The Value of a Business Case in Mainstreaming TSMO

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16. Abstract The goal of this white paper is to help transportation agencies develop an effective business case to show the value of transportation systems management and operations (TSMO) and support efforts to mainstream TSMO in their agencies. It identifies the role of a business case in mainstreaming TSMO, discusses how to evaluate the effectiveness of a TSMO business case, and describes examples of TSMO business cases from eight State departments of transportation. The paper provides information on current TSMO resourcing in transportation agencies and identifies additional resources for developing a TSMO business case.			
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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

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

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2,000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	2.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND ACRONYMS

ATMS	advanced transportation management system
CHART	Coordinated Highways Action Response Team
DOT	department of transportation
FHWA	Federal Highway Administration
FTE	full-time employees
FY	fiscal year
ITS	intelligent transportation system
MPO	metropolitan planning organization
NOCoE	National Operations Center of Excellence
SHRP2	second Strategic Highway Research Program
TMC	transportation management center
TSMO	transportation systems management and operations
VMT	vehicle miles traveled

1. INTRODUCTION

Transportation agencies use transportation systems management and operations (TSMO) to enhance the reliability and safety of their systems. There are a number of ways to support mainstreaming TSMO in transportation agencies and the advancement of TSMO as a way of doing business. The Federal Highway Administration (FHWA) has developed a series of white papers focused on mainstreaming TSMO through formal policies and processes, changes in agency culture, advances in decisionmaking and information management, and development of business cases for TSMO. This white paper focuses on how a business case can support mainstreaming TSMO in transportation organizations.

Integrating and mainstreaming TSMO across business and geographic units of departments of transportation (DOTs) require making the case for the benefits of TSMO to all aspects of a DOT. This can be accomplished formally and informally to educate agency leadership, management, and staff about what TSMO includes, how it can support agency goals, how it interfaces with different DOT functions, and why staff should care. A TSMO business case can help DOT personnel across the agency understand TSMO's potential and anticipated benefits, encourage agency commitment to TSMO as a way of doing business, and support adoption of TSMO strategies across the agency. A business case tells a compelling story about how things are, how they could or should be, and the ways in which TSMO can be applied to get there.

Objectives

The goal of this white paper is to help transportation agencies develop an effective business case to mainstream TSMO in their agencies. The objectives of this white paper are to:

- Define mainstreaming TSMO
- Define a business case
- Describe how a business case can advance mainstreaming TSMO
- Provide an overview of measuring the effectiveness of a TSMO business case
- Provide examples of TSMO business cases from State DOTs and other transportation agencies as well as business cases from other industries
- Identify materials available to support business case use and development

Chapter 2 discusses the role of a business case in mainstreaming TSMO. Chapter 3 discusses evaluating the effectiveness of a TSMO business case. Chapter 4 provides information on resourcing for TSMO at transportation agencies. Chapter 5 provides example business cases from several State DOTs. Chapter 6 discusses business cases from other industries and how they might apply to TSMO. Lastly, Chapter 7 lists some resources for agencies interested in developing a TSMO business case.

Intended Audience and Users

The audience for this white paper is State transportation agencies interested in advancing TSMO in their organizations. The content may also be beneficial to metropolitan planning organizations (MPOs) and local transportation agencies that are implementing TSMO and want to build an understanding and appreciation of TSMO benefits.

Why Mainstream TSMO?

Transportation agencies have traditionally focused on design, construction, and maintenance of transportation facilities. TSMO is intended to expand this focus to operational improvements to maintain and restore system performance, before adding physical capacity. Mainstreaming in the context of business processes is defined as, "[P]roducts and services which are readily available to and appealing to the general public, as opposed to being of interest only to a very specific subset of the public." (Business Dictionary 2020)

TSMO mainstreaming is making management and operations strategies readily understood, considered, appealing, and available to system users (i.e., the public) and agency leadership and staff. Typically, TSMO has been initiated in operations and maintenance business areas in transportation agencies and has evolved alongside intelligent transportation system (ITS) technologies, functions, and deployment programs (e.g., maintaining signal systems, detecting and clearing incidents). Mainstreaming TSMO allows a broader range of strategies to be integrated throughout transportation departments and related agencies and organizations. Mainstreaming TSMO engages planners, designers, operators, and system users (public and private sector). It touches all aspects of mobility, including congestion, air quality, sustainability, safety, security, reliability, and related quality-of-life concerns. The goal of mainstreaming is to routinely consider TSMO strategies as solutions of equal substance with other options for improving transportation system performance and addressing transportation needs within a community or region.

2. THE ROLE OF A BUSINESS CASE IN MAINSTREAMING TSMO

A TSMO business case can help DOT personnel across the agency understand TSMO's potential and benefits. TSMO can provide cost-effective improvements that are delivered more quickly than construction projects. To mainstream TSMO programs and strategies, the case must be made for their value and contribution to the overall mix of solutions adopted to improve transportation system performance. It is important to know your audience (executive leadership, DOT business units, legislators, general public, etc.) when developing a business case and to use real-life examples and data to appeal to the audience's interests and priorities. Some agencies have found that personalizing a business case makes it more effective by helping specific audiences see how it relates to them.

What Is a Business Case for TSMO?

Making the business case for TSMO involves defining challenges and problems faced by DOTs and determining how those issues can be addressed through TSMO. These challenges include transportation system safety, reliability, and congestion that affect management and operation of the system and decisions about investments. A business case can be outward facing to provide information on how TSMO can improve transportation systems for users. It can also be inward facing to encourage a greater commitment to TSMO through agency policies, processes, organizational changes, and development of a TSMO culture to improve system performance before investing in additional capacity. The business case is also made less formally through presentations across the agency or ongoing conversations with colleagues. For success in mainstreaming TSMO, a TSMO business case should be made formally and informally on an ongoing basis to help develop an understanding of and commitment to TSMO.

A TSMO business case lays out how TSMO can address current and anticipated challenges to the transportation system. It also discusses the value to the agency, in terms of cost savings and the ability to deliver on agency goals, and the value to system users and elected officials in terms of improved safety, decreased congestion, enhanced system reliability, economic vitality, quality of life, and effective use of taxpayer funding.

FHWA's *Developing and Sustaining a Transportation Systems Management & Operations Mission for Your Organization: A Primer for Program Planning* (FHWA 2017, p. 23) provides the following questions when developing a TSMO business case to help agencies frame the benefits of TSMO:

- What issues and trends are affecting the performance of our transportation system?
- What are the agency's unique transportation needs and challenges?
- What opportunities does TSMO offer in addressing the challenges?
- Who are the users of our transportation system?
- What is most important to the system users?
- What is most important to our decisionmakers?
- What constraints must we work with to manage and operate the system effectively?

