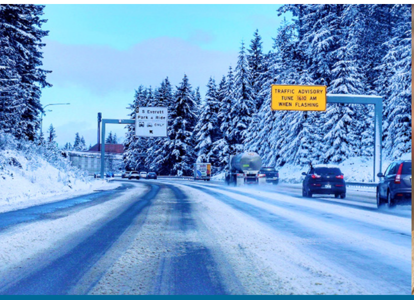
U.S. Department of Transportation
Federal Highway Administration

Applying Transportation Systems Management and Operations (TSMO) to Rural Areas



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16. Abstract This publication provides local and State agencies with resources they can use to explain the benefits of implementing transportation systems management and operations (TSMO) in rural areas. This document also provides case studies of the benefits, challenges, and considerations of implementing TSMO strategies in rural areas. The publication presents a business case for TSMO in rural areas, funding opportunities, and emerging trends and technologies. The document also details 10 case studies in rural areas based on five topics: road weather management, traffic incident management, work zones, seasonal demand, and special events. The document concludes by recognizing the conversation of implementing TSMO in rural areas is just beginning, suggesting that more research and outreach are still needed to progress TSMO in rural communities.			
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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 (2000 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

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

SI* (MODERN METRIC) CONVERSION (continued)

APPROXIMATE CONVERSIONS TO 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 (2000 lb)	T
TEMPERATURE (exact degrees)				
°C	Celsius	1.8C+32	Fahrenheit	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

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

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LIST OF ABBREVIATIONS

BIL	Bipartisan Infrastructure Law
CHAMP	Coordinated Highway Assistance and Maintenance Program
CMF	Capability Maturity Framework
CMM	Capability Maturity Model
DMS	dynamic message sign
DOT	Department of Transportation
ESS	environmental sensing station
FHWA	Federal Highway Administration
GPS	global positioning system
HERO	Highway Emergency Response Operators
HSIP	Highway Safety Improvement Program
HST	high-speed telecommunications
ITS	intelligent transportation system
NOAA	National Oceanic and Atmospheric Administration
RQDWS	rural queue and delay warning system
RWIS	road weather information system
TIM	traffic incident management
TMC	transportation management center
TNC	transportation network company
TSMO	transportation systems management and operations
TxDOT	Texas Department of Transportation
UAS	unmanned aerial system
VMS	variable messaging sign
WSDOT	Washington State Department of Transportation

Chapter 1. Introduction

BACKGROUND

The Federal Highway Administration (FWHA) works with State and local agencies to improve safety, mobility, and reliability, and to enhance transportation systems management and operations (TSMO). TSMO involves the use of strategies, technologies, mobility services, and programs to optimize the safe, efficient, and reliable use of the existing transportation infrastructure without adding capacity. Although many TSMO strategies have predominantly been applied in urban areas, some have also been applied in rural areas.

Because of their low densities and sometimes remote locations, rural areas can experience unique and challenging conditions, such as:

- Rural areas usually consist of larger geographical areas, which accounts for longer trip durations.
- Crashes in rural areas usually occur at higher speeds than crashes in urban areas.
- Rural areas have a high number of one- or two-lane roads, which may experience disruptions caused by accidents and slow-moving agricultural vehicles. According to FHWA, 90 percent of rural roads are one or two lanes.[1]
- Rural areas and the rural transportation network provide few alternate routes.
- Rural distances and large geographical areas lead to longer emergency response times, which affects motorists or citizens who need emergency response.
- Many rural roads are made of gravel and dirt, which may make them unpassable in bad weather and a potential safety hazard.
- Rural areas usually provide challenging driving conditions such as steep mountain grades, steep drop-offs, sharp curves, trees close to the roadway, and narrow bridges.
- Rural areas have telecommunications gaps due to the lack of power and infrastructure deployed. Telecommunications capabilities, where available, can be spotty and less dependable.
- Evacuating traffic from natural disasters, such as hurricanes, wildfires, and flooding, can be more challenging in rural environments.
- Avalanches in rural areas disrupt transportation on roadway networks and are a safety hazard for the travelling public.
- Collisions between animals and vehicles and the presence of animals on the roadsides are common safety issues encountered in rural areas. Several States have deployed animal warning systems to reduce the number of collisions between animals and vehicles.

[1] "What Is Rural Transportation? Why Rural Matters," Western Transportation Institute, Montana State University, https://westerntransportationinstitute.org/about/what-is-rural-transportation/.

For the 2020 census, the U.S. Census Bureau defines an urban area as a territory with more than 2,000 housing units or 5,000 people, while rural areas encompass all population, housing, and territory not included within an urban area.[2] Based on 2010 Census data, 97 percent of the Nation's land is estimated to be rural[3] and 70 percent of the Nation's road network is also estimated to be rural.[4] Posted bridges or weight-limited bridges are also a concern in rural areas. 90 percent of posted bridges are in rural areas, and heavy trucks are prohibited from crossing posted bridges. Heavy trucks hauling in rural areas traverse three times the distance as needed in metropolitan areas in order to find a safe bridge to cross.[5]

TSMO can be applied to all modes of transportation:

- **Private and commercial vehicles** encounter congestion on an irregular basis in rural areas. Work zones, crashes, and large weather events are typical nonrecurring events that can cause congestion. Although high levels of congestion in rural areas may be less frequent compared to urban areas, they are no less disruptive to daily lives. For instance, nonrecurring congestion can create the potential for unexpected and lengthy delays, long detours, increased emergency response times, and severe crashes, which can be detrimental to freight and rural communities that rely more heavily on vehicles for travel. TSMO strategies can be applied in rural areas to help reduce congestion as well as crash incidence and severity.
- **Public transit** is less prevalent in rural areas. While providing transportation services to large, low-density areas can be challenging, it gives an option to individuals in rural areas who cannot drive due to health or economic reasons but require transportation to work, shopping, healthcare, and education.
- **Pedestrians and bicyclists** can find the rural roadway environment challenging. Vehicle speeds are generally higher in rural areas and pedestrian and bicyclists are fewer, so drivers are less likely to expect them. Shoulders on rural roadways are often either too narrow or nonexistent. Roadway signs may impede the safe passage of pedestrians and bicyclists or obstruct their ability to see oncoming traffic. Pedestrians may walk within the traffic flow. Bicyclists and pedestrians may not wear protective gear or reflective clothing and may be more difficult to see if lighting is reduced in rural areas. Having dedicated facilities for bicyclists and pedestrians can provide a stable surface off the roadway and can reduce crashes of these travelers that would normally travel along the roadway in addition to providing access to natural and recreational areas.[6]

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[2] "2020 Urban Area FAQ," U.S. Census Bureau, accessed August 1, 2022, https://www2.census.gov/geo/pdfs/reference/ua/2020_Urban_Areas_FAQs.pdf. "2020 Final Urban Area Criteria Federal Register Notice", U.S. Census Bureau, accessed August 1, 2022.

[3] "What is Rural America," U.S Census Bureau, Accessed August 1, 2022. https://www.ers.usda.gov/amber-waves/2003/february/rural-america/.

[4] Western Transportation Institute, Rural Matters, https://westerntransportationinstitute.org/wp-content/uploads/2017/04/WTI-Brochure-120608-LR.pdf.

[5] U.S. Department of Transportation (USDOT), "Rural Opportunities to Use Transportation for Economic Success (ROUTES)," https://www.transportation.gov/rural.

[6] Federal Highway Administration (FHWA), "Small Town and Rural Multimodal Networks", https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/small_towns/

DOCUMENT OBJECTIVES

The FHWA initiated this project to enhance TSMO strategies in rural areas and facilitate discussion among practitioners. This publication explores using TSMO strategies in rural areas and identifies case studies that showcase opportunities for deployment in other rural areas. The objectives of this document are to:

- Synthesize the state of TSMO practice in rural areas through a scan of ongoing research and recent publications.
- Share successful prior uses of TSMO in rural areas that may be more widely applicable.
- Showcase emerging technologies that offer promise in expanding TSMO strategies in rural areas.
- Highlight funding opportunities available for rural areas, which are presented in the appendix.

Entities that may benefit from exploring TSMO strategies include:

- Rural planning organizations.
- Regional councils/councils of governments.
- Development districts that coordinate planning for multiple counties.
- Counties and cities that conduct their own planning.
- State departments of transportation (DOTs).

While any of the above entities can implement TSMO strategies, the term "agency" is used throughout this document for simplicity.

CHAPTER 2. BUSINESS CASE FOR TSMO IN RURAL AREAS

WHAT IS TSMO?

TSMO is a broad set of strategies that aims to optimize the safe, efficient, and reliable use of existing transportation infrastructure for all modes and areas. The objectives of TSMO strategies are to increase safety and reliability and reduce congestion by improving the day-to-day operations of existing roads.

TMSO strategies are initiated from a systemwide perspective that often spans multiple jurisdictions, agencies, and transportation modes. TSMO institutional strategies and TSMO technology-based strategies proactively address road user needs and actively manage the transportation system. These strategies can involve influencing travel demand, managing traffic congestion, responding to planned and unplanned events, and providing traveler information.

Traditional TSMO strategies include work zone management, road weather management, special event management, traveler information systems, and traffic incident management (TIM). Many of these strategies are enabled or supported by intelligent transportation systems (ITS). Newer strategies, including integrated corridor management and active traffic management, combine technologies such as traffic signal coordination, driverless vehicles, ITS, and more sophisticated data processing and analytics.

A TSMO plan can integrate all these strategies under one program to optimize the safety, efficiency, and reliability of the existing transportation system through low-cost and high-impact solutions. A TSMO plan can enhance the return on existing investments by optimizing the use of resources, personnel, equipment, and assets.

A common element of many TSMO strategies is ITS. Devices such as vehicle detectors and portable message signs, as seen in figure 1, benefit transportation system users and operators by monitoring for situational awareness, data analysis, and real-time reporting to travelers. Conducting analysis during construction or in work zones is important because of the dynamic nature of traffic patterns. ITS can also eliminate the need for certain restrictions (e.g., limited lane closure hours) and resource-intensive activities (e.g., flaggers and on-site data collection).

Figure 1. Photo. Portable changeable message sign in Washington State. *Source: FHWA*

WHAT ARE THE BENEFITS OF TSMO IN RURAL AREAS?

Rural areas usually have more limited resources and have larger geographical coverage than urban areas. TSMO strategies can help agencies that have limited funding to optimize the multimodal transportation system by better understanding the causes of congestion and leveraging technology to address the causes, as exemplified below, to meet changing customer needs and expectations:

- Rural areas often experience short-term or seasonal peak travel (e.g., recreation), which does not warrant high-investment capacity-increase projects. TSMO strategies can enable a balance of resource supply and demand with relatively low-cost solutions. For example, dynamic demand management can improve system performance at a fraction of the cost of adding new capacity.
- While only 19 percent of individuals in the United States live in rural areas, 68 percent of our Nation's total lane miles are located in rural areas.[7] Rural areas, however, tend to have fewer available detour routes, which causes challenges during incidents, road weather events, or work zones; well-planned TSMO strategies can be especially beneficial in these situations.
- Crashes occurring in rural areas tend to be more severe due to higher travel speeds; TSMO strategies such as dynamic message signs (DMSs) or speed warning signs can remind drivers to maintain a safe speed and alert them to slowed or stopped traffic ahead.
- While only 19 percent of the United States population lives in rural areas, 45 percent of all highway fatalities occur on rural roadways. The fatality rate on rural roads is also two times higher than on urban roads.[8]
- In rural areas, a higher percentage of traffic is often for freight and tourism, the disruptions of which can have notable economic impacts. A TIM program can help clear roadways of incidents and reduce these impacts.

Rural areas can benefit from using TSMO strategies in the following ways:

- Smoother and more-reliable traffic flow.
- Improved traveler safety.
- Reduced congestion.
- Cleaner air and less wasted fuel from reduced idling in bottlenecks.
- Improved livability by encouraging alternative travel modes.
- Increased economic vitality.
- More efficient use of resources (facilities and funding).

