Aligning Traffic Management Center Staffing Capabilities for the Future of Systems Operations

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16. Abstract This report explores the range of issues that agencies face in evaluating staffing needs to plan, implement, operate, and maintain traffic management systems (TMSs), with an emphasis on staffing needs at the traffic management center (TMC). As TMSs grow more complex and agencies migrate to their next generations, advanced technologies and new operating approaches may come into play, along with new considerations for TMC staff roles, functions, technical skills, and capabilities. Agencies can meet staffing needs in a variety of ways, including through training and technical capacity building, revising job descriptions, creating new staff positions, and contracting for services. This report addresses a range of issues agencies and contractors face when providing staff to agencies for TMS operations, including determining TMC technical staff requirements, recruiting and acquiring staff, retaining TMC staff, and aligning job descriptions and classifications with technical requirements. The report includes sample job descriptions; issues to consider in developing or updating staffing plans; approaches to identifying the knowledge, skills, and abilities to support a TMC; and issues to consider when using agency, contracted, or hybrid staffing approaches.		
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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

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

APPROXIMATE CONVERSIONS FROM SI UNITS

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

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

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LIST OF ABBREVIATIONS

AI	artificial intelligence
ASCT	adaptive signal control technology
ATDM	active transportation and demand management
ATIS	advanced traveler information system
ATM	active traffic management
ATMS	advanced traffic management system
CAD	computer-aided dispatch
Caltrans	California Department of Transportation
CCTV	closed-circuit television
CHART	Coordinated Highways Action Response Team
CMF	capability maturity framework
CMM	capability maturity model
CMS	changeable message sign
ConOps	concept of operations
DelDOT	Delaware Department of Transportation
DMS	dynamic message sign
DOT	department of transportation
EM	electromagnetic
FDOT	Florida DOT
FHWA	Federal Highway Administration
FTE	full-time equivalent
ICM	integrated corridor management
IMSA	International Municipal Signal Association
IRT	incident response team
IT	information technology
ITS	intelligent transportation systems
KC	Kansas City
KPI	key performance indicator
KS	knowledge and skills
KSAOs	knowledge, skills, abilities, and other characteristics
KSAs	knowledge, skills, and abilities
LEDS	Law Enforcement Data System
NCHRP	National Cooperative Highway Research Program
NOCoE	National Operations Center of Excellence
ODOT	Ohio DOT
PCB	professional capacity building
PENNDOT	Pennsylvania DOT
PIO	public information officer
QA	quality assurance
QC	quality control
SCADA	supervisory control and data acquisition
SOP	standard operating procedure
SR	State Route
TIM	traffic incident management

TMC	traffic management center
TMS	traffic management system
TOC	traffic operations center
TSMO	transportation systems management and operations
UDOT	Utah DOT
VMS	variable message sign
WSDOT	Washington State DOT

CHAPTER 1. INTRODUCTION AND OVERVIEW

INTRODUCTION

Over the last several decades, transportation agency roles and responsibilities in managing surface transportation networks have evolved. During this time, traffic management was often associated with urban-area freeways. Agencies began to develop and implement systems to help mitigate increasing congestion during weekday peak commutes. Agencies implemented technologies, tools, and management strategies to respond to growing congestion management needs. Urban freeway management strategies demonstrated benefits to agencies by allowing them to detect problems; monitor traffic, weather, and road conditions; alert travelers; and communicate with other agencies.

Today, agencies recognize that congestion management extends to all forms of recurring and nonrecurring congestion. Traffic incidents planned special events, road and weather conditions, and work-zone capacity restrictions are just a few examples of nonrecurring events that affect safety and mobility on the road network. Both recurring and nonrecurring events extend beyond peak travel periods, and these travel disruptions may adversely impact travel on portions of the surface transportation system or may have broader impacts on a region. The staff at agency traffic management centers (TMCs) serve in an important role, collaborating with other agencies (including law enforcement, emergency responders, and adjacent transportation management agencies) and service providers (such as tow truck operators) to coordinate responses and mitigate the impacts of these events.

Traffic management systems (TMSs) represent a suite of tools, technologies, software, systems, and processes that transportation agencies use, typically from a TMC, to respond to impacts and events on the road network. TMSs include a range of subsystems and components that can enable a wide range of operations strategies, services, functions, and actions to proactively manage and operate traffic.

TMCs that support the staff responsible for managing and operating TMSs in the monitoring, control, and management of TMS assets—are often important components of TMSs. While some subsystems and components of a TMS may be highly automated, other functions, services, and actions may require staff for engineering judgment or specific technical knowledge and capabilities. As agencies' TMSs have evolved to meet the increasing demands of managing and controlling traffic, so have the expectations of TMC staff.

PURPOSE AND FOCUS

This report provides information to support transportation agencies in assessing the required skill sets and staffing they may need to support TMS management and operation. Staff must have the required knowledge, skills, and abilities (KSAs) to meet the evolving technical and operational needs of a TMS' operating environment, management, and operational strategies. Furthermore, the active management and

operation of TMS involves considering a full spectrum of possible job duties, responsibilities, technical training, and operational decisionmaking.

This report also provides information that helps agencies assess whether they are meeting the staffing needs of their TMSs and considering improvement opportunities. Agencies can meet staffing needs in many ways, such as through training and technical capacity building, revising job descriptions, creating new staff positions, and contracting for services. The methods and information captured in this report draw from national resources and interviews with State departments of transportation (DOTs). This report includes sample job descriptions; issues to consider when developing or updating staffing plans; approaches to identifying the KSAs to support a TMC; and issues to consider with using agency, contracted, or hybrid staffing approaches.

This report supports agencies to accomplish the following:

- Identify issues to consider when establishing or updating staff's KSAs to meet the current or expected future capabilities of a TMS.
- Identify issues to consider when developing or updating staffing plans for TMSs.
- Examine options to meet agency staffing needs for TMSs.
- Provide issues to consider when recruiting, retaining, or developing career paths for TMC staff.

INTENDED AUDIENCE

This report examines the range of issues agencies face as they examine staffing needs to plan, implement, operate, and maintain their TMSs, with an emphasis on staffing needs at the TMC. The influences of new and emerging technologies associated with TMSs and new operating strategies may require staff with new technical skills or may require agencies and contractors to provide training so that staff can support expanded expectations. This report provides readers with strategies to help identify technical staff requirements, strategies and successful practices in recruiting and acquiring staff, and methods to align job descriptions and classifications with technical requirements.

Both agency TMC managers and private sector TMC staffing contract managers can learn from State DOT practices and strategies for how staff roles can be developed and updated to align with enhanced TMS operation strategies. This report details the complexities of documenting TMS staff roles and may offer unique contexts on ways to collaborate with TMC managers in planning for future staff. Additionally, consultants and researchers can benefit from the methods and resources presented in this report.

CHALLENGES

Shifting from roles focused on monitoring and responding to more active and proactive system operations affects transportation agencies at many levels. Staff responsible for planning, designing, implementing and operating, and maintaining these systems can represent multiple groups within an agency or even be from different sources (such as contractors or vendors). New systems, the implementation of new operating strategies, and the use of new technologies can present challenges for agencies needing to align specific requirements with staffing.

Many agencies also face broader staffing challenges, such as recruiting, staff transitions and retirements, and limitations on acquiring additional staff. In a 2022 survey of State and local government agencies regarding workforce trends, 53 percent of respondents reported that staff had accelerated their retirement plans over the previous 2 yr, and 41 percent anticipated an even larger number of staff would retire within the next few years.[(1)] Institutional and technical knowledge is often lost if succession planning is insufficient to mitigate the impact of staff transitions, such as retirements, which can have significant impacts on a TMS' operational resiliency.

Agencies face challenges in both staffing TMCs and assessing staff needs to support planning, operating, and managing TMSs. Some of these challenges include the following:

- Quantifying needed skills for TMSs: Understanding TMS operating requirements, system interactions, and performance expectations is essential. Lacking knowledge in this area creates knowledge gaps about technical needs for operating, managing, and maintaining TMSs.

- Developing, operating, and maintaining TMSs: Staff with specific technical expertise, knowledge, and skills are required. These skills can include software, communications, networking, hardware, and other skills that can incorporate information technology (IT), software development, system integration, electrical engineering, traffic engineering, and other specialties. The human resources processes used to identify the KSAs required for different positions may have internal agency challenges. These KSAs may support identifying position classifications, compensation, certification requirements, education, or experience requirements. Agencies may be competing with the private sector for specialized technical skills or may not be able to attract candidates that have the required technical training, certifications, or knowledge within public sector salary ranges.

- Training staff: Limited training resources are available to TMC staff beyond on-the-job training. The technical training resources available for operations staff at TMCs, beyond standard operating procedures (SOPs) and system documentation, are frequently lacking. Expanding TMS capabilities and functions requires training for TMC operations staff on new operating processes, performing operational analyses, and operations strategy implementation. Equipment vendors and TMS developers can provide training on the mechanics

and steps of interacting with software and systems, and staff are challenged to focus on the "how" and the "why" for strategy implementation.

- Modifying staff roles and job descriptions and increasing staff and support resources: For TMCs that rely primarily on agency staff for TMC operations roles, internal challenges may exist in redefining or reclassifying job descriptions to better align with TMS operating needs. Hiring additional staff or cross-training staff with the required operating skills might be limited due to caps on staff numbers, union restrictions, or other internal barriers. Contractor-provided staff can, in some ways, be more flexible with scaling numbers of staff and providing specific technical skill sets. The available budget within a contract for TMC staff can be a limiting factor for agencies (and contractors) to scale staffing levels.

- Supporting TMSs with ranges of skills and resources: Heavy emphasis relies on the technical capabilities needed to fully realize the benefits of more complex and sophisticated TMSs. Additional roles and functions, such as communicating with responders via radio, monitoring social media, sending emails to internal or external stakeholders, or compiling reports may not require unique skills and capabilities. Agencies need staff that can be effective with highly technical skills and tasks and routine tasks.

- Expanding on current staff capabilities and resources: The proactive management and operation of a TMS and the capabilities of the next generation of an agency's system may require expansion within an organization. Organizations shifting from TMC staff roles focused on monitoring and reacting to roles that actively manage transportation networks need strong leadership support and a culture that values performance-based operations and recognizes the complexities that TMC staff navigate because of robust system-operating approaches.

OPTIONS FOR TMC STAFFING

Transportation agencies typically follow one of three staffing approaches for TMC staff, as follows:

- Public sector staff: Agency employees fill roles for TMC operations, management, maintenance, staff supervision, and project and program management of TMS components. Arizona DOT and Ohio DOT are examples of models that use all agency staff for all aspects of TMC management, operation, and maintenance.

- Contractor staffing: Agencies establish contracts with private sector firms to staff various functions, services, and tasks, such as TMC operations, staff management, and maintenance. Contractors can also fill roles associated with providing services or functions for traveler information, coordinating incident responses, analyzing data, and more. Multiple contractors may furnish staff as part of different contracts focused on operations, maintenance, safety service patrol, IT, public information, and other aspects of TMC operations. North Carolina DOT,

Missouri DOT and Kansas DOT's Kansas City (KC) Scout (KC's bistate TMS), New York State DOT, and Georgia DOT are examples of agencies that contract staff to support TMC operations.

- Hybrid staffing: A hybrid staffing approach may use contractors for specific services and functions with agency staff involved in key roles. Typically, agency staff are responsible for providing oversight of contractor staff and their functions and/or provisions of services, such as traveler or public information, IT support, and overall program management. Contractors fill key roles for device and component maintenance, day-to-day TMC operations, and express lane operations. Iowa DOT, Wisconsin DOT, and Florida DOT (FDOT) are examples of States with hybrid staffing approaches.

Whether agencies use public sector staff, contractor staff, or a hybrid staffing approach, they face the challenges of adapting to expanded TMS requirements and TMC roles, functions, and/or services. Transportation agencies and contractors that supply staff also have challenges with defining specific technical roles, aligning compensation with roles, and/or recruiting and retaining staff.

In some instances, the public sector can find it challenging to attract and retain TMC operations staff with the right technical skills, abilities, and training due to agency compensation ranges or limited opportunities for career advancement. The technology space is competitive, and transportation agencies are competing with a myriad of industries for staff with specific skill sets, such as data analysis, system operations and integration, and advanced computing. Providing career paths and opportunities for advancement for niche technical skill sets within a DOT can be challenging. DOT career paths and opportunities for advancement to leadership roles within a transportation agency often favor civil engineering degrees, backgrounds, and professional registration. Staff with technical skills that align with TMS operations and maintenance can come from a variety of technical backgrounds and may not have an engineering degree or the corresponding registration.

The private sector may be able to offer a different set of opportunities for technical staff, including higher compensation and more opportunities for career path progression. However, private sector contractors can also face challenges with recruiting and retaining experienced staff. Contractual arrangements may limit compensation levels, even for highly skilled technical staff. Defining the specific skill sets needed for future TMS operations that are more technical and complex, aligning these skill sets with compensation and classifications, and providing career opportunities are challenges facing all these staffing approaches.

REPORT ORGANIZATION

This report is organized into the following chapters:

- Chapter 1—Introduction and Overview: This chapter presents the purpose of the report and challenges facing agencies in quantifying and assessing their TMS staffing strategies and preparing for future staffing needs. Additionally, the chapter provides an overview of staffing approaches for TMCs and outlines the overall organization of the report.

- Chapter 2—TMS Influences on Staffing: This chapter provides context for next-generation TMSs and details how advanced systems, technologies, and operating approaches can influence TMS staffing needs at the TMC. The chapter includes a discussion on when to engage staff in different stages of TMS planning and implementation and presents tools for agencies to better assess staffing needs and changes.

- Chapter 3—TMS Staffing Plans: This chapter identifies issues for agencies to consider when developing or updating staffing plans and typical elements to consider, including in a TMS staffing plan. Additionally, the chapter highlights methods for acquiring TMC staffing resources and discusses different aspects of in-house versus contractor TMC staffing approaches. The chapter also provides information to consider when developing TMC staff KSAs, describes how those KSAs influence TMC job descriptions, and discusses training resources for staff.

- Chapter 4—TMC Staff Development: This chapter provides information agencies may consider when they are exploring strategies for recruiting and retaining TMS staff. It includes examples of best practices from several transportation agencies and private sector staffing contractors.

CHAPTER 2. TMS INFLUENCES ON STAFFING

The capabilities of TMSs have been evolving for many years, including a wide range of monitoring, control, management, and operational capabilities all focused on providing safe and reliable travel on the surface transportation system and network. A TMC is often a central location where staff are responsible for many realtime functions associated with TMS operations. As agencies explore opportunities to assess the capabilities of their TMSs and improve performance, current and future TMC staffing needs and resources are appropriate to address.

As transportation agencies consider options to enhance their existing TMSs or prepare to transition from their legacy systems to next-generation TMSs, the impact of these potential changes on staffing needs can be reviewed in parallel with TMS transition plans. As components of a TMS become more complex, data-driven, and automated, agencies may also consider potential influences on staff roles, skill sets, and technical competencies—and whether changes are needed to numbers and types of staff.

Interviews with transportation agencies and research gathered to support developing this report yielded a wide range of approaches for addressing staffing needs to support TMS operations. Numerous combinations of TMC staffing approaches are currently in use throughout the United States, as follows:

- Agency staff, including operators, supervisors, managers, engineers, and technicians.
- Contracted staff with oversight from agency staff.
- Contracted staff, including operators, supervisors, managers, engineers, and technicians.
- Hybrid staff, with approaches that may include some positions as agency employees and other positions provided by contractors. The combination of staff is based on the agency's business and operating objectives and preferences in how the agency achieves the desired level of TMS management and operations.

In addition to planning TMS staffing at the TMC, an agency can determine the best strategy for addressing staffing needs for other components of its TMS, such as device and equipment maintenance, system planning and design, procurement, and other functions. Agencies commonly contract staff services for specific functions or activities, such as device maintenance or system design. Depending on agency organizational structure, these functions may reside in different groups or divisions within the agency.

This chapter presents some unique TMC staffing issues to consider as agencies explore TMS enhancements and expansions. These issues can include how to integrate staffing considerations at different stages of planning, designing, developing, implementing, initiating, managing, operating, and maintaining TMSs. This chapter also provides

information about tools and resources that agencies can use to examine potential staffing issues and needs to improve the performance of their TMSs.

The chapter is organized to provide the reader with a context for staffing needs for the next generation of TMSs, with an emphasis on TMC staffing needs to potentially support new technologies and increasingly complex operating strategies. Additionally, this chapter provides agencies with information to consider in support of assessing staffing needs and choosing priorities to support expanded TMS functions and services. This chapter also provides context for subsequent report chapters that discuss how to facilitate aligning possible staff roles and duties when identifying KSAs and staff resources that may be needed to meet the current or future needs of a TMS.