FHWA's *Advancing TSMO: Making the Business Case for Institutional, Organizational, and Procedural Changes* (FHWA 2018, pp. 26–27) looks at why an agency would make changes to

how it operates, internally and in collaboration with partners, to advance TSMO. It suggests including the following content in a TSMO business case:

- Describe the jurisdiction's current system performance and TSMO activities as a baseline for change.
- Describe how current problems or events suggest that an effective TSMO response requires institutional, organizational, and procedural changes that integrate TSMO into agency activities on a more formal (rather than ad hoc) basis.
- Specify recommended or required institutional, organizational, and procedural actions.
- Identify the external and internal benefits and payoffs from the proposed institutional, organizational, and procedural changes.
- Identify and quantify institutional, organizational, and procedural improvement costs and resource requirements.
- Discuss the overall balance between rate of return and risks.
- Identify the responsibilities for change management at the unit and agency level.

How a Business Case Can Advance Mainstreaming

To mainstream TSMO, the business case must shape an agency's understanding of what TSMO is. It must also provide a vision for how TSMO enhances management and operations of transportation systems and across lines of business in an agency.

A business case for TSMO can be used to gain support and funding for deploying TSMO strategies, modifying business processes to better integrate TSMO, making organizational changes to better deliver TSMO, integrating TSMO into standard training programs, and allocating more staff to TSMO activities. These outcomes can all advance the mainstreaming of TSMO within transportation agencies.

The motivation behind a business case may be a desire to maximize return on investment, or it may be a public- or media-driven motivation resulting from a significant event that impacts major facilities. As public entities, transportation agencies must meet user needs and expectations within the limits of available funding and regulatory requirements.

TSMO definitions vary across DOTs. Some agencies take a more traditional operations focus, while others include more business areas within TSMO. FHWA defines TSMO as:

> A set of strategies that focus on operational improvements that can maintain and even restore the performance of the existing transportation system before extra capacity is needed. The goal here is to get the most performance out of the transportation facilities we already have. This requires knowledge, skills, and techniques to administer comprehensive solutions that can be quickly implemented at relatively low cost. This may enable transportation agencies to

> "stretch" their funding to benefit more areas and customers. TSMO also helps agencies balance supply and demand and provide flexible solutions to match changing conditions. (FHWA 2019)

This means DOTs can identify and implement strategies to optimize the current system to improve operations without adding new capacity. If additional capacity is needed, there may be opportunities to reduce the scope and extent of capital investment through TSMO strategies.

Mainstreaming TSMO typically evolves over time as key stakeholders gain a better understanding of TSMO and the business case becomes more compelling. Mainstreaming requires broad support for considering TSMO strategies as integral to planning, program and project development, and day-to-day operations. This can involve multiple reinforcing actions:

- **Developing a common understanding of TSMO.** Managing and operating the system to optimize current and future investments applies to all aspects of a DOT. This includes traffic operations, system planning, design, construction, and maintenance. It is important to frame the TSMO business case to provide a clear understanding of TSMO and to highlight the benefits and opportunities of TSMO across all DOT functional areas.

- **Aligning TSMO initiatives with agency goals and objectives.** The business case for TSMO should align with a DOT's strategic goals and objectives. It should articulate how TSMO supports agency goals in a cost-effective manner, and how TSMO can be a method of delivering those goals and meeting agency objectives. The business case should help agency leadership, management, and decisionmakers see that TSMO is not a separate activity but a set of strategies for obtaining agency priorities.

- **Building support for TSMO initiatives across the agency, among decisionmakers, and with system users and the public.** Building support for TMSO should include clear examples of TSMO projects, services, and activities that have been implemented by the DOT to help realize agency goals and maximize return on investment. Building on successes can help engender support. As agencies realize benefits from specific strategies, such as traffic incident management, successful initiatives can be highlighted as examples of how TSMO can support DOT goals and illustrate the opportunities for return on investment in TSMO.

- **Expanding allocation of resources to TSMO.** An effective business case for TSMO can help integrate TSMO projects, services, and activities in investment planning and resource allocation processes. With an understanding of what TSMO has to offer, its potential benefits, and the return on investment, DOTs can more effectively allocate resources for personnel, funding, and assets to advance TSMO activities. The business case can help elevate the status of TSMO within the agency to a core business line integral to the DOT's mission.

- **Providing a basis for integrating TSMO into all business sectors of the DOT.** Integrating TSMO into existing business processes makes TSMO a part of every aspect of how agencies approach their work, helps people see the value of TSMO, and helps advance and mainstream TSMO.

3. EVALUATING THE EFFECTIVENESS OF A TSMO BUSINESS CASE

To gauge the effectiveness of a business case, it is helpful to develop indicators of how well TSMO is mainstreamed throughout the organization and periodically evaluate them to assess changes. Potential indicators may include the following:

- Increased TSMO resources (funding and staffing)
- More effective use of transportation resources to solve issues
- Greater use of TSMO strategies
- Realization of TSMO goals and objectives
- Increased collaboration and integration of TSMO strategies in other areas of the agency (project development, design and construction, maintenance, and safety)
- Alignment of agency strategic goals with TSMO strategic goals
- Greater awareness by staff of TSMO strategies, benefits, and opportunities
- Rate at which TSMO shows up in senior leadership meeting agendas
- Development of TSMO committees that include leadership and staff across the agency
- Rate at which TSMO is considered in asset management plans and programs
- Overall system performance through the advancement of TSMO

Why Evaluation Is Important

Agencies can evaluate the effectiveness of the business case to determine if it is working to support mainstreaming. It is important to determine whether the business case is reaching the right people with the right message. For example: Are all lines of business within the agency integrating TSMO into how they do business? Is TSMO siloed in a particular office or business unit within the organization? Evaluating the effectiveness of the TSMO business can provide insights into making a more compelling case throughout the agency.

How the Effectiveness of the Business Case Can Be Evaluated

Evaluating the effectiveness of the business case can involve outreach across business units, surveys, policy and procedure reviews, project reviews, and resource allocation tracking.

A general indicator of effectiveness is how well TSMO is understood and accepted across the agency and among political and elected leadership. For example:

- Are TSMO strategies part of project planning and scoping?
- Does the maintenance division consider how its activities interact with TSMO strategies and objectives?
- Is TSMO integrated into the planning and programming process to allow TSMO investments to compete effectively with capacity investments?
- Are TSMO approaches looked to first to solve operational issues?

Another indication of effectiveness is funding increases for TSMO initiatives. Initiatives may include TSMO projects, services, or other activities designed to optimize the system without major investments in capacity. Funding increases in operations or services (i.e., highway service

patrol or traveler information) may indicate that the TSMO business case is effective. Similarly, adequate or increased staffing to plan, deploy, and manage TSMO initiatives can indicate increasing organizational commitment to TSMO.

Review of agency policies and procedures can also shed light on the effectiveness of an agency's TMSO business case. Reviews should look at how policies and procedures are evolving to advance TSMO strategies. For example:

- Does the project planning and scoping process include consideration of TSMO strategies as a viable alternative to capacity construction?
- Are procurement processes flexible enough to include evolving and emerging TSMO strategies?
- Is there a process for multi-disciplinary coordination across divisions to integrate TSMO strategies into all functional areas?
- Are new policies or processes designed specifically to integrate or mainstream TSMO?