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[7] "Rural Opportunities to Use Transportation," USDOT, https://www.transportation.gov/rural.

[8] Ibid

CHALLENGES OF IMPLEMENTING TSMO PROGRAMS IN RURAL AREAS

Rural areas pose challenges for implementing TSMO strategies and programs because of individual geographic characteristics, such as:

- Large geographic coverage area.
- Fewer resources compared to urban areas (e.g., funding and staff).
- Smaller number of staff responsible for multiple duties who may have less expertise (e.g., running more complicated technology).
- Underserved rural areas due to historic underinvestment.
- Difficulty hiring and retaining skilled maintenance technicians for rural technologies.
- Difficulty accessing power and communications.
- Cost to develop power and communications infrastructure.
- Fewer, if any, alternate route options.
- Vandalism and theft of rural technologies and materials (e.g., copper theft).
- Public transit or alternative transportation options—when they do exist—typically offer less-frequent service with limited service areas.

Rural road weather management issues:

- Collecting and sharing road conditions and closure information in rural areas that lack quality sensors or data.
- Crashing due to high speeds and winter weather, compounded by a lack of illumination at rural curves and intersections.
- Blocking and spilling into traffic lanes of vehicles at chain-up areas.
- Informing and managing evacuating traffic from natural disasters such as hurricanes, forest fires, and flooding.
- Managing snowplow operations over a large geographic area.

Rural traffic incident management issues:

- It is difficult to gauge the proper incident response level needed given reduced monitoring, equipment, and communications.
- Transportation agencies are typically supporting law enforcement/emergency responders rather than providing initial incident response.
- Maintenance crews often lead incident response in rural areas and are called off projects to respond to incidents, thus disrupting workflow.

- Dedicated incident response requires ongoing commitment to funding, which has traditionally been less available in rural areas.
- There is limited understanding of whether a dedicated incident response program in rural areas is cost-effective.
- Greater spacing of interchanges on rural interstates makes access to incidents more difficult.
- There is roughly a 50 percent longer emergency response times in rural areas.[9]

Rural work zone management issues:

- Multiple active work zones in a single corridor can limit movement of oversize vehicles and create long detours
- High speeds and limited alternate routes in rural areas require more advance notification
- Unexpected queues in areas that are usually uncongested can lead to severe crashes and delays
- Inattention on long rural work zones, or long stretches leading up to work zones, causing increased crashes
- Single-lane closures on two-lane rural highways require more traffic control, such as pilot vehicles or temporary traffic signals

Rural seasonal demand management:

- Notable increase in traffic demands resulting in congestions and travel delays (e.g., beaches in the summer or mountains during snowstorms)
- Potential weather conditions that only allow roadwork during peak tourism season

Rural special event issues:

- May not have permanent traffic management/traveler information infrastructure
- Fewer lanes, parking, and traffic control devices available to manage event traffic
- Collaboration with law enforcement, event managers, and traffic and public transportation agencies is needed to plan and coordinate event management, but personnel available in rural areas is limited
- Difficult to anticipate demand and projected congestion conditions and determine appropriate event management strategies because all events are unique; this is true in urban areas as well, but in rural areas events are usually less frequent (many are once per year), thus providing fewer opportunities to learn what works best

[9] "Rural Intelligent Transportation System (ITS) Toolkit," National Center for Rural Road Safety, accessed May 1, 2021, https://ruralsafetycenter.org.

Table 1 summarizes common TSMO strategies found in the literature review. While use of these strategies is not unique to rural areas, they have proven to be beneficial in improving safety and mobility in rural areas. The strategies are grouped by focus areas as well as some strategies that can be applied to all focus areas. More detailed descriptions of each focus area with specific challenges, considerations, strategies, and case studies are presented in chapters 6–10.

Table 1. Common Transportation Systems Management and Operations Strategies.

FOCUS AREAS	STRATEGIES
Road weather management	▪ Flashing beacons may be activated manually or automatically if tied to a road weather monitoring system to alert travelers of conditions. ▪ DMS can provide real-time weather alerts and pavement condition information to travelers about conditions happening or developing while they are traveling. ▪ Speed advisory messages encourage drivers to voluntarily comply with recommended safe travel speeds in response to deteriorating weather conditions.
Traffic incident management	▪ Quick clearance policies and procedures aim to promptly remove vehicles. ▪ Traffic incident management programs can provide courtesy patrols/service patrols.
Work zone management	▪ Smart work zone systems with DMS, video cameras, and radar can provide motorists with real-time traffic updates as motorists approach a work zone. ▪ Drivers should be required to turn on their emergency warning flashers in areas where stopping is mandatory in a work zone to alert following vehicles of the work zone stopping condition.
Seasonal demand management	▪ Contraflow or reversible lane operations and emergency shoulder use can increase capacity of a roadway network. ▪ Adaptive signal control can be used to manage seasonal congestion for fluctuating travel demand.
Special Event Management	▪ Ensuring open communication among stakeholders before, during, and after the event. ▪ During the event, have separate radio frequencies to ensure constant open communication among event coordinators and staff. ▪ Scheduling sufficient time before the event for planning and coordination among stakeholders. ▪ Holding after-action or post-event meetings to identify lessons learned, shortcomings, and successful practices for future events..

FOCUS AREAS	STRATEGIES
All Areas	▪ Improving interagency and intra-agency coordination and integration to develop multi-agency response plans. ▪ Using passive warning signs to alert travelers to potentially hazardous driving conditions downstream, or at a specific location. ▪ Using active warning systems with flashing beacons to supplement passive warning signs. ▪ Using social media or online applications to provide pre-trip road condition information and forecast systems. These systems can influence a traveler's choice of travel mode and departure time, as well as reduce potential congestion. ▪ Providing real-time alerts and traffic condition information to travelers who are en route about events, delays, or incidents developing ahead of them. The message content dynamically changes to reflect current road conditions. ▪ Providing options for alternative modes of transportation in rural areas and influencing its attractiveness (transit, bicycle, pedestrian, etc.)..

CHAPTER 3. PLANNING FOR TSMO IN RURAL AREAS

Traditionally, transportation planning and TSMO have been independent activities. Planners typically focus on long-range transportation plans and project programming. Operators are primarily concerned with addressing immediate system needs, such as incident response, traffic control, and work zone management. Planning for TSMO connects these two components by bringing operations needs and solutions to the planning processes and bringing longer-term, strategic planning to operations managers.

In rural areas, such as in figure 2, development is limited and dispersed, and travel options are often limited. Traffic safety and weather conditions are often the largest concerns. While congestion may generally be a minor concern, some rural areas may experience seasonal, off-peak congestion due to tourism or events.

Successful planning for TSMO involves reliable evaluation and selection of TSMO strategies. The agency should clearly understand the problems, needs, and goals, and the available resources (e.g., funding, already deployed strategies and technologies, data, institutional expertise and capabilities) to select the strategies that will produce the most successful results. Planning for TSMO in rural areas has some unique considerations related to services available, geographic challenges, and local agency organization.

WHY IS PLANNING FOR TSMO IN RURAL AREAS NEEDED?

The benefits of TSMO in rural areas can be achieved through coordinated, strategic implementation and ongoing support through day-to-day operations and maintenance. All TSMO strategies may involve some investment of resources, which could be in the form of funding, data, equipment, technology, or staff time. Planning is needed to obtain these resources and ensure their proper use. Addressing the challenges of implementing TSMO while ensuring TSMO strategies are cost-effective requires careful planning. For example, resources are usually limited at one rural agency or one rural geographic area; a TSMO plan can seek opportunities for collaboration and resource sharing with other agencies or geographic areas. Careful planning also helps identify areas that can benefit the most from TSMO strategies and prioritize and schedule implementation of different strategies to maximize the return on investment. This may be especially useful to rural areas with limited funding.

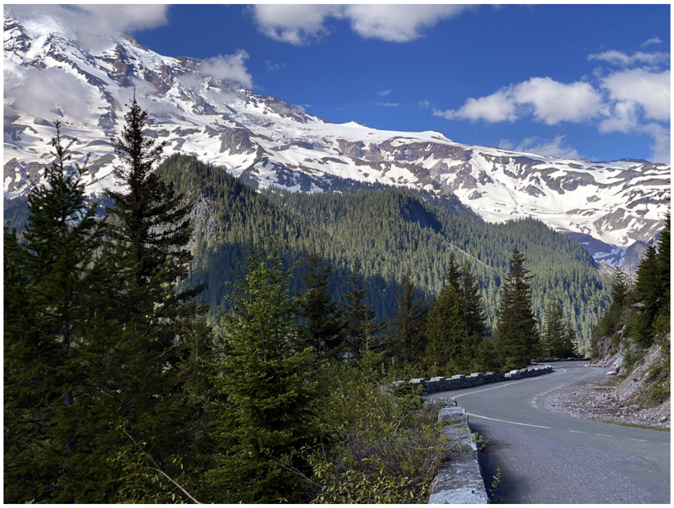

Figure 2. Photo. Paradise Valley Road in Washington. *Source: FHWA*

Approach to Planning for TSMO in Rural Areas

Regardless of the planning context, several fundamental activities such as programming, design, and systems engineering are all important when planning for TSMO. This approach is introduced and described in the *Deployments in Corridors and Subareas Primer*.[10] To account for the broad range of contexts in which TSMO may be planned for in rural areas, the following section builds upon previous knowledge and outlines planning steps that can be applied to rural areas.

Figure 3 outlines the overarching approach to planning for TSMO within rural areas. Although there is no universal approach to TSMO planning and no legal requirement for it, the steps listed below, and other resources listed in the References section of this document, can help promote the understanding of available TSMO strategies and their potential applications. These resources combined with local agencies and staff's understanding of area-specific issues form the essential basis for TSMO planning.

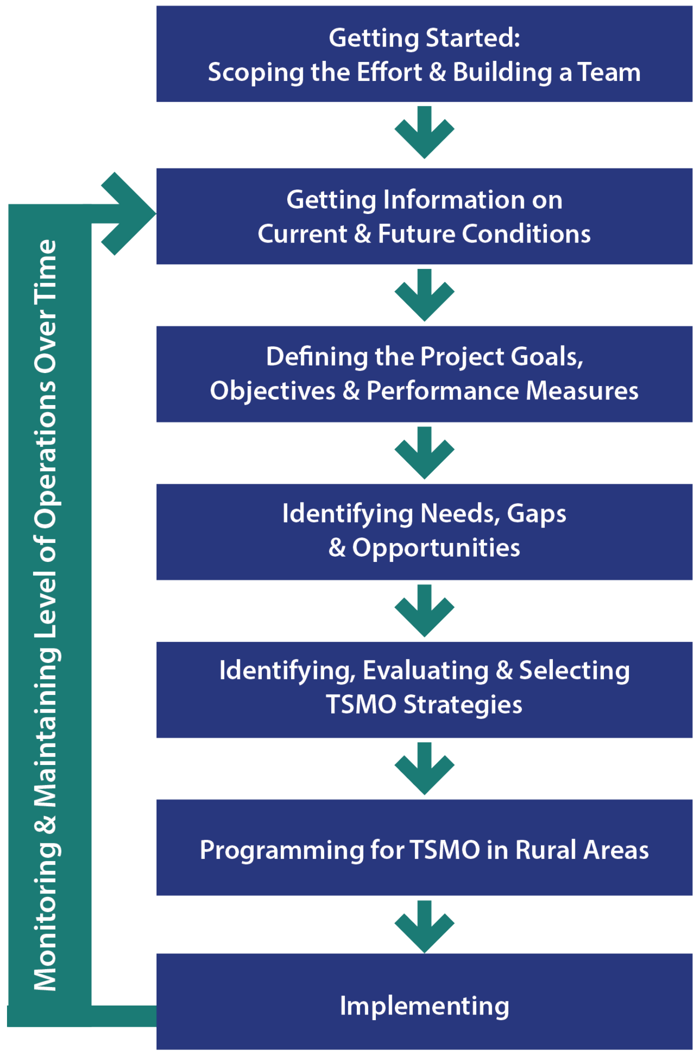

Figure 3. Diagram. Planning for transportation systems management and operations.
Source: FHWA

Getting Started: Scoping the Effort and Building a Team

Developing an effective system management plan involves scoping the effort and building a team of stakeholders to work together on its development. Key considerations in scoping the effort include the identified need, the geographic area, and key personnel.