CONTEXT FOR THE NEXT-GENERATION TMS

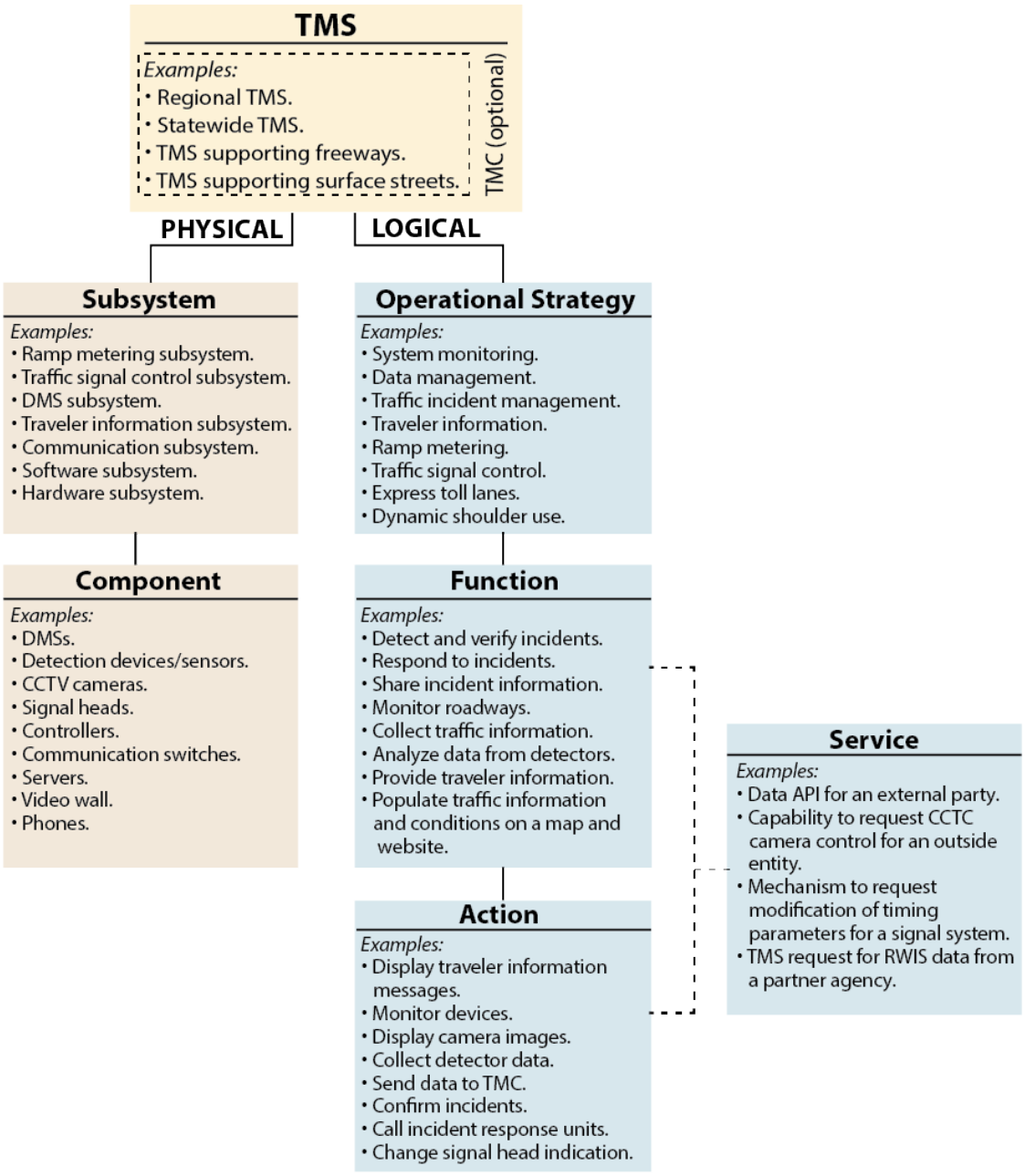
As technology and practices continue to evolve, the next generation of TMSs may introduce new technologies, new functions, increased system automation, and enhanced analytics and decision-support capabilities. Existing or legacy TMSs may require significant manual interventions (e.g., functions, services, and tasks) by TMC staff to continue to manage and operate as technology changes. Additionally, new services, functions, and tasks and/or the use of new operating strategies may impact staffing needs. Following is a summary of staffing issues to consider when exploring possible TMS improvements:

- Operating strategies, such as integrated corridor management (ICM), active traffic management (ATM), multimodal coordination, and road weather response monitoring and management will influence—and, in some cases, increase—agency operating responsibilities. These strategies are closely tied to realtime performance management, increasing the analysis and analytics expected from the TMC.

- Emerging capabilities, such as artificial intelligence (AI) and decision support, may require additional skills to manage and calibrate these capabilities. In some instances, these capabilities may help to automate certain functions that may currently require manual operations in legacy TMSs.

DEFINITION OF A TMS

A TMS encompasses physical system and device elements, functions enabled by software and logic, and actions and processes completed by operations staff or through automated TMS processes that result in various services supporting overall system operations. Both physical (subsystems and components) and logical (strategies, functions, actions, and resulting services) elements comprise a TMS. Figure 1 illustrates details and definitions for each of these elements of the TMS.



Source: Federal Highway Administration (FHWA).

Figure 1. Flowchart. TMS structure with examples.[2]

TMS physical elements, including subsystems, devices, and components, are the tangible assets that staff (and/or systems) monitor, manage, and control. Some components, such as controllers and switches, support infrastructure for other types of devices. TMSs are often composed of multiple subsystems and components. Operations processes and SOPs outline how operators monitor, interact with, and use TMS components and subsystems.

The logical elements of a TMS include operational strategies, which are a set of functions and actions that combine to deliver a specific operational activity. For example, detect

and verify incidents includes a combination of different actions and activities that will be accomplished by a TMS subsystem or through operator procedures. Actions are basic, singular tasks that, when combined, complete a function and the ultimate delivery of an operational strategy. Several actions are typically required to accomplish each function.[1]

The next generation of an agency's TMS may introduce a host of new capabilities and functionality. Where these changes may require a different suite of operational strategies, functions, services, or system requirements may have different implications on staffing, such as technical skills, training, or operating processes. New technologies might streamline some functions that were part of legacy systems.

Many agencies rely on TMC staff to verify system actions, approve changes to strategies, monitor traffic responses to strategies that have been automatically implemented, and/or manually adjust strategies. Operational decisions and actions that staff make may be guided by SOPs; certain strategies may require specific engineering judgments to implement. Agencies may want to consider how new TMS capabilities may change or modify the working environment and how these changes may impact overall TMC staffing plans. This process may include distinguishing what tasks or functions can be accomplished through documented processes and procedures and what tasks or functions require more technical engineering decisions. Possible elements of change in this process include the following:

- Modifying staff roles, job descriptions, and responsibilities.
- Modifying technical training, specialized education, and/or certification and licensure requirements.
- Identifying specific functions requiring engineering analysis, judgment, and decisionmaking versus what functions can be documented through updated SOPs.
- Recruiting individuals with needed technical skill sets, such as data analysis and performance management, who might not exist within a traditional pool of candidates.
- Developing or modifying staffing plans that identify where new staff or functional skills can augment day-to-day operations roles.
- Procuring staff resources to address technical needs for specific functions or during TMS development phases (intelligent transportation system (ITS) architecture development, concept of operations (ConOps) development, TMS design, or TMS maintenance).
- Updating operating procedures to identify where specific functions and tasks needs to be addressed by specific staff with appropriate skills and technical training (such as modifying ramp meter operations, adjusting speed limits, or changing traffic signal timing).

Staffing Considerations for TMSs

A first step for agencies in identifying considerations for TMC staff who will interact with a TMS is to understand the different TMS elements. The examples provided in figure 1 represent typical elements found in a TMS; agencies can expand on these examples to consider any unique elements that are part of their TMS.

Examples of considerations for agencies when evaluating the potential impacts or influences of TMSs on TMC staffing are presented in table 1. This table is not an exhaustive list; these considerations are examples to prompt questions for further exploration by agencies. Based on the questions these examples prompt, agencies can then assess how their TMC staff aligns with current requirements and the expectations on which their TMS design and implementation was based on.

Table 1. Staffing considerations for TMS elements.

TMS Element	Considerations
Subsystems and components require processes to monitor, operate, manage, and maintain.	• If processes are not documented, errors and inconsistencies may result. • If relationships between subsystems and components or among components that support multiple subsystems are not understood, systems may not function in an integrated fashion. • If staff lack awareness of roles and responsibilities for monitoring, managing, or verifying subsystem and component status, inconsistent processes for operating TMS elements may result. • If staff do not know how to troubleshoot malfunctions, unnecessary maintenance or equipment downtime may result. • If training tools, resources, and SOPs provide the necessary knowledge, skills, and methods, staff are supported in their interactions with TMS subsystems and components for optimum operations. • If staff are aware of the performance expectations associated with each subsystem and component, staff can accurately identify performance issues.

TMS Element	Considerations
Actions, functions, and specific activities (tasks and combinations of tasks) support operational strategies.	• Documenting SOPs for functions and actions can promote consistency and understanding among staff. • Making distinctions between automated and manual actions may help staff understand when manual intervention is needed. • Showing connectivity for functions in a documented architecture promotes staff understanding of the relationship of actions on different operational strategies or plans.
Operational strategies combine functions, actions, subsystems, and components to deliver a desired mobility, safety, or reliability objective.	• Documenting agency goals for operational strategies promotes broader understanding of relationships between TMC actions and resulting system operations. • Understanding different components' and subsystems' roles in supporting operational strategies can improve operations decisionmaking by staff. • Recognizing unique or specialized skills required to facilitate operational strategies and learning how to improve proficiency through training is beneficial for staff. • Providing training and clear SOPs can furnish staff with technical steps and knowledge if staff does not have these particular skills. • Engaging in daily interactions with TMS components, subsystems, and procedures can give staff the ability to provide context to leadership in terms of developing, updating, and maintaining processes to support operational strategies. • Establishing authority levels to implement or adjust different operational strategies can align staff with appropriate technical expertise to make specific operations decisions.

The considerations presented in table 1 provide examples of the types of interactions or issues agencies may want to consider with efforts to assess or identify TMC staffing needs, including job roles and expectations, KSAs, and training needs. Considering any new or expanded capabilities that staff will need to support can help agencies to do the following:

- Identify specific roles and responsibilities that may need to be documented or updated.
- Identify unique or specialized skill sets that may be required to operate, manage, or maintain TMS elements.
- Evaluate staff training needs.
- Identify any additional staff resources that may be needed to support any current or planned enhancements to system capabilities, functions, or geographic coverage.
- Consider modifying or redefining staff roles and job descriptions.

Examples of two recent agency efforts from ODOT and FDOT to assess staffing needs in relation to system upgrades and new TMS capabilities are presented in the following two sections.

ODOT TMC Specialist[1]

ODOT established key goals to improve travel time reliability, preserve reliable capacity into the future, improve freight travel, reduce vehicle delay, and improve person throughput. ODOT drafted these goals as part of a statewide active transportation and demand management (ATDM) study and carried them out in conjunction with establishing a transportation systems management and operations (TSMO) program. ODOT embarked on a pilot project to implement hard shoulder running to address recurring congestion on a segment of I–670 in Columbus, OH. The I–670 SmartLane project included variable speed limits, additional closed-circuit television (CCTV) cameras, additional dynamic message signs (DMSs), fiber optic cable, and reconstruction of the shoulder to allow for shoulder operations during peak congestion.(3) This new operating strategy included expanded TMS capabilities to support monitoring and managing SmartLane operations. The strategy also required ODOT to examine the staffing capabilities needed to effectively operate the system. All operations staff at the ODOT TMC in Columbus were classified as "computer operator," with either a 1, 2, or 3 designation, indicating increasing levels of training and tenure.

With the I–670 SmartLane project, ODOT's TMC operations were shifting from traffic monitoring to traffic management.(3) However, this shift was not captured in the existing TMC operator job descriptions. Thus, ODOT recognized that a different type of operator

[1]Interview by FHWA partner with ODOT TMC staff, January 2021.

was needed and created a new TMC specialist position in response to the TMC's operating requirements. This position has the authority to open the shoulder and oversee TMC operations staff. A TMC specialist currently covers the first and second shifts because those time frames correspond to typical operating times when shoulder operations are activated. As TMS capabilities expand to other locations, ODOT will assess whether additional TMC Specialist capabilities are needed.

FDOT District 4

FDOT's district 4 includes five counties and the cities of West Palm Beach, Fort Lauderdale, Stuart, Vero Beach, and Fort Pierce. The regional TMC manages both freeway and arterial traffic operations and management systems, with express lanes comprising freeway management system responsibilities. An additional TMC in Palm Beach County coordinates with the SMART SunGuide Regional TMC in Broward County.[4]

The freeway management program in district 4 is operated 24 hours per day, 7 days per week and includes a TMC manager and assistant manager, floor managers, 30 TMC operators, 8 express lane operators, and a managed lane engineer. The program operates Monday through Friday, 7 a.m. to 7 p.m., and includes signal timing engineers and dedicated operators for the two arterial management deployments.[5]

At the time of this writing, district 4 is advancing an ICM initiative that will include freeway, arterial, and rail systems and a new TMS with enhanced decision-support capabilities. As part of the arterial components, the district envisions several transit enhancements and adaptive traffic signal controls to support the ICM. Prior to the implementation—during the development of the ICM's ConOps—stakeholders took a close look at future operating scenarios and identified the need to expand staff numbers, skill sets, and roles at the operations centers.[5]

FDOT determined it needs to add new in-house IT support and staff with the technical skills to manage data and its performance measures. Additionally, FDOT determined it should upgrade current operations staff positions to account for the growing complexity of future operating strategies. For arterial operations, more traffic signal timing engineers will be needed, and staff with multimodal expertise, which may include agency staff and/or consultant resources.[5]

A helpful resource to better understand how various TMC staffing needs may change in the future as agencies plan for next-generation TMSs can be found in the report titled *Developing and Using a Concept of Operations for Traffic Management Systems—Current Practices*.[6] Staffing issues to consider when migrating to more complex and robust TMSs include the following:[5]

- Increased automation of TMSs and associated systems may introduce new considerations for type of staff to hire for TMS operations, training areas to cover, and needed modifications to operating processes and procedures.

- Partnerships can be explored to help support more advanced functions, such as data analytics. An example of this type of partnership is Iowa DOT and Iowa State University, where Iowa DOT is migrating to a more robust TMS and data management strategy and can leverage expertise from the University's Institute for Transportation.[7]

- TMS operator roles are gradually shifting, and job functions will adjust as system capabilities provide more automation and push notifications. This change may result in the job duties of TMC staff becoming more focused on analyzing data and interpreting TMS outputs.

Staffing Considerations for Stages of Planning and Developing a TMS

Staff that works daily with TMS components can provide valuable perspectives during all the stages of planning and developing a TMS. The roles that TMC staff will play in planning for, operating, monitoring, managing, and maintaining different elements of a TMS are valuable to consider. By identifying specific engagement points for staff at each stage of TMS development, agencies can gain perspectives from staff that will have frequent, if not daily, interactions with the systems being implemented.

For example, during the TMS planning and design stages, TMC staff can provide insights on system usability and how operators will need to navigate different screens, processes, or TMS modules as part of daily operations. Staff can ask critical questions, such as the following:

- Do opportunities exist to automate certain functions, such as reporting or data analysis, which would typically require a significant amount of manual effort?

- Can multiple functions be integrated into a single platform to limit the number of independent systems an operator must monitor and manage?

Later stages of TMS development (such as design, development, and testing) can benefit from staff perspectives on what functions and features should be prioritized, based on how the operators will be interacting with different elements of the TMS. This perspective can also help to identify potential conflicts among different workflows or processes that operators encounter. Upgrades or replacements of different TMS elements should also factor into feedback from TMC staff on any potential impacts to current processes or predictions of whether system interactions will change due to introducing new TMS elements.

Table 2 offers examples of types of inputs TMC staff may provide during the planning and development of a TMS.

Table 2. TMC staff involvement in TMS planning and development.

TMS Development Stage	TMC Staff Perspectives
TMS system planning: • ITS architecture. • ConOps.	• Provide input to concepts and operational scenarios. • Identify system interactions and information exchanges. • Develop use cases for TMS operations at the TMC. • Provide user needs from the TMC perspective.
TMS design: • Requirements. • System design. • System development.	• Identify system operations, data sharing, or functional needs based on TMC workflows. • Identify potential conflicts with existing systems and workflows. • Inform and confirm priorities for system operations. • Develop user interface requirements. • Define functional requirements.
TMS implementation: • Implement and integrate. • Test.	• Support implementation and testing. • Provide feedback on usability and interoperability of TMSs at the TMC. • Identify gaps or inconsistencies with operational workflows at the TMC.
TMS operations and maintenance: • Operate systems. • Manage systems and performance. • Maintain systems.	• Develop, maintain, and update SOPS. • Monitor system functionality. • Troubleshoot system operating issues. • Analyze TMS and overall system performance data. • Recommend operational changes to the TMS to address performance issues. • Document and maintain system issue log. • Implement configuration management strategies. • Coordinate with technical resources to address system maintenance and operation needs.
TMS transition: • Upgrade. • Replace.	• Identify new TMS functions and capabilities that are needed. • Assess upgrade implications on current systems, processes, and workflows at the TMC.

STAFFING CONSIDERATIONS FOR OPERATIONAL STRATEGIES AND FUNCTIONS

Operational strategies, such as ATDM and adaptive control, may introduce different responses from TMC staff—and, potentially, other entities. These types of operating strategies may introduce new requirements that can influence staffing, such as decisionmaking for activating or adjusting operational strategies (such as hard shoulder running or variable speed limits). Other requirements and changes that agencies may

consider as a result of new operational strategies include training, updated processes, and different types of collaboration with other transportation agencies, such as transit or arterial operating agencies.

This section discusses potential operational changes that may influence how a TMC is managed and operated. These changes may result in changes in the KSAs and technical competencies needed for staff to manage and use these new technologies and capabilities.

ATDM

ATDM represents a suite of transportation operations strategies focused on dynamic management, control, and influence of travel demand; traffic demand; and traffic flow of transportation facilities.[8] As part of an ATDM approach, both the TMS functions and the operations decisionmaking are focused on highly variable conditions, active management of the TMS, and proactive response and planning to anticipated travel conditions.