Although a few of these indicators may be quantifiable (i.e., funding or staffing allocated to TSMO), others are better evaluated qualitatively through surveys or review of documentation of changes in policies or processes. The business case provides the foundation for promoting TSMO throughout the organization. It should be adjusted to address areas where the benefits of TSMO have not been well understood or embraced as a way to optimize the transportation system.

TSMO management and staff should develop a process for evaluating the effectiveness of the TSMO business case as a tool for mainstreaming TSMO. The evaluation process can identify areas of resistance within the organization (i.e., people, policies, and procedures) to help improve the message of TSMO benefits and identify opportunities for additional outreach and collaboration in areas that may not have fully embraced a TSMO philosophy.

4. CURRENT RESOURCING FOR TSMO

Resource levels are one possible indicator of how accepted and supported TSMO is within an agency. A TSMO business case can help an agency make the case for enhancing resources directed at TSMO efforts, such as additional projects, services, and staffing.

To understand the current state of TSMO budgets and staffing, information was gathered from agency websites and during interviews. Table 1 summarizes budgets and staff for TSMO implementation at State DOTs, including overall budgets and staffing counts. Basic statistics for the States are also included to help provide context, including miles of public roads, population, and annual vehicle miles traveled (VMT). (USDOT n.d.)

The research team also included information, if available, as to whether a State's TSMO resources are increasing, decreasing, or staying the same. Table 1 is for reference only; it is not a definitive statement about how agencies invest in TSMO, and it does not compare State DOT TSMO investments. However, table 1 does offer examples of how agencies approach their commitment of resources to TSMO initiatives. Rather than providing a model, agencies in table 1 are examples of how TSMO programs may expand or change based on population, miles of roads under DOT management, budget limits, and staffing availability.

Gathering data on TSMO-related budgets and staff through online research proved to be difficult. The research team gathered some of this information through direct interviews; certain agencies did not have defined numbers. The following are some key observations:

- Agencies do not consistently define what a TSMO-related activity is or is not. TSMO-related activities are often grouped in a larger traffic, operations, or maintenance budget.
- As TSMO becomes more mainstream in an agency, the ability to separate specific TSMO activities from other activities becomes more difficult and lines become blurred. This made it difficult to identify specific, relevant information and also means overall information across agencies should not be compared.
- Staff at many agencies may have a role in TSMO activities, but they are often not dedicated to TSMO functions, which made it difficult to count staff.
- TSMO budgets appear to be stable or slightly increasing, but this is based on a small sample.
- TSMO-specific line items in the budget generally represent only a portion of TSMO funding. For example, TSMO applications may be included within larger capital investment projects and not identified as a TSMO investment.
- Separating TSMO funding from other activities may not support mainstreaming and may be perceived as a threat to funding for other DOT activities.

Table 1. Examples of States' TSMO budgets and staffing.

State Information	Department of Transportation (DOT) Budget Information	Staffing Information
Arizona • 66,558 mi of public roads • 7.2 million population • 65.1 billion vehicle miles traveled (VMT)	• $3.4 billion total Arizona DOT budget (Arizona DOT 2018) • $42 million transportation systems management and operations (TSMO) budget, including maintenance, operating the system, people, and projects (Cain 2020)	• 4,552 full-time employees (FTE) in Arizona DOT for fiscal year (FY) 2018 (Arizona DOT 2018) • 290 FTEs in TSMO Division (Cain 2020)
Colorado • 88,818 mi of public roads • 5.7 million population • 53.4 billion VMT	• $1.96 billion total Colorado DOT budget • TSMO budget categories (Colorado DOT n.d.): o Mobility Operations: Planning, Performance, and Programs – $2.8 million o Mobility Operations: Real-Time Operations – $10.6 million o Mobility Operations: Intelligent Transportation System (ITS) Asset Management – $21.2 million o Mobility Operations: ITS Investments – $10 million. o Traffic Signal and Ramp Metering Program – $16.1 million o RoadX: Program intended to carry out Colorado DOT's vision to transform Colorado's transportation system into one of the safest and most reliable in the nation by harnessing emerging technology – $12.1 million o National Highway Freight Program: may include some TSMO-related projects – $23.1 million o Congestion Mitigation and Air Quality budget – $50.2 million	• 3,327 FTEs in Colorado DOT (Colorado DOT n.d.)

Note: Table 1 is for reference only and it is not a definitive statement about how agencies invest in TSMO.
Source: Federal Highway Administration.

Table 1. Examples of States' TSMO budgets and staffing. (continuation)

State Information	Department of Transportation (DOT) Budget Information	Staffing Information
Florida • 122,848 mi of public roads • 21.3 million population • 218.8 billion VMT	• $10.8 billion Florida DOT budget for FY 2018–19 (Florida DOT 2017) • $231 million per year TSMO-related annual budget; includes TSMO cost feasible plan, annual maintenance, connected and autonomous vehicles, operations, and replacement; does not include Florida DOT staff costs Some exceptions: • Some of the work on motor carrier size and weight may also be TSMO. • Does not capture entire cost of major managed lanes projects, such as Interstate 4 Ultimate and Tampa Bay Next, but does capture costs of ITS technology within those types of major projects. It could be argued that managed lanes are a TSMO strategy, so the entire cost could be applicable. • Does not capture bus rapid transit projects that may be funded locally or by the transit office (Ponnaluri, 2018) • Does not capture projects funded by local agencies	• Approximately 6,500 employees (Florida DOT 2014) • Approximately 80 FTEs with full-time TSMO role; includes both freeway and arterial management staff, some from traffic management centers, etc. • Approximately 12 FTEs with a part-time TSMO role; includes lead roles in several areas, including traffic operations and other offices (Ponnaluri 2018)
Iowa • 114,880 mi of public roads • 3.2 million population • 33.8 billion VMT	• $1.3 billion total Iowa DOT budget for FY 2020 (Iowa DOT 2018) • $20–21 million TSMO budget identified for FY 2019, roughly the same budget for FY19 and FY20 • $15–18 million spent the prior year. TSMO program budget has been in place approximately 3–4 years; budget has been held fairly steady over the program years. • TSMO budget does not include staff salaries; includes ITS maintenance statewide and on-call consultant TSMO support to any bureau within the Operations Division. (Matulac 2018)	• 2,722 total FTEs in Iowa DOT for FY 2019 (Iowa DOT 2017) • Currently three TSMO positions across the State. One position in the central office and two positions in the district offices (Matulac 2018)

Note: Table 1 is for reference only and it is not a definitive statement about how agencies invest in TSMO.
Source: Federal Highway Administration.