Gathering Information on Current and Future Conditions and Capabilities

A key early step in developing any strategy is gathering information about current and future institutional and technical capabilities, resources, and system performance. Baseline information helps identify challenges and problem areas.

[10] Federal Highway Administration (FHWA), *Model Transportation Systems Management and Operations Deployments in Corridors and Subareas Primer*, FHWA-HOP-18-026 (Washington: February 2018).

Defining the Project Goals, Objectives, and Performance Measures

Operations goals are high-level statements of what transportation in the area would look like if it reflects the needs, values, and priorities of operators and users. Objectives define desired outcomes in relation to how the transportation system will perform. Objectives should be specific, measurable, achievable, realistic, and timebound.

Identifying Needs, Gaps, and Opportunities

Gathering and analyzing data for performance measures are important in identifying gaps between desired outcomes (objectives) and current conditions, and initially identifying potential opportunities for improvements.

Identifying, Evaluating, and Selecting TSMO Strategies

A variety of methods exist to identify the best TSMO strategies to address specific needs. While many TSMO or operations strategies have benefits, properly assessing strategies can be challenging. After identifying potential strategies, the first step is to screen the strategies for feasibility, and then conduct a more detailed evaluation. Given the wide array of potential strategies to consider, selection often involves quantitative and qualitative analyses. This document outlines recommendations, case studies, and other resources listed in the References section that can be used during the planning process when identifying, evaluating, and selecting TSMO strategies.

Programming for TMSO Strategies

Programming funds for TSMO strategies is a key step in making TSMO strategies a reality. TSMO investments and strategies can be funded by a combination of Federal, State, and local sources. The goals and objectives of the TSMO plan should direct funding decisions and the selection of projects at the State and regional levels.

Implementing Selected TSMO Strategies

To be successfully implemented, an integrated TSMO plan requires close coordination among transportation and non-transportation agencies. A systems engineering process is important to providing an organized approach, reducing schedule and cost risks, and ensuring user needs and requirements are met.

CHAPTER 4. CAPABILITIES TO ADVANCE RURAL TSMO

TSMO program effectiveness is not only related to the level of funding and technology deployment, but also agency processes, culture, and institutional capabilities. TSMO programs benefit from appropriate planning and development. The capability maturity model (CMM), shown in figure 4, can be used as a self-assessment tool to identify current levels of capability. The CMM, when applied effectively, can help agencies develop consensus on improvements, prioritize those selected improvements, and improve capability maturity in planning and designing TSMO implementation. Many agencies have used this model to assess their overall capabilities. There may be advantages to using CMMs focused on their rural capabilities, where they have different levels of staff resources and technologies available to them. Furthermore, there are additional capability maturity frameworks (CMFs) that focus on improvement actions for specific TSMO programs, such as road weather management, planned special events, TIM, work zone management, and active demand management. More information related to these specific CMFs can be found on the FHWA TSMO Framework Tool website.[11]

WHAT IS A CAPABILITY MATURITY MODEL?

The CMM can be used to assist agencies in determining gaps and common barriers to implementing successful TSMO strategies. It includes three process-oriented dimensions:

- **Business process** refers to issues related to scope, planning, programming, budget, and project development. Business processes are especially important in rural areas where TSMO strategies or programs are not currently implemented.
- **Systems and technology** refer to use of systems architecture standards, equipment interoperability and standardization, software, and data centers. Some TSMO strategies may require more skills and capabilities in technology and field devices than others.
- **Performance measurement** refers to the importance of performance measures definition, data acquisition, and data utilization. Performance metrics are important to accurately assess the effectiveness of TSMO strategies in rural areas.

The following three dimensions of the CMM are institutional:

- **Culture** refers to technical understanding, leadership, outreach, and legal authority. Developing a culture of innovation is important to advance TSMO strategies, not only to develop safer and more efficient transportation systems, but also to encourage new ideas for transportation solutions.
- **Organization and staffing** refers to organizational structure, staff development, recruitment, and retention. Agencies may need new and specific knowledge, skills, and abilities to advance TSMO in rural areas. To increase the likelihood of success, it is important to develop an organization that understands and supports TSMO strategies, especially at the senior management level.

[11] "Welcome to Business Process Frameworks for Transportation Operations," Office of Operations, FHWA, last modified February 11, 2022, https://ops.fhwa.dot.gov/tsmoframeworktool/index.htm.

- **Collaboration** refers to the importance of relationships with public health and safety agencies, local governments, transit agencies, metropolitan planning organizations, and the public sector. Rural areas can span a wide range of jurisdictional boundaries that should be considered during the planning process. Initiating collaboration at all stages, with all stakeholders, is particularly important for special events in rural areas.

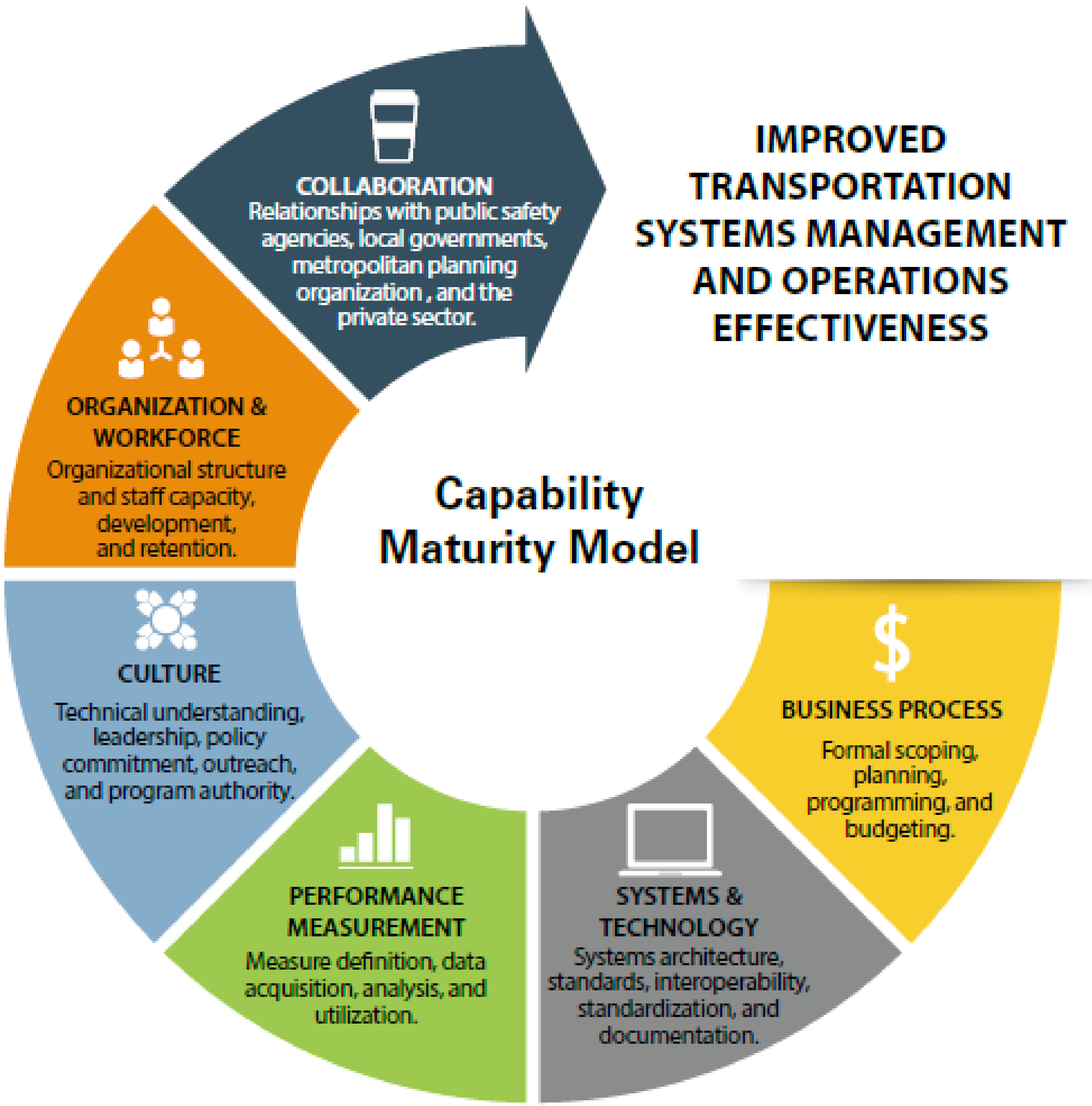

Figure 4. Diagram. Capability maturity model for improved transportation systems management and operations effectiveness. *Source: FHWA*

KEY QUESTIONS FOR CONSIDERATION

The following questions listed below should be considered by agencies:

- Business process:
  - Has the agency developed and implemented the business case for TSMO in rural areas?
  - Has the agency developed and implemented a standardized funding strategy or concept of operations?
  - Has the agency identified what agency will bear these costs and resources?
- Systems and technology:
  - Has the agency standardized a deployment approach for equipment?
  - Has the agency identified issues with its TSMO strategy in rural areas?
  - Has the agency determined if there any issues with access to right-of-way, power, or communications infrastructure?
  - Has the agency identified how the field equipment fits into its regional ITS architecture?
- Performance measurement[12]:
  - Has the agency reviewed the performance measurement requirements for its TSMO strategy?
  - Has the agency identified performance metrics to be used to assess improvement after deployment?
  - Is the agency routinely reporting the TSMO strategy performance to key stakeholders?
- Culture:
  - Does the agency embrace innovation and technology?
  - Are the agency's TSMO training programs periodically improved and revised based on performance data?
- Organization and staffing:
  - Does the agency have champions for TSMO in its organization at the leadership level?
  - Does the agency have champions at the decision-making level, and does the agency have the necessary budgets to implement TSMO in rural areas?
- Collaboration:
  - Does the agency have a forum for collaborator agencies to discuss, and share knowledge about implementing TSMO strategies in rural areas?
  - Can training programs be developed and implemented across multiple agencies?

[12] The use of the term "Performance Measurement" in this context do not pertain to the FHWA performance management program under 23 CFR part 490.

CHAPTER 5. ROLE OF EMERGING TRENDS AND TECHNOLOGY

Emerging technology creates new opportunities to address rural transportation challenges. It is important for agencies to understand technologies available today, and plan and design implementations to leverage future technologies.

TRENDS

Transportation Network Companies

Different types of trips are made every day—from a rural area to an urban area, internal to the rural area, and through the rural area. Not all of these trips can be supported by rural areas. For example, public transit usually stays within the urban areas, limiting the available mode choice of people living in rural areas, especially those who do not have access to personal vehicles. Transportation network companies (TNCs) are an increasingly popular alternative to driving a personal vehicle. TNCs use online platforms, often a smartphone application, to connect passengers to drivers who provide on-demand rides based on real-time information.[13] TNCs can enable one passenger or a group of passengers to share a vehicle based on similar origins and destinations. By ridesharing, passengers can travel to and from special events in rural communities, which can reduce post-event congestion. Also, ridesharing services can reduce the potential of impaired driving on rural roads after recreation or social activities. TNCs can be used in rural areas to provide an alternative transportation choice where there are limited transit routes or mobility options. Table 2 presents potential benefits, challenges, key components, and an example use case of transportation network companies.

[13] Mi Diao, Hui Kong, and Jinhua Zhao, "Impacts of Transportation Network Companies on Urban Mobility," *Nature Sustainability* 4 (2021): 494–501, https://www.nature.com/articles/s41893-020-00678-z.

Table 2. Emerging Trend—Transportation Network Companies.