Active Management Cycle

With ATDM, an increased emphasis on managing overall corridor or system performance exists, recognizing that many activities and actions need to be more dynamic than previous operations strategies, which were much more reactive to incidents, events, and bottlenecks on the network. Figure 2 shows the active management cycle.

Source: FHWA.

Figure 2. Diagram. Active management cycle.[8]

Following are descriptions of each stage of the cycle:[8]

- Monitor system: This monitoring includes both system and operator monitoring activities using TMS tools, such as sensors, cameras, data, and other technologies. Active management emphasizes continuous monitoring, which can often be achieved through advanced technology and algorithms combined with staff monitoring of conditions.

- Assess system performance: The system is continuously assessed for current system performance against expected or predicted performance (historical or typical for time of day, day of week). TMS capabilities can build in these functions for continuous performance assessment, and these capabilities may be supplemented by operator performance assessments. Active management emphasizes these functions in realtime, as opposed to prior operating strategies that might have relied more on daily, weekly, or monthly performance assessments.

- Evaluate and recommend dynamic actions: Using the realtime performance analysis, the system evaluates potential strategies and operating approaches to evaluate potential dynamic actions to implement to respond to realtime (or predicted) conditions. Decision-support systems are a tool to support this process and are built on business rules established during the system design phase. Legacy operating approaches may have placed more emphasis on operator decisionmaking; next-generation TMS capabilities can be designed to facilitate more dynamic assessment and strategy selection through functions, such as decision-support systems.

- Implement dynamic actions: Based on available condition data, business rules, and system logic, the response strategy (or strategies) are activated to actively manage the transportation system. This activation requires an agency to implement rules and processes that allow for automatic implementation or control of TMS components to implement the strategy or may rely on staff to implement the recommended operating strategy or system change.

Staffing Considerations and Resources

FHWA continues to develop resources and tools to help transportation agencies as they migrate from legacy operating approaches to more active management strategies. Resources to support ATDM can be accessed on the FHWA Office of Operations ATDM website.[9]

Additionally, Lukasik et al.'s (2020) report, titled *Enhancing Active Transportation and Demand With Active and Emerging Technologies and Data Sources*, is a good resource on this topic. The report discusses organizational changes that may be needed in a range of areas—staffing, technology, and operating philosophies—to support shifting from static and responsive transportation management to a role that is more active and responsive.[10]

Chapter 3 details how ATDM applications are expected to evolve and future capabilities may be enhanced through new TMS capabilities, data, and other emerging technologies. The role of the TMC operator is contrasted in both the traditional scenario (today's systems, technologies, and TMC operator role) and the new technology-enabled scenario.(10)

Chapter 4 presents important considerations for agencies planning to migrate to more active management and use of operational strategies and functions. The chapter recognizes that improvements to TMC operations and transportation management functions result both from enhanced TMS subsystems and components and from updated approaches to TMC staffing and training. The chapter adds that, in addition to an overall cultural and organizational shift to more active agency roles in system operations and management, the following are key staffing and education considerations:(10)

- Staffing:
    - What is the level of preparation of agency TMCs to use emerging data (e.g., their challenges, technical skills)?
    - What is the expected user experience for agency operators? User experiences are as important as data and system integration in the success of new software functions.
    - What are the desired outcomes of the end user's tasks? Will these tasks impact other aspects of the organization or other users? Designing user interfaces and business process flows to be intuitive is a consideration in software adoption.
    - How will agency users access data subsystems and decision-support tools (e.g., local client software, Intranet, Internet)?
- KSAs:
    - What skills do agency staff already have in databases, software installation, software maintenance, developing and maintaining application program interfaces, dashboarding, and analytics? How can additional personnel with these skills be obtained as needed?
    - What flexibility does the agency have in acquiring staff with these skill sets? Can the agency redefine roles? Expand technical skills services may be procured?
    - What mechanism is available to obtain these skills if they cannot be addressed by current staff or roles? Can the skills be contracted or outsourced? Can agency staff be provided with additional training to learn the skills?

RESOURCES TO HELP IDENTIFY TMS STAFFING NEEDS

Planning for Future Improvements to TMSs

Agencies can gain valuable information about anticipated staffing roles, actions, and staff technical skill requirements from a variety of TMS planning activities, particularly for staff at the TMC. Inputs from systems engineering processes, such as the ConOps and system requirements, can provide insights on roles, responsibilities, and staff interactions with various TMS components, subsystems, and functions, as follows:

- User needs are typically included in the ConOps. The ConOps also usually includes use cases, which provide user-oriented operational descriptions and outline operator systems, operational steps, procedures, and so on. These use cases can provide context to workflow, decisions to be made, systems, and sources of information that an operator relies on to accomplish tasks and anticipated results. Multiple use cases may capture different processes or aspects of TMS operation at a TMC (such as traveler information, incident monitoring and response, and traffic monitoring and management). Identifying these use cases provides a foundation for identifying requirements.

- Requirements are typically delineated in a separate document and include the specific activities, actions, outputs, and processes required to meet the ConOps user needs. The ConOps user needs can ultimately be translated in this process into the anticipated tasks (e.g., decisions and changes in how operational strategies are operated), responses, and procedures needed to complete specific activities and what actions, data, or system operating steps are needed. Following are examples of how to translate TMS needs and requirements into staffing considerations, using sample requirements and needs from the report titled *Model Systems Engineering Documents for Adaptive Signal Control Technology (ASCT) Systems*:[11]

    - Requirement: ASCT system shall operate nonadaptively when a user manually commands the system to cease adaptive operation.

    - Need (ConOps): System operator overrides adaptive operation if needed.

    - Staffing considerations: Operating ASCT systems requires technical skills or training. Knowledge of how to interpret when conditions warrant nonadaptive operations, the authority level to change system operations, knowledge of alternate signal timing plans to implement, and the ability to follow SOPs are also necessary.

Capability Maturity Model Assessments

Capability maturity model (CMM) self-assessment is a tool that many transportation agencies are using to help identify the capabilities, performance, and maturity of various operating processes. Over the last decade, the CMM has been widely used at the multistate, State, and regional levels by agencies developing or improving their TSMO

programs. The assessment looks at capabilities across eight key dimensions: business processes, systems and technology, performance measurement, culture, organization and staffing, collaboration, management and operations, and maintenance and repairs. Using a facilitated process, stakeholders provide feedback within each dimension about strengths (what is working well), weaknesses (challenges, gaps, or barriers), and priority actions.(12)

The organization and staffing dimension provides the most direct input to needs for workforce staffing, technical skills, and training. The business process dimension can identify planning for future TMSs, which may have an impact on staffing. The systems and technology dimension might identify needs or strategies that affect TMC staff or that could benefit from input from staff that operate and manage various components of the TMS. Table 3 provides examples of potential insights for TMC staffing needs from CMM discussions.

Table 3. Example staffing insights from CMM assessment.

CMM Dimension	Example Staffing Insights and Considerations[2]
Business processes	• Develop corridor performance-based improvement projects. (Does staff with knowledge of day-to-day performance have input into project needs?) • Integrate TMS device operations, maintenance, and upgrade needs into agency asset management processes. (Can staff support identifying TMS equipment issues, trends, and performance deficiencies?) • Plan for next-generation TMS or plan for TMS enhancements. (What, if any, staffing considerations should be examined or documented in these planning efforts?)
Systems and technology	• Identify needed technical capacities and KSAs for TMS (including operations, maintenance, and repair). • Provide training and improve awareness of systems engineering processes. • Expand geographic coverage of TMS and consider impacts on staffing levels. • Develop guidance and SOPs for new TMS subsystems, components, devices, or requirements and consider how operating processes may need to be performed and the influence of any changes on staffing needs.

[2]Adapted from *Organizing for Reliability—CMM Assessment and Implementation Plan Support White Papers*. 2014. Unpublished.

CMM Dimension	Example Staffing Insights and Considerations[2]
Performance measurement	• Define and actively measure performance for operational strategies and consider what roles staff will perform to support these functions. (Which, if any, existing staff has the corresponding skills and knowledge to address performance management, data, and measure reporting?) • Aggregate, analyze, and report on TMS and system performance measures through various formats, such as dashboards. (Which, if any, existing staff has the corresponding skills and knowledge to support the analysis needed for the agency's TMS and system performance measure strategies?) • Identify data sources and gaps to support TMS performance measures.
Culture	• Facilitate peer exchanges to share best practices. • Identify solutions to specific technical staffing needs, such as outsourcing specific positions. • Promote awareness within the agency of TMS functions and staff roles.
Organization and staffing	• Develop staffing plans for the TMC. • Examine career paths and identify options for staff growth and career progression. (Is lack of a career path a factor in staff retention?) • Develop and provide technical training and cross-training for staff at the TMC to support TMS operations. • Develop position and job descriptions that align with TMS operating needs. • Identify specialized skill sets needed and methods for acquiring staff with those skills. • Implement methods for evaluating staff technical competencies and proficiency.
Collaboration	• Leverage university relationships to provide additional technical support and analysis to TMS functions at the TMC. • Identify potential staff resource sharing arrangements with partner agencies. • Identify collaboration opportunities within the agency where staff responsible for the TMS are located in different divisions or groups (such as IT, procurement, and maintenance).

In addition to CMMs, FHWA developed several capability maturity frameworks (CMFs) modeled after the TSMO CMM.[13] These frameworks focus on specific operations functions, including traffic management, traffic incident management (TIM), road weather management, planned special events, work zone management, traffic signal management, and active demand management. The CMFs use the same six dimensions as the TSMO CMM. Online tools are available on FHWA's Business Process Frameworks for Transportation Operations website to help facilitate CMF assessments.[14]

The traffic management CMF provides the most applicable framework for examining TMS staffing needs—particularly for the staff located at the TMC. The organization and workforce dimension focuses on several aspects of staffing-related issues, including the following:[15]

- Organizational structure.
- Recruitment and retention.
- Staff development and professional capacity building (PCB).

The CMFs provide agencies with tools to assess current capabilities and performance and determine how an agency is meeting staffing challenges to meet TMS needs. These types of assessments also help agencies identify possible enhancement topics to consider and potential actions to support enhancing staffing capabilities. The CMFs are not intended to be solely focused on staffing, but they facilitate agency examinations of staffing issues and impacts as parts of broader discussions on assessing traffic management capabilities and improvements to operational capabilities and processes.

Table 4 provides a summary of the organization and workforce traffic management CMF agency actions outlined within the CMF online tool.

Table 4. Traffic management CMF organization and workforce action summary.[15]

Level	Organizational Structure	Recruitment and Retention	Staff Development/PCB
1–2	• Develop a comprehensive list of traffic management roles and responsibilities across the organization and identify cross-links to facilitate coordination. • Provide list of cross-linked traffic management roles to all traffic management staff across the organization for reference and use in daily and strategic activities. • Develop high-level training mechanisms for traffic management staff related to all critical traffic management functions within the agency. • Schedule regular training offerings to reduce personnel turnover.	Consider developing an action plan to address vacancies in critical traffic management program roles and capabilities.	Assemble basic PCB activities with critical supporting material for specific traffic management functions.
2–3	• Establish a core group for traffic management that includes staff for key roles requiring redundancy. • Compile a database of traffic management personnel and resources across all organizational units and identify redundancy within core group roles. • Create training courses and seminars that focus on critical aspects of all traffic management functions.	• Identify the ideal staff for succession into key traffic management positions. • Create a clearly defined and consistently applied process for career advancement for traffic management staff. • Establish a retraining program for staff to facilitate job reassignment for traffic management needs (e.g., systems engineering, modeling,	• Develop a formal and ongoing training PCB program on traffic management that is offered and supported by the agency. • Create a formal certification and/or training program for all traffic management operators.

Level	Organizational Structure	Recruitment and Retention	Staff Development/PCB
	• Devise a training program that periodically cross-trains all staff on critical functions and is regularly updated as roles, responsibilities, duties, and/or functions change. • Construct a basic hierarchy of backup staff for critical functions that can be handled by cross-trained staff as needed.	software development and procurement, ITS hardware maintenance).	
3–4	• Establish a core group for traffic management that includes staff for key roles requiring redundancy. • Compile a database of traffic management personnel and resources across all organizational units and identify redundancy within core group roles. • Create training courses and seminars that focus on critical aspects of all traffic management functions. • Devise a training program that periodically cross-trains all staff on critical functions and is regularly updated as roles, responsibilities, duties, and/or functions change. • Construct a basic hierarchy of backup staff for critical functions that can be handled by cross-trained staff as needed.	• Establish a formal succession plan for traffic management positions to ensure capabilities are maintained. • Structure a mentoring and training program to ensure that staff members slated for succession are prepared at the appropriate time. • Implement procedures for capturing institutional knowledge for planned and unplanned personnel transitions.	Regularly offer certification and/or training that supports recruitment and retention efforts.

By using this tool and focusing on the organization and workforce dimension, agencies can consider current capabilities and resources, how staffing approaches are meeting current needs, and where staffing gaps may need to be addressed as part of future enhancements. Agencies can then assess which levels best reflect their current staffing capabilities and begin to identify supporting actions to advance to the next level. Focusing only on the organization and workforce dimension of the traffic management CMF will help to inform the overall staffing strategy and staffing plan. Additional staffing considerations may be included as part of discussions within the other CMF dimensions, including business processes, systems and technology, culture, and collaboration.

Other CMFs, including Road Weather Management, Work Zones, and Signal Management, also provide some level of staffing needs, insights, or considerations as part of the organization and workforce dimension.[14] However, these CMFs are not necessarily specific to TMS staff at the TMC.

Additional Tools and Resources

Other resources to support agencies considering KSAs or workforce development opportunities for TMSs include reports, information, job descriptions, workshop proceedings, training resources, and webinars developed through FHWA, National Cooperative Highway Research Programs (NCHRP) and the National Network for the Transportation Workforce, among others. These resources are included on the National Operations Center of Excellence (NOCoE) website for TSMO Workforce Development.[16]

NOCoE's Workforce website will continue to add resources as new products and tools are developed. The human resources section on NOCoE's Workforce website includes model TSMO position descriptions and discussions of the evolution of traffic engineering, ITS positions, and future roles and responsibilities.[17] These resources provide additional context for human resources staff to understand the complexities of evolving staff roles, including for TMS staff at the TMC.

Additionally, NOCoE's Workforce website has links to National and State-specific resources regarding TMC staffing and operators.[16]

The TMC Pooled Fund Study developed a body of work to support agencies in planning, implementing, operating, and expanding TMCs. Several fundamental resources are available to support agencies in assessing overall workload analysis for TMC staff, scheduling, staff planning, and developing job descriptions. Additionally, the TMC Pooled Fund Study website includes resources and information for next-generation TMSs, including information related to staffing considerations.[18]

Resources to help agencies in assessing improvements or enhancements to staffing strategies continue to evolve. The following sections from NOCoE's Workforce website provide information to support agencies in their staffing discussions and assessments:[16,18]

- Staffing and operators: Resources from the TMC Pooled Fund Study, NOCoE, and FHWA can help agencies assess staffing capabilities, roles, and operating requirements as they seek to expand or enhance management and operation of TMSs and TMCs. The TMC Pooled Fund Study website provides links to reports on TMC staffing and scheduling, TMC operator requirements and position descriptions, human factors guidelines, and TMCs. Guidance from the TMC Pooled Fund Study project on Procuring, Managing, and Evaluating the Performance of Contracted TMC Services includes links to other websites (including NOCoE's TSMO Workforce Development) with examples from specific agency practices.[16,19]

- Next-generation TMSs: This section includes work products to support agencies transitioning from legacy TMSs to next-generation TMSs, current practices, and future efforts focused on asset management. All these stages of next-generation TMSs will have staffing considerations that will impact TMC staff.

- Day-to-day management of TMSs and TMCs: Staff involved in TMC staffing decisions can benefit from resources developed to support TMC staffing and scheduling, including an interactive tool to estimate numbers of staff per shift. This section also includes helpful information about the TMC role for TSMO strategies and provides links to resources for advanced corridor operations including ramp metering, TIM, and ATM.

CHAPTER 3. TMS STAFFING PLANS

CHAPTER PURPOSE AND OBJECTIVES

This chapter provides considerations for agencies as they develop or update staffing plans to support operating needs and system operation objectives. Planning for staffing needs to support day-to-day TMC operations, future expansions of TMS capabilities, or new operations strategies may involve examining staffing needs from several perspectives. Issues agencies may need to consider when developing staffing plans include understanding how a TMS currently functions and analyzing whether current staff and processes meet needs, how staffing may need adjustment for future operating requirements, and how agencies will staff TMCs. A TMC staffing plan is intended to support agencies in identifying, planning, and leveraging opportunities as they arise and to ensure necessary resources are available to meet the staffing needs and performance expectations of the TMC, including the TMS.

This chapter focuses on TMS staffing needs for TMCs. Agencies may also consider developing staffing plans for other components of their TMSs, such as device and system maintenance, which may have different considerations than staffing for TMC operations.

Developing a TMS staffing plan provides many benefits, including the TMC staffing plans included within, and these plans can support a transportation agency's operating objectives, including components of the TMS. A TMS staffing plan supports agency resource planning and a business case for additional resources or realignment of current staffing resources, can identify needs and methods to acquire staff with specific skill sets, and can help agencies identify where future TMS enhancements may require assessing staff capabilities.

