and/or ITS programs in place/operation** ***Check all that apply.***

	TSM&O Programs	ITS Programs
1. Freeway Management	☐	☐
2. Arterial Management	☐	☐
3. Traffic Incident Management	☐	☐
4. Road Weather Management	☐	☐
5. Planned Special Event Management	☐	☐
6. Emergency Transportation Operations	☐	☐
7. Parking Management	☐	☐
8. Work Zone Management	☐	☐

Business Processes Section 3

17. **Has Statewide Long Range Plan integrated TSM&O component as key dimension?** ***Mark only one oval.***

- ◯ Yes
- ◯ No
- ◯ Information not readily available

18. **Does the TSM&O plan have revisions and mid-course assessment options?** ***Mark only one oval.***

- ◯ Yes
- ◯ No
- ◯ Information not readily available

System and Technology Section 1

19. **Is Incident Management Process documented?** ***Mark only one oval.***

- ◯ Yes
- ◯ No

20. **How frequently is Incident Management Process documented?**

____

21. **What contracting alternatives are considered during an ITS system procurement?**

____

22. **Is there formal guidance for appropriate ITS procurement process?** ***Mark only one oval.***

- Yes
- No
- Information not readily available

23. **Approximately what percent of the regions in the state have documentation explaining systems operational concepts and architectures for key highway applications?**
Mark only one oval.

- None of the regions/very few regions (~<25%) *Skip to question 33.*
- Some of them (~ 25%-49%)
- Majority of them (~50%-75%)
- Almost all of them (~75% - 100%)

System and Technology Section 1 - Evidence

24. **Select all areas that have a document explaining systems operational concepts and architectures for key highway applications**
Check all that apply.

	Document explaining system operational concept and architectures
1. Freeway Management	☐
2. Arterial Management	☐
3. Traffic Incident Management	☐
4. Road Weather Management	☐
5. Planned Special Event Management	☐
6. Emergency Transportation Operations	☐
7. Parking Management	☐
8. Work Zone Management	☐

System and Technology Section 2

25. **Is there a standard document for Incident Management Process** ***Mark only one oval.***

- Yes
- No
- Under Development

26. **To what extent are the standards applied to Incident Management Processes** ***Mark only one oval.***

- Not at all
- To some extent
- In a majority of cases
- In all cases

27. **Are all ITS systems > $1 Million in capital costs developed following the standard rigorous systems engineering process?**
Mark only one oval.

- Yes
- No
- Information not readily available

28. **Is a standard systems engineering method documented for major ITS system development?** ***Mark only one oval.***

- Yes
- No *Skip to question 33.*
- Information not readily available

System and Technology Section 2 - Evidence

29. **Select all areas where ITS and IMS systems are standardized** ***Check all that apply.***

- 1. Freeway Management
- 2. Arterial Management
- 3. Traffic Incident Management
- 4. Road Weather Management
- 5. Planned Special Event Management
- 6. Emergency Transportation Operations
- 7. Parking Management
- 8. Work Zone Management

System and Technology Section 3

30. **Is the regional ITS system integrated with other authorities and agencies (local transit & MARTA)?**
Mark only one oval.

- Yes
- No *After the last question in this section, skip to question 33.*

31. **Does a 'configuration management' plan exist?**
A configuration management plan is a systems engineering process for establishing and maintaining consistency of a product's performance, functional, and physical attributes with its requirements, design, and operational information throughout its life.
Mark only one oval.

- Yes
- No *After the last question in this section, skip to question 33.*

32. **How frequently are systems updated?** ***Mark only one oval.***

- Every year or less
- 2-4 years
- 5 years or more
- Other: ______________________

Performance Measures Section 1

33. **Has the DOT identified operations performance output measures for reporting?** ***Mark only one oval.***

- Yes
- No
- Under Development

34. **Are the output measures dash-boarded?** ***Mark only one oval.***

- Yes
- No
- Under Development

35. **Are the measures used in reporting and improvements?** ***Mark only one oval.***

- Yes
- No *Skip to question 47.*

Performance Measures Section 1 - Evidence

36. **Select all areas where output measures are identified and reported** ***Check all that apply.***

- [ ] 1. Freeway Management
- [ ] 2. Arterial Management
- [ ] 3. Traffic Incident Management
- [ ] 4. Road Weather Management
- [ ] 5. Planned Special Event Management
- [ ] 6. Emergency Transportation Operations
- [ ] 7. Parking Management
- [ ] 8. Work Zone Management

Performance Measures Section 2

37. **Are outcome level measures identified?** ***Mark only one oval.***

- Yes
- No
- Under Development

38. **How frequently are the measures recalculated?** ***Mark only one oval.***

- Every year or less
- 2-4 years
- >4 years

39. **Is there a standard storage system for the outcome measures?** ***Mark only one oval.***

- Yes
- No
- Under Development

40. **Are there standard reporting systems for the outcome measures?** ***Mark only one oval.***

- Yes
- No
- Under Development

41. **Are these measures used in decision making?** ***Mark only one oval.***

- ◯ Yes
- ◯ No — ***Skip to question 47.***

Performance Measures Section 2 - Evidence

42. **Select all areas where outcome level measures are identified, reported and used in decision making**
Check all that apply.

	Outcome measures identified	Outcome measures reported	Outcome measures used in decision making
1. Freeway Management	☐	☐	☐
2. Arterial Management	☐	☐	☐
3. Traffic Incident Management	☐	☐	☐
4. Road Weather Management	☐	☐	☐
5. Planned Special Event Management	☐	☐	☐
6. Emergency Transportation Operations	☐	☐	☐
7. Parking Management	☐	☐	☐
8. Work Zone Management	☐	☐	☐

Performance Measures Section 3

43. **Is there a system to use past output and outcome measures for future decision making?** ***Mark only one oval.***

- ◯ Yes
- ◯ No
- ◯ Under Development

44. **Is there documentation of the measures in a format supporting the accountability of the agency to the public?**
Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Under Development

45. **Are these documents used for new/previous program justification?** ***Mark only one oval.***

- Yes
- No
- Under Development

46. **Is the internal reporting of the measures standardized?** ***Mark only one oval.***

- Yes
- No
- Under Development

Data and Tools

47. **What current sources of data are available and in use for TSM&O performance measures?**

48. **Are there any tools developed to support TSM&O activities?** ***Mark only one oval.***

- Yes
- No
- Under Development

49. **Please list tools developed internally to support TSM&O activities below, if any.**

50. **What commercial software applications are currently used to support TSM&O activities? Please list the names of the software applications/tools.**

51. **What current and anticipated hurdles exist in advancing the TSM&O Program using data driven techniques?**

Thank You!