POTENTIAL BENEFITS	POTENTIAL CHALLENGES
▪ Improves mobility choices. ▪ Improves access to services. ▪ Increases ability for shared-use vehicles (e.g., ridesharing) and cost savings. ▪ Reduces potential impaired-driving collisions.	▪ Although popular in urban areas, TNCs are not yet expanded as widely into rural areas. ▪ The typical funding model of a mobile application may not be sustainable for areas with low numbers of participants, fewer destinations, and potentially longer trips. Alternate funding opportunities include Federal Transit Administration formula funding (Sections 5310 and 5311), mobility-on-demand grants, community initiatives, and other local or State grants.
KEY COMPONENTS	**EXAMPLE**
▪ General public user base. ▪ Public-private partnerships. ▪ Mobile service. ▪ Mobile application platform.	▪ North Mankato, Minnesota, is a rural community that has a population of around 40,000 and has limited public transit. In 2019, the city council funded and launched a public-private partnership to provide a ride-sourcing service to address mobility needs of older adults, immigrant communities, post-secondary students, and disabled people.[14] The ride-sourcing service directly employs drivers to provide residents a city-subsidized rate of $4/trip or $49/month for unlimited membership. Overall, the program has improved mobility gaps for disadvantaged populations.

Crowdsourced Data

Crowdsourcing involves collecting data from a large sample of people. Typically, data are gathered from the internet or mobile applications that use a global positioning system (GPS) on a smartphone to follow user movements.[15] Crowdsourced data can provide real-time information about weather conditions, potholes, incidents, and travel time delays in areas that cannot be monitored regularly. Crowdsourced data systems are a relatively low-cost solution for rural locations compared to installation of vehicle detector infrastructure, especially for agencies with limited staff and technology deployments to monitor rural transportation networks. Table 3 presents potential benefits, challenges, key components, and examples of crowdsourced data.

[14] Ranjit Godavarthy and Jill Hough, *Opportunities for State DOTs to Encourage Shared-Use Mobility Practices in Rural Areas*, National Cooperative Highway Research Program (Washington: December 2019), http://onlinepubs.trb.org/onlinepubs/nchrp/2065/Task76Report.pdf.

[15] "Rural Intelligent Transportation System (ITS) Toolkit," National Center for Rural Road Safety, https://ruralsafetycenter.org.

Table 3. Emerging Trend—Crowdsourced Data.

POTENTIAL BENEFITS	POTENTIAL CHALLENGES
▪ Improves operations and maintenance of infrastructure. ▪ Reduces potential of weather related collisions by providing real-time information to inform travelers about potentially hazardous road surface and weather conditions. ▪ Improves traffic management. ▪ Improves tourism and travel information	▪ Abundant and high-quality data inputs produce valuable and accurate crowdsourced data. In rural areas where there are low densities and geographically dispersed settlements, there may not be sufficient participants required to identify and solve transportation-related issues that may arise. As a result, larger areas are more likely to have information gaps across the geography. ▪ Lack of broadband access may contribute to information gaps.
KEY COMPONENTS	**EXAMPLE**
▪ Smartphone or computer application. ▪ Users are the general public or trained reporters. ▪ Staff to process data from the public. ▪ Staff training. ▪ Cameras to validate reports (optional).	▪ Idaho Transportation Department Citizen Reporting uses its 5-1-1 system[16] to submit weather reports. The cost to develop the web interface was $65,000 in 2015. ▪ Iowa Department of Transportation using a commercial crowdsourced data application to provide real time traveler information (weather, crashes, traffic, and road closures) through websites, phones, and mobile applications. ▪ Software applications are available that crowdsources information to show the closest truck stop, available parking, weigh station information, fuel pricing, and optimized routing. These applications helps drivers know which parking lots have available space, rather than drivers parking in undesignated or unsafe areas.[17]

Broadband Communications

High-speed telecommunications (HST), also known as broadband, can have a large impact on society, especially in rural communities. HST aims to provide dependable, high speed internet, which is key for individuals living in rural communities. Broadband can support transportation needs and can play an important role in strengthening economic development. A study conducted in 2007 found that implementing broadband in rural communities showed an increase of 1–1.4 percent in population growth rate and an increase of 0.5–1.2 percent in the number of businesses over a 4-year period.[18]

Due to limited communications infrastructure, adults who live in rural areas remain less likely than urban or suburban adults to have home broadband or own a smartphone. Laying fiber

[16] "511 Idaho," Idaho Transportation Department, accessed May 1, 2021, http://511.idaho.gov/.

[17] Aaron Marsh, "Crowd-Souring Helps App Get around Parking Data Limitations," *FleetOwner*, November 5, 2015, https://www.fleetowner.com/technology/article/21692143/crowdsourcing-helps-app-get-around-parking-data-limitations

[18] FHWA, *Rural Interstate Corridor Communications Study* (Washington: August 2007), https://ops.fhwa.dot.gov/int_its_deployment/rural/congrpt0807/report_to_congress.pdf.

lines and setting up related infrastructure can require funds that can be burdensome for rural residents. Data from the Federal Communications Commission show rural areas are less likely to be wired for broadband services and tend to have slower internet speeds compared with other areas of the country.[19] There are also fewer broadband providers operating in rural areas, which means consumers tend to have limited options when subscribing to high-speed services. A key factor for successfully implementing HST is public-private partnerships. There are efforts in several States to share public right-of-way to foster development of broadband communications. Expanding broadband communications will allow transportation agencies to connect to existing cellular-only devices or add new TSMO strategies or devices in rural areas that have no current communications available. Reliable internet facilitates efficient and reliable communication between different ITS devices and traffic management centers (TMCs). Table 4 presents potential benefits, challenges, key components, and an example of a broadband communication study.

Table 4. Emerging Trend—Broadband Communication.

POTENTIAL BENEFITS	POTENTIAL CHALLENGES
▪ Improves access to affordable high-speed internet. ▪ Increases access to healthcare (e.g., telemedicine). ▪ Allows rapid response to incidents or emergencies (e.g., weather). ▪ Improves tourism and travel information.	▪ Potential high installation costs. ▪ Current infrastructure in many rural areas does not support consistent and dependable high-speed broadband access. Based on the 2021 Broadband Deployment Report, 17.3 percent of Americans in rural areas and 21 percent of Americans in Tribal lands lack coverage from fixed terrestrial 25/3 megabits per second broadband, compared to 1.5 percent of Americans in urban areas.[20]
KEY COMPONENTS	**EXAMPLE**
▪ Optical fiber ▪ General public user base ▪ Staff to design infrastructure to support new broadband ▪ Staff training and maintenance crews ▪ Public-private partnerships	▪ 843 miles on the Interstate 90 Corridor through South Dakota, southern Minnesota and western Wisconsin. Two-thirds of this Interstate 90 corridor, which runs from Seattle, Washington, to Boston, Massachusetts, is in rural areas.

TECHNOLOGIES

Connected Vehicles

Technology is a powerful tool for addressing transportation challenges in rural areas, where resources are scarce, maintenance and operations of transportation systems can be costly, and information about large geographic areas can be difficult to collect. One emerging technology that may benefit rural areas is connected and automated vehicle technology. Connected and automated

[19] Federal Communications Commission, 2015 *Broadband Progress Report* (Washington: February 2015), https://www.fcc.gov/reports-research/reports/broadband-progress-reports/2015-broadband-progress-report

[20] Federal Communications Commission, 2021 *Broadband Deployment Report* (Washington: January 2021), https://www.fcc.gov/document/fcc-annual-broadband-report-shows-digital-divide-rapidly-closing.

vehicle technology, as seen in figure 5, enables cars, trucks, buses, and other vehicles in the traffic stream to communicate with each other, surrounding infrastructure, and smartphones.

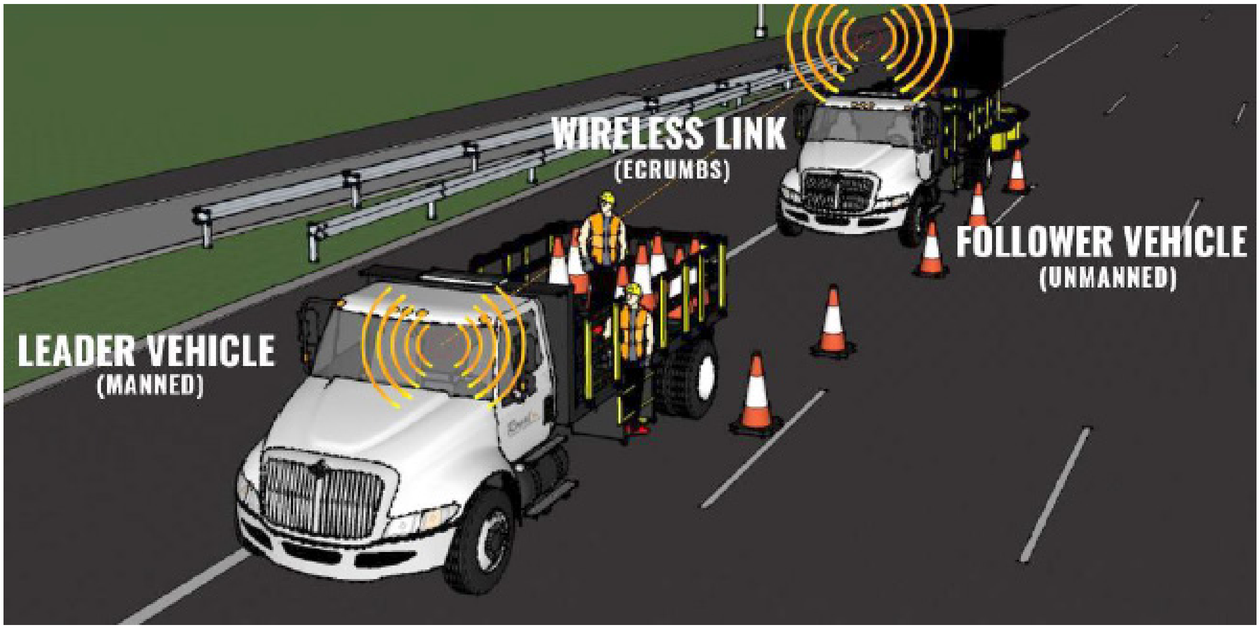

Figure 5. Illustration. Minnesota Department of Transportation testing an autonomous vehicle. *Source: Minnesota DOT*

With connected and automated vehicle technology, signals are transmitted through a wide range of platforms to provide information about other vehicles (vehicle-to-vehicle) and surrounding infrastructure (vehicle-to-infrastructure). The infrastructure contains sensors that gather real-time traffic information, which is then transmitted to connected vehicles, smartphones, or GPS devices. Connected vehicles could dramatically improve safety by warning drivers in rural areas about nearby hazards such as a traffic light about to turn red, dangerous driving conditions, sharp curves, or merging vehicles. Use of autonomous vehicles during routine roadway maintenance activities, such as roadway striping or shoulder repair, can also improve safety by removing maintenance workers from active work zones. Table 5 presents potential benefits, challenges, key components, and examples of connected vehicle deployments.

Table 5. Emerging Technologies—Connected Vehicles.