Chapter 2 identified TMS influences on staffing needs and tools that agencies can use to consider how staffing may need to change in response to TMS enhancements or new operating strategies. This chapter provides elements for agencies to consider in preparing a staffing plan that documents staffing needs, technical capabilities, and opportunities and methods to acquire needed staffing resources. Developing a new staffing plan or updating an existing plan can be considered at several stages of TMC and TMS lifecycle evaluations, as follows:

- When assessing current capabilities, performance, resources, and approaches to meeting staffing needs to manage and operate the TMS, understanding how future expansion (e.g., service area, services) and changing operating responsibilities may influence future staffing needs at the TMC is vital.

- If considering planning for or developing a next-generation TMS, identifying staff levels, types of staff needed, and staff capabilities to meet transportation system operating objectives is needed. This process includes TMC staff.

- When developing a staffing plan for TMS understanding timelines for how and when staff might be needed, hiring or procuring staff through a contract, or obtaining support for resources (e.g., funding) that may be needed are key issues to consider. These timelines, options for obtaining staffing resources, and other key resources may assist with forecasting future funding needs, identifying gaps in current staffing levels or capabilities, and providing time for agencies to garner support and funding for needed TMC staffing resources.

Another important benefit of a staffing plan is to identify specific timelines for TMS improvements, system upgrades, expansions, or other significant operational changes that will influence an agency's staffing needs at the TMC. If new technical capabilities are needed or future operational strategies will require training for staff, agencies can plan for when those staffing needs must be in place and identify how those resources will be acquired.

This chapter addresses the following key topics:

- Current practices with how agencies may build, support, and obtain the resources and issues to consider in a process to develop a staffing plan.
- Components of a TMC staffing plan.
- Methods for the staff recruitment, including comparisons between in-house, contracted, and hybrid TMC staffing approaches.
- Resources and tools for the development of effective job descriptions for TMC staff that align with an agency's mission, objectives, and overall TMS program.
- Tools for the establishment of a training or development program.

The prior chapter provided issues and possible methods for considering impacts of future technologies, operating strategies, or other changes (e.g., area of coverage, services) on staffing resources that may be needed to support a TMS. All of these aspects are important when planning for expanded or new roles at the TMC.

GETTING STARTED

Current practice for TMC staffing plans varies among transportation agencies. For many TMCs, particularly those TMCs that use primarily agency staff, a staffing plan might consist of an organization chart, shift schedule, and descriptions of job roles. Staffing needs associated with emergency operating processes (such as scaling up staff or implementing back-up staff during major events) and reporting requirements may be captured as part of a plan to support the needs for the TMC continuing to operate during different types of emergencies. Job/classification descriptions, employee career paths, or agency-specific training are often captured in human resources or similar types of resources.

In contrast, agencies that use contractors to provide staffing for some or all TMC operations, services, and functions often require developing and maintaining a staffing plan. An agency may require a contractor to develop and maintain staffing plans as part of its contractual responsibilities. These staffing plans for contractors may include issues that expand beyond what an agency may include in a staffing plan. Plans for contractors may include shift schedules, staff roles and reporting responsibilities, staff management and supervision responsibilities, recruiting and onboarding processes, reporting relationships within the TMC and other entities within or outside the agency, emergency staffing procedures and protocols, codes of conduct, and (potentially) other requirements.

Developing a staffing plan requires significant effort. Agencies may need management support to allocate the staff resources to develop, review, and prepare a staffing plan. The process might include involving and obtaining input from different groups or departments across an agency or organization. Adequate time, resources, and expertise may be needed to assist with development of the plan.

Steps that agencies can consider in developing the TMC staffing plan include the following:

- Assemble existing resources (such as job descriptions, staff classifications, lessons learned, TMC operating procedures, existing training programs/materials, etc.) and identify key stakeholders to include in plan development.

- Analyze current and future system and TMS operating needs and document current and potential future functions.

- Review current TMC job roles and descriptions, identify gaps in current roles and duties, and develop new job roles, responsibilities, and duties.

- Document current TMC staffing levels and identify gaps that affect shift coverage or emergency operations.

- Define current and future operating requirements, coverage, and hours of operation; develop preferred staffing strategies and staff coverage for each TMC shift.

- Assess future technical requirements staff must meet for new or expanded TMS components and expanded operating responsibilities (such as ICM, managed lanes, performance management).

- Forecast timelines for major TMS expansions or when operational improvements are intended to be in place and identify when additional staff or training will need scaling to meet those needs.

- Identify future KSAs needed by TMC staff.

- Identify internal and external training resources to support staff technical capacity building.

- Determine methods for acquiring any additional staff needs to support TMC and TMS operations, such as through recruiting or through procuring contracted services.

- Document the operational risks of not implementing or fully achieving staffing plan recommendations.

A staffing plan may be scalable based on the size, complexity, capabilities, and resources an agency has available to support TMS management and operation responsibilities. The plan may consider addressing current or future staffing gaps, needs, new capabilities, and future operating requirements. A TMC that operates 24 hours per day, 7 days per week; covers a large geographic area; supports a robust overall TMS (e.g., services, functions); and actively manages and operates operating strategies can benefit from developing or having a staffing plan. A transportation agency that manages and uses different contracts with multiple providers to perform different TMS or TMC tasks, activities, or services may need to align multiple different staffing plans. The operating environment for the TMC, the objectives the agency wants to achieve with its staffing plan, and how the plan will inform key processes (such as procurement or system expansion) will help to guide the level of detail within the plan that is most appropriate.

Agencies may want to consider the following considerations as they prepare for, develop, and initiate new staffing plans; facilitate stakeholder involvement in staffing plans; and/or update an existing TMC staffing plan:

- Define purpose and objectives. How will the staffing plan be used to inform staffing needs and organizational changes and align with future operating responsibilities?

- Obtain approval and support from agency management to develop the staffing plan.

- Designate a lead to coordinate development of the plan and obtain input from key stakeholders.

- Identify if current staff have the capacity to lead the development of the staffing plan or if the plan should be developed by contracted resources, and if so, how those resources will be acquired and managed.

- Assemble the right stakeholders to provide input to key sections of the plan. Input may come from TMC staff and from human resources, contracting and procurement, IT, maintenance, capital projects, and other agency groups or divisions as needed.

- Gather the existing resources and documents, including TMC shift schedules, organization charts, job descriptions, SOPs, and training materials. Determine other materials that can inform future staffing needs, such as studies, contracts, TMS plans, concept reports, and other similar resources.

- Develop a schedule for developing the plan and inform internal and external stakeholders involved in developing the plan of their roles, anticipated stakeholder involvement, and timeframe. Identify milestones to update agency management during development of the staffing plan.

OUTLINE AND CONTENTS FOR A TMC STAFFING PLAN

Possible topics to consider in a TMC staffing plan are described in the following sections, with additional context for what agencies may or may not want to include in each section. For transportation agencies that plan to have contracted staff supporting a TMC, a collaborative effort may be needed between agency TMC managers and the contractor. This effort would prepare a plan that outlines use of the contractor's staff if a current staffing plan for the management and operation of the TMC does not exist. System improvements, expansions in service, new functions, how the TMC is used for special events (e.g., virtually manage other TMSs, virtually manage and operate TMC, special events, emergencies), and expectations for staffing during emergency operations are all elements that agencies can consider in various sections of the overall staffing plan.

TMC mission, role, objectives, and operational scope include the following:

- Identify the overall role and mission of the TMC and alignment with the transportation agency operating objectives and goals, including TMS operations.

- Define the objectives of the TMC staffing plan and time horizon (e.g., staffing needs for 5-yr horizon, 10-yr horizon).

- Describe the geographic area of TMC responsibility (regional, statewide, multistate), services supported, future planned TMC improvements, operating environment, facility, and current staffing strategy (agency staff versus contracted staff).

TMC operating responsibilities include the following:

- Define and describe primary operating responsibilities at the TMC, such as freeway operations, TIM, traveler information, ICM, winter operations, and operations for managed lanes. This section can be tailored to the specific operating responsibilities of a particular TMC and reflect typical day-to-day operational duties and emergency operations at the TMC.

- Define and describe additional functions conducted at the TMC. These functions may include performance monitoring, responder or maintenance dispatch, data management, system maintenance, security monitoring, and so on.

- Describe major TMS subsystems and components and the TMC's role and interactions as part of typical operational duties in carrying out functions, actions, and services. This description may include the TMC's role in supporting operational strategies and coordinating with external agencies (such as law enforcement, first responders, and adjacent transportation management agencies) and other supporting functions required by subsystems and components.

- Identify where current processes and procedures are captured, such as SOPs.

TMC operating hours, shifts, and staffing assignments include the following:

- Describe TMC operating hours, TMC shifts, schedules, staff roles, classifications, and number of staff assigned to each shift.

- Identify processes for backfilling staff (e.g., absence, vacation, turnover) or for addressing staff coverage during emergency operations (e.g., evacuations, severe weather event). Agencies can consider including processes for adjusting or approving changes in staff coverage or staff schedules.

TMC organization chart (current): The chart illustrates the current TMC organization, lines of communication, reporting relationships and staff roles, and numbers of positions within each level of the TMC organization. This chart can be used by agencies to identify potential areas for improvement or revisions needed to support future TMS objectives.

TMC staff roles and descriptions include the following:

- Identify job duties and responsibilities for each position within the TMC, including managers, shift supervisors, operators, dispatchers, technicians, and others, as appropriate. Chapter 2 included links to information and resources from the TMC Pooled Fund Study and NOCoE TSMO Workforce Development that can be useful for this topic.

- Identify existing gaps in current role and duty descriptions; examples are as follows:

    - The current TMC supervisor job description does not adequately capture duties and requirements for daily performance monitoring and reporting.

    - The most recent data technician job description and duties have not been updated to reflect current processes for cloud-based data storage and queries, which add complexity and additional coordination responsibilities.

Analysis of TMC staffing needs include the following:

- Summary of gap analysis for TMC staffing needs. This section identifies adequacy (or inadequacy) of current TMC staffing levels, types of staff needed, and technical capabilities needed by staff.

- Consideration of specific justifications and rationale, based on feedback from TMC staff, analysis of operational efficiencies, and recommended staffing levels based on TMC operating requirements. Examples of these justifications may include the following:

    - TMC operators enter similar incident data into multiple systems, and this information may need to be updated in multiple places as the response progresses. This updating creates inefficiencies, adds time, introduces risk, and distracts operators from primary duties during incidents and events.

    - Limited staff are often available to cover shifts overnight or on weekends, and with the turnover of operations staff, existing staff are stretched thin. The agency is not able to support overtime for these positions for the additional work needed.

    - Agencies are challenged with recruiting and retaining staff with the technical skills and capabilities the TMC needs in this competitive labor market. The pay scale is not commensurate with opportunities in other technical fields for top talent.

Resources that agencies can use to support developing this section of the plan include the following reports:

- *Transportation Management Center Staffing and Scheduling for Day-to-Day Operations*.[20]

- *Human Factors Guidelines for Transportation Management Centers*.[21]

Operational influences on TMC staffing needs include the following:

- Identify future system expansions or enhancements that may require additional resources for the agency to effectively operate and manage. These add-ons may include geographic expansion of agency TMS field equipment, new operating systems, and new operating strategies.

- Document possible needed TMC responses to these new operating responsibilities, such as anticipated additional full-time equivalent (FTE) staff resources, specialized technical skills and capabilities, additional coordination with internal and external entities, and so on.

- Identify operational risks facing the agency if the agency does not modify TMC staffing, either to support existing operations or for future operations.

Future TMC organization and staffing needs include the following:

- Consider including a graphic showing the desired future organization of the TMC to meet anticipated needs, including staff positions, number of staff, and reporting relationships.

- Identify future staffing numbers needed to address current staff deficiencies and the staff that may be needed to meet future operating requirements.

- Define management responsibilities for the TMC. For agencies that contract part or all their TMC operations, identify whether agency staff will supervise day-to-day operations conducted by contractors or if agency staff will share oversight and management with contractor manager staff.

- Define future roles and changes needed to TMC job descriptions, duties, and KSAs; identify specialized skills or new roles needed. This identification may include additional staff depth at the operator level, enhanced skill sets for shift supervisors, and additional responsibilities for TMC managers. New roles not currently in the TMC can be identified in this section.

- Consider identifying career paths as examples of increasing levels of responsibility. This identification may include requirements for moving from operator to supervisor if required trainings or certifications are needed to advance to increased levels of responsibility or proficiencies are needed to facilitate career growth.

- Consider identifying what gaps may be introduced if a shift to different operating roles occurs or the focus for operating philosophies shifts, such as toward more incident response-based operations versus traffic management capabilities. If engineering judgment is required for certain operating functions (such as signal timing adjustments or changing the speed limit), identify how to address these needs.

- Consider engaging human resources staff to collaborate on developing job descriptions, duties, requirements, and classifications. Resources agencies can use to support developing new job descriptions include the following:

    - *TMC Operator Requirements and Position Descriptions* (draft report published by FHWA).[22]

    - "Model TSMO Position Descriptions" (NOCoE web page).[23]

    - Sample TMC position descriptions from transportation agencies (appendix of this report).

Methods to acquire needed TMC staff resources include the following:

- Identify recommended staff to be acquired through agency hiring processes.
- Identify roles/functions that may be contracted or outsourced, such as systems engineering support, maintenance support, TMC operations, dispatch, and other functions.
- Identify agency contracting mechanisms and procurement processes, which may influence how additional staff can be acquired.

Staff training needs include the following:

- Document internal training requirements for staff, including agency training programs and requirements and training delivery method, frequency, and format.
- Outline training expectations based on SOPs.
- Identify specific technical training needs and potential sources for that training. Technical training may include vendor-provided training on specific technologies and systems, operational training (such as traffic incident responder training, courses to provide broader TSMO context for operating strategies like ICM, managed lanes, winter operations), sources for training, format/delivery (in-person, virtual, self-paced), and costs.
- Identify what trainings are suitable or required for specific staff levels.
- Consider cross-training opportunities to build technical capacity and redundancy.

Implementation timeline include the following:

- Identify approximate timeframes for when key TMC resources will be needed and align with anticipated TMS implementations, enhancements, expansion to operating responsibilities, and other influences identified earlier in the staffing plan. Agencies may consider aligning these recommendations with other TSMO program expansions beyond TMS implementations or updates.
- Identify links to time horizon identified in the first section of the plan (TMC mission, role, objectives, and operational scope).

Process for reviewing, monitoring, and updating staffing plan includes the following:

- Identify frequency of reviews and updates to the plan. Identify agency staff responsible for reviewing, monitoring, and initiating updates.
- Identify timeframe for major updates to the plan.
- Identify frequency of reporting on progress to agency management.

EXAMPLES AND RESOURCES

Kansas DOT Transportation Operations and Management Center Implementation Plan Outline

The following outline, adapted from the Kansas DOT *Transportation Operations and Management Center Implementation Plan,* starts with daily activities within the TMC and moves to detailed job descriptions for each of the positions identified.[24]

- Make a list of all daily activities, estimate daily hours.
- Make a list of all weekly activities, estimate weekly hours.
- Make a list of as-needed activities, estimate additional hours.
- Calculate the FTE requirements based on these estimations for 2,080 h per year.
- Define general staff position descriptions as baseline.
- Estimate annual salary costs based on FTE calculation.
- Write detailed staff position descriptions.

Kansas DOT Transportation Operations and Management Center Implementation Plan—Considerations for Staffing Plans

The outline highlights considerations for defining staffing levels within the TMC structure based on staff's experience and daily activities as follows:[24]

- Complexity or simplicity of user interfaces.
- Types and quantities of integrated ITS field devices.
- Intensity of active events, incidents, emergencies.
- Need for partnership with special events.
- Policies on frequency and timeliness of updates for DMSs, highway advisory radio, and other external communication.
- Centralization or decentralization of control.
- Frequency, scope, and duration of system and communications testing and diagnostics.
- Reliability of communication, ITS field devices, and networks.
- Availability of staff and budget to monitor functions.
- Availability of key staff after hours or on-call to monitor functions.
- Ability of users to access interface from home or other convenient locations.

The following outline, taken from *Transportation Management Center Staffing and Scheduling for Day-to-Day Operations*, provides considerations for defining adequate position numbers to achieve the technical tasks defined for the TMC across all shifts.[20]

- Considerations:
    - Position hierarchy: Typically, district engineer, district operations manager, TMC manager, operations supervisor, shift supervisor, senior operator, operator, trainee.
    - Hours of operation.
    - Budget.
    - Compensation and benefits.
    - Recruiting sources.
    - Demographics and diversity.
    - Labor market analysis.
    - Job analysis information (knowledge, skills, abilities, and other characteristics (KSAOs)).
    - Performance data and evaluations.
    - Redeployment plans.
    - Retention data.
    - Retirement plans.
    - Selection and staffing information.
    - Success planning information.
    - Training and development.
    - Work-life balance.

- Objectives:
    - Ensure staffing levels are appropriate.
    - Ensure organization employs staff with necessary KSAOs.
    - Ensure organization adapts to change within and outside of organization.
    - Provide systematic approach for human resource management.
    - Provide a shared vision of human resource functions.

The TMC staffing plan is a tool for agencies to use to periodically review staffing needs and identify where and when changes to the forecasted staffing needs will be updated. This plan provides agencies with feedback on technical and resource gaps that must be addressed in the nearterm and in the future and establishes a business case for staff to support operational strategies. Two outcomes from the staffing plan are identifying specific technical skill sets or revisions needed to TMC staff job duties and their descriptions and identifying how specific technical skill sets can be acquired. The next sections of this chapter focus on strategies to address these outcomes.