Appendix C: Manual for PM3 Tool

GDOT PM3 TOOL
FOR TSMO REPORTING

Instruction Manual

Prepared for Georgia Department of Transportation, Office of Planning

Prepared by Georgia Institute of Technology

October 16, 2020

Jeff Wilson
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Overview

This document provides details on installing, configuring, and running the GDOT PM3 Tool. This tool calculates the following performance metrics:

- Percent of person-miles traveled on the Interstate that are reliable
- Percent of person-miles traveled on the non-Interstate NHS that are reliable
- Truck Travel Time Reliability (TTTR) Index
- Annual Hours of Peak Hour Excessive Delay (PHED) Per Capita
- Percent of Non-Single Occupancy Vehicle (SOV) Travel, and
- Emissions totals related to CMAQ

System Requirements

The GDOT PM3 Tool can run on a variety of PC/workstation/server platforms. The tool requires a minimum of 500 GB of storage if processing a year's worth of data. The RAM requirements are minimal and no processor requirements are defined. The tool is implemented in Python which is cross-platform and allows for running on Windows, OSX, and Linux operating systems. Regarding Windows, any version newer than NT should work.

Installation

The GDOT PM3 Tool is a command-line Python tool. The tool is provided in a zip file that can be decompressed onto any PC/workstation/server with an OS that supports Python 3.7 (e.g., Windows, OSX, Linux). The decompressed zip file should be placed in a location with read-write permissions and a large amount of file storage (around 500 GB). This is necessary due to the large size of input data as well as storing intermediate data and final results.

The directory structure should look like the following:

./cache/ - storage location for intermediate processing of data
./data/ - configuration and input data for the tool
./documents/ - instructions and relevant reference documentation
./output/ - output results of the tool are written here
README.md - basic description of software
VERSION.txt - version number
gdot.py - executable command-line script for the tool
gdot_interactive.py – executable graphical interface for the tool
gdot_data.py - support script (not called by user)
gdot_process_monitor.py - support script (not called by user)
gdot_util.py - support script (not called by user)
gdot_config.py - support script (not called by user)

gdot_generate_config_template.py - executable script that generates config file
heapqfilemerge.py - support script (not called by user)
csvsort_updated.py – support script (not called by user)

In order to run the software, Python 3.7.2 needs to be installed and configured as described in the next section.

Set up Python Environment

First you need to set up a Python environment on the machine you wish to run the GDOT Reporting Tool on. It is recommended that you run on a server with plenty of file storage space for the very large data sets (at least 500 GB). The Python environment must be Python version 3.7 and several libraries must be available. The most reliable way to accomplish this is to set up a dedicated environment. Miniconda is recommended for environment management.

For any computer (Windows, OSX, or Linux)

Install miniconda3

All platforms (e.g. Windows, MacOSX, Linux) should use 64-bit version of miniconda3.

https://docs.conda.io/en/latest/miniconda.html

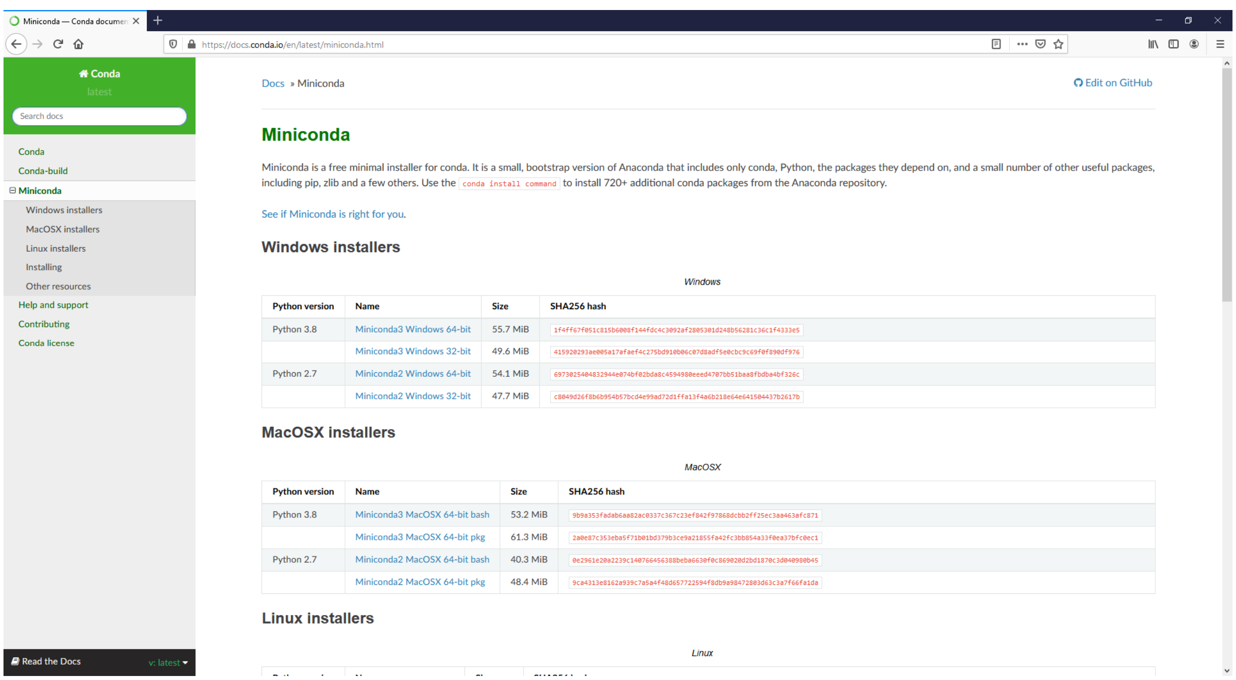

Figure 1: conda website with selection of installers available.