POTENTIAL BENEFITS	POTENTIAL CHALLENGES
▪ Connected vehicle technology could reduce unimpaired vehicle crashes by 80 percent.[21] ▪ 94 percent of crashes are due to human error, so removing the potential for human error protecting drivers, passengers, bicyclists, and pedestrians.[22] ▪ Improves safety through stop sign gap assistance and warnings for curve speed, Do Not Pass, spot weather impact, reduced speed zones, and work zones using dedicated short-range communication.[23] ▪ Improves access to emergency services. ▪ Helps freight carriers operate more efficiently and safely with truck parking, truck platooning, or other applications to reduce unnecessary travel risks. ▪ Improves traffic management. ▪ Allows rapid response to incidents or emergencies (weather). ▪ Improves tourism and travel information.	▪ Lack of funding. There is a potentially high implementation cost to deploy connected vehicle technology and applications in rural areas. ▪ The lack of reliable communications and power infrastructure may be an obstacle to deploy connected vehicle applications. Dedicated short-range communication and cellular and broadband communications are recommended for a robust connected vehicle system.[24]
KEY COMPONENTS	**EXAMPLE**
▪ Vehicle-to-infrastructure and vehicle-to-vehicle connectivity.	▪ The I-80 Corridor Connected Vehicle Pilot project in Wyoming will deploy vehicle-to-infrastructure and vehicle-to-vehicle technology to warn drivers about road weather advisories and reduced speed conditions.[25] The primary goal is to improve safety and reduce weather-related incident delays. ▪ Minnesota DOT initiated a pilot where 10 snowplows on I-35 were outfitted with connected vehicle technology that activated digital message signs to notify drivers "snowplow ahead, use caution." The project is intended to increase safety and improve traffic flow. ▪ Colorado DOT installed connected vehicle technology along 18 miles of I-25 and in 100 State-owned vehicles that travel along the corridor. The goal is to collect and store data from the highway system so the data can be used to coordinate emergency responses and manage traffic[26]

[21] USDOT, *Intelligent Transportation Systems (ITS) Benefits for Rural Communities*, https://www.its.dot.gov/factsheets/pdf/Rural.pdf.

[22] USDOT, *Intelligent Transportation Systems Benefits*.

[23] FHWA, *Rural Connected Vehicle Gap Analysis: Factors Impeding Deployment and Recommendations for Moving Forward*, FHWA-JPO-18-612, (Washington: August 2017), https://rosap.ntl.bts.gov/view/dot/34723.

[24] FHWA, *Rural Connected Vehicle Gap Analysis*.

[25] "CV Pilot Deployment Program," Intelligent Transportation Systems, accessed May 1, 2020, https://www.its.dot.gov/pilots/wave1.htm.

[26] Rachel Riley, "Colorado Paves Way for 'Vehicle-to-Everything' Highway Pilot," *The Gazette*, January 7, 2019, https://www.govtech.com/fs/transportation/colorado-paves-way-for-vehicle-to-everything-highway-pilot.html.

Unmanned Aerial Systems

Unmanned aerial systems (UAS) are aircrafts that operate by a remote control or an onboard computer. UAS can be used for evaluating road conditions in hazardous locations, monitoring traffic, mapping unpaved roads, or inspecting existing infrastructure (e.g., underneath bridges). These devices can also be used for emergency services such as aerial observation (e.g., scene of a crash or wildfire detection) or search-and-rescue efforts to scout areas with difficult terrain. During or after natural disasters, such as floods, UAS can deliver medical supplies and allow those in need to communicate with medical personnel. Table 6 presents potential benefits, challenges, key components, and an example of an UAS.

Table 6. Emerging Technologies—Unmanned Aerial Systems.

POTENTIAL BENEFITS	POTENTIAL CHALLENGES
▪ Improves access to emergency services and facilitates appropriate level of response. ▪ Provides aerial observation or surveying during crashes or natural disasters. ▪ Enables ability to inspect infrastructure or map new roads. ▪ Enables ability to monitor traffic.	▪ May require trained technical staff to operate and maintain. ▪ Changing Regulations, technology, and public acceptance.
KEY COMPONENTS	**EXAMPLE**
▪ Aircraft (drone) with camera. ▪ Remote controller and flight software. ▪ Training for UAS operators	▪ In 2018, the Tippecanoe County Sheriff's Office used drones 20 times to map crash scenes and used them 15 times to support specialty law enforcement teams in Tippecanoe County and neighboring counties and jurisdictions. Overall, it can cut 60 percent off the down time for traffic flow following a crash.[27]

[27] "Public Safety Implementation of Unmanned Aerial Systems for Photogrammetric Mapping of Crash Scenes," *Transportation Research Record* 2673, no. 7 (2019): 567-574, https://journals.sagepub.com/doi/abs/10.1177/0361198119850804.

CHAPTER 6. APPLICATION OF TSMO STRATEGIES TO RURAL ROAD WEATHER MANAGEMENT

WHAT IS ROAD WEATHER MANAGEMENT?

Weather events can impact roadway mobility and safety by increasing travel time delays and increasing crash risk and exposure to weather related hazards. Informing and managing evacuating traffic from natural disasters, such as hurricanes, forest fires, and flooding, can be more challenging in rural areas. Road weather management strives to mitigate weather related impacts by implementing three types of strategies: advisory, control, and treatment.[28] Advisory strategies involve predicting weather conditions and providing that information to transportation managers and travelers. One way to do this is by using DMSs, as shown in figure 6. Control strategies involve regulating or restricting traffic flow. Treatment strategies supply resources to roadways to reduce or eliminate weather impacts (e.g., providing snowplows and salt trucks). FHWA has a developed a CMF and several case studies specifically for road weather management. [29]

Figure 6. Photo. Dynamic message signs in Washington. *Source: Washington State DOT (WSDOT).*

Example Strategies

Examples of TSMO strategies used as part of road weather management include:

- Flashing beacons for active warning tied to road weather monitoring systems.
- DMSs to provide real-time traveler information about weather and pavement conditions.
- Speed advisory messages that are activated by weather conditions and/or specific vehicle speeds.

[28] FHWA, *Best Practices for Road Weather Management Version 3.0*, FHWA-HOP-12-046, (Washington: June 2012), https://ops.fhwa.dot.gov/publications/fhwahop12046/index.htm.

[29] FHWA, *Using Capability Maturity Frameworks for Transportation System Management and Operations (TSMO) Program Advancement: Case Studies and Lessons Learned*, FHWA-HOP-19-011, (Washington: January 2019), https://ops.fhwa.dot.gov/publications/fhwahop19011/ch2.htm#ss3.

Potential Benefits

Potential benefits of using TSMO strategies in road weather management include:

- Improved road user safety through early weather detection and warning in rural areas that generally have higher speeds.
- Improved pre-trip planning due to quality real-time information; rural areas usually have less up-to-date information and less granularity.
- Limited road weather equipment and resources for greater efficiency.
- Mitigating the impact winter maintenance can have on the environment.
- Improved travel time reliability and fewer unexpected delays. Improved information allows management strategies to be employed sooner in areas that may require more travel time to reach due to their rural location.

Common Questions to Consider

Common questions for agencies to consider when using TSMO strategies in road weather management:

- Is there a method to collect and share information about road conditions or road closures?
- Is there a way to monitor and/or maintain rural areas that lack surveillance or sensors to collect road surface condition data?
- Is there a plan to inform and manage traffic evacuation in the event of a natural disaster such as hurricane, forest fire, or flooding?
- Is there a management plan for snowplow operations over a large geographical area?

Table 7 and table 8 provide two case studies related to road weather management strategies in rural areas. One case study integrates the specific needs in the rural area within a statewide strategy, and the other institutes a traffic operation center dedicated to the operations of the rural areas of the State.

Table 7. Washington State Department of Transportation Strategic Plan Case Study.

PROJECT DESCRIPTION AND GOALS

WSDOT wanted to provide better road weather information to support its transportation goals, so it implemented road weather information system (RWIS) devices, both fixed and stationary. Through its strategic plan WSDOT is providing travelers a safe and integrated multimodal system. A large portion of this plan revolves around the issues related to rural areas. The WSDOT Strategic Plan[30] was developed to provide travelers with the most information, as soon as possible, and continue to move goods and services throughout the State. The WSDOT mission is to provide safe, reliable, and cost-effective transportation options to improve communities and economic vitality for people and businesses. Multi-agency collaboration with traffic maintenance centers, snowfighter groups charged with removing snow from roads, and Pathfinder proactive transportation system management strategies used ahead of and during weather events, helped achieve many of the goals outlined in WSDOT's Strategic Plan.

Figure 7. Photo. Portable environmental sensing station unit. *Source: WSDOT.*

BENEFITS	CHALLENGES
Pre-trip planning: Partnerships were developed with a company that provides weather decision support services, the National Oceanic and Atmospheric Administration (NOAA), WSDOT Public Information Office, TMCs, and maintenance management (headquarters and region) to determine and synchronize travel condition messaging, weather forecasts, and travel alerts. **Winter operations dashboard:** WSDOT uses internal displays that provide snowfall amounts, automated vehicle location data, equipment deployed, and other snow-fighting information in real time. **RWIS:** Provides valuable information and forecast analytics from the meteorological community that helps WSDOT prioritize where to deploy snowplows. The public can access the information to aid with route planning.	**Determining where to install limited resources:** As seen in figure 7, WSDOT's RWIS network consists of 105 permanent environmental sensing stations (ESSs) and several portable ESS units with varying costs. Being specific as to where the sites are located takes a lot of communication. **Determining maintenance:** Clarifying who is responsible for maintaining and calibrating ESS sites. **Determining funding:** Ensuring there is enough funding for maintenance and upgrading or replacing existing equipment. **Determining replacement:** Developing a process for the replacement cycle of ESS sites as they age or become obsolete. **Improving visualization:** The current software needs to be upgraded for better graphics and user experience.

[30] *Washington State Department of Transportation Strategic Plan*, Washington State Department of Transportation, https://www.wsdot.wa.gov/about/secretary/strategic-plan/

Table 7. Washington State Department of Transportation Strategic Plan Case Study. (continuation)

LESSONS LEARNED
▪ **Consider routine maintenance and calibration costs:** If routine maintenance is not considered or performed, inaccurate ESS observation data can degrade confidence in the system. ▪ **Implement communication improvements:** Among all stakeholders, work together to refine site locations, enhance maintenance of existing sites, and regularly calibrate equipment. ▪ **Train employees:** Develop a training program to reduce impacts of turnover to include maintenance of the ESS sites, users of the data, and WSDOT leadership to help achieve the goals and objectives of the strategic plan. ▪ **Continue collaborations:** Continue to maintain and expand collaborations as needed. ▪ **Prepare for the future:** Consider future process enhancements such as variable speed limits and advanced traffic management systems to improve existing systems.

Table 8. Montana Department of Transportation Rural Transportation Management Center Case Study.

<table>
<tr><th colspan="2">PROJECT DESCRIPTION AND GOALS</th></tr>
<tr><td colspan="2">Montana’s rural TMC provides 24-hour, year-round support for maintenance operations for all Montana DOT employees for all five districts and statewide support for emergency providers. The centralized TMC was created to improve the frequency and consistency of travel-related messaging. This center also provides an organization base for future ITS implementations. The goal of the TMC is to provide better information to the public and improve tracking of agency resources. In 2019, seven new full-time positions were approved to improve staffing. Existing positions were transitioned from the five divisions to headquarters to centralize operations. Also, Montana DOT used the new positions to hire six permanent dispatchers and a communications technician.

The TMC communicates weather and roadway conditions primarily from visual observation by Montana DOT field staff and data provided by 76 ESS sites throughout the State. The RWIS is helpful for assessing road surface conditions, wind speeds, wind direction, and air and surface temperature.</td></tr>
<tr><th>BENEFITS</th><th>CHALLENGES</th></tr>
<tr><td>Standard operating procedure: Montana DOT developed comprehensive standard operating procedures to appropriately train staff. This improved consistency and communication with local emergency providers and State and local law enforcement.

Improved relationships: The TMC staff is now on a first-name basis with many law enforcement officials, which improves efficiency and communication to deploy appropriate resources and messaging about incidents and maintenance needs. There are approximately 50 different 9 1-1 centers in the State, and it is key to have open and effective communication with them.

Preemptive messaging: Relationships with the NOAA, the Pathfinder program, and the four weather service operations in Montana have improved the ability to forecast weather and provide information to travelers in real time via DMS. In winter 2021, Montana DOT was able to post 36 preemptive events compared to the previous year, where only 20 events were posted.</td><td>Winter coverage: Prior to implementing the TMC, 24-hour per 7 days office coverage only existed between November and March (the winter road condition reporting season). During the remainder of the year, radio coverage (e.g., analog with relays) only existed during normal business hours.