NEW TMC STAFFING ROLES

Based on the defined needs, TMC staffing plans define specific positions and quantities, organizational structures, and even hours of operations to be covered. Some of the needs

that drive the staffing levels include specific data related to the services provided, functions performed, actions carried out, coordination supported with other systems or service providers, number of shifts supported, and support anticipated with different types of special events. The TMC staffing plans focus on the sustainability and longevity of the program and define opportunities in career paths for the staff supporting the TMS. This focus is represented across all position levels and defines progressions for operators, specialists, supervisors, and management.

Effective staffing plans are commensurate to the size of the program. This correspondence includes the number of positions required to appropriately staff each shift and the size of each shift. An agency's organizational structure and TMS maturity level may influence level of supervisory and management positions within the TMC structure, but includes the following:

- TMC/operations manager.
- Shift lead/shift supervisor.
- Senior (experienced) TMC operator/dispatcher/specialist.
- Operator/dispatcher/specialist.

Senior-level positions and supervisors provide a level of quality control for the activities occurring within the TMC. These positions may assist operations staff in decisionmaking, such as when incidents should be escalated and when a manager should be involved in the response. Engineering decisions, such as adjusting ramp metering rates or adjusting speed limits for variable speed limit systems, may be beyond the duties and expertise of a typical TMC operator. These decisions may require licensed engineers with expertise in traffic flow and impacts to be made.

Additionally, technical requirements for staff positions can be influenced by the maturity of an agency's program. For example, some legacy programs are elevating positions that were previously defined as TMC operators to become traffic management specialists. Agencies may consider redefining titles and roles to represent the complexity of the responsibilities of these positions in the agency's TMC operating environment.

Some transportation agencies are implementing specialized roles that are staffed within the TMC or closely coordinated with TMC operations. These positions include the following:

- Information specialist, data analyst, business analyst—These roles acknowledge an emphasis on realtime performance monitoring and analysis for operating strategies such as ATM, ICM, managed lanes, and similar.

- Meteorologist—This dedicated meteorological specialist can interpret forecasts, align forecast information with realtime road condition information from TMS devices, and provide valuable coordination with TMC operations staff during weather events.

- Safety service patrol dispatch—This specialized training and dispatch staff will collaborate with service patrol during incident response and can relay realtime information to TMC operations staff to inform traffic management and traveler information needs. These positions may have additional coordination with incident responders, such as law enforcement, fire, and emergency medical services.

- Work zone coordinator—This position may have responsibility for actively monitoring work zones for safety and compliance with approved project traffic management plans and may coordinate with field crews, contractors, or agency resident engineers to adjust the work zone if needed.

- TIM specialist—This specialized resource may coordinate with incident command in the field during incidents; liaise with responder dispatch centers; and evaluate improvements or new TMS technology to support enhanced incident detection, monitoring, and response by the TMC.

- TMC training coordinator—This position may be responsible for developing and refining training materials and processes for different TMC positions and functions; providing consistent levels of training, particularly when multiple TMCs are involved; and reviewing and updating TMC training to align with TMC SOPs. Additionally, this position may identify where TMC staff can benefit from broader training on TSMO strategies and the methods and resources for providing that training.

- Telecommunications specialist—This position has specialized technical training and expertise in telecommunications systems for TMCs and TMSs, including different field communication technologies (such as fiber, wireless).

- IT—This position has technical expertise and knowledge in systems engineering, hardware, applications, and security of computers and networks. Some TMCs have a dedicated resource or team within the TMC with these capabilities; others rely on agency IT staff to support specific technical requirements.

- Engineer or engineering technician—A licensed engineer can provide guidance, recommend changes to operating strategies, or approve strategy changes for operational decisions that require engineering decisionmaking. This position is particularly relevant for more complex operating strategies, such as ATM, which can potentially include adaptive control systems, decision-support systems, variable speed limits, and other dynamic strategies.

- Corridor manager—This staff resource understands the bigger picture of corridor strategies and operating needs with adjacent state/local agencies and can take responsibility for identifying changes or improvements needed based on corridor performance. As agencies implement more robust corridor management strategies, this position will become increasingly important. With many functions for corridor operations and management spread across different entities within the

TMC and within transportation agencies, a central point of responsibility can bring those different perspectives together to identify strategy improvements and needed staffing updates and changes to support those strategies.

NCHRP's *Transportation Systems Management and Operations (TSMO) Workforce Guidebook* identified several model TSMO position descriptions that are relevant to current and future TMCs. Many of these positions support a continuing trend toward more technology-based applications and TSMO strategies, increased automation, and expanded reliance on data as an integral part of TMC and TMS operations. In addition to the operator, supervisor, and manager roles, additional TMC positions that can be considered within the staffing structure include the following: [25]

- Computer engineer—Provides advanced engineering and technical guidance, as a specialist, for computer systems used in TSMO.

- Systems engineer—Provides advanced engineering and technical guidance for systems engineering applications in TSMO.

- Telecommunications engineer—Provides advanced engineering and technical guidance as a specialist for telecommunications systems used in TSMO. Future position descriptions should include knowledge of specialized hardware and software or protocols specific to TMCs and use of licensed electromagnetic (EM) spectrum to support wireless communications as it becomes more dominant.

- Cyber security engineer—Ensures safe TSMO activities by assisting in building cybersecurity into critical operations systems. This position will ensure that the architecture and design of developmental and operational systems are functional and secure. The position will also assist in developing innovative approaches to drive change in cybersecurity risk management across the agency to prevent or minimize disruptions to critical information infrastructure.

- Data management specialist—Uses a wide variety of information, knowledge, and tools to develop, modify, and administer databases used to store and retrieve data and to develop standards for the handling of data. Future position descriptions should include knowledge of specialized hardware and software specific to TMCs from which data are likely to be extracted.

- Traffic data scientist—Takes information obtained from a variety of traffic data sources and extracts, organizes, integrates, analyzes, and communicates the data.

- Traffic analysis and decisionmaking—Is possible leader in the selection and development of next generation AI and machine learning-enabled Internet of Things solutions for TMS operations and management.

- Surface weather specialist—Provides support relating to weather applications and new technologies to support weather-responsive traffic management.

DEVELOPING NEW TMC JOB DESCRIPTIONS

Transportation agencies may have specific procedures and templates that are structured for hiring agency staff. Job descriptions and postings often follow an agency's human resources framework. Meanwhile, these descriptions also address the unique qualifications driven by the roles and responsibilities for staff within the TMC. Collaborating with agency human resources staff will help agencies understand all the considerations that go into developing job descriptions, determining classifications, identifying required qualifications, and understanding how KSAs are translated within established agency job descriptions and templates. Program managers can leverage conformance within this framework as a baseline while integrating additional specific KSAs within the agency's established templates.

Notably, many external job descriptions and postings will be abridged or abbreviated versions of the actual role and duty statements used internally by agencies. External job descriptions typically focus on high-level descriptions of general duties, desired qualifications and experience, preferred skills, required education or training, and agency-specific processes for submitting applications. More detailed duties and responsibilities are included as part of internal role descriptions.

To develop an accurate and comprehensive description of various TMC staffing roles, agencies and contractors should first gain an understanding of the KSAs required to effectively meet operational needs. These KSAs can be shared with, or developed in partnership with, agency human resources staff. While full KSAs may not be shared as part of external job postings, they can provide human resources with insights on types of tasks, levels of complexity, types of systems with which TMC staff will need to interact and operate, desired qualifications, and expected proficiencies.

Understanding KSAs for TMC Positions

The KSAs for TMC-related staff capture ways to articulate how skills are acquired, proficiency level, and other attributes that make a particular staff person qualified to perform their duties. *TMC Operator Requirements and Position Descriptions* captures the following definitions for KSAs:[21]

- Knowledge is defined as the intellectual possession and command of information necessary to qualify for the position (entry level) and the information to be acquired after assuming a position to perform the required tasks. The knowledge of a TMC staff member or candidate may be assessed by measuring the accuracy of responses to a set of TMC operations-related questions.

- Skill is defined as the level of proficiency in exercising knowledge and/or performing TMC tasks. Skills are typically assessed by task performance time and accuracy assessments.

- Ability is defined as the basic intellectual and physical capacities necessary to successfully perform in a TMC operations position, acquire the necessary skills,

and apply the necessary knowledge. The ability of a TMC staff member or position candidate may be assessed by aptitude tests or may be assumed based on level of education and job history.

Distinct differences between entry-level KSAs and advanced-level KSAs are as follows:[22]

- Entry-level KSAs can include staff with little or no direct experience but basic abilities that indicate they can gain the skills and knowledge through training to complete required tasks in the TMC operating environment.

- Advanced-level KSAs should indicate staff can perform required tasks with full proficiency and require minimal supervision or direction, or staff have a unique technical skill that addresses a specific TMC or TMS operating requirement. Additional expectations may include that staff have specific education, training, or system knowledge as part of advanced-level KSAs.

Developing KSAs for TMC Staff Positions

The methodology for developing TMC staff KSAs that was presented in *TMC Operator Requirements and Position Descriptions* can be adapted to current and future TMS operating requirements. Agencies can use the TMS structure from figure 1 to begin developing requirements for the different positions that will be responsible for monitoring, operating, managing, and maintaining different TMS elements. The functions and actions from figure 1 serve as primary inputs to the operator requirements, including specific operating responsibilities for TMS components and subsystems.[22]

TMC Operator Requirements and Position Descriptions provides a methodology for aligning KSAs for TMC staff with a range of operational activities, tasks and responsibilities that are typically carried out at TMCs.[22] Agencies may find this resource helpful as they develop KSAs for job descriptions for TMC staff.

Agencies can define top-level operational strategies and begin identifying specific functions and actions within those strategies, as follows:[22]

- Agencies can, at a minimum, focus on the functions required to support priority operational strategies to identify where specific skills, competencies, and proficiencies are needed. This process forms the basis of requirements that will inform needed KSAs.

- Agencies can provide actions with more granular detail on specific activities that might be better suited for SOPs and training activities.

- Agencies will need to integrate specifics about their TMS components and subsystems and ensure requirements align with their operating objectives.

Using TIM as an example operational strategy, table 5 illustrates how to develop associated requirements for TMC operators and outlines KSA considerations.

Table 5. Sample KSA derivation process—TIM operational strategy.

Sample Function	Sample Corresponding Action	Sample Requirement
Detect and verify traffic incidents on freeway.	• Receive system alert for abnormal conditions. • Confirm incident location with CCTV cameras. • Monitor updates from public safety agencies.	Use TMS tools to detect incidents (e.g., alerts and visual monitoring systems).
Coordinate responses to incidents.	• Enter confirmed incident into lane closure database. • Determine response needs from DOT. • Dispatch safety service patrol. • Receive updates from safety service patrol and responders. • Respond to questions and requests.	• Use lane closure system. • Coordinate with internal resources for responses. • Coordinate with external resources for updates and support needs. • Actively monitor incident scene with TMS tools.
Share incident information with agencies and travelers.	• Update details of incident response in lane closure database. • Activate DMSs with appropriate message from library. • Notify affected agencies (e.g., local agencies and other responders). • Monitor social media alerts. • Confirm 511 and other agency traveler information systems have issued alerts.	• Use TMS to provide enroute traveler information. • Use and monitor public-facing tools. • Update systems that support external information sharing.

Knowledge includes the following:

- Familiarity with road network.
- Knowledge of system capabilities for alerts and notifications.
- Knowledge of SOPs for using TMS elements to detect and confirm incidents.
- Knowledge of partner agency processes and systems that provide information to the TMC and TMS.
- Knowledge of incident command systems.

Skills include the following:

- Use TMS monitoring subsystem (e.g., CCTV and other detection technologies) to visually confirm incident, location, direction, and impacts with 100-percent accuracy.

- Use TMS traveler information system (DMS) to post messages about incident, location, potential impacts, and recommended actions travelers should take within 5 min of incident verification.

Abilities include the following:

- Determine appropriate response coordination needs, including use of DOT responder resources or additional emergency support.

- Interpret and organize data from multiple internal and external sources.

- Communicate effectively with field responders for incident status updates and additional resources needed.

Additional Attributes for TMC Job Descriptions

In addition to the KSAs presented in the last section, several TMCs identified additional core competencies that were essential for TMC operators, including the following:

- Ability to work on a team.
- Ability to organize information and data in a logical manner.
- Ability to follow oral and written directions.
- Ability to prioritize multiple tasks.
- Skill in keeping records and maintaining references.
- Knowledge of safety standards, policies, and procedures.
- Ability to interact successfully with news and other public media.
- Ability to operate radio dispatch equipment.

As responsibilities within the TMC gain complexity, agencies may consider updating their TMC staff descriptions and qualifications to reflect the technical needs of those roles. In addition, accurate and current job descriptions that reflect those evolving responsibilities help to support commensurate compensation and recognition for staff in those roles, which can help to attract the staff with the right skill sets in a competitive marketplace. TMC staff may need to balance technical requirements and duties with the tasks that may be more repetitive and less technical. Explaining the range of requirements within the TMC operating and technical positions will help to clarify this balance.

The AZTech Partnership in the Phoenix metropolitan area is a regional traffic management partnership that guides the application of ITS technologies for managing regional traffic.[26] A recent AZTech project examined a range of different TMC, ITS, and TSMO positions to develop standardized job descriptions that agencies can use when

updating or modifying current job descriptions.[27] Several unique considerations existed that made it challenging for agencies to standardize the job descriptions, as follows:[26]

- Agency human resource requirements and processes differed between State, county, and local agencies.
- TMS programs uniquely combined operations, engineering, computer software and hardware, and telecommunications roles. Human resources staff sometimes looked to align specific duties with certain pay scale, education, and certification requirements to be able to develop an appropriate staff classification.
- Processes for assigning staff classifications varied based on agency-adopted standards.
- Compensation for TMC roles varied among agencies even though general duties were sometimes similar.

AZTech developed a job description generation tool for its partner agencies in the region to reference when hiring new staff within TMS programs. The tool includes guidance and ranges on different types of skill sets that comprise different TMS-related roles, including TMC operations and management and technicians to maintain devices and systems. This tool was developed for agencies in the Phoenix area to use as they evaluated current and future job postings and staff classification efforts.[27]

The appendix of this report contains example job descriptions for TMC roles programs in several States. Included with these descriptions are entry-level TMC roles, technical specialties, unique requirements, and qualifications. Agencies and contractors may consider a range of approaches to articulate different TMC roles and expectations. Variations in how these job descriptions are displayed and the level of detail included are the result of different agency processes and templates for documenting job duties and descriptions.

STAFFING APPROACHES: IN-HOUSE, CONTRACTED, AND HYBRID

Agencies employ different staffing approaches based on policies, procedures, and organizational structure. The staffing approach is driven by the defined FTEs from a staffing plan, the preferred approach that can accomplish the defined staffing needs, and available resources. The staffing approach may include a composition of all in-house staff, all contracted staff, or a hybrid of both in-house and contracted staff positions. The preferred staffing approach an agency considers will influence the supporting staffing plan. This designation influences the amount of funding needed, the way staff is managed, and the number of positions that the agency defines.

Agencies may decide to contract or outsource TMC services for various reasons, as follows:[28]

- Due to restrictions on number of FTEs for an agency or division.
- Due to lack of qualified in-house staff or limited technical specialties for certain aspects of TMS operations.
- For the ability to manage variations in workload or expand staff levels to meet demands when an inability to add FTEs exists.
- For access to specialized skills for the TMC, TMS components, or subsystems that are not available at the agency. Some examples include systems engineering and integration, software development or modifications, equipment and technology maintenance, IT for TMS, and weather forecasting.
- To address short-term staffing needs, such as seasonal fluctuations where demand for staff increases (such as winter operations).
- To gain potential longer-term cost savings for the agency over in-house FTEs or to acquire staffing services as a capital project versus expanding an operations budget.

This section presents a discussion of in-house, contracted, and hybrid staffing approaches for TMCs, including benefits and challenges for each option. Agencies will need to determine what approach (or combination of approaches) will yield the most effective and advantageous method for providing the required staff to meet TMC and TMS operating needs.

In-House Staffing Approach

When an agency employs in-house staff for TMC operations, the agency is typically responsible for all aspects of staff recruiting, training, development, and retention. The staff is comprised of predominantly agency employees. Some professional services or tangential responsibilities can be supported by the private sector (such as design consultants, system vendors), but all day-to-day operational activities are owned and addressed by those agency employees.

The agency is responsible for establishing system operations performance requirements and aligning TMC staff to help achieve these requirements. This process includes establishing processes for TMC staff coverage during typical and atypical operating conditions, providing TMC coverage during planned and unplanned staff absences, virtual operation, managing other systems, and ensuring operational continuity of key processes and systems. The operating agency is responsible for providing, testing, and verifying the TMC facility, resources to support virtual operation, all systems and equipment, operator workstations and operator interface (e.g., video walls, computer, and

laptop), phones, radios, and all facility amenities for staff (including restrooms, workspaces, offices, and break rooms).

The agency is also fully responsible for operating the TMC. Many TMCs use a typical model of contracting for these services through various system vendors or IT contractors. Often, multiple entities provide various systems, subsystems, or services that are used at the TMC, including lane closure subsystems, 511 traveler information systems, third-party data and analytics packages, dispatch systems and software, and a host of other potential services. Maintenance contract options are often available with any software procured through a vendor, and these options will also be the responsibility of the operating agency to fund and administer.

Based on the business processes and procurement rules of the operating agency, the responsibility for the maintenance and repair of IT equipment may be performed by a combination of agency or contracted staff. In some instances, an IT group from a separate State agency is responsible for all State agency IT support needs. Business rules at the agency can have some separation between a TMC, IT systems, and networks needed for the State's TMS versus enterprise IT applications, such as email, intranets, and internal networks and communication equipment.