Once miniconda3 (64-bit) is installed, start an interactive shell/command line. On a Windows OS, you will need to select the Anaconda Prompt from the Start Menu for the installed software. Otherwise, on OSX or Linux simply open a new terminal shell.

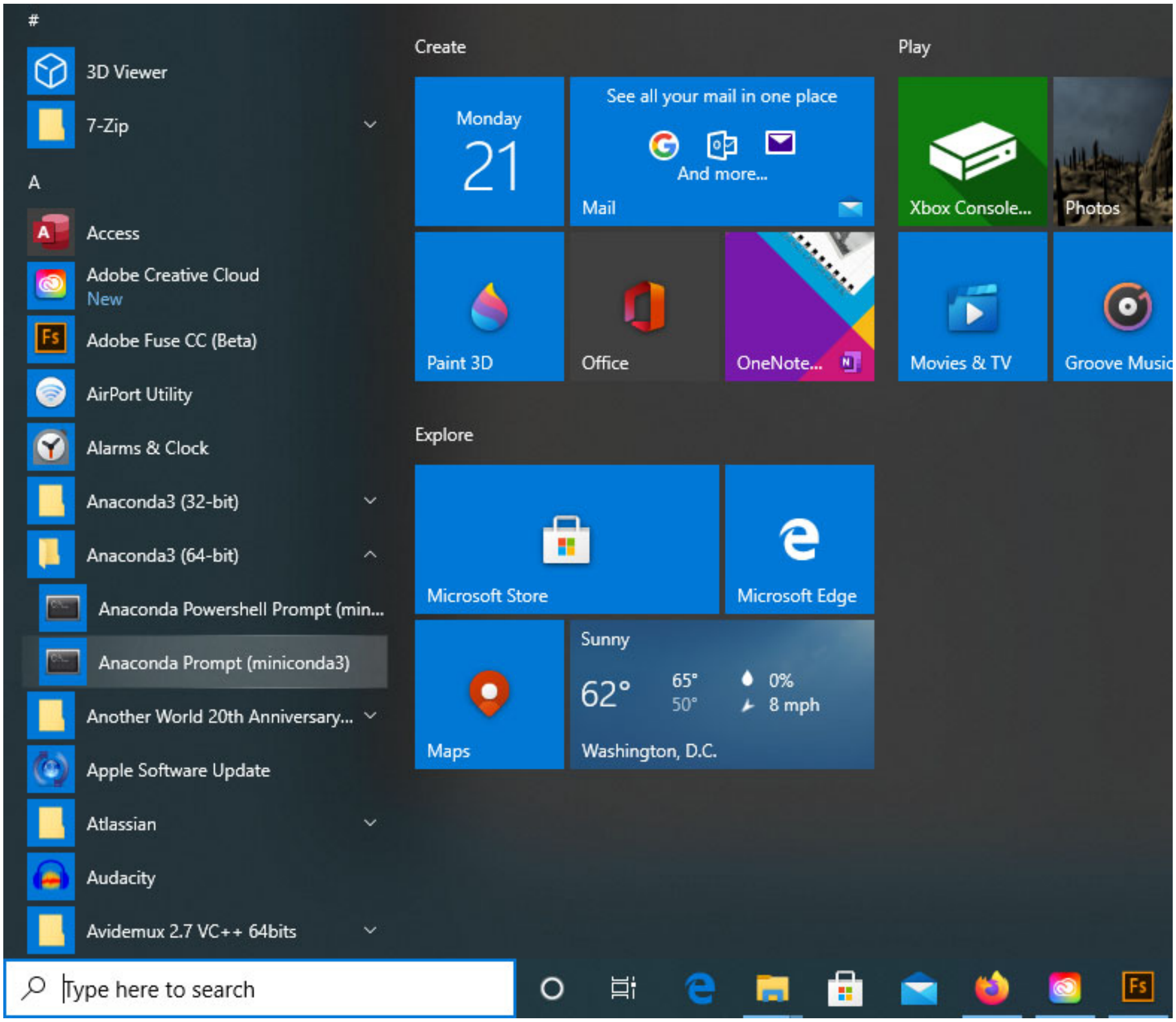

Figure 2: Example of running the Anaconda Prompt in Windows from the Start Menu

From the Anaconda Prompt, create an environment for the reporting tool on the command line:

conda create -n gdot python=3.7.2

Make sure to answer “y” when asked to confirm creation of the new environment.