Table 1. Examples of States' TSMO budgets and staffing. (continuation)

State Information	Department of Transportation (DOT) Budget Information	Staffing Information
Maryland • 32,211 mi of public roads • 6.1 million population • 60 billion VMT	• $6.1 billion total Maryland DOT budget for FY 2019 (Maryland Department of Budget and Management 2019) • $3–4 million for TSMO planning efforts; $6 million if State planning and research (SPR) budgets are included • Maryland DOT State Highway Administration's Coordinated Highways Action Response Team (CHART) Program annual budget is $30 million for capital, operations, and maintenance activities. Approximately $15–18 million per year is used for capital projects, such as ITS infrastructure and advanced transportation management system (ATMS) upgrades, which enable TSMO strategies. Some of the ongoing major projects, such as the Interstate 270's $100-million project and traffic relief projects, include coordinated ramp metering, adaptive signal software, ATMS, and information technology components. (Mahapatra 2018)	• Approximately 11,000 FTEs at Maryland DOT (Maryland Department of Budget and Management 2019) • TSMO deputy director was the first job description. Recent mid-management hires, such as the active traffic management program manager, have the required understanding and experience in TSMO. Moving forward with other vacancies, job requirements will have TSMO aspects included, for example, planning/engineer positions include TSMO knowledge as a criterion. (Mahapatra 2018) CHART has reorganized to support the TSMO program and specific TSMO strategies.

Note: Table 1 is for reference only and it is not a definitive statement about how agencies invest in TSMO.
Source: Federal Highway Administration.

Table 1. Examples of States' TSMO budgets and staffing. (continuation)

State Information	Department of Transportation (DOT) Budget Information	Staffing Information
New Jersey • 38,896 mi of public roads • 8.9 million population • 77.5 billion VMT	• $3.7 billion total for FY 2019 Transportation Capital Program: o $2.3 billion for New Jersey DOT o $1.4 billion for New Jersey transit • Approximately $50 million in FY 2020 for staffing and program/project funding (Cowan 2020) • New Jersey DOT program provides $337 million to address highway congestion through infrastructure improvements as well as through efforts to better manage traffic and respond to incidents. • New Jersey DOT program provides more than $90 million for multimodal investments that support maritime, freight, and rail initiatives as well as bicycle and pedestrian improvements. (New Jersey DOT 2018)	• New Jersey DOT Transportation Mobility Division is considered the DOT's TSMO unit. • 183 FTEs in Transportation Mobility Division, working under three groups (Cowan 2020): o Mobility Operations: 136 (traffic operations center, safety service patrol, central dispatch, Office of Emergency Management/Incident Management) o Mobility Engineering: 45 (ITS, signals, connected vehicles, construction analysis) o Mobility Planning and Research: 2 (resource center/SPR planning)

Note: Table 1 is for reference only and it is not a definitive statement about how agencies invest in TSMO.
Source: Federal Highway Administration.

Table 1. Examples of States' TSMO budgets and staffing. (continuation)

State Information	Department of Transportation (DOT) Budget Information	Staffing Information
Ohio • 122,987 mi of public roads • 11.7 million population • 119.6 billion VMT	• $2 billion total Ohio DOT budget for 2019 (Ohio DOT 2018) • Approximately $5 million Ohio DOT TSMO capital budget (MacAdam & Kieffer 2020)	• 4,857 Ohio DOT employees in FY 2018 (Ohio DOT 2018) • Some staff are partially dedicated to TSMO; others are fully dedicated to TSMO. • Roughly five TSMO positions have been added in the central office as a direct result of recommendations from Ohio DOTs TSMO plan. Other central office staff impact TSMO activities (traffic management center, ITS, traffic management, traffic incident management, etc.). • Districts are shifting resources toward more staff time to TSMO. There are three or four total new TSMO positions at the districts, as recommended by Ohio DOT's TSMO plan. Two districts have dedicated TSMO coordinators; the other 10 districts are partially dedicated. (MacAdam and Kieffer 2018)

Note: Table 1 is for reference only and it is not a definitive statement about how agencies invest in TSMO.
Source: Federal Highway Administration.

Table 1. Examples of States' TSMO budgets and staffing. (continuation)

State Information	Department of Transportation (DOT) Budget Information	Staffing Information
Oregon • 79,275 mi of public roads • 4.2 million population • 36.8 billion VMT	• $5.3 billion total revenue during the 2017–2019 biennium (Oregon DOT n.d.) • Exhibit 18–8 in Oregon DOT's *Analysis Procedure Manual Version 2* lists potential TSMO funding sources and application cycles. (Oregon DOT 2019) • Oregon DOT's 2018–2021 State Transportation Improvement Program showed 58 TSMO-related entries classified as OP–ITS, such as: o $2.3 million for Clackamas County Regional Freight ITS – improves reliability of the regional freight system by reducing freight delays in known congested areas through a variety of ITC system enhancements. o $79,000 for SMART Employer Outreach Program – travel options, including vanpooling, riding transit, bicycling, walking, and telecommuting. o $770,364 for Canby (M J Lee) Ferry ITS project o $1.9 million for TSMO/ITS 2020 – to provide strategic and collaborative program management, including coordination of activities for TransPort TSMO committee o $2 million for TSMO/ITS 2021 – to provide strategic and collaborative program management, including coordination of activities for TransPort TSMO committee o $6 million for Interstate 205: Interstate 5 – OR213, phase 3 – install active traffic management improvements throughout the project limits to help travelers get where they are going safely and efficiently. These signs can display traffic flow information, roadway conditions, and advisory speed limits.	• Approximately 4,500 employees at Oregon DOT (Oregon DOT n.d.)

Note: Table 1 is for reference only and it is not a definitive statement about how agencies invest in TSMO.
Source: Federal Highway Administration.

Table 1. Examples of States' TSMO budgets and staffing. (continuation)

State Information	Department of Transportation (DOT) Budget Information	Staffing Information
Pennsylvania • 120,521 mi of public roads • 12.8 million population • 101.6 billion VMT	• $9.1 billion total Pennsylvania DOT budget (Pennsylvania DOT 2019) • Approximately $5 million dedicated TSMO budget per year, with a planning partner match. Statewide funding is provided for transportation management center (TMC) staff and maintenance of ITS equipment. (Tomlinson 2018)	• 11,375 employees at PennDOT (PennDOT n.d.) • 38 TSMO staff including TMC management staff but does not include TMC operators or supervisors (Tomlinson 2020)
Tennessee • 95,986 mi of public roads • 6.8 million population • 82.3 billion VMT	• $2.2 billion Tennessee DOT budget (Tennesee DOT 2018) • $30 million per year TSMO program, not considering specific TSMO deployment projects in the 3-year program; currently have 17 deployment projects programmed, totaling $101,100,000 over the next 3 years (Freeze 2018)	• About 3,400 employees (Tennessee DOT n.d.) • 40 FTEs in headquarters traffic operations division. 186 FTEs in the regions carrying out activities of the traffic management center and Highway Emergency Local Patrol programs (Freeze 2018)
Texas • 314,319 mi of public roads • 28.7 million population • 273.0 billion VMT	• Almost $13 billion total Texas DOT budget (Texas DOT 2017) • Texas DOT executed four engineering consultant contracts in October 2018 for TSMO planning and implementation in the various districts and divisions statewide. Each contract is 5 years and can be funded up to $5 million. (Cameron 2018)	• 12,419 total FTEs at Texas DOT (Texas DOT 2017) • Each of the 25 Texas DOT districts has identified TSMO coordinators and champions who will be leading TSMO planning and facilitating collaboration among stakeholders in their respective districts; these are not official Texas DOT job titles or roles defined in agency or district organizational charts. (Cameron 2018)

Note: Table 1 is for reference only and it is not a definitive statement about how agencies invest in TSMO.
Source: Federal Highway Administration.