Contracted Staffing for TMCs

Contracted staff is composed of private sector employees from either staffing contractors or consulting firms that can provide professional services to support agency TMC operations. The level of detail within staffing contracts can vary, but mapping the contract to a high-level staffing plan that demonstrates the agency's vision and day-to-day objectives is crucial. In this approach, the detailed staffing plan is the responsibility of the contractor, with oversight from the agency. Additionally, contract mechanisms contain a balance of flexibility and clarity that support establishing an effective partnership between the agency and the selected contractor. Examples of methods that promote a more effective contract include the following:

- Clearly defined methods for addressing contract amendments:
    - Define the appropriate level of approval required for each contract amendment.
    - Establish the process and templates up front.
- Documented emphasis on effective staff development.
- Demonstrated transparent and measurable key performance indicators (KPIs):
    - Define how the contractor will be measured.
    - Define the frequency and relationship of the KPIs to contract delivery.

- Define the requirement of effective transition plans (onboarding and transitioning out).

Along with considerations surrounding the ability to provide defined staffing levels, other considerations drive an agency's considerations around contracting staff, as follows:

- Budgets and funding sources.
- Agency FTE restrictions or requirements.
- TMC services provided.
- Technical skill sets.
- Staff turnover and retention.

Procuring the services of a private contractor for TMC staffing typically involves collaboration between TMC managers and agency procurement staff to structure an appropriate procurement method, scope of work, and specifications. Time is needed to develop a scope of work, document contract requirements, identify budget and funding sources, advertise, evaluate responses, and negotiate with a preferred contractor. These procurement processes are governed by specific agency business rules, and TMC managers need to understand the timeframes, internal approval processes, and other requirements (such as securing project numbers or updating capital program budgets). The steps and responsibilities required, from procurement advertisement through bid review and post-award activities, must be fully understood.

Once an agency has made the determination to initiate a procurement, the TMC manager, in collaboration with the agency procurement staff, typically assemble the resources needed to prepare for and support the procurement. This process may involve internal agency staff, or agencies may seek to get supplemental support through a contractor to prepare a scope, requirements, performance metrics, and other key components of the procurement before the bid is posted.

The type of contract mechanism may influence how the agency procurement is structured. Understanding the differences between different contract options, including performance-based contracts, fixed-price or lump-sum contracts, cost-plus and cost-plus-fixed-fee, and time and materials is essential to developing a contracting strategy that will meet the agency's TMC operating objectives. For example, if an agency recognizes that some level of flexibility is needed to allow contractors to staff up for seasonal coverage during winter months, a fixed-price contract may not be a viable option. If an agency knows that a major system enhancement, such as managed lanes, are being installed during the contractor performance period, a contract mechanism that allows for periodic updates to roles, responsibilities, and costs may be a more feasible option.

Table 6 summarizes the pros and cons of four different contracting options that are frequently used for TMC staffing service contracts.

Table 6. Comparison of four contract types.

Contract Type	Advantages	Challenges
Performance based	Contractor is provided incentives based on achieving performance milestones or performance thresholds, as outlined in the contract. This contract type provides some flexibility to contractors in how they achieve milestones and thresholds while still addressing operations priorities.	Performance expectations, metrics, milestones, and other criteria must be clearly defined and are the incentive to the contractor for achieving expectations. Defining how contractors will be evaluated and measured can be challenging.
Fixed price	Multiple variations exist on fixed-price contracts, but limited flexibility exists to adjust scope or cost in response to changing operating needs. Risk is firmly on the contractor to deliver operational and performance expectations within the agreed-upon price.	Contractor may build in risk to costs or rates to cover effort that is not initially anticipated. Agency may have limited flexibility to expand contractor scope or request additional resources. Fixed price requires a well-defined scope. A formal scope change and corresponding price change may be needed to facilitate any modifications. Contractor is not required to disclose profit, rates, or effort expended. The agency is paying a fixed price for a specific service or time duration.
Cost plus fixed fee	This contract features cost reimbursement with a negotiated fee. The contractor is guaranteed this fee, even if resources change. The risk to the contractor is relatively low, as costs can be passed through to the agency. Contractors do not need to build in risk. Can adjust contract based on expanding scope of TMC operating requirements.	Agency must clearly identify what costs can be reimbursed to the contractor under this type of contract. Agency must review and approve contractor costs submitted. Periodic monitoring is required to implement any adjustments.

Contract Type	Advantages	Challenges
	The contractor is incentivized to use high-quality staff. The agency is less at risk of unaccounted costs.	
Time and materials	This contract type is a relatively low-risk vehicle for the contractor because the contract provides assurance that costs will be covered. The contractor can adjust staffing resources (if authorized) based on need and be reimbursed per the terms of the contract.	Requires additional effort for contractor to track, report, and provide detailed supporting information with invoices. Monthly and annual contractor costs can vary. Agencies may not be able to accommodate escalating labor costs based on negotiated billing rates agreed on at the start of the contract. Without a fixed budget, the agency may need to plan ahead so funds are available and can be allocated to the contract.

Agency responsibilities in a contracted staffing approach may include providing the TMC facility, operator workstations and equipment (monitors, desktop computers, phones, radios, and other equipment), operating system software and systems (including networks and servers), video wall, and facility amenities (such as restrooms, showers, or break rooms). Facility requirements provided by the agency typically also extend to janitorial services, parking, and facility security. The agency may also be responsible for providing appropriate oversight and management of the contractor, including reviewing and evaluating contractor performance, expenditures, and invoices and coordinating with the contractor's project manager.

TMSs, lane closure subsystems, databases or data subsystems, dashboards, social media accounts, and agency data and file sharing systems may be available through TMC operator workstations (such as email, agency intranets, or wikis). Some aspects of data and file sharing systems may require coordination with the agency IT group. System maintenance, repairs, or upgrades are also an agency responsibility, although the agency might contract maintenance of the TMS or 511 to the developer or another contractor rather than maintain with internal agency technical staff. IT services can be provided by the agency or through a separate contract arrangement, depending on how the agency approaches IT needs. In some instances, the TMC systems (including the TMS) are outside of an agency's firewall, allowing the TMC staff or contractor to have more control of and responsibility for the associated systems and networks.

The transportation agency will often provide the TMC standard operating policies and procedures that contractor staff need to follow. Contractor staff are typically expected to help identify where SOPs might need to be updated or modified and coordinate with the agency to help facilitate updates. Instances may occur where multiple contractors participate in various aspects of SOP development, maintenance, and updates.

The typical responsibilities and requirements expected of a TMC staffing contractor may include the following:

- Recruiting and hiring qualified staff.
- Supervising and overseeing staff. Overall contract management oversight is provided by the transportation agency.
- Providing required training for TMC operations staff. Typically built on the SOPs, with additional training for emergency TMC operations, new systems, and/or professional conduct.
- Implementing processes for retaining and developing TMC operations staff. May include providing a career path or levels for TMC operations staff to advance within the contractor model.
- Verifying TMC operator proficiency with TMS operations and compliance with SOPs, agency conduct rules, and contractor performance expectations.
- Operating, monitoring, and troubleshooting systems at the TMC in compliance with SOPs.
- Addressing staff performance and conduct issues, including disciplinary action and processes.
- Coordinating with agency staff for operational needs in compliance with contract requirements and performance expectations outlined by the contracting agency.
- Interacting with additional agencies, stakeholders, or other contractors, as per SOP requirements during operations.
- Documenting and reporting on TMC activities and performance.
- Providing contractor-specific software, such as for staff timesheets or supporting equipment, such as mobile phones or vehicles.
- Supporting agency performance reporting, as per any requirements in contractor scope.
- Escalating issues related to operations or staffing in accordance with provisions included in the contractor scope or contract.

Comparison Between In-House and Contracted Staffing Approaches

Table 7 compares the in-house and contracted staffing approaches for consideration, but an individual agency's decisions on staffing approach may be driven by specific institutional guidelines and executive-level support. Additionally, table 7 provides a comparison of some of the specific elements of each approach. This information was synthesized from previously identified sources and expanded with additional information. (Please see references 1, 2, 8, 11, 15, 19, 20, 21, and 22.)

Table 7. TMC staffing approach benefits and challenges.

Approach	Benefits	Challenges

Contracted	• Ability to allocate FTE across agency operations.
	• Flexible definition of job roles and classifications.
	• Flexible pay scale.
	• Enhanced contractor responsibility for hiring process.
	• Enhanced contractor responsibility for scaling up resources in emergencies or covering during vacations and absences.
	• Enhanced contractor responsibility for implementing strategies for staff retention.
	• Increased opportunity for employee advancement.
	• Extended incentives and recognition provided by contractors (recognition is not allowed in public agencies).
	• Extended and expanded training opportunities provided by contractors:
	  o Strategic Highway Research Program 2.[29]
	  o TIM Responder.[30]
	  o NOCoE webinars.[31]
	  o International Municipal Signal Association (IMSA).[32]
		• Tradeoffs with contract duration.
		• Potential additional scope and fee with changes to contract.
		• Potential for void of knowledge for agency.
		• Transition periods between contractors.
		• Alignment of contract type and payment method needed to consistently achieve operating expectations.
		• Need for internal staff with required skill set and authority to manage and evaluate contractor performance.
		• Challenges in defining contractor performance expectations and thresholds.

Approach	Benefits	Challenges
In-house	• Understanding of broader agency missions and functions. • Understanding of agency organization • Access to internal agency resources, publications, processes. • Eligibility for retirement and benefits offered to State or public sector employees. • Retaining of institutional knowledge, expertise, and lessons learned. • Integration among agency TMC staff may be facilitated. • Incentivized tenure and long-term employment from civil service benefits.	• Administrative rules may apply that can slow advancement within organization. • Operational budgets and hiring processes may make it challenging to expand staff quickly. • Agency compensation limitations can make it challenging to attract qualified candidates. • Career growth can be limited within public agencies or within TMCs.
Hybrid	• Flexibility for agencies to contract for specific technical resources to support the TMC without acquiring additional FTEs. • Ability to plan for specific budget needs. • Ability to retain control of functions, such as management and oversight.	• Staff required to plan, procure, and manage specific contracts and provide technical direction to contractors. • Risk of not developing agency technical capabilities for specific functions.

A list of example requests for proposal for contracting TMS staffing support is provided on the NOCoE website's "Resources" page in the Staffing and Operators section.[33]

TRAINING AND CERTIFICATIONS

Training programs are foundational for onboarding and sustained skills development of operations staff. Today, more agencies than ever are implementing formalized training programs for TMC staff and even institutionalizing these programs with certification programs. This section presents an overview of the typical components of a training program that agencies have used to support TMCs, benefits and challenges of certifications, and case study highlights from established training programs.

A training program may include the following:[22]

- Orientation to the TMC—TMC, division, and agency organizational structure; TMC work environment; security requirements; safety processes and protocols;

agency training opportunities/required training; work shifts; email; personnel policies; and more.

- Control room basics—staff roles, equipment, key functions, reference manuals, workstation, telephone/radio equipment.

- Transportation system knowledge—geographic coverage of the TMC, partner agencies that support TMS operations, primary contacts, road system basics, agency operating priorities.

- Knowledge of the TMS—SOPs, key functions, training program overview, operating systems, terminology, traveler information tools.

- Public and media communications—responding to media inquiries, social media, external communications.

- Software and equipment—steps involved in utilizing TMS software, troubleshooting, daily recurring tasks, required reporting.

- Technical traffic engineering principles (full performance level).

- Advanced training options (full performance to advanced level).

Training programs can integrate flexibility within the curriculum to accommodate different levels of staff, roles within the TMC, agency knowledge, and operations experience. Transportation agencies may have required training beyond the technical training needed for efficient TMS operations. For example, Pennsylvania DOT (PENNDOT) customized a refresher course for staff that supported TMC operations during seasonal peaks.[3]

Training Resources

As a supplement to on-the-job training for TMC staff positions, opportunities exist for additional training resources that are relevant to TMC operations roles, as follows:

- Owning agencies that employ contracted services may have internal training modules or programs that cover contract oversight, project management, procurement, and other processes. If agencies do not have formalized training courses on these topics, they may leverage existing resources with the knowledge and capabilities to provide effective training.

- Agency human resources may provide agency training, such as contract management, project management, supervisor/staff management, and other internal processes that may be beneficial for specific staff in the TMC responsible for managing and leading projects or supervising staff and teams.

[3]Interview with PENNDOT, December 2020.

- Contractors may offer additional training to staff supporting TMCs, usually online, as part of a more comprehensive training program across multiple TMCs. These trainings may not be specific to the TMC where the operator is working but may provide a basis for additional knowledge on certain TSMO topics, such as road weather management, TIM, or new technologies.

- Webinars or peer exchanges through FHWA, NOCoE, Institute for Transportation Engineers, and other associations can provide operators with information on best practices or lessons learned from other transportation centers and programs. These activities can introduce operators to new operating strategies such as ATM, ICM, and other active operations. Hearing from peers in other States and regions who have hands-on experience with these advanced strategies or new aspects of TMSs can provide valuable insights. Often, senior agency staff or project management staff will participate as part of webinars and peer exchanges; offering these opportunities to day-to-day operations staff can help elevate awareness and understanding of new operating approaches from varying perspectives.

- IMSA offers a Transportation Center Systems Specialist certification (levels 1 and 2). This training and certification focuses on local agency TMCs with significant roles operating traffic signals, and all of the material may not be applicable to highway operations. However, the training may offer some valuable information for TMC and communications protocols that may be applicable to a State-level operations center. Information on this certification can be found on the IMSA website on the Transportation Center Certifications web page.[34]

Agency Training Examples

TMC training programs can include onboarding programs for new employees. These efforts span a few weeks followed by close coordination and peer reviews as the operator steps into their role. Some training programs include levels of testing and certification to validate an operator's KSAs. Many agencies also have systems in place that allow for auditing the operator's performance to confirm effective application of SOPs, completing functions, and performing actions in response to changing traffic conditions and events.

A range of training approaches from TMCs throughout the country are presented in this section. Some of the practices derived from these training approaches are as follows:

- Participation in shadowing operators before working on their own.

- Participation in shadowing responders in the field to better understand field response processes.

- Participation in onboarding with DOT and contractors.

- Certifications for TMC positions on an annual basis or to move to the next level of a career path.

- Monthly audits of the position and team performance.
- Clearly defined coursework (device, software, soft skills, etc.).
- Clearly defined expectations and documentation.
- Standard hours or time period for which hires can expect training to occur.
- Quizzes/evaluation of understanding from courses and training with minimum scores for passing and demonstrating proficiency.
- Demonstrations required by staff to show proficiency.
- Additional training online, through webinars, and IMSA.

Following are some examples of specific State training initiatives:

- FDOT district 6 TMC:[4]
    - Shadowing of existing operations staff for 1 w.
    - Onboarding of contractor.
    - Onboarding of FDOT.
    - Monitoring of aptitude through monthly audits.
    - Renewing of staff annual certification based on validation of aptitude.
- PENNDOT TMC boot camp training program:[5]
    - Includes mix of in-house and contract staff.
    - Is part of the employee's integration program.
    - Includes 2-w, in-person training boot camp in Harrisburg, PA.
    - Includes classroom portion, so each attendee can interact with the training site of the advanced TMS (ATMS) software and other TMS components.
    - Includes tours of facilities (statewide TMC, emergency management, and State Police headquarters).
    - Includes 2 d of shadowing—1 d at the statewide TMC; 1 d at 911 dispatch.
    - Includes certification after completion of boot camp.
    - Includes local TMC providing localized training supplement for specific TMS operating strategies following boot camp.

[4]Interview with FDOT, January 2020.
[5]Interview with PENNDOT, December 2020.

- Includes potential for strong relationships for boot camp attendees that continue to yield interregional benefits for coordination.

- PENNDOT modified TMC boot camp for seasonal operations:[6]
  - District 1 TMC activates during the winter months.
  - District 1 local staff typically manages maintenance and supports TMC operations.
  - Mini-boot camps identify staff for specific winter operations and coordination.
  - Specialized boot camp yields higher consistency and accuracy.

- Washington State DOT (WSDOT) in-training plan for Transportation Engineer 2:[7]
  - Includes training requirements needed to accompany 12-mo trial service.
  - Includes a clear list of classes required for in-training: TMS device training, software proficiency demonstration, courses from online learning platforms (e.g., communications and time management).
  - Documents the dates the classes were completed.
  - Allows management to modify in-training plan to add or remove courses, as needed.
  - Includes performance appraisal at each level.

- WS DOT technician in-training:[8]
  - 12-month training from Technician I to Technician II.
  - 12- to 24-month training from Technician II to Technician III.
  - Additional documentation of demonstrated skills from Technician II to Technician III:
    - Server knowledge.
    - Computer knowledge.
    - Traffic management software database knowledge.
    - Express lane operations.
    - Incident response.
    - Tunnel system operations.
    - Radio operations.
    - Hazardous materials.

[6]Interview with PENNDOT, December 2020.
[7]Interview with WSDOT, March 2020.
[8]Ibid.

    - Data and performance analysis.
    - Communication and training.
  - Additional requirements set by trainer.
  - Performance appraisal documentation.

- Coordinated Highways Action Response Team (CHART) Highway Operations technician training:[9]

  - Highway Operations Technician II Certification Test 2019—33 questions.
  - Various fill-in-the-blank and demonstration exercises.
  - Clear scorecard for expectations.
  - Clear documentation for evaluation and proof of progress in training.