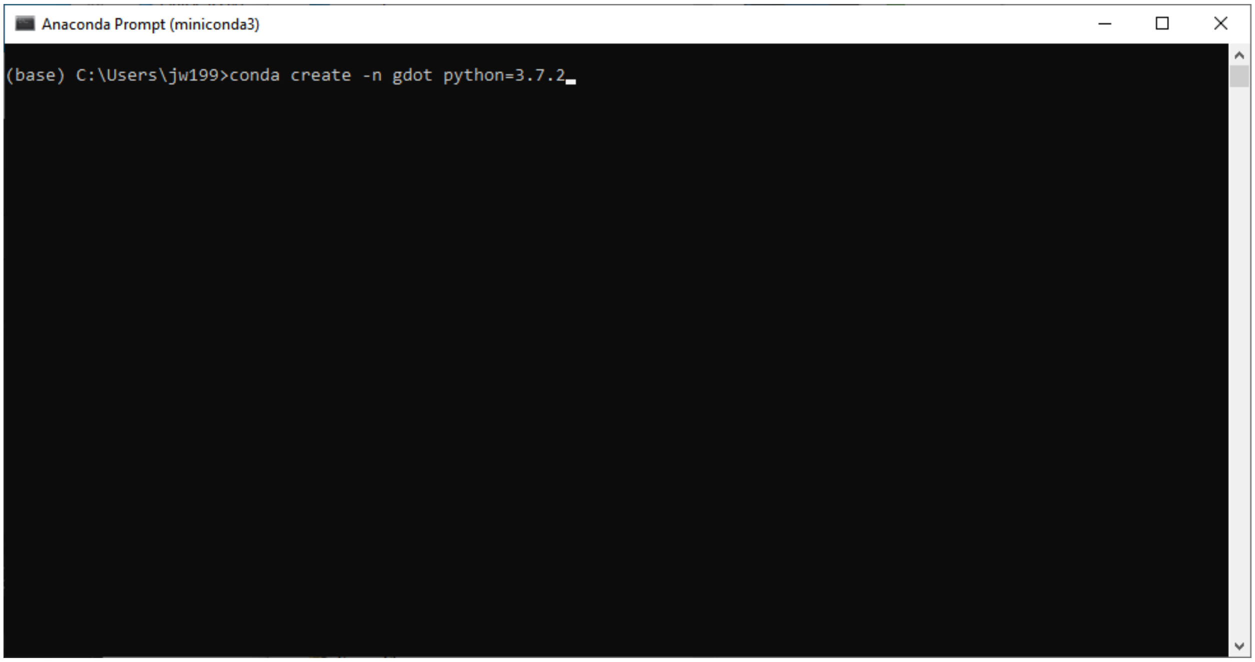

Figure 3: Example of creating a conda environment

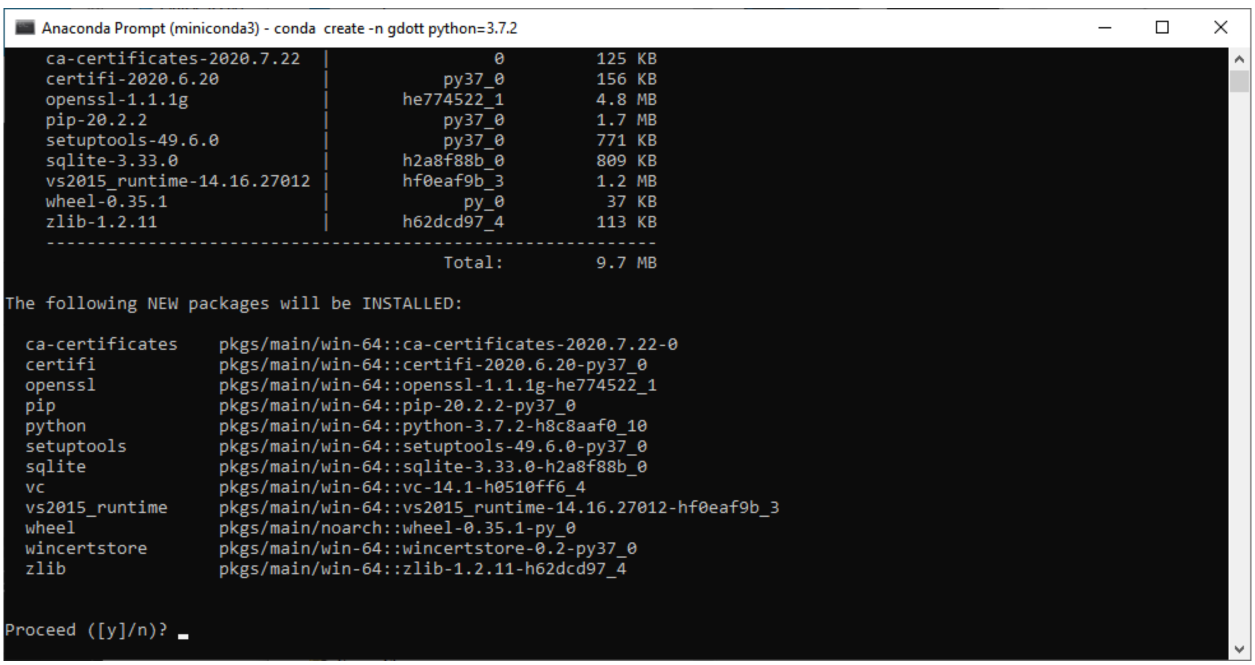

Figure 4: Example of confirmation question for creating conda environment, answer "y"

Switch to the environment:

conda activate gdot

Note that if you are **not** using Windows, you might get an error in which case try the following: *source activate gdot,* but try *conda activate gdot* first

Note that after activating the environment you should see: “(gdot)” for your prompt

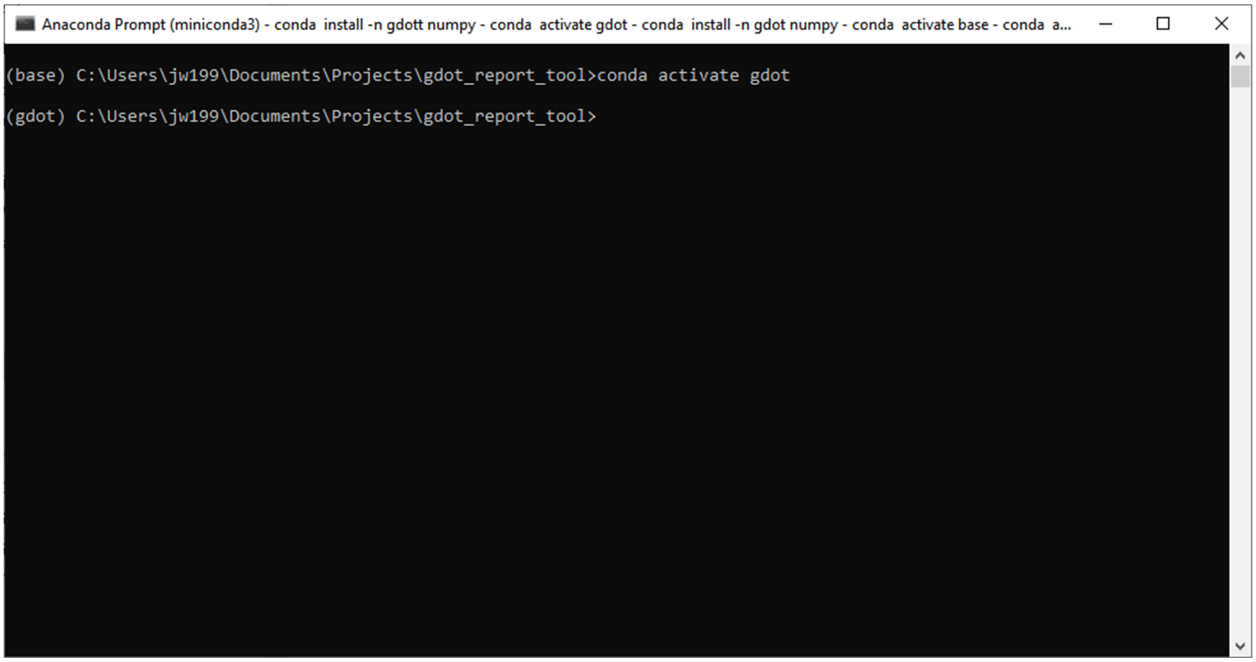

Figure 5: Example of activating conda environment.