Table 1. Examples of States' TSMO budgets and staffing. (continuation)

State Information	Department of Transportation (DOT) Budget Information	Staffing Information
Virginia • 75,348 mi of public roads (2019) • 8.5 million population • 85.4 billion VMT (2019)	• $6.4 billion total Virginia DOT annual budget (Virginia DOT 2019) • Within Virginia DOT's maintenance program: o Transportation Operations Services (604004) improves mobility, safety, travel time reliability, and security on the transportation system through the deployment of a variety of operational strategies, including regional smart traffic centers, emergency services, traveler services, congestion management, and traffic signalization optimization. Budget: ▪ FY 2018: $168,477,856 ▪ FY 2019: $148,056,155 ▪ FY 2020: $160,899,429 o Ground Transportation System Research (602002) includes a number of research areas; a portion of the budget is dedicated to operations research. Budget: ▪ FY 2018: $9,197,341 ▪ FY 2019: $9,500,838 ▪ FY 2020: $9,606,334 o Toll Facility Maintenance and Operation (606003) provides for the operational costs of the four toll facilities operated by Virginia DOT. Budget: ▪ FY 2018: $24,929,766 ▪ FY 2019: $41,532,467 ▪ FY 2020: $45,814,657 (Virginia DOT 2018)	• About 7,735 FTEs at Virginia DOT (Virginia DOT 2019)

Note: Table 1 is for reference only; it is not a definitive statement about how agencies invest in TSMO.
Source: Federal Highway Administration.

Table 1. Examples of States' TSMO budgets and staffing. (continuation)

State Information	Department of Transportation (DOT) Budget Information	Staffing Information
Washington • 80,429 mi of public roads • 7.5 million population • 61.4 billion VMT	• $6.75 billion total Washington DOT 2019–2021 biennium budget (Washington State DOT 2019)	• More than 6,800 FTEs at Washington DOT (Washington State DOT n.d.) • 250 FTEs related to TSMO in regions and headquarters traffic operations and incident response; does not include other aspects of the agency, such as public and active transportation (Nisbet, Harwood, and Neeley 2018) • Has a statewide TSMO development engineer (Washington State DOT n.d.)
Wisconsin • 115,547 mi of public roads • 5.8 million population • 65.3 billion VMT	• $6.8 billion Wisconsin DOT biennial budget (July 1, 2017–June 30, 2019) across all programs (Wisconsin DOT Office of Management and Budget 2019) • $300.4 million Wisconsin DOT FY 2019 budget for State highway maintenance, repair, and traffic operations • $299.4 million budget for FY 2018 was a broad budget that included more than just TSMO items. (Wisconsin DOT 2018)	• About 3,400 FTEs at Wisconsin DOT (Wisconsin DOT 2018)

Note: Table 1 is for reference only and it is not a definitive statement about how agencies invest in TSMO.
Source: Federal Highway Administration.

5. BUSINESS CASES FOR TSMO

Many State DOTs have developed a business case to advance TSMO in their organizations. These business cases vary from formal, stand-alone documents to sections of TSMO plans to informal talking points shared across divisions and offices. This section provides business case examples, identified through document reviews and agency interviews, that focus on the transportation challenges faced by agencies in their State, and how TSMO can be used to address them.

Arizona

Arizona DOT's mission is "Connecting Arizona. Everyone. Everywhere. Every Day." (Arizona Department of Transportation n.d.) The TSMO division's focus areas include Operational and Traffic Safety, System Maintenance, Systems Technology, and Traffic Maintenance and Management. Arizona DOT has identified a number of challenges that TSMO can address and has articulated the importance of TSMO in addressing these challenges. This information is on Arizona DOT's website and helps make a business case for advancing TSMO. The challenges Arizona DOT identified are (Cain 2016):

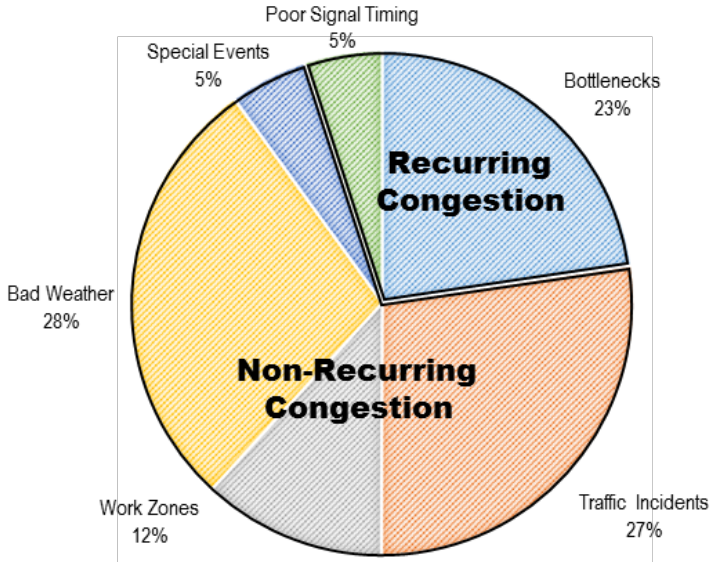
- Congestion and delay increasing as the economy and population grow
- High value placed on reliability
- No longer able to build its way out of congestion
- Over $3 billion of economic loss due to vehicle crashes in 2014

Arizona DOT makes the case that TSMO is important for the following reasons:

- It provides better alignment with present and future operations.
- System preservation and operations are more important than ever.
- There are synergies through improved interagency coordination.
- It maximizes the efficiency of existing infrastructure.
- It maximizes the effectiveness of tools and data for mobility, reliability, and safety.
- It advances technologies.

Iowa

A section of the Iowa DOT TSMO strategic plan, entitled "The Case for TSMO," outlines the benefits of TSMO in terms of safety, efficiency, and reliability. It also discusses how TSMO supports Iowa DOT's vision of "Smarter, Simpler, Customer-Driven." (Iowa DOT 2016) Iowa DOT leadership presented the business case across the agency to increase understanding of TSMO and its benefits for all levels of the organization. Iowa DOT also made the case for TSMO to the public and elected officials to enhance support and funding for the TSMO program. The plan presents statistics on congestion in Iowa, shown in figure 1, and discusses the impacts of congestion on system delay, reliability, and safety.



Source: Iowa DOT.

Figure 1. Chart. Iowa congestion from 2013 to 2015.

Iowa DOT estimates $2 billion of unanticipated transportation costs in Iowa associated with delay. These costs include wasted time, wasted fuel, financial costs of traffic, and vehicle costs. The TSMO strategic plan argues that TSMO:

> Offers resources and strategies to realize the full capacity of the existing transportation system, increase reliability, improve safety, and target safety and operational problem locations. With increasing travel demand reflected in a growing population and VMT, and with funding constraints for construction of additional lanes, TSMO brings together Iowa DOT and its external partners to reduce traffic congestion and address nonrecurring traffic disruptions in a collaborative and cost-effective program. These strategies can be implemented faster and more economically than new construction and support environmental and sustainability objectives by reducing congestion and avoiding more impactful construction options. (Iowa DOT 2016, p. 5)

Michigan

Michigan DOT developed multiple business cases, tailored to various stakeholder groups and audiences, that summarize the mobility, safety, and reliability benefits of TSMO. Figure 2 shows Michigan DOT's business case developed for the public.