- KC Scout 6-w training—contractor training/in-training:[10]

  - Operator training presentation about ITS and TMC principles.
  - Contractor-specific onboarding (contractor policies, procedures, employee conduct, etc.).
  - ATMS overview.
  - Emergency response training.
  - Indepth ATMS module and operations training.
  - Incident management in live system.
  - Roadwork/special events/weather/traveler information system/amber alerts/sporting events.
  - Rural corridor training.
  - Traveler management system.

[9]Interview with Maryland CHART, September 2020.
[10]Interview with Missouri DOT, February 2020.

CHAPTER 4. TMC STAFF DEVELOPMENT

CHAPTER PURPOSE AND OBJECTIVES

This chapter highlights agency practices supporting TMC staff development. The chapter provides insight into strategies and resources that can support an agency in recruiting and retaining TMS staff, with an emphasis on staff to support the TMC. TMS operations may require staff with unique knowledge, technical abilities, and staff skills. Knowledge may need to expand over time as new technologies or new operating approaches are integrated into TMSs and transportation system operations missions. Transportation agencies and contractors may pursue a range of training and development initiatives to help TMC staff acquire and expand technical skills so that staff can support TMS operating needs.

Once hired and onboarded, TMC staff may complete training to gain familiarity and proficiency with TMC operating processes, TMS components, SOPs, and the overall role and function of the TMC. If staff does not possess all the KSAs to carry out requirements for their TMC role, significant training time may be required before the staff can function at a level proficient with the TMC and operating systems. This time lag is regardless of whether staff is employed by a transportation agency or working at the TMC as a contractor. There may be ongoing training needs to help maintain TMC staff operations proficiency and to provide additional technical training for building specific capabilities. Even for experienced staff, training may be needed to introduce new technologies, systems, and operating processes.

The objective of this chapter is to demonstrate the value of agencies implementing strategies to promote TMC staff retention and career development. Chapter 3 presented strategies for developing and identifying KSA requirements, which help to inform TMC job roles and duty descriptions. Key topics addressed within this chapter include the following:

- Strategies that support recruiting efforts based on unique TMC KSAs and the value of partnering with human resources to develop accurate job descriptions and staff classifications and identify education, certification requirements, and preferred qualifications for specific positions.

- Strategies that focus on the retention of staff, including team building and team dynamics, leadership development opportunities, and other strategies.

- Examples of career paths for TMC staff, including providing opportunities for staff to advance and grow their KSAs. Opportunities to grow and expand beyond entry-level operations roles can provide staff with career growth and advancement opportunities.

RECRUITMENT STRATEGIES

Partnering With Human Resources

Recruiting qualified candidates for TMC positions is a collaborative effort between TMC managers and agency human resources staff. Human resources staff may have the experience, resources, and examples to help formulate job descriptions, align TMC job descriptions with appropriate staff classifications, or help determine key qualifications and requirements needed for TMC roles. The technical perspective from TMC managers or project managers for contractors supporting a TMC may focus primarily on the technical skills and requirements. Providing human resources staff with the full breadth of expectations—including technical requirements and nontechnical aspects of the TMC staff positions—may lead to more productive recruiting strategies.

Human resources staff may prompt TMC managers with specific questions to identify potential recruiting strategies, including the following:

- What level of experience is required for the role? Is it essential or desirable?
- What types of training will be provided to new hires? What are the KSAs candidates must possess before they can start the job? What KSAs can be acquired later by candidates who demonstrate they can learn specific skills over time with proper training?
- How will the TMC manager quantify entry-level for these types of roles?
- What nontechnical skills or personality characteristics should an ideal candidate possess? Attributes such as leadership, communication skills, multitasking, familiarity with data entry software, and other skills may help human resources to identify types of candidates that TMC managers or supervisors may not have considered.

Recruiting Strategies

Transportation agencies and TMC staffing contractors use a variety of recruiting tools and methods to attract qualified candidates to TMC operations roles. Online job posting services and professional social networks can reach a broad audience of potential candidates. Universities, community colleges, or technical training programs may be able to provide different types of candidates for different roles.

Targeting job advertisements and TMC career opportunities to specific candidate pools was identified as a successful strategy by several TMCs that were interviewed as part of developing this document. Several State DOTs identified staff with prior military experience as being strong candidates. WSDOT encourages service people to apply in their recruiting notices and job postings. The human resources department at WSDOT

encourages potential candidates from the military to visit the TMC to see the systems in action.[11]

Additionally, ODOT indicated that staff with former military experience fit well with the TMC operating environment.[12]

California Department of Transportation (Caltrans) noted that the TMC recruited candidates with former State or local police dispatch experience. Caltrans' district 11 even changed the title of the TMC operator to dispatcher to appeal to candidates with that background.[13]

KC Scout representatives highlighted their practice of recruiting TMC operations staff with a background in dispatch for law enforcement or other public safety units. These candidates possessed a knowledge of the State highway network, were comfortable multitasking, and were also comfortable communicating with law enforcement and maintenance teams via radio, which was a unique skill.[14]

ODOT also noted that prior experience with law enforcement or corrections provided candidates with increased familiarity communicating with the radio and using cameras, which are often important functions of TMC operators.[15]

Staff Recruiting Considerations and Practices

Interviews with several State DOTs identified some additional considerations. Delaware DOT (DelDOT) mentioned lack of competitive salaries relative to the skill sets being sought increased their challenge of recruiting qualified candidates. DelDOT stated that the job responsibilities are increasing in complexity, which widens the gap between job responsibilities and pay. To mitigate these challenges, DelDOT has partnered with technical and community colleges to develop a course that can help train potential candidates. DelDOT cannot control the frequency or reliability of the course being offered but tries to encourage course availability.[16]

Staffing contractors may have more flexibility in their ability to recruit and target specific candidates for TMC roles. In Kansas, the contractor has a recruiter who actively screens and seeks out candidates through career hiring sites. Other initiatives, such as the development of career paths and opportunities for employee growth, help support recruitment and retention efforts indirectly. Additionally, some contractors may recruit from State agencies or other contractors to capitalize on existing institutional, infrastructure, and operations knowledge.[17]

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[11]Interview with WSDOT, March 2020.
[12]Interview with ODOT, May 2021.
[13]Interview with Caltrans' district 11 staff, February 2020.
[14]Interview with Missouri DOT, February 2020.
[15]Interview with ODOT, May 2021.
[16]Interview with DelDOT, February 2020.
[17]Interview with Missouri DOT, February 2020.

FDOT's district 6 and KC Scout noted the impact of a strong economy on the talent pool. Candidates have more options for employment, and the TMC may consider investing more into training less skilled operators that are hired into an entry-level position.[18]

One advantage that Maryland DOT's program has witnessed with contract staff is the ability to expand interview processes and questions beyond the restrictions of State recruitment. Maryland DOT recruited individuals who were previously in operations positions, such as police dispatch or former troopers from State patrol. Maryland also noted that the DOT operates different types of TMCs throughout the State. The CHART center in Hanover, MD is a full-service, 24 h per d TMC. Other regional TMCs in Maryland focus on dispatching a safety service patrol, so the staff skill sets needed at those centers are different.[19]

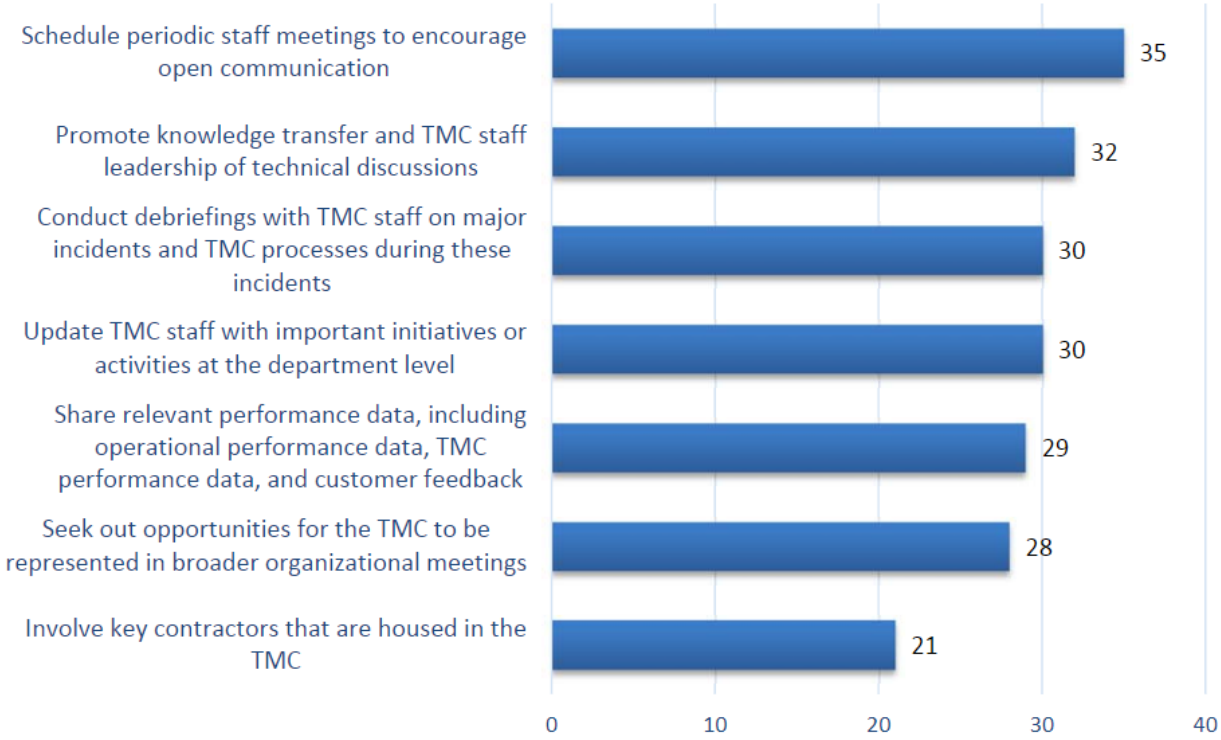
WSDOT partners with the University of Washington to acquire engineering student interns and resources to perform data analysis to support toll pricing and ramp metering. WSDOT noted that a benefit of the student internship program is that many of the interns express an interest in continuing to work for the TMC or go into ITS design to create systems based on what they experienced as an intern. This partnership is mutually beneficial and supports the TMC in recruiting qualified and cost-effective help to accomplish entry-level tasks, and the university has been able to establish a laboratory that replicates the TMC functions for academic purposes.[20]

TMC STAFF RETENTION

Retaining staff at the TMC is a challenge for both the contracted operations model and the in-house staff model. Strong links exist between identifying and recruiting the right staff, providing a competitive wage, and providing professional development opportunities and career advancement within the TMC or within the agency/contractor. Transportation agencies and contractors that provide staff for TMCs may experience challenges retaining staff due to issues such as pay scale and compensation, competition with other jobs and industries, particularly for entry-level TMC positions, limitations on career path options within the TMC and aligning staff with the right skill sets with TMC operations needs and working environment.

Jin, Zhaohan, and Albert's (2014) report *Traffic Management Centers: Challenges, Best Practices, and Future Plans* identified several strategies and priorities for providing opportunities for staff development, as shown in figure 3. These strategies include engaging TMC staff in strategic discussions, debriefings, sharing key updates at a departmental level, and in general, making TMC staff a more integral part of agency operations teams.(28)

[18]Interviews with FDOT, January 2020 and Missouri DOT, February 2020.
[19]Interview with Maryland CHART, September 2020.
[20]Interview with WSDOT, March 2020.



Source: National Center for Transportation System Productivity and Management, USDOT University Transportation Center.

Figure 3. Chart. Staff development strategies used at TMCs.[28]

Agencies can help to address TMC staff retention needs through multiple avenues, including competitive pay and compensation, career development, and advancement opportunities.

- Private sector contractors may have additional flexibility to provide incentives for staff, such as performance bonuses, recognition, and performance-based pay increases. There also could be opportunities within the contractor structure for high-performing, experienced staff to advance to TMC supervisory and management roles at other TMCs where that contractor provides similar services.

- Agencies have helped to address TMC staff retention issues through redefining TMC operator positions into different classifications. As noted previously, Utah DOT (UDOT) and Caltrans' district 11 both reclassified TMC operations staff into a dispatch classification, which provided an increase in pay ranges and help staff qualify for additional career levels within the dispatcher classification.

- UDOT, KC Scout, and Caltrans' district 11 have noted that an important element to retention is to get the right staff in the TMC roles.[21,22,23] At times, the tasks can seem repetitive and redundant, at other times a TMC operator's role is highly stressful and needs someone who can effectively manage many competing priorities during a major incident or event. Some staff are enthusiastic about the role, and they will excel and advance; other staff might not be as well-suited, and time and resources can be wasted if invested in training staff who are not a good fit. Thus, the role is generally best reserved for the first type of staff.

- Linking advancement opportunities to performance- and skill-based milestones can help to incentivize employees to want to achieve those milestones.

CAREER PATHS

Many synergies exist between career development and retention, as discussed in the prior section. Emphasis has increased on the need to provide career paths and career advancement opportunities for TMC staff as part of both the agency in-house staffing model and the contractor TMC staffing model.

Career Path Examples

Career path options may vary based on the contractor structure, and the agency classifications available to TMC operators. There may be minor differences in daily duties between different levels of operators, as most operators within a TMC are responsible for similar functions, processes, and procedures. A career path can be defined as advancement within the TMC operator roles, such as moving from entry level operator to a more senior operator or can also include taking on additional leadership roles and responsibilities, such as supervisory and management roles, training or advancing to different positions within the agency and organization.

The following two sections offer examples of paths for operators to advance from entry-level roles to more advanced roles and roles from UDOT and WSDOT.

UDOT Operator Certification Checklist[24]

UDOT has an operator certification checklist for operators to go from entry-level to fully trained. UDOT indicates this process takes approximately 6 mo for operators to be fully trained on all aspects of the TMC operator role. The certification checklist is a combination of tasks and proficiencies and includes such items as understanding basic conduct and performance expectations, being able to explain how certain systems operate, demonstrating familiarity with tools and systems that operators use, and

[21]Interview with UDOT, February 2020.
[22]Interview with Missouri DOT, February 2020.
[23]Interview with Caltrans district 11 staff, February 2020.
[24]Interview with UDOT, February 2020.

demonstrating proficiency with different tasks within software and ATMS that are used at the TMC .

This checklist helps UDOT assess whether operators understand where to get information and data they need to do their jobs and demonstrate that operators understand policies and procedures that affect a TMC operator's job (such as UDOT's CCTV blocking policy or procedures for developing a DMS message). The tasks and proficiencies within the checklist are acknowledged by the operator and the supervisor. Once the operator completes the checklist, they are eligible for their first pay raise.

WSDOT TMC In-Training Plan Class Levels[25]

WSDOT developed an in-training plan that identifies the steps TMC operators should take to advance from entry level (Transportation Technician 1) to Transportation Technician 3. Employees are considered probationary at Levels 1 and 2 and become permanent at Level 3. Each level has specific skills, proficiencies, and requirements for staff to achieve before advancing to the next level. A financial incentive to reach the next level exists in that each level is at a different salary range.

Supervisors, TMC trainers, and others at the TMC help operators achieve the skills and proficiencies to achieve the different levels. WSDOT indicated that a Level 3 is achieved after operators demonstrate the required skills and proficiencies for a 6-month period. A similar process exists for staff at the Transportation Engineer position, which is a 12-mo process to go from Level 1 to Level 2.

Career Development Examples

In addition to advancing within the operator career ladder, opportunities may also exist to provide experienced TMC staff with additional duties and roles that will help them to continue to grow and develop professionally:

- Shift supervisors or shift leads represent a natural progression for strongly performing TMC operators. These roles can have staff supervisory responsibilities or more authority levels to approve different processes, where required by SOPs.[26]

- Designating a staff member as a training coordinator was a strategy noted by KC Scout. This position is responsible for overseeing training for TMC operators, verifying operator compliance with SOPs, and identifying where new training may be needed to address performance issues or for new systems and processes.[27]

- Creating new roles can meet specific needs of TMC operations and provide paths for TMC staff to grow professionally. Examples include allowing staff with demonstrated technical capabilities to grow into more technically focused roles,

[25]Interview with WSDOT, March 2020.
[26]Ibid.
[27]Interview with Missouri DOT, February 2020.

such as traffic signal timing, incident management support, and data analysis and reporting.[28]

- Maryland CHART requires operators to work in other Maryland centers (than their primary one) to achieve certain certification levels. This requirement affords operators knowledge of other facilities and helps build relationships across regions.[29]

[28]Ibid.
[29]Interview with Maryland CHART, September 2020.

APPENDIX. SAMPLE TMC JOB DESCRIPTIONS

This appendix includes example job descriptions across a variety of TMC roles. Agency job descriptions were provided by the State DOTs for the following positions:

- Private sector job descriptions:
  - Traffic Operations Center (TOC) Operator I.
  - TOC Operator III.
- KC Scout—TMC Operator 1.
- WSDOT:
  - Transportation Engineer 2.
  - Transportation Engineer 3.
- Oregon DOT—Transportation Telecommunication Specialist 1 and 2.

PRIVATE SECTOR EXAMPLE—TOC OPERATOR I[23]

Major Function/Role

This position manages traffic congestion, planned events, and unplanned incidents in a TOC and provides data entry and quality assurance (QA) and quality control (QC) for information in the State DOT ATMS or advanced traveler information system (ATIS). This position typically works under supervision but must be capable of directing their own work, implementing response plans as outlined in the SOPs, and coordinating with personnel outside the facility.