Install the packages detailed below that are necessary to run the GDOT Reporting Tool:

conda install -n gdot numpy
conda install -n gdot pandas
conda install -n gdot pytables
conda install -n gdot psutil

Note: Be sure to answer “y” to confirm install for each.

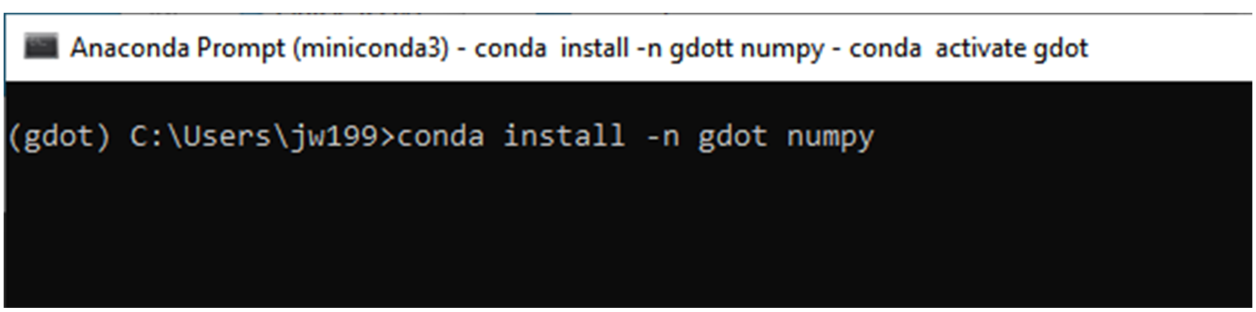

Figure 6: Example of installing package dependencies. Repeated for each package (with varying package name). Answer “y” when asked to confirm

Configuring the GDOT Reporting Tool

The GDOT Reporting Tool can be run via command line or by graphical interface. If using the graphical interface, one can perform configuration within the application. However, if using the command line interface for execution, a configuration file must first be edited in a text editor. Both approaches for running/configuring are discussed in the "Running the GDOT Reporting Tool" sections below.

Regardless of how you choose to configure and run the GDOT Reporting Tool, it is necessary to collect and prepare dependent data and place it in an accessible location on the computer that you are using. It is recommended that you place the data under */data* folder of the directory where you installed the GDOT Reporting Tool. The next section describes recommended processes for obtaining the data.

Collecting and Preparing Data

You will need to collect data from a variety of sources in order to run the PM3 tool. The sources include: NPMRDS, GDOT, American Community Survey, and CMAQ public access database.

NPMRDS

The NPMRDS data can be obtained from https://npmrds.ritis.org/analytics/

Note that this requires an account. Furthermore, for any calendar year one wishes to perform analysis, conflation with AADT data must be present.

The RITIS site allows you to download data up to a month at a time. You can download all 12 months of the same calendar year, or a subset. However, some metrics may not be accurate without the full 12 months of data.

For each month desired, two reports should be generated: "Trucks" and "Trucks and passenger vehicles". Each NPMRDS month report should be configured for 15-minute averaging, seconds for travel time units, all available measures enabled, and null records enabled. Figure 1 shows an example configuration of the RITIS web reporting tool.

If running a report for more than one month, each month's data download will contain a *TMC_Identification.csv* file. All versions of this file month to month within the same year should match; however, you should still preserve them all in case a future version of the GDOT PM3 Tool makes use of them. For now, only one of the *TMC_Identification.csv* files will be specified in the GDOT PM3 Tool's configuration.

Confirm that AADT columns are present in the *TMC_Identification.csv* of the downloaded data.

Figure 7: RITIS NPMRDS Web Reporting Tool

Example expected csv format for conflated NPMRDS data:

```
tmc_code,measurement_tstamp,speed,average_speed,reference_speed,travel_time_seconds,data_density
101-07580,2018-01-01 00:00:00,66.00,,,435.99,A
101-07580,2018-01-01 00:15:00,,,,,
101-07580,2018-01-01 00:30:00,,,,,
…
```

Example expected csv format for TMC_Identification (accompanies the csv above):
(NOTE the following lines of text are too long to fit single line in this document)

```
tmc,road,direction,intersection,state,county,zip,start_latitude,start_longitude,end_latitude,end_longitude,miles,road_order,timezone_name,type,country,tmcline
ar,frc,border_set,f_system,urban_code,faciltype,structype,thrulanes,route_numb,route_sign,route_qual,altrtename,aadt,aadt_singl,aadt_combi,nhs,nhs_pct,strhn
t_typ,strhnt_pct,truck,isprimary,active_start_date,active_end_date
101P13107,10TH ST,EASTBOUND,US-41/US-19/GA-9/GA-3/NORTHSIDE DR,GA,FULTON,30318,33.781555,-84.407549,33.781557,-
84.407103,0.025613,1,America/New_York,P1.11,USA,,3,,,,,,,,,,,,,,,,,,,,,2018-01-01 00:00:00-05:00,2019-01-01 00:00:00-05:00
101+13107,10TH ST,EASTBOUND,US-41/US-19/GA-9/GA-3/NORTHSIDE DR,GA,FULTON,30318,33.781578,-84.411143,33.781555,-
84.407549,0.206370,2,America/New_York,P1.11,USA,,3,,,,,,,,,,,,,,,,,,,,,2018-01-01 00:00:00-05:00,2019-01-01 00:00:00-05:00
tmc,road,direction,intersection,state,county,zip,start_latitude,start_longitude,end_latitude,end_longitude,miles,road_order,timezone_name,type,country,tmcline
ar,frc,border_set,f_system,urban_code,faciltype,structype,thrulanes,route_numb,route_sign,route_qual,altrtename,aadt,aadt_singl,aadt_combi,nhs,nhs_pct,strhn
t_typ,strhnt_pct,truck,isprimary,active_start_date,active_end_date
101+13108,10TH ST,EASTBOUND,I-85/I-75/GA-401/GA-403,GA,FULTON,30318,33.781557,-84.407103,33.781551,-
84.3916026,0.890083,3,America/New_York,P1.3,USA,,3,,,,,,,,,,,,,,,,,,,,,2018-01-01 00:00:00-05:00,2019-01-01 00:00:00-05:00
```