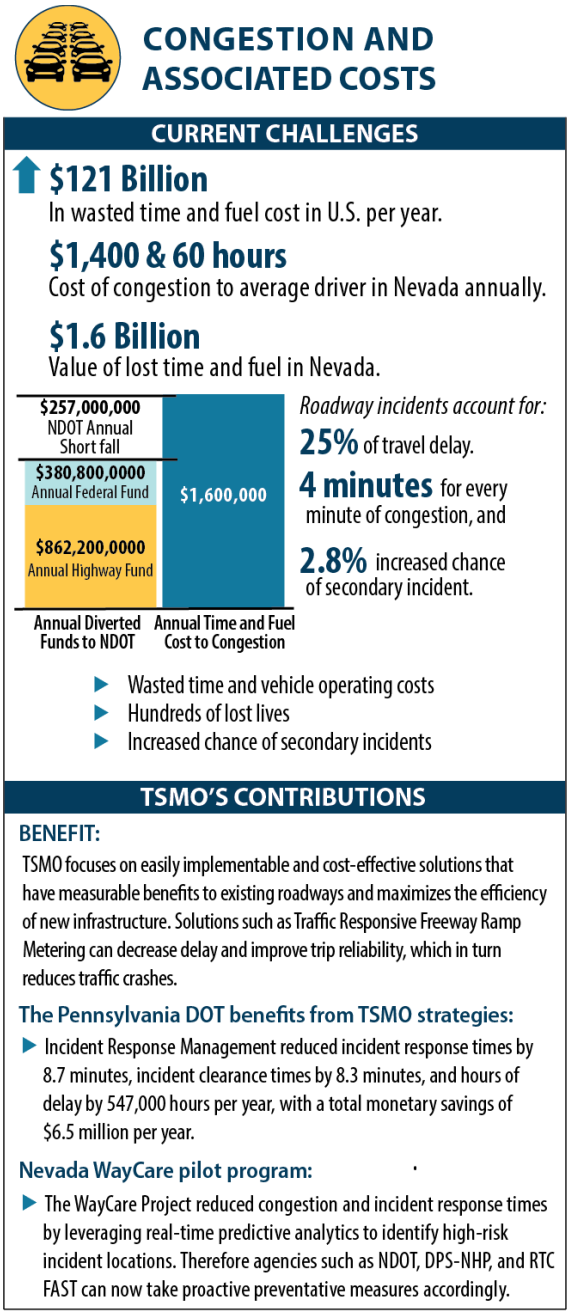
Michigan DOT's *TSMO Implementation and Strategic Plan* includes a section on the importance of TSMO for Michigan DOT. (Michigan DOT 2020) This section discusses the opportunities for TSMO's "'toolbox' of cost-effective and quick-to-implement transportation solutions that can complement and enhance traditional capital expansion projects for the approximately 60 percent of traffic congestion that is due to … nonrecurring traffic issues." (Michigan DOT 2020, p. 8) It makes the case that "TSMO solutions increase mobility, reliability, and safety during incidents, bad weather, work zones, and special events." (Michigan DOT 2020, p. 8)

Source: Michigan DOT.

Figure 2. Infographic. Michigan Department of Transportation's public business case for TSMO.

Nevada

As part of Nevada DOT's TSMO program planning process, it developed a business case for TSMO that addresses current challenges and the benefit of TSMO in addressing those challenges. The challenges include population growth, a tourism-based economy, congestion and associated costs, increasing vehicle miles traveled (VMT), deficient roads and bridges, safety, truck and freight movement, and asset and performance management. The business case is presented in a two-page graphical format (one page shown in figure 3) that highlights the current need, the benefits provided by TSMO strategies to address the need, and example projects underway by various DOTs to apply TSMO strategies.



Note: NDOT = Nevada DOT, DPS-NHP = Department of Public Safety Nevada Highway Patrol, RTC-FAST = Regional Transportation Commission Freeway and Arterial System of Transportation

Source: Nevada DOT.

Figure 3. Infographic. Element of Nevada Department of Transportation's TSMO business case.

Pennsylvania

PennDOT is developing a business case and believes that good data are essential to building the case. In the agency's *TSMO Strategic Framework for Pennsylvania*, the section "Why TSMO" highlights mobility, safety, and funding issues and how TSMO can address those. (PennDOT 2018) "The TSMO Business Case" section states that we cannot build our way out of congestion. Additionally, capacity-adding projects generally cost more and provide a lower return on investment compared to operations solutions. Traditional road capacity adding projects have generally shown benefit/cost ratios of 2:1 to 5:1, while TSMO strategies that target specific causes of congestion at a specific location are extremely cost effective with benefit cost ratios as high as 60:1. (PennDOT 2018)

In addition to formal efforts to define the TSMO business case, TSMO staff are committed to making the case on an ongoing, informal basis through elevator speeches and short pitches across the agency whenever an opportunity presents itself. This is intended to build understanding and mainstreaming of TSMO through everyday conversations.

Utah

Utah DOT recently completed its business case for TSMO as the first step toward developing its TSMO program plan. The six-page document, which advances Utah DOT's slogan "Keeping Utah Moving," is summarized in an overview section that states:

> UDOT is taking an integrated, agency-wide approach to continually improve our work by promoting TSMO solutions that leverage technology and partnerships to optimize network performance. This includes raising awareness of how TSMO helps advance all UDOT work and of the many

> opportunities to apply TSMO solutions to the full spectrum of UDOT projects to improve safety, reliability, and efficiency for all UDOT travelers. This document presents the UDOT-specific business case on the benefits of advancing TSMO solutions capabilities – and of 'mainstreaming' TSMO solutions across the agency. (Utah DOT 2019, p. 1)

Utah's *Keeping Utah Moving by Advancing TSMO: The Business Case* includes the following topics (Utah DOT 2019):

- **Why TSMO?—**addresses TSMO's cost-effective solutions for today and tomorrow's transportation challenges; the benefits of TSMO; and the institutional, organizational, and procedural changes for improving TSMO.

- **TSMO at Utah DOT Today**—describes current TSMO activities within the DOT; UDOT TSMO strengths, challenges, and opportunities; and how TSMO fits into the executive director's top-10 goals for Utah DOT.

- **Next Steps at Utah DOT**—discusses TSMO planning and outreach activities to advance TSMO at Utah DOT.