Communications: Radio coverage was a major challenge to centralizing the TMC. Radio coverage was acceptable at the district level, but not Statewide. By adding specialized hardware in many of the field offices, incoming radio signals were digitized and sent over the network to the TMC. Each dispatcher radio console costs approximately $40,000. The TMC purchased seven consoles. Emergency medical services and the Montana Highway Patrol need to be able to easily contact the TMC at any time. The TMC has a phone number primarily used by these agencies to communicate with Montana DOT.

Network reliance: Although there are backup generators and a backup phone line in case of power outages, if there is long-term network failure, TMC operations would temporarily revert to the districts.</td></tr>
</table>

Table 8. Montana Department of Transportation Rural Transportation Management Center Case Study. (continuation)

LESSONS LEARNED
▪ **Create a career ladder and operating procedures:** Develop promotional opportunities to increase staff retention and reduce turnover. TMC staff have clear operating procedures, roles, and responsibilities periodically updated over time.
▪ Increase temporary staff: **Workload during the winter road condition reporting season is much g**reater due to an increase in field staff and weather affecting travel conditions. To address the added workload, Montana DOT supplements full-time staff with trained temporary workers. Hiring more workers at less than full time provides flexibility to staff up during storms and reduces stress on the permanent workforce.
▪ **Improve existing systems:** Rather than replace all radios in the existing truck fleet with newer models, TMC staff installed additional radio hardware, which was used to digitize incoming analog signals and transmit them over the State network using radio over internet protocol.
▪ **Improve existing processes:** Montana DOT is working to improve its check-in and check-out processes for drivers to make it more efficient when snowplow drivers enter and leave service. For safety, drivers are required to check in and out of service any time they are working outside normal business hours. This often occurs statewide at the same times, creating a communication bottleneck. Montana DOT will use new software and pilot handheld devices in snowplows to improve check-in and check-out efficiency.

CHAPTER 7. APPLICATION OF TSMO STRATEGIES TO RURAL TRAFFIC INCIDENT MANAGEMENT

WHAT IS TRAFFIC INCIDENT MANAGEMENT?

Based on the *Traffic Incident Management Handbook*, incident management involves the "systematic, planned, and coordinated use of human, institutional, mechanical, technical resources to reduce the duration and impact of incidents, and improve safety of motorists, crash victims, and incident responders."[31]

Figure 8. Photo. Emergency services in Washington State. *Source: FHWA.*

TIM in rural areas presents challenges, such as limited sight distance due to curves and hills, constrained geography caused by ditches adjacent to the roadway, and limited areas to park response vehicles and perform work (see figure 8). Other factors for consideration include a minimum number of alternate routes; extended response times to arrive on scene at rural events; and delays in getting specialized equipment such as heavy wreckers, cranes, and rotators on site. The FHWA has a developed a CMF and several case studies specifically for TIM.[32]

One common response in rural communities is related to crashes involving livestock, slow-moving agricultural vehicles, and horse-drawn carriages prevalent in Amish and Mennonite communities. These events require a specialized response, particularly crashes involving livestock. Standard operating procedures must incorporate these considerations.

Rural TIM also incorporates a large number of roads controlled by counties or local jurisdictions. State DOTs are not the owners or maintainers of these roadways. However, many of the jurisdictions have developed mutual aid with State DOTs for assistance.

Vast rural areas do not have cellular phone or radio communication coverage for responders. Some counties have as much as a 60-percent dead-air area. These counties have developed alternative ways to get messages relayed to TMCs and 9-1-1 dispatch centers. One such method is to partner with commercial truckers to use their radios to relay a message down the line.

Rural services for fire, emergency medical services, and rescue is provided mostly by volunteer agencies. Response times can be as long as 30–60 minutes in many of these areas. Rural areas, especially non-State roads, are often served by small local law enforcement agencies. In some

[31] "Traffic Incident Management Handbook," Office of Travel Management, FHWA, https://rosap.ntl.bts.gov/view/dot/3702.

[32] "Traffic Incident Management Capability Maturity Self-Assessment Tool," Office of Operations, FHWA, https://ops.fhwa.dot.gov/tsmoframeworktool/available_frameworks/traffic_incident.htm.

instances, the State patrol serving rural roads may only have one or two units patrolling a vast area. Response times can be very long. Towing agency responders can also have a long response time. Clever and creative contract incentives that encourage an enhanced towing agency response are in place in some jurisdictions.

Example Strategies

Examples of TSMO strategies used as part of traffic incident management include:

- Quick clearance policies and procedures to promptly remove vehicles.
- TIM programs to provide courtesy patrols or service patrols.

Potential Benefits

Potential benefits of using TSMO strategies in traffic incident management include:

- Reduced duration and impacts of traffic incidents.
- Improved safety of motorists, crash victims, and emergency responders.
- Improved and more efficient allocation and deployment of limited equipment and resources.
- Minimized delays and road closures.

Common Questions for Agencies to Consider

Common questions to consider when using TSMO strategies in traffic incident management:

- How many incident response teams and law enforcement responders are available?
- Do maintenance crews have additional support when they are often disrupted with calls to assist incidents in rural areas?
- Is there ongoing funding to support TIM? Unlike capital construction projects, dedicated incident response requires ongoing commitment to funding.

Table 9 and table 10 provide two case studies related to TIM strategies in rural areas. One case study institutes a rural-focused incident response program, and the other highlights the development of rural incident management plans.

Table 9. Georgia Department of Transportation Coordinated Highway Assistance and Maintenance Program Case Study.

PROJECT DESCRIPTION AND GOALS

CHAMP started in November 2016 as a Statewide roadway assistance and maintenance patrol. CHAMP evolved from the original Highway Emergency Response Operators (HERO) program that provided dedicated incident responders in urban areas.

The difference with this program is the addition of maintenance activities and use of contracted personnel. CHAMP is a free service to the public that patrols 16 hours per day, 7 days per week, and 365 days per year. CHAMP covers 26 routes and 1,062 interstate miles. The goal of CHAMP is to improve motorist safety and support service patrols by assisting with incident management and maintenance crews. In each Georgia district, there is a specific CHAMP dispatcher who can help coordinate efforts in rural areas.

Figure 9. Photo. Coordinated Highway Assistance and Maintenance Program vehicle.
Source: Georgia DOT.

BENEFITS	CHALLENGES
Interstate assistance: CHAMP vehicles, as seen in figure 9, provide interstate assistance (tire change and fuel, battery, or tow coordination) to motorists and TIM assistance (lane clearance, temporary traffic control, 5-1-1 coordination, and on-call and after-hours response when needed). **Maintenance activities:** CHAMP helps rural areas with activities such as maintaining cable posts, removing debris, removing abandoned vehicles, assisting with hurricane evacuation and snow/ice coordination, delineating potholes, clearing drainage, and removing vegetation on the roadway. **TIM training:** CHAMP provides rural Georgia TIM training and established a TIM team to provide more educational outreach.	**Initiating Georgia DOT approval:** One of the main challenges was obtaining support for CHAMP within GDOT. Once internal staff understood its benefits, CHAMP became more widely used amongst district staff.

LESSONS LEARNED

- **Conduct regular meetings with stakeholders:** CHAMP members meet with more than 20 rural county TIM teams every 3–4 months to discuss new strategies and training opportunities.
- **Develop partnerships:** Meeting other stakeholders in person greatly improves communication and collaboration among rural communities and local agencies. Also, having regular patrols in the field provides the opportunity to meet local contacts and find local TIM champions.
- **Proactively maintain roads:** Conducting routine maintenance on rural roads can keep the roadway clean and safe. If there is a large storm or risk of flooding, CHAMP can go into the field and clear drains and roads from debris to reduce the risk of water on the road.

Table 10. Texas Department of Transportation Rural Incident Management Plans Case Study.

PROJECT DESCRIPTION AND GOALS	
TxDOT has initiated a broad range of TSMO strategies to advance rural TIM. One of the initiatives is to assist rural districts, such as the El Paso District and Odessa District, to develop rural incident management plans. The purpose of rural incident management plans is to pre-define alternate routes for major corridors, as well as the role of first responder agencies in the incident. Other goals of the rural incident management plans are to include contact information for key stakeholder agencies for quicker coordination and to publish the document online to improve accessibility.	
BENEFITS	**CHALLENGES**
Relationship building: Agency coordination and communication are important for a successful TIM program. External stakeholder agencies that should be involved need to be identified, and their roles and responsibilities understood. TIM training offers the opportunity to invite and meet external stakeholders, such as 9-1-1 call center staff, law enforcement, emergency responders, and maintenance crews. **After-action reviews:** This is a tool that can be used to improve incident detection verification, response, clearance, and recovery.	**Meeting in person:** Meeting local agencies and stakeholders in person is a more efficient and more effective way to implement rural incident management plans and formalize interagency coordination. However, it can be difficult to engage stakeholders in person since TxDOT staff have to travel long distances to reach stakeholders in geographically dispersed rural areas.
LESSONS LEARNED	
▪ **Conduct regular training meetings:** Provide recurring interagency TIM training for rural first responders and maintenance staff. Develop a TIM training facility that includes a variety of road types (interstates, on-ramps/off-ramps, farm to market, and ranch to market). Ensure the training content is relevant and relatable to the audience. ▪ **Understand current legislation and policies:** Understand applicability of quick clearance laws (rapidly removing temporary obstructions on property). In Texas, there are three general law types: move over, driver removal, and authority removal.	

CHAPTER 8. APPLICATION OF TSMO STRATEGIES TO RURAL WORK ZONES

WHAT ARE WORK ZONES?

Work zones are areas where construction, utility, or maintenance work is being conducted, typically involving lane closures, moving equipment, and detours. Work zones can be challenging in rural areas where there may be limited or no alternate routes, and where weather may limit work seasons to times of peak tourism.

Figure 10. Photo. Rural construction zone.
Source: FHWA

Technology, such as smart work zones, can use site-specific traffic control technology within a work zone to provide real-time travel information to motorists. For example, radar speed display signs, as shown in figure 10, are effective in slowing down motorists approaching a work zone. FHWA has a developed a CMF and several case studies for work zone management.[33]

Example Strategies

Examples of TSMO strategies used as part of work zone management include:

- Smart work zone systems with DMSs, video cameras, and radar to provide motorists with real-time traffic updates as they approach a work zone.
- Where stopping is mandatory in a work zone, require drivers to turn on their emergency warning flashers to alert following vehicles of the work zone stopping condition.

Potential Benefits

Potential benefits of using TSMO strategies in work zone management include:

- Enhanced safety for road users, construction workers, and work zone personnel.
- Reduced potential for aggressive maneuvers at work zones.
- Improved ability to react to stopped or slow traffic.
- Reduced impact on worker productivity.

[33] FHWA, "Work Zone Management Capability Maturity Self-Assessment Tool." (2016), https://ops.fhwa.dot.gov/tsmoframeworktool/available_frameworks/work_zone.htm

Common Questions for Agencies to Consider

Common questions to consider when using TSMO strategies in work zone management:

- If detours are necessary to reroute traffic, has the length and travel time delay (which can be significant in rural areas) been considered?
- Can work be scheduled to avoid the biggest impact periods (e.g., major annual festival)?
- Are there strategies to divert traffic on alternate routes to avoid travelling through a work zone, where possible?
- Is there equipment available, such as portable flaggers or signals, to avoid having personnel on the road?
- Since advance signing for work zones can stretch over a longer distance, evaluate setup, move, and take-down efforts.

Table 11 and table 12 present two case studies related to work zone strategies in rural areas. Information about impacts to travel time can be displayed on permanent variable message signs (VMSs) in advance of the work zone so that long-distance travelers have a chance to divert to avoid possible delays.

Table 11. Oregon Department of Transportation Work Zone Intelligent Transportation System Equipment Case Study.