GDOT – Speed Limits per TMC

GDOT must provide speed limit data. The GDOT PM3 Tool expects a CSV with columns: TMC, ROAD, DIRECTION, SPEED_LIMIT. The TMCs should match the TMCs from the NPMRDS data. ROAD and DIRECTION aren't currently used but TMC and SPEED_LIMIT are.

Sarah Lamothe (SLamothe@dot.ga.gov) has previously provided a file titled "TMCs_PSL and Occupancy Rate.xlsx". Within this Excel document, there is a tab titled, "TMCs_PSL". The worksheet of this tab can be saved as a CSV file for the purpose of using with the GDOT PM3 Tool.

Example expected csv format for speed limits:

```
TMC,ROAD,DIRECTION,SPEED_LIMIT
,,,
101+04098,I-75,NORTHBOUND,65
101+04099,I-75,NORTHBOUND,65
101+04100,I-75,NORTHBOUND,65
101+04101,I-75,NORTHBOUND,65
101+04102,I-75,NORTHBOUND,65
101+04103,I-75,NORTHBOUND,65
…
```

American Community Survey (ACS)

Refer to the following document for obtaining the appropriate ACS data:

"FHWA Computation Procedure for Travel Time Based and Percent Non-Single Occupancy Vehicle (non-SOV) Travel Performance Measures" (FHWA HIF-18-024)
https://www.fhwa.dot.gov/tpm/guidance/hif18024.pdf

In particular, refer to Appendix B and Appendix C. You will be saving tables DP05 and DP03.

Note that the data must be in the ACS 5-year format.

The expected header format is:

for DP03: (abbreviated)

GEO.id	GEO.id2	GEO.display-label	[a bunch of HC?_??? columns]	HC03_VC28	[a bunch more HC?_??? columns]

for DP05: (abbreviated)

GEO.id GEO.id2 GEO.display-label [a bunch of HC?_??? cols] HC01_VC03 [a bunch more HC?_??? cols]

Only GEO.id2 and either HC03_V28 or HC01_VC03 columns (depending on DP03 or DP05) need to appear. The program ignores all other columns.

CMAQ

CMAQ data can be obtained from:

https://fhwaapps.fhwa.dot.gov/cmaq_pub/

Select the "Reports" tab. Then select "Detailed project listing - CMAQ Emissions Performance Measure – State" with format "Excel". Select "Project State" as Georgia and pick a year. Download, then adjust the query as necessary to obtain all desired years.

Finally, use Excel to save the documents as CSV files.

The expected header format is:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1																	
2																	
3	CMAQ Performance Measure Project Listing Report for 2018																
4	Georgia																
5	STATE	CMAQ PROJECT ID			CONTINUING PROJECT?		Is this an	PROJECT TYPE	PROJECT TITLE	PROJECT	VOC	CO	NOx	PM10	PM2.5	Is congestion	
6			State Project ID	YEAR		MPO	obligating project?			DESCRIPTION	(kg/day)	(kg/day)	(kg/day)	(Kg/Day)	(Kg/Day)	reduction project?	end
7	Georgia	GA20160010	12646	2018	Yes	Atlanta Regional Commission	N	Congestion Reduction and Traffic Flow Improvements	CR 653/COVINGTON BYPASS @ CR 181/FLAT SHOALS ROAD	Intelligent Transportation Systems, Signalization Upgrades						Y	
8	Georgia	GA20170007	12826	2018	Yes	Atlanta Regional Commission	N	Congestion Reduction and Traffic Flow Improvements	SR 155 @ 4 LOCS IN DEKALB	Intelligent Transportation Systems, Signalization Upgrades						Y	
9	Georgia	GA20180001	12824	2018	No	Atlanta Regional Commission	N	Congestion Reduction and Traffic Flow Improvements	SR 8 @ 4 locs in DeKalb	Intelligent Transportation Systems, Signalization Upgrades	0.8		1.98		0.13	Y	
10	Georgia	GA20180002	13142	2018	No	Atlanta Regional Commission	N	Congestion Reduction and Traffic Flow Improvements	I-285 WB @ SR 6 - DIVERGING DIAMOND INTERCHANGE	Congestion Reduction	3.8		12.9		0.7	Y	
11	Georgia	GA20180003	13322	2018	No	Gainesville-Hall MPO	N	Congestion Reduction and Traffic Flow Improvements	SR 53 CONN/SR 60 @ SR 60/SR 369	Congestion Reduction	0.001		0.02		0.001	Y	
12	Georgia	GA20180004	12618	2018	No	Atlanta Regional Commission	N	Congestion Reduction and Traffic Flow Improvements	SR 5 FROM CS 736/STEWART PKWY TO CS 857/CONCOURSE PKWY	Intelligent Transportation Systems, Signalization Upgrades	1		3.02		0.14	Y	
13	Number of of Projects:	6								Total Emission Benefits	5.601	0	17.92	0	0.971		

Chart 1: An example of CMAQ Data

Vehicle Occupancy Factors

Vehicle Occupancy Factors necessary for metric calculations are defined in the JSON configuration manually or by the interactive tool under the GDOT section. Recommended defaults are listed below:

(Units are Individuals per vehicle type)

Cars: 1.7 – used for both PHED and reliability metrics
Atlanta buses: 10.3 – used for PHED
Trucks: 1.0 – used for PHED

Urbanized Area Population

Urbanized area population is defined in the JSON configuration manually or by the interactive tool under the GDOT section.