Texas

The Texas DOT website explains that congestion is increasing throughout Texas and that the statewide TSMO program is intended to improve mobility and safety by coordinating mobility strategies. The agency focuses on creating a culture that recognizes traffic management systems as a core priority and states: "TSMO brings a customer-centric focus to the project development process by prioritizing mobility solutions which apply technology and other innovative techniques. TSMO mobility strategies are relatively low in cost compared to adding capacity, can be implemented in less time, and potentially offer higher benefit-cost ratios." (Texas DOT 2020)

Texas DOT's *TSMO Statewide Strategic Plan* includes a section on how TSMO helps meet specific transportation needs. (Texas DOT 2018) The plan is considered Texas DOT's business case for TSMO. It argues that "TSMO is an effective approach to planning for and delivering projects using innovative and efficient strategies. TSMO helps agencies provide safe, reliable, efficient, and sustainable mobility for all users." (Texas DOT 2018, p. 7) It includes six ways TSMO improves system management:

- Effective use of funding
- Collaboration with stakeholders and across disciplines
- Data-driven, performance-based implementation
- Immediate improvements to system reliability
- Integration of TSMO strategies in all project phases
- Improved mobility, reliability, and safety

Washington

Washington State DOT's assistant secretary for multimodal development and delivery provided the business case for TSMO in a presentation, which identified the State's challenges and need for TSMO. (Elizer 2018) It discusses how the State's robust economy continues to add challenges to the transportation system, as documented in Washington State DOT's *Corridor Capacity Report*. (Washington State DOT 2018) It outlines the importance of freight movement to the State economy, the cost of transportation incidents, the impact of congestion, and the inability to provide enough lane miles to solve congestion through construction. Washington State DOT's approach to solving these challenges is through its Practical Solutions initiative. This approach is based on smarter designs and better system operations: "TSMO offers the potential to provide an integrated program to optimize the performance of existing infrastructure through the implementation of specific systems and services that preserve capacity and improve reliability and safety." (Elizer 2018)

Washington State DOT believes that "TSMO is foundational to the delivery of [its] three Strategic Plan Focus Areas:" (Elizer 2018)

- **Inclusion**—focuses on diversity and engagement across the organization to ensure all voices are heard.
- **Practical Solutions**—TSMO supports cost-effective planning, design, construction, operations, and maintenance of the transportation system.
- **Workforce Development**—TSMO's focus on out-of-the-box thinking supports the creation of a motivated, modern workforce.

6. BUSINESS CASES AND FINDINGS FROM OTHER INDUSTRIES

The business case for public-sector investments is often different from the private sector, including regulated industries. In the private sector, the primary beneficiary is often the owner, shareholder, investor, or lender who realizes gains from improved operations, which lead to growth in market share, revenue, and profitability. The business case is often made by showing a rate of return on the investment that justifies making the investment.

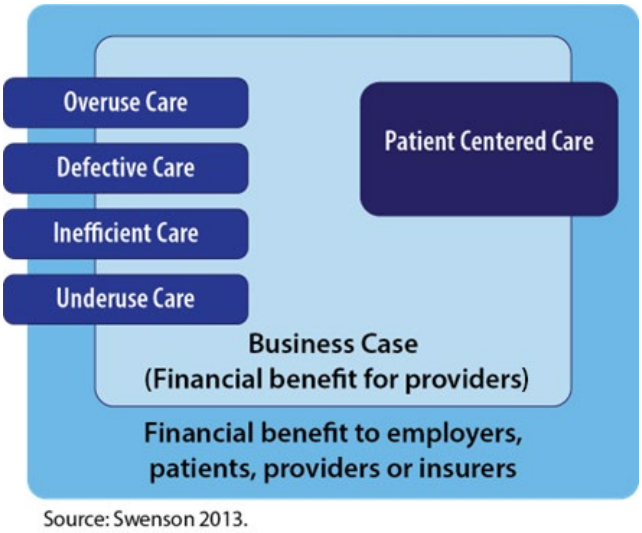
In the public sector, including most transportation agencies, the primary beneficiary of investments is the system user, including other public-sector entities (e.g., local agencies and first responders benefit from mobility improvements); however, investments are typically made by agencies that must compete with other agencies and community needs for investment funds. Competition also exists within an individual agency because of internal priorities.

There are similarities, however. Public- and private-sector entities must identify and quantify, to the extent possible, the needs or opportunities associated with investment alternatives. They must also demonstrate how these investments benefit the population served (i.e., the use case) or the investors, owners, and shareholders who make the investments.

This section discusses how select industries similar to transportation agencies make the business case for improving management and operations. Three industries are discussed: health care, electric utilities, and power generation. Each industry provides services instead of tangible products that are typically offered on demand rather than stored for later use or consumption. The transportation system has similarities and differences with these industries. Electric utilities and power distribution systems require continuous service along a fixed path of distribution lines. They cannot tolerate frequent interruptions or delays, so the capacity must be designed to accommodate the maximum demand and continue to do so under varying conditions. Transportation is also a vital need, but there is more flexibility in routes, modes, and schedules for some portion of users. Health care delivery shares common features of transportation, in that it deals with immediate demands (e.g., emergency departments), elective demand (i.e., scheduled to match the availability of services), and urgent but less critical demand.

Health Care

The Mayo Clinic in Rochester, Minnesota, developed a business case for multiple investments designed to reduce waste, improve efficiency, and improve the effectiveness of the care provided. (Swenson 2013) Figure 4 illustrates the framework used to develop the business case, focusing on the areas where benefits



Source: Swenson 2013.

Figure 4. Diagram. Quality improvement beneficiaries associated with health care business case.

accrue to providers and patients. The focus areas include inappropriate use of resources (overuse, defective, and inefficient) and underuse of care, which results in subsequent health care needs that are more costly and complex.

The study team at the Mayo Clinic developed solid business cases for improvements in orthopedic surgery and the cardiovascular outpatient clinic, which resulted in reduced waste. The business case was developed primarily through incremental implementation of proposed actions that were likely to reduce costs and improve patient outcomes. The results were then carefully monitored and compared to the baseline metrics. While one might hope to establish a solid business case prior to implementation, it is difficult to make reliable estimates prior to implementation. Ultimately, standardizing care processes resulted in $2.6 million annual savings in orthopedic surgery compared to the baseline metrics. Beyond reductions in cost, meaningful quality improvements included a 40-percent reduction in blood product utilization and reduced infection rates. In the 1-year period during which changes were implemented, the average length of stay decreased from 3.8 to 2.7 days, with a decline in hospital readmissions from an average of 3 percent to 2.6 percent. Staff satisfaction improved with no negative effect on patient satisfaction.

Similarly, improvements in the cardiovascular outpatient clinic resulted in increased physician fill rates from 70 to 92 percent, decreased cancellations and no-shows from 30 to 10 percent, reduced wait time to access appointments by 91 percent (from 33 to 3 days), and increased face time with providers from 240 to 285 minutes. The resources devoted to developing and implementing these improvements yielded a 5:1 return on investment.

Mayo Clinic's Department of Finance developed guidelines for identifying the financial impact of investments and organized them into hard and soft impacts.

Hard impact has these general attributes:

- Effect on cash flow is definite.
- Effect on cash flow is readily quantifiable.
- Timing tends to be near term (i.e., months; maybe even 1–2 years, depending on project scope and duration).
- Items tend to have transaction-based evidence.