PROJECT DESCRIPTION AND GOALS
Oregon DOT used work zone ITS equipment for a 6-mile highway project that reduced lanes to one per direction for pavement and bridge preservation. The project is located on I-5 near the border of Oregon and California, where there is 6-percent grade and 30-percent truck traffic. The amount of freight along this corridor was a priority concern for this project. The project used two portable solar-powered ITS trailers, shown in figure 11, with wireless technology, to detect and collect on-site data (e.g., delay, volumes, vehicle classification, speed). The data were sent to transportation managers and travel time information was provided to motorists via DMS.

Figure 11. Photo. Portable intelligent transportation systems trailer.
Source: Oregon DOT.

Table 11. Oregon Department of Transportation Work Zone Intelligent Transportation System Equipment Case Study. (continuation)

BENEFITS	CHALLENGES
Remote data collection: Work zone ITS included sensors and cameras that remotely collected data and provided real time travel time information to drivers on message boards. **Real-time information:** The portable ITS trailers measure travel time between trailers (6–8 miles apart) and send the information to portable changeable message signs, as well as an online database that provides real-time images and traffic information the public can view. **Improved coordination:** Cameras and sensors in rural areas allow staff and maintenance crews to better understand current conditions and potential incidents that may arise.	**Issues with pan-tilt-zoom cameras:** Using cellular service will limit frame rate of video; controlling camera movement is more difficult with slower communication speeds. **Power:** Portable units rely on solar power, and sometimes there is no sunlight for long periods of time in the Northwest. **Vandalism/damage:** Although most equipment is locked, cases of theft of batteries or solar panels generate maintenance and replacement costs. The portable equipment needs to be removed during winter due to the potential of being buried in snow or damaged by snowplow operation.

LESSONS LEARNED
▪ Design the size of the portable ITS trailer's solar panels to work year-round, including the winter. ▪ Place the cameras and sensors very high on the portable units to avoid theft. ▪ Collaborate with resident engineers and maintenance crews to maximize use of the system.

Table 12. Missouri Department of Transportation Rural Queue and Delay Warning Systems Case Study.

PROJECT DESCRIPTION AND GOALS
In January 2016, Missouri DOT implemented RQDWS. In 2017 it was awarded Best Project from ITS America's Heartland Chapter. The RQDWS was initially implemented along rural I-70 to automatically warn motorists via dynamic message signs (DMSs) of slow or stopped traffic ahead. In rural areas, congestion and queues can be especially unexpected. The goal of the project was to improve safety by notifying high-speed motorists, especially freight traffic, about upcoming slow or stopped traffic in a work zone. Previously, transportation managers had to rely on public phone calls or have cameras operating in the area to know traffic conditions, which can often be subjective.[34] In contrast, the RQDWS relies on GPS-based live traffic probe data to feed data into the advanced traffic management system, which uses vendor-specific software. The data are compared with the preset threshold for slowed traffic, and appropriate messages are automatically posted to a rural DMS. Missouri DOT has existing DMSs every 10–20 miles along State corridors in rural areas. Missouri DOT's Information Systems Department also developed a complementary field traffic alert system where contractors and Missouri DOT staff can sign up for email and text alerts when speeds drop below a certain threshold along the highway corridor. The location and speed threshold are customizable so users can easily set up and configure alert notifications where work zone queues are anticipated. Statewide probe data power all DMS, text, and email notifications and provide a high level of work zone situational awareness for traffic management centers, Missouri DOT staff, and contractors.

[34] "Missouri's Smart Solution for Rural Road Monitoring," *ITS International*, accessed May 1, 2021, https://www.itsinternational.com/feature/missouris-smart-solution-rural-road-monitoring.

Table 12. Missouri Department of Transportation Rural Queue and Delay Warning Systems Case Study. (continuation)

BENEFITS	CHALLENGES
Automatic updates: The software automatically updates the appropriate queue warning messages to the DMSs without any action needed. **Improved safety:** High-speed secondary crashes at the back of traffic queues are a primary crash concern in Missouri. This warning system can prevent future collisions by notifying drivers of slowdowns ahead.	**Costs:** Implementing ITS systems can involve significant resources.

LESSONS LEARNED
▪ **Build upon existing infrastructure:** Missouri DOT had an extensive DMS system in rural areas it could use to deploy warning messages. When a bridge collapsed, operational staff were able to notify travelers within a 200-mile radius of the bridge closure using DMSs. Missouri DOT staff worked with software consultants to integrate its existing automatic vehicle location systems, rather than purchase new transponders. Automatic vehicle location systems use GPS to remotely report vehicle information such as location, speed, and stops. ▪ **Using the data:** Missouri DOT has existing trucks specifically outfitted with additional traffic control equipment. It uses the trucks to travel the congested areas to verify traffic probe data and confirm traffic conditions with operational staff. Conditions may change between sensor locations, and these trucks can provide additional information.

CHAPTER 9. APPLICATION OF TSMO STRATEGIES TO RURAL SEASONAL DEMAND

WHAT IS SEASONAL DEMAND?

Seasonal demand in transportation refers to a change in travel patterns in a certain area due to recurrent seasonal events. For instance, people may visit the coasts or lakes during summer or the mountains in winter, as shown in figure 12, which increases the traffic demand on rural roads for a certain period of time during the year. Some recreational travel also coincides with severe weather conditions, further exacerbating traffic conditions (e.g., driving in snow conditions to reach a ski area). Fluctuations in traffic volumes related to seasonal demand represent a small percentage of overall traffic in urban areas, but in rural areas, fluctuations are more pronounced as traffic volumes often double, or more. As the transportation network typically remains the same throughout the year, seasonal demand can create notable congestion on rural roads that are not designed to serve higher capacities.

Figure 12. Photo. Vehicles queue on the way to Mount Rainier in Washington.
Source: FHWA.

Example Strategies

Examples of TSMO strategies used as part of seasonal demand management include:

- Contraflow or reversible lane operations and emergency shoulder use to increase capacity.
- Adaptive signal control to manage seasonal congestion for fluctuating travel demand.

Potential Benefits

Potential benefits of using TSMO strategies in seasonal demand management include:

- Enhanced safety for road users and visitors new to the area.
- Reduced congestion on narrow rural roads.
- Improved travel time reliability.

Common Questions to Consider

Common questions for agencies to consider when using TSMO strategies in seasonal demand management:

- Can rural roadways handle increased demands during peak seasons?
- Is there a way to communicate potential delays and alternative routes to travelers to alleviate congestion?
- In case of an evacuation or an emergency, is there a way to incorporate adaptive signal timing?
- Is there a way to encourage travelers to use attraction-specific transit options?

Table 13 and table 14 present two case studies related to TSMO strategies used for seasonal demand in rural areas. One case study looks at rural strategies complicated by weather, and the other focuses on congestion and parking availability.

Table 13. Utah Department of Transportation Little Cottonwood Canyon Centralized Communications Channel Case Study.

PROJECT DESCRIPTION AND GOALS
Little Cottonwood Canyon is a vast mountainous area located south of Salt Lake City, Utah, that experiences extreme winter weather conditions. This area experiences increased traffic congestion during the winter months related to recreational travel. In winter 2019, Utah DOT launched a centralized communications channel for the Little Cottonwood Canyon area. The purpose of the centralized communications channel is to improve safety, reliability, and mobility for the traveling public by providing timely, reliable, and accurate information. This information is collected and distributed through a variety of methods. A website was developed to centralize information for the public by providing traffic conditions, cameras, avalanche closures, interactive maps, winter travel trips, and other resources. Utah DOT also developed a Cottonwood Canyon traffic information dashboard that shows the level of traffic congestion and approximate travel times. Social media is also heavily used to distribute meaningful and timely updates to visitors in the areas.

Table 13. Utah Department of Transportation Little Cottonwood Canyon Centralized Communications Channel Case Study. (continuation)

BENEFITS	CHALLENGES
Accessibility: The website can be used on personal mobile devices (76 percent of site visitors are mobile users). This website is specifically focused on the Little Cottonwood Canyon area so that travelers have one main resource to help with travel information. **Pre-trip planning:** Real-time updates can help reduce traffic congestion and reduce the risk of crashes by allowing travelers to make informed travel decisions. **Coordination and communication:** A dedicated communication channel helps visitors, and also partners and staff. For instance, plow drivers can focus solely on their duties while law enforcement can focus on incidents.	**Developing trust:** Developing relationships among all stakeholders can be time consuming. Avalanche groups, law enforcement, and local agencies each have individual goals and objectives that require time, respect, and understanding to coordinate a centralized communication channel. **Software:** Utah DOT developed an in-house system. However, much effort was required to integrate and coordinate all the stakeholders' data.

LESSONS LEARNED

- **Develop a business case:** Be prepared with a business case for leadership to get approval for a new project. Have a valid case that outlines the positions required, level of effort, funding sources, and project goals.
- **Develop social media channels:** These provide visual, real-time updates to hundreds of users via hashtags that group relevant information together. A dedicated communications position and experience in social media campaigns are key to communicate unexpected events to the public.
  - A survey was conducted with 1,338 responses received. Ninety-two percent of respondents agreed that Utah DOT's Little Cottonwood Canyon communication plan had an impact on their travel decisions during winter 2020–2021.[35]
- **Build consensus on common operating goals:** Work with stakeholders early on to build consensus on goals and objectives.

[35] AASHTO, Little Cottonwood Canyon Outreach, https://benefits.transportation.org/little-cottonwood-canyon-outreach/

Table 14. National Park Service Grand Canyon Parking Management System Case Study.

<table>
<tr><th colspan="2">PROJECT DESCRIPTION AND GOALS</th></tr>
<tr><td colspan="2">Grand Canyon National Park has more than 6 million annual visitors. Ninety percent visit Grand Canyon Village, which has about 1,900 day-use parking spaces. Seasonal visitation spikes occur during holidays, summers, and spring break periods. The park's transportation system includes roadways, parking areas, a shuttle bus, and 12 miles of multiuse paths. There is a very high demand for parking spaces. Grand Canyon National Park uses ITS (e.g., highway advisory radio, portable VMSs, and real-time traffic updates [see figure 13]) to inform visitors about traffic conditions and provide options for getting around Grand Canyon Village. The park plans to implement ITS technologies to improve parking management and help visitors decide how and when to travel to Grand Canyon Village. Proposed ITS technologies include parking lot and entrance surveillance, portable VMSs, static signs with light-emitting diode inserts, and a traveler application.


Figure 13. Photo. Grand Canyon National Park promotes shuttle bus services on social media.
Source: Grand Canyon National Park.</td></tr>
<tr><th>BENEFITS</th><th>CHALLENGES</th></tr>
<tr><td>**Encourages other modes of transportation:** ITS equipment provides valuable information in real time to travelers looking for parking and encourages people to use shuttle buses. The shuttle buses are equipped with bike racks to accommodate cyclists. The information also provides real time updates on the park's website and social media.

Reduces pressure on staff: ITS equipment enables the limited number staff to work in other needed areas, rather than direct motorists in parking lots.</td><td>**Cost:** Implementing ITS systems can involve significant resources.</td></tr>
<tr><th colspan="2">LESSONS LEARNED</th></tr>
<tr><td colspan="2">▪ **Maximize flexibility:** Position portable VMSs where they are most needed and ensure they can support a variety of messages.
▪ **Be flexible:** Pilot the alternative solutions if something is not working or if conditions change.</td></tr>
</table>

CHAPTER 10. APPLICATION OF TSMO STRATEGIES TO RURAL SPECIAL EVENTS

WHAT ARE SPECIAL EVENTS?