Running the GDOT Reporting Tool (Graphical Interface)

The basic steps to run the interactive software are as follows:

Select the previously created conda environment. Run the following on the miniconda command line (shell):

conda activate gdot

Next, enter the root directory of the GDOT Reporting Tool (e.g. *cd <some_directory>*). Now you can run the software. The simplest way to run is:

python gdot_interactive.py

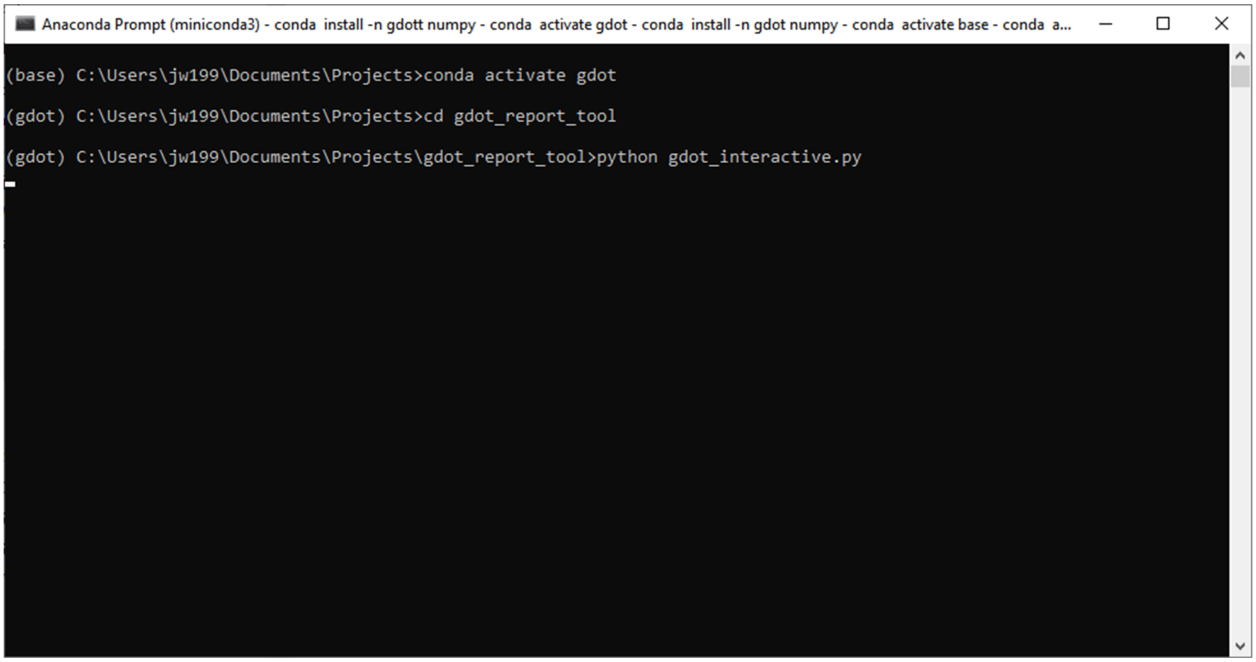

Figure 8: Example of running the interactive configuration and launch tool from the conda prompt. The *change directory* command ("cd") will vary according to your file system.

Upon successful execution, you should see a small window like shown below:

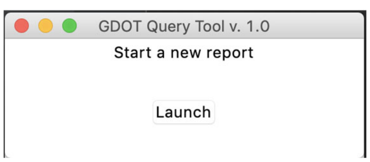

Figure 9: Interactive tool start window

Click the "Launch" button to begin configuration. You should see the following configuration window:

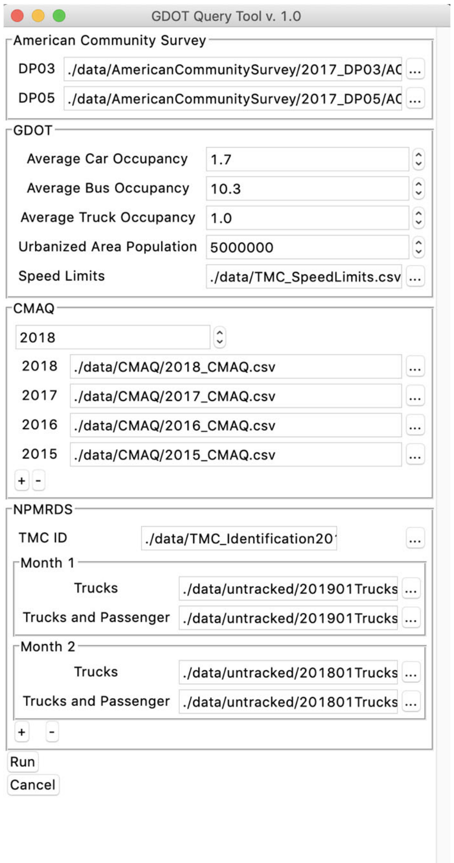

Figure 10: Configuration screen of the interactive tool

Populate the fields as appropriate for the report to be run. Refer to "Collecting and Preparing Data" section above. The + and - buttons can be used to add/delete additional lines to the CMAQ and NPMRDS section. The CMAQ section requires that a "latest year" be selected. Consecutive lines after the "latest year" should be CMAQ yearly data in decreasing year date starting from the data matching the "latest year". Note that only 12 months can be entered for NPMRDS data.

Once configured, choose "Run" to execute the report generation. Note you may need to use the scroll bar to find the "Run" button.

Once executed, this process can take quite a while. Potentially 24 hours or more depending on the amount of data.