Soft impact has these general attributes:

- Effect on operations is identifiable; however, cash flow is indirectly impacted.
- Effect on cash flow is indefinite or not quantifiable.
- Timing tends to be long term (i.e., may require 1–2 years, or more, before cash flow impact is realized).
- Long-term impact is likely realizable.

The business case was made for each improvement based on the positive financial impact of identifiable and measurable improvements in patient care. The financial impact came largely from reducing waste and from avoiding adverse events to patients (e.g., falls and infections) that might extend their length of stay.

The primary takeaway for TSMO is that major improvements were achieved though incremental improvements in the way services were delivered, rather than through added capacity. These improvements required engaging stakeholders to gain a deep understanding of current procedures and looking for opportunities to standardize procedures to reduce waste and improve efficiency. The business case for TSMO often includes showing how TSMO strategies make more effective use of available capacity, and also how these strategies can improve the movement of goods and people through reduced delays and fewer incidents.

Electric Utilities

"Globally, the replacement and maintenance of utility infrastructure is providing the industry with an important opportunity to upgrade and modernize the electric network." (Groark 2019) A similar statement could be made about transportation infrastructure, and many aspects of the business case for upgrading and modernizing electric utilities apply to transportation infrastructure and operations.

The business case in Groark (2019) is for a utility monitoring and diagnostic center that enables utility companies to identify current and imminent problems so that they can avoid catastrophic failures and allocate investment more efficiently. While similar to a traffic management center, in that it monitors system performance, the utility monitoring and diagnostic center is not a real-time control system that responds and adjusts to system changes. Instead, it seeks to ensure longer-term performance of the system through more effective investment strategies. The business case for the center begins with identifying the high-value use cases for the center. These use cases are the "bedrock of integrated monitoring and diagnostic centers, backed by cross functional and technical expertise and include catastrophic failure avoidance, capital spending optimization, optimizing maintenance, analyzing and scoring risk, compliance productivity and dynamic asset rating." (Groark 2019)

The business case for investing in the monitoring and diagnostic center that can support these use cases is made based on cost avoidance and revenue enhancements in several areas, including:

- Avoided catastrophic failure costs
- Avoided asset replacement costs
- Reduced routine maintenance
- Increased revenues from operational efficiency
- Reduced inventory value carrying costs
- Deferred asset replacement costs

Power Generation

In a 2017 article, Boston Consulting Group authors assert that the power generation industry is experiencing a sweeping transformation and that, over the next decade, unprofitable power plants will be "culled from the ranks of competitors by mergers and plant shutdowns." (Stock 2017) It believes that producers must take a much broader approach to survive and create long-term value, going "far beyond traditional cost reduction and consolidation measures, to continually improving operational efficiency over the long term." (Stock 2017)

Their solution is to apply the principles of lean management to power generation by transitioning "to an integrated, sustainable lean production system that covers all aspects of business requirements, operational improvements, people management, and performance governance," starting by identifying its core business requirements and objectives and then applying lean tools to improve the high-priority areas of its operation.

The key to this integrated approach is to take full advantage of what the authors call "Industry 4.0 technologies," including big data, advanced robotics, and additive manufacturing. "Power Generation 4.0 is a set of technology levers that provides the basis for achieving a step-change in efficiency across the power-generation value chain and for promoting improvements in health, safety, and environmental protection." (Stock 2017) For example, implementing a new monitoring center that reports both system performance and the condition of the plant at the part level enabled one power producer to reduce the number of unplanned shutdowns by 50 percent in 5 years, saving approximately $3.55 million dollars per year. The pathway to making the business case for the benefits of Power Generation 4.0 begins with answering a number of questions:

- Have we thoroughly considered the full set of levers available for improving operational efficiency that is currently at our disposal?

- To what extent have our recently applied efficiency measures enabled continuous improvements rather than one-off cost savings? How effectively are we laying the foundation for sustained productivity growth?

- Are our employees ready, willing, and able to autonomously identify and appropriately address inefficiencies in their daily work?

- Have we agreed on a technology roadmap for the next 5–10 years that would generate efficiency gains across all areas from procurement to sales?

What These Examples Tell Us about Developing an Effective Business Case for TSMO

Key takeaways for effectively developing and using a business case:

- Tell a story using scenarios, in non-technical language, of everyday transportation situations that show the personal impacts of congestion, unreliability, etc., and how TSMO can help
- Engage a wide range of stakeholders and decisionmakers so that they understand the potential value of TSMO investments to their organizations and to system users
- Clearly define needs and opportunities where TSMO strategies can be viewed as potential solutions
- Quantify the measurable or predictable cost of TSMO investments, including capital requirements and operating costs
- Identify and quantify the benefits that accrue to each category of beneficiary: agencies, system users, and society at large
- Use appropriate discounting methods to recognize the time phasing of costs and benefits

7. RESOURCES FOR DEVELOPING A TSMO BUSINESS CASE

This section provides examples and a brief description of resources that can help develop a TSMO business case.

Advancing Transportation Systems Management and Operations: Making the Business Case for Institutional, Organizational, and Procedural Changes Business Case

This document provides a process for developing and communicating the business case for making institutional, organizational, and procedural changes to advance TSMO. It is structured in four parts that discuss how to get started, prepare the business case, develop agency leadership support, and tailor the business case for specific audience.

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

This primer was developed to help State DOTs, MPOs, and regional operations organizations consider the key elements of TSMO program planning and enhance their TSMO capabilities. A key strategic element of TSMO program planning is the business case. This section of the primer provides an overview of a TSMO business case and some considerations for starting the conversation within an agency.

Second Strategic Highway Research Program Materials

The second Strategic Highway Research Program (SHRP2) portfolio includes a number of tools and resources that can be helpful in developing a business case for TSMO. Organizing for Reliability Tools (L06/L01/L31/L34) includes guidance on organizing to advance systems operations and management (L06/L31) and integrating business processes to improve travel-time reliability (L01/L34). Framework for Improving Travel-Time Reliability (L17) provides a range of resources and expertise about transportation systems operations and reliability.

Transportation Systems Management and Operations in Action

This publication provides an overview of various TSMO strategies and examples of their deployment across the country. It also discusses what TSMO is and the benefits associated with TSMO.

Transportation Systems Management and Operations in Smart Connected Communities

This primer helps make the case for TSMO in communities that are taking advantage of innovative technologies and collaborative institutional arrangements. It provides several examples of how TSMO can leverage extensive information networks and communications protocols that allow public and private entities to go beyond single agencies, functions, or jurisdictions to improve quality of life.

Transportation Systems Management and Operations Fact Sheet Series: Communicating the Role and Value of Transportation Systems Management and Operations to Other Programs

The TSMO Fact Sheet Series addresses nine topic areas to provide context for how TSMO can support, impact, and relate to State and local transportation agency functions such as design, maintenance, and safety to support stronger connections between these disciplines and TSMO.

National Operations Center of Excellence Case Studies

Beginning in 2018, the National Operations Center of Excellence (NOCoE) initiated TSMO Awards to celebrate TSMO successes and to showcase agency practices. These awards and the submitted projects are being shared on the NOCoE knowledge center as case studies that highlight successful and innovative TSMO practices.

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