Special events are occasions that bring a large number of people together. Planned special events can vary in size and can either be a one time event or occur on a cyclical basis, such as a parade or an annual bike ride. Regardless of the type or size, special events can increase the travel demand on the rural roadway network, and the accompanying transit systems and parking lots should be capable of handling the increase in traffic volume. TSMO strategies, such as ITS devices or temporary signals, shown in figure 14, can help improve the efficiency of available roadways and parking facilities to accommodate these events.¬

Figure 14. Photo. Temporary signal in Washington. *Source: FHWA.*

Example Strategies

Examples of TSMO strategies used as part of special event management include:

- Ensuring open communication among all stakeholders before, during, and after the event
- During the event, having separate radio frequencies to ensure constant open communication among event coordinators and staff
- Scheduling sufficient time before the event for planning and coordination among stakeholders
- Holding after-action or post-event meetings to review lessons learned, identify shortcomings, and highlight successful practices for future events

Potential Benefits

Potential benefits of using TSMO strategies in special event management include:

- Enhanced safety for locals and visitors.
- Reduced travel delay by managing the increased traffic volume.
- Increased ability of event participants to smoothly and efficiently enter and exit the event.
- Greater use of multimodal transportation options.

Common Questions to Consider

Common questions for agencies to consider when using TSMO strategies in special event management:

- If permanent traffic management devices are not at the event location, has temporary traffic management been considered?
- Has the agency collaborated with event organizers, law enforcement, and local agencies prior to the event?
- Has the agency provided advance notice about the event's duration to local authorities, business owners, residents, and others who may be affected by the traffic influx?
- Has the agency researched the event's potential size and scale that should be accommodated, based on prior experience or other case studies?
- Has the agency considered varying normal traffic control, such as changing signal timing, converting bidirectional streets to one-way travel, or having dedicated pedestrian paths?

Table 15 and table 16 present two case studies related to TSMO strategies used for special events in rural areas. One case study looks at the impacts of an event that moves along a rural route, while the other coordinates movements among multiple rural sites.

Table 15. Colorado Department of Transportation Colorado Classic® Bicycle Event Case Study.

PROJECT DESCRIPTION AND GOALS
The Colorado Classic® is an international multiday bicycle event that impacts metropolitan and rural roadways in Colorado. Due to the large scale of the bicycle event, multiple roadways are impacted by closures, delays, and detours. Event routes create issues on interstate ramps, State highways, county roads, city roads, and State Forest Service roads. The goal is to minimize the impact of the event on traffic for in-State and out-of-State visitors. The specific objectives are to ensure the safety of spectators, participants, and support crews and ease delays on the traveling public. The project focuses on interagency cooperation across multiple stakeholders, including Colorado State Patrol, Colorado DOT, local law enforcement, roadway maintenance crews, and communities. Interagency coordination is important for this event, and significant pre-planning is conducted by all affected stakeholders before and after the event. Actions include cross-discipline communications and coordination. Maintenance and law enforcement work together to ensure roadways are properly cleared of debris and maintained to ensure attendees, spectators, media, and local residents are safe during the event. Multiple public messaging strategies communicate event information and updates, such as VMSs, the event's website, and door-to-door contact with local residents.

Table 15. Colorado Department of Transportation Colorado Classic® Bicycle Event Case Study. (continuation)

BENEFITS	CHALLENGES
Pre-event planning: Pre-event planning to inform stakeholders of procedures and road closures, and for communication coordination with traffic operations centers may be beneficial. **Traveler information:** Public messaging using VMSs before and during the event informs residents, motorists, and spectators of changes. The event's website provides real-time updates and links to maps of detours and closures. **Communication:** A mutual-aid channel was used among multiple jurisdictions as a single channel to communicate rolling closures to open and close road segments at different times.	**Roadway impacts:** Race routes affect significant roadway distances (often more than 100 miles) including mountain passes and local-resident and emergency access; race routes close or delay popular tourist and commercial traffic routes. **Labor intensive:** Prior to the event, door-to-door contact with people along the route is important to inform residents of closures and emergency contact information. This effort can be time consuming and labor intensive. Multiple law enforcement and community agencies are required to monitor and patrol the race route for unplanned incidents. Both State and local maintenance forces are required to clear the routes of debris and other hazards before and during the event.
LESSONS LEARNED	
▪ **Pre-event planning is beneficial:** Planning makes stakeholders aware of issues and helps ensure a safe event. ▪ **Reliable communication is key:** Reliable communication during the event enables multiple agencies and event organizers to coordinate activities and incident response. ▪ **Need to improve traffic flow:** Providing real-time route updates and coordinating information with traffic operations centers can improve traffic flow. Regularly updating the website ensures timely and accurate traveler information.	

Table 16. South Dakota Department of Transportation Sturgis® Motorcycle Rally™ Case Study.

<table>
<tr><th colspan="2">PROJECT DESCRIPTION AND GOALS</th></tr>
<tr><td colspan="2">The Sturgis® Motorcycle Rally™ is an annual event in Sturgis, South Dakota, that lasts 1 week in August. South Dakota DOT's traffic goal is to efficiently provide a safe traveling experience for all travelers—not just for commuters or visitors. The rally traffic plan involves reducing speed limits along highways; implementing temporary signals; and using portable signal trailers, message boards, speed trailers, incident support, and the traffic operations center in Sturgis. Equipment rental costs about $60,000, and 10–12 people work full time at the traffic operations center during the day for this event.</td></tr>
<tr><th>BENEFITS</th><th>CHALLENGES</th></tr>
<tr><td>Traffic control devices: Using a variety of traffic control methods and equipment can influence how motorists travel. This event involves speed limit changes on existing routes, temporary signals, portable message signs, and speed trailers.

Incident support: Call-out vehicles in strategic areas can reduce the time for law enforcement to reach crash locations, enabling them to focus on incident response rather than traffic control.

Traffic operations center: The traffic operations center can monitor cameras for incidents, equipment issues, and backups.</td><td>Large areas: This multi-day event causes a significant influx in travel demand; the event spans a large geographic area that involves several rural highways.

Determining location of devices: Many people request speed trailers to reduce the speed of motorists. It can be difficult to allocate limited resources.

Moving large number of participants: Large groups of motorcyclists need to be escorted by South Dakota Highway Patrol.</td></tr>
<tr><th colspan="2">LESSONS LEARNED</th></tr>
<tr><td colspan="2">▪ Deploy immediately: Deploy call-out vehicles and update message boards based on the radio messages it receives and by watching traffic software. The traffic operations center can also preempt traffic signals based on video surveillance.
▪ Spread call-out vehicles in various locations: Rather than a central location, spreading call-out vehicles can reduce the time law enforcement spends at a crash location. Reaching the scene quickly and moving the incident off the roadway can reduce travel delays.
▪ Change the existing speed limit: This requires locals to change their routine behavior. It can help to have more law enforcement or speed cameras.</td></tr>
</table>

CHAPTER 11. CONCLUSION

This document offers potential solutions for TSMO strategies in rural areas and encourages a dialogue about the benefits of TSMO strategies and the need for additional research and outreach on the topic. This document can be a resource for agencies considering expanding their use of TSMO in rural areas. It provides a business case for implementing TSMO in rural areas; describes funding opportunities that can help support TSMO strategies; and highlights case studies related to road weather management, TIM, work zone management, seasonal demand, and special events.

Based on the research conducted and the case studies provided, planning and implementing successful TSMO strategies in rural areas involves a variety of key elements to be successful:

- **Developing a business case:** TSMO strategies may be a worthwhile investment in the long term if they are properly planned, funded, and implemented. This is particularly true for rural areas, given their unique characteristics and challenges. Creative and cost-effective solutions can help address issues such as communications and power gaps, which can affect strategy implementation.
- **Identifying TSMO champions:** TSMO champions in State and local agencies can help prioritize strategic advancements for TSMO practices. Personnel experienced in the challenges of implementing rural operational strategies can better present the vision and roadmap to successful implementation.
- **Applying technology:** As part of work zone management in rural areas, queue warning systems in rural locations where queues are not expected can be helpful. Public service campaigns notifying motorists about these systems can increase successful implementation. Rural TIM service patrols are instrumental in responding to rural incidents, clearing travel lanes, and minimizing the need for long detours. A business case for rural TIM service patrols may need to include additional value-added capabilities, such as roadway maintenance capabilities.
- **Collaborating with stakeholders:** Involve all relevant stakeholders, such as law enforcement, emergency responders, 9-1-1 dispatchers, event coordinators, and maintenance crews, early in the planning process of special events, such as concerts, sporting events, and State fairs.
- **Communicating and being responsive:** Develop a process and implement communication protocols or update software to enable efficient and effective communication methods among key stakeholders during seasonal traffic demand variations in rural areas.

APPENDIX A. USDOT FUNDING OPPORTUNITIES

Implementation costs vary widely depending on the project, location, size, duration, and equipment required. This section provides an overview and resources for some funding opportunities for rural communities. In addition to FHWA grants, there are other grants available from the Bipartisan Infrastructure Law (BIL).[36] This table is not intended to be comprehensive. There may be other funding opportunities on USDOT websites. For any additional questions on this, please contact the local FHWA Division Office.

Table 17. USDOT Funding Opportunities.

FUNDING OPPORTUNITIES	WEB LINKS
Formula Grants for Rural Areas Program BIL, continues this program, which provides capital, planning, and operating assistance to States and Federally recognized Indian tribes to support public transportation in rural areas with populations less than 50,000.	Visit for more information: https://www.transit.dot.gov/funding/grants/fact-sheet-formula-grants-rural-areas
Ferry Service for Rural Communities Program BIL provides $200 million in fiscal year (FY) 2022 and an additional $200 million per year from FY 2023 – FY 2026 (subject to annual appropriations) to make Federal resources available to States to ensure basic essential ferry service is provided to rural areas.	Visit for more information: https://www.transit.dot.gov/funding/grants/fact-sheet-ferry-service-rural-communities
Rural Surface Transportation Grant Program (23 U.S.C. 173) This program will provide $2 billion (total available FY 2022-FY 2026) to support projects to improve and expand the surface transportation infrastructure in rural areas to increase connectivity, improve the safety and reliability of the movement of people and freight, and generate regional economic growth and improve quality of life.	Visit for more information: https://www.transportation.gov/grants/rural-surface-transportation-grant Notice of Funding Opportunity for the Department of Transportation's Multimodal Project Discretionary Grant Opportunity, 87 FR 17108 (Mar. 25, 2022), https://www.govinfo.gov/content/pkg/FR-2022-03-25/pdf/2022-06350.pdf
Highway Safety Improvement Program (HSIP) The BIL continues the HSIP objectives to reduce the number of traffic fatalities and serious injuries on all public roads. The HSIP requires a data-driven, strategic approach to improving highway safety on all public roads with a focus on performance.	Visit for more information: https://safety.fhwa.dot.gov/hsip/ https://www.fhwa.dot.gov/bipartisan-infrastructure-law/hsip.cfm

[36] Source: https://www.transportation.gov/bipartisan-infrastructure-law

Table 17. USDOT Funding Opportunities. (continuation)

FUNDING OPPORTUNITIES	WEB LINKS
Accelerated Innovation Deployment Program The **AID Demonstration** provides funding as an incentive to accelerate the deployment and adoption of innovate practices and technologies in highway transportation projects. Between 2014 and 2020, FHWA has awarded more than $86.9 million in 117 grants to Tribal governments, Federal Land Management Agencies, and State departments of transportation. AID Demonstration is authorized within the Technology and Innovation Deployment Program (TIDP) under the Infrastructure Investment and Jobs Act and the anticipates $10 million of TIDP funding to be made available for AID Demonstration in each FY 2022 through FY 2026. The grants are administered through the FHWA Office of Transportation Workforce Development and Technology Deployment.	Visit for more information: https://www.fhwa.dot.gov/innovation/grants/
Federal Highway Administration State Transportation Innovation Council Incentive Program This program provides funding up to $100,000 per State per Federal fiscal year to support or offset the costs of standardizing innovative practices in the State transportation agency or other public sector State Transportation Innovation Council stakeholder. STIC Incentive funds may be used to develop guidance, standards, and specifications; implement process changes; organize peer exchanges; offset implementation costs; or other activities the STIC identifies that address Technology and Innovation Deployment Program (TIDP) goals.	Visit for more information: https://www.fhwa.dot.gov/innovation/stic/guidance.cfm https://www.fhwa.dot.gov/innovation/stic/STIC-Factsheet_2021-508.pdf

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