You can monitor the progress by observing the launcher window. While running you will see the following:

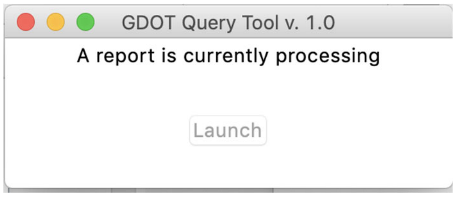

Figure 11: Example of a running report launched from the interactive tool

Once complete, you will see:

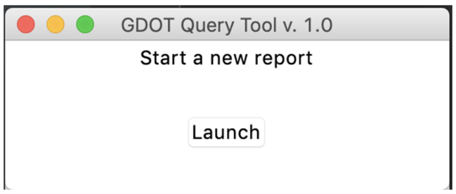

Figure 12: Example of what the window looks like after the launched report is complete

The output data is contained within the */output* directory with a date/time stamp and can be navigated to via a file explorer or shell. Refer to "Results" section below for more details. Be prepared to wait a very long time (as much as 24 to 48 hours) for completion. You may need to modify OS settings so that your computer does not go to sleep, shut down to install updates, etc.

Running the GDOT Reporting Tool (Command Line Interface)

The GDOT Reporting Tool can also be run via command line program. In this case, all configuration is done currently via the *data/gdot_config.txt* file.

This file must be configured with the appropriate data for analysis. The data files referenced in the *gdot_config.txt* file can also be placed within the */data* folder.

This configuration file is specified in the JSON format (https://www.json.org). It is recommended when creating a new configuration to copy the example file to make a backup and simply edit the appropriate paths in the file as necessary. You can also use the interactive tool for configuration. Both methods are described in a later section.

See section "*Collecting and Preparing Data*" below for how to obtain data for analysis.

Note: The most likely causes of problems in the JSON format are:

1.) Unmatched open and close characters of a section such as *{* and *}* or *[* and *]* or double-quotes (*"*) at the beginning and end of strings
2.) Missing or extraneous commas (*,*). For instance, the "monthly_logs" section of the NPMRDS data are arrays of the file paths of month-based data. There must be a comma between each element of the array, but not after the last item.

Configuration example:


```
{
  "American_Community_Survey": {
    "TableDP03": "./data/AmericanCommunitySurvey/2017_DP03/ACS_17_5YR_DP03_with_ann.csv",
    "TableDP05": "./data/AmericanCommunitySurvey/2017_DP05/ACS_17_5YR_DP05_with_ann.csv"
  },
  "CMAQ": {
    "MostRecentYear": 2018,
    "YearRecordsDescending": [
      "./data/CMAQ/2018_CMAQ.csv",
      "./data/CMAQ/2017_CMAQ.csv",
      "./data/CMAQ/2016_CMAQ.csv",
      "./data/CMAQ/2015_CMAQ.csv"
    ]
  },
  "GDOT": {
    "average_bus_occupancy": 10.3,
    "average_car_occupancy ": 1.7,
    "average_truck_occupancy ": 1.0,
    "tmc_speed_limits": "./data/TMC_SpeedLimits.csv",
    "urbanized_area_population": 5000000
  },
  "NPMRDS": {
    "TMC_identification": "./data/TMC_Identification2019.csv",
    "trucks": {
      "monthly_logs": [
        "./data/untracked/201901Trucks15minutesWithNull/201901Trucks15minutesWithNull.csv"
      ]
    },
    "trucks_and_passenger": {
      "monthly_logs": [
"./data/untracked/201901TrucksAndPassengers15minutesWithNull/201901TrucksAndPassengers15minutesWithNull.csv"
      ]
    }

  }
}
```


In the above JSON, note that the *NPMRDS* sections for *trucks* and *trucks_and_passenger* include sections for *monthly_logs*. These *monthly_logs* sections are arrays and can vary in the number of files provided. However, the number of log files referenced should match between *trucks* and *trucks_and_passenger* and also each should correspond to the same months.

To run the tool, be advised that it can take a very long time to process. For an entire year's worth of NPMRDS data, you can expect around 24 to 48 hours to complete the run. Because of this, you will likely prefer to use a server that you can leave running and not impact other work you are doing.

The basic steps to run the software are as follows:

Select the previously created conda environment. On a Linux server this will be to run the following on the command line (shell):

source activate gdot

Next, enter the root directory of the GDOT Reporting Tool (e.g. *cd <some_directory>*). Now you can run the software. The simplest way to run is:

python gdot.py

However, if you want to be able to log out of a Linux server with the tool still running (and come back later) then you might consider:

nohup python gdot.py &

(The *&* allows the tool to run in the background and *nohup* allows you to log out without the tool stopping. Note that this *only* applies to installation on a Linux machine)

Also, you can optionally specify a different config file using the following syntax:

python gdot.py -i <config_file_path>

or on Linux machines:

nohup python gdot.py -i <conf_file_path> &

A log file is available under *output/<unique_date_time_dir_name>/gdot.log*
This log file can be monitored for progress. Also on Linux machines, command *top* can be useful to quickly check if the tool is still running (just look for a very busy process named "python"). Alternatively, you can use the command *ps* (on Linux) to check running processes. On Windows, you might use the Task Manager to observe the running process.

Results

Upon completion of the calculation of the metrics, you can find the results within the *output/* directory in the root directory of the GDOT Reporting Tool. For each run, a special datetime name is assigned to a subdirectory within *output*/.

For example: *output/2019_06_12_10_39_18.668/*

Within this output directory you will find a number of different files:

Most Useful:

- **gdot_config.txt** – This file details the configuration that was used to generate the report
- **gdot.log** – A log from the running of the tool
- **full_report.csv** – A report of all metrics in one file. Each column denotes a different measure

Individual Metrics:

- **cmaq_result.csv**
- **phed.txt**
- **reliability.txt**
- **sov.txt**
- **PercentSOVTravelByUrbanizedArea.csv**

Raw Data with Intermediate Calculations:

- **result_tmcid.csv** – Metrics associated with TMCs are joined with the TMC_Identification.csv file from the input configuration
- **npmrds_annotated.csv** – Intermediate calculations joined with all provided NPMRDS timestamped data

Other Considerations

The GDOT Reporting Tool generates a number of intermediate files. These files help reduce memory requirements and also reduce computation on subsequent runs of the software when using some of the same NPMRDS data. Much of this data is stored in the *cache/* directory. You may periodically wish to purge the contents of the *cache/* directory. Also, some of the data sorting routines use temporary files. These files are stored in the operating systems temp directory and should automatically be purged by the operating system.