Job Duties

Following is a description of the job duties for Private Sector TOC Operator I:

- Monitors congestion and incident information using various tools, including ATMS and ATIS, EM radio traffic, computer-aided dispatch (CAD) feeds, and traffic reports from local media partners for incidents.
- Creates identified incident in ATMS, notifies appropriate personnel, and provides additional responses as required.
- Actively reviews or implements traffic management using tools such as ATMS, ATIS, DMS/changeable message signs (CMSs), ramp metering, and 511 floodgates. Develops alternate route provisions when an incident or heavy congestion is detected and verified.

- Implements travel time postings on DMSs and CMSs during peak traffic hours as needed.
- Manages traffic signal timing or notifies appropriate agency, as outlined in SOPs.
- Activates county alerts (targeted floodgates) for incident response as appropriate.
- Activates Amber/Silver alerts or other messages on regional devices, as outlined in SOPs.
- Receives and responds to emails or redirects to appropriate staff, as necessary.
- Monitors feedback messages from 511 system users and provides customer service by returning calls for feedback messages.
- Compiles daily 511 feedback report for vendor and client review.
- Coordinates with other DOT agencies.
- Researches, identifies, and reviews planned construction, maintenance, and special events and activities as required.
- Assists with data collection to include in monthly reports, travel speed and travel time reports, incident reports, and any other reports requested.
- May occasionally perform such other assignments, as the supervisor deems necessary.
- May dispatch as needed.

Scope

The scope of the job includes the following:

- Complexity (variety or uniqueness of tasks; relative difficulty or importance of work performed; size of unit supported, etc.): Work involves relatively uncomplicated but varied tasks. Responsible for gathering and disseminating information in a courteous and pleasant manner to reflect the department's high standards and professionalism.
- Decisionmaking (supervision received, independent judgment or initiative, and consequence of error): Generally, works under supervision but must be able to use judgment and tact in communicating with external agencies and formulating response plans.
- Work direction given to others (titles and number of personnel and type of direction given): None.

- Internal contacts (required interaction and relationships with others within the organization): Frequent contact with supervisors; coworkers; client project managers; and other members of the client team, such as roadway assistance operators.

- External contacts (required interaction and relationships with others outside the organization): Regular contact with external partners and first responders.

Education and Experience

High school diploma (or equivalent) and 6 mo related experience in dispatch center or 911 operations or comparable relevant experience are required. Experience in a position involving public contact and telephone responsibilities is preferred. Must be proficient with computer skills.

Special Skills

Excellent oral communication and interpersonal skills are required. Must have good command of the English language. Ability to perform in a professional, courteous manner and remain friendly while under pressure is required. Must have an aptitude for geography and maps.

Professional Registrations

No professional registrations are required.

Competencies

General competencies expected of all employees are as follows: Client service, commitment, communication, innovation, continuous improvement, professionalism, quality, and teamwork. (Clients may be internal managers and staff.)

PRIVATE SECTOR EXAMPLE—TOC OPERATOR III[23]

Major Function/Role

Manages traffic congestion, planned events, and unplanned incidents in a TOC and provides data entry and QA and QC for information in the State DOT ATMS or ATIS. Typically works under supervision but must be capable of directing their own work, implementing response plans as outlined in the SOPs, and coordinating with personnel outside the facility. As needed, can fill in for dispatcher and perform basic public information duties. Fills in for supervisor as needed.

Job Duties

The job duties for Private Sector TOC Operator III include the following:

- Monitors congestion and incident information using various tools, including ATMS and ATIS, EM radio traffic, CAD feeds, and traffic reports from local media partners for incidents.
- Creates identified incident in ATMS, notifies appropriate personnel, and provides additional responses as required.
- Actively reviews or implements traffic management using tools, such as ATMS, ATIS, DMS/CMS, ramp metering, and 511 floodgates; develops alternate route provisions when an incident or heavy congestion is detected and verified.
- Implements travel time postings on DMS/CMS during peak traffic hours as needed.
- Manages traffic signal timing or notifies appropriate agency as outlined in SOPs.
- Activates county alerts (targeted floodgates) for incident response as appropriate.
- Activates Amber and Silver alerts or other messages on regional devices, as outlined in SOPs.
- Receives and responds to emails or redirects to appropriate staff as necessary.
- Monitors feedback messages from 511 system users and provides customer service by returning calls from those leaving feedback messages.
- Compiles daily 511 feedback report for vendor and client review.
- Coordinates with other DOT agencies and serves as primary point of contact for the Southern Traffic Incident Management Exchange within the State.
- Researches, identifies, and reviews planned construction, maintenance, and special events and activities as required.

- Assists with data collection to include in monthly reports, travel speed and travel time reports, incident reports, and any other reports requested.

- Dispatches units to the locations of incidents or hazards as needed for location, providing clear directions and accurate incident descriptions—as advised by citizens, public safety entities, or department personnel—by means of two-way radio communication.

- Uses radio, telephone, and pagers as needed to communicate with personnel statewide, including maintenance and construction personnel, technicians, traffic operations management, and FHWA as appropriate to provide clear and accurate information regarding incidents, traffic, road, maintenance and construction activity, and related weather conditions.

- Ensures that any needed radio communication at the location remains in compliance with DOT and Federal Communications Commission rules and regulations.

- Dispatches, as needed.

- Performs basic public information duties as needed.

- Fills in for supervisor as needed.

- Performs other assignments, if needed, as the supervisor may deem necessary occasionally.

Scope

The scope of the job includes the following:

- Complexity (variety or uniqueness of tasks; relative difficulty or importance of work performed; and size of unit supported, etc.): Work involves relatively uncomplicated but varied tasks. Responsible for gathering and disseminating information in a courteous and pleasant manner to reflect the department's high standards and professionalism.

- Decisionmaking (supervision received; independent judgment or initiative; consequence of error): Works under limited supervision and must be able to use judgment and tact in communicating with external agencies and formulating response plans.

- Work direction given to others (titles and number of personnel; type of direction given): Provides direction to TOC operators in the absence of supervisor.

- Internal contacts (required interaction/relationship with others within the organization): Frequent contact with supervisors, coworkers, client PM, and other members of the client team, such as roadway assistance operators.

- External contacts (required interaction/relationship with others outside the organization): Regular contact with external partners and first responders.

Minimum Requirements

Education and Experience

High school diploma (or equivalent), 2 yr related experience in dispatch center, or 911 operations or comparable relevant experience is required. One yr experience as supervisor fill-in is required. Proficiency with computer skills is required.

Special Skills

Excellent oral communication and interpersonal skills are required. Must have good command of the English language. The ability to perform in a professional courteous manner and remain friendly while under pressure is required. Must have an aptitude for geography and maps.

Professional Registrations

TOC basic certification is required.

Competencies

General competencies expected of all employees are client service, commitment, communication, innovation, continuous improvement, professionalism, quality, and teamwork. (Clients may be internal managers and staff.)

KC SCOUT—TMC OPERATOR 1[35]

Role Description

The TMC operator is responsible for the proper operation of the ATMS software interface to field devices and equipment from the TMC for traffic management. Basic duties include monitoring traffic flow, emergency situations, work zones, and traffic congestion. Personnel are expected to respond with appropriate actions for warning drivers, informing response agencies, and taking any steps necessary to assist in restoring traffic flow to normal conditions.

Qualifications

Following is a description of the qualifications for KC Scout Traffic Center Operator 1:

- Good verbal and written communications skills.
- Rapid situation assessment and decisive action.
- Minimum computer proficiency: Microsoft® Windows®, Word®, Excel®, and Access®.
- Customer service or call center experience is a plus.
- Listening and detail verification.
- General navigational skills.
- Multitasking.
- Teamwork.

Job Duties

Following is a description of the job duties:

- Create and post messages for the DMSs.
- View traffic conditions on the CCTV.
- Monitor traffic status, special events, scheduled events, active events, and incident fault status by using CCTV cameras, emergency response, law enforcement reports, internal systems, etc.
- Communicate with emergency services, such as State and local police, emergency communications centers, emergency response and motorist assistance, maintenance departments, and media outlets.
- Facilitate incident management, which includes detection, verification, response, and clearance.
- Dispatch emergency response personnel.

- Monitor all active traffic events occurring during the shift and ensure the information is entered correctly into systems and traffic related messages.

- Troubleshoot and resolve system related problems.

- Coordination with other operations staff with regard to various agencies and general control room coordination, especially at shift change.

- Assist with data collection for various reports, travel speed and travel time reports, incident reports, field equipment failures, and any other reports that are provided by the TMC.

- Perform duties as assigned.

KC SCOUT—TMC SHIFT MANAGER[35]

Role Description

The TMC shift manager is responsible for operational consistency across all shifts in KC Scout. The shift manager is responsible for overseeing and leading TMC operators, including training, scheduling, and operational performance. The shift manager provides monthly refresher training on pertinent topics.

As directed, the shift manager is available to support the updating of operating protocols and procedures, and include any new policies, directives, and guidelines issued by the client for use in the TMC. Due to the nature of operations, this task is ongoing and will take place at any time a protocol or procedure needs to be updated at request of the local operations manager. The TMC shift manager will be a direct report to the TMC operations manager and be available to operate the system if requested.

Qualifications

Following is a description of the qualifications for KC Scout TMC shift manager:

- Proficiency in all aspects of KC Scout TMC operator duties.
- Understanding of proactive TMC operations, incident management, and congestion management.
- Ability to assess a situation rapidly and act decisively.
- Computer proficiency, including but not limited to Windows, PowerPoint®, Word, and Excel.
- Dedicated to employee development.
- Flexible schedule.
- Good verbal and written communications skills.
- Multitasking.
- Teamwork.

Job Duties

Following is a description of the job duties:

- Directly supervise the TMC operations staff, facilitating a cohesive and balanced operation.
- Develop monthly training refresher courses for employees.

- Provide QAs and QCs to events to determine training needs.
- Provide guidance and actively provides a role model for operations staff, ensuring that all SOPs are maintained and followed.
- Are available to provide hands-on training to all shifts on a scheduled basis.
- Are able to be proficient in operations as a working operator if requested by the TOC operations manager.
- Assist with data collection to include in monthly reports, travel speed and travel time reports, incident reports, and any other reports that are requested.
- Perform administrative functions, including shift scheduling, training, personnel performance reviews, and conflict resolution.
- Perform duties as assigned.

WSDOT—TRANSPORTATION ENGINEER 2[36]

Position Objective

In the northwest region TMC, this position is required to guide operations and make daily decisions that impact driver safety and traffic flow. Duties and responsibilities include operating the region's ITS, guiding and assisting staff on the use of these systems, and coordinating system activation around major events that impact WSDOT roadways.

This position supports WSDOT's mission in the following ways:

- Lead daily operations in the TMC using the latest incident management systems and principles.
- Use ITS and managed facilities in response to an incident's impact to the roadway network. Use engineering judgment and response protocols and coordinate with management, local agencies and transit and field crews.
- Respond to internal and external customers; retrieve, analyze, and report on traffic data; and reply to constituent feedback and requests.
- Provide support to staff to ensure proper usage of ITS systems, including devices and facilities, such as various computer servers supporting ITS, ATM, ramp meters, variable message signs (VMSs), express toll and high-occupancy toll lanes, highway advisory radio, and fire suppression and environmental central control system in the I–90 and SR–99 tunnels.

Assigned Work Activities (Duties and Tasks)

Table 8 illustrates the various tasks associated with the duties of an Engineer 2 at WSDOT and the target percentages of time that should be dedicated to completing each duty.

Table 8. WSDOT Duty Statement—Engineer 2.

Percentage of Time (Must Total 100)	Duty	Assigned Tasks in Order of Importance
20	ITS system analysis and optimization	Reviews ITS system operations, such as ramp meters and ATM variable speeds. Collects traffic data and observes systems from CCTV camera and field reviews. Analyzes data and reports on operations; helps prepare system performance reports for internal and external customers. Makes recommendations if supervisory approval is required and implements changes to enhance operations.

Percentage of Time (Must Total 100)	Duty	Assigned Tasks in Order of Importance
		Performs before and after studies of systems and reports on changes.
15	Training, training resources, and documentation	Conducts training for new and current staff on topics including FLOW traffic detection software, ATM, express toll, express lanes, and SCADA.[37] Prepares and maintains training materials derived from SOPs. Maintains and updates SOPs under the guidance of a supervising engineer.
10	ITS design and plan review	Designs low-cost ITS enhancements and coordinates review, approval, and work order submissions. Reviews contract plans to ensure designs meet standards and promotes operating goals of TMC systems and procedures.
10	Constituent response and public information	Acknowledges and responds to constituent feedback. Coordinates with staff and other groups to formulate responses, identify remedies, or assign action items. Reviews and updates websites or publications.
5	Tolling	Monitors and verifies toll rate and information display within toll systems. Responds to blocking incidents or planned closures with appropriate override messaging. Identifies system and sign errors, troubleshoots, and escalates to appropriate staff. Assists tolling engineer with data retrieval, analysis, and reporting.
5	Express lane scheduling, coordination, and operation analysis	Assesses express lane operation using archived traffic data. Summarizes and reports on performance to management and the public. Analyzes and proposes changes to express lane operation for management review and approval. Coordinates with internal and external parties to change scheduling for special events or construction. Drafts reversal or closure scheduling and presents for approval. Maintains schedule for publication.
5	Tunnel SCADA monitoring and operation	Operates the I–90 and SR–99 tunnel central control systems, supervising the fire life safety systems utilizing CCTV, traffic detection, carbon monoxide sensors, heat detection, incident detection cameras, and other detection systems. In the event of an incident, follows SOP as approved by fire marshals, tunnel maintenance, and/or supervising engineers. Employs fire suppression, ventilation, lighting, or other control systems to respond to incidents.

Percentage of Time (Must Total 100)	Duty	Assigned Tasks in Order of Importance
		Coordinates incident response with emergency responders, maintenance crews, TMC operators, radio, engineers, external agencies, PIOs, and management. Applies TIM protocols to manage traffic approaching tunnels and divert traffic away on adjacent roadways. Documents and informs staff of incidents, system events, and alarms. Identifies system errors and escalates to appropriate staff; responds per SOP. Assists staff during system testing and maintenance.
5	Other	Other work as assigned.

PIO = public information officer; SCADA = supervisory control and data acquisition; SR = State route.

Decision Approval and Input

Decisions this position can make without approval or input include the following:

- TIM: congestion management, including driver diversions; messaging on VMSs; ramp metering; monitoring and operation of ITS hardware; operation of ATM system; and operation of toll systems.
- Preliminary emergency coordination for incidents: actions include requesting lane closures and personnel response.
- Tunnel monitoring and control: operation of fire suppression system during the incidents, or scheduled maintenance/construction projects.
- Data analysis: selecting and processing data to produce traffic reports, e.g., routine closures or optimizing ramp meters.
- I–5 express lane operation: gathering traffic data and making recommendations for express lane operation and coordinating with northwest region construction traffic and central operations manager, construction offices, and field operators.
- Communications for planned events: Coordinate, create, and review messaging plans for routine planned construction or roadway closures.
- Architecture and design of ITS: Preliminary design and review of ITS.

Decisions that require input or approval include the following:

- Major, long-term roadway closures or diversion response plans.

- Data analysis and reporting for major operational changes needing executive-level approval, e.g., permanent changes to express lanes schedule and time of operations.

- Data analysis and reporting for public distribution.

- Final approval of I–5 express lane schedule changes for special events or construction.

- Changes to policy or procedures.

- ITS design and plan review acceptance, licensing stamp, and work orders.

Work Assignment Process for Position

Traffic management and tunnel control is independent work requiring the engineer to continuously monitor TMC response to incidents and guide response to ensure the team is following established procedures. This position receives general direction for assignments from supervisors, such as traffic data retrieval and analysis, review of plans or procedures, and training new staff or assembling draft training documentation. Routine analysis and response coordination is self-assigned to meet the demands of scheduling express lane operations or construction closures. Additional work may be self-assigned for routine responses to internal or external customer requests.

Personnel Interactions

This position coordinates with University of Washington interns, radio dispatch operators, tunnel maintenance personnel, PIOs, tolling groups, signal groups, construction offices, Seattle DOT, Olympic region TMC supervisor and operators, various local agencies, and northwest region traffic engineers. Additionally, this position works closely with the direct supervisor and lead supervisor in the TMC group and with managers within WSDOT.

Qualifications

Required qualifications are as follows:

- Bachelor of science in civil engineering, master of science in civil engineering, and/or engineer-in-training certificate or 1 yr experience as a Transportation Technician 3 or Transportation Planning Technician 3.

- Working knowledge of freeway management practices and principles. Must be able to make operational assessments of freeway flow conditions and derive traffic management strategies and tactics in occasionally stressful environments.

- Strong analytical skills. Must have working knowledge of data collection, analysis, and reporting practices and principles. Must be able to analyze and summarize data to create actionable reports for traffic and tolling operations.

- Strong verbal and written communication skills.
- Ability to work independently.
- Ability to train and coach others.
- Ability to comprehend and verify contract plans.
- Strong understanding of computer operation and ability to rapidly multitask between multiple software applications in emergency situations.

Preferred and desired qualifications are as follows:

- Experience in a major metropolitan transportation operations center.
- Experience with Excel and large datasets.
- Coordination and communication with teams and the public .
- Operation of mission-critical software suites.
- Response to emergency situations.

Desired education, skills and abilities, licensing, and certification include the following:

- Bachelor of science in civil engineering.
- Valid engineer-in-training certificate in the United States.
- One yr of experience as a Transportation Technician 3.
- One yr of experience as a Transportation Planning Technician 3.

WSDOT—TRANSPORTATION ENGINEER 3[36]

Position Objective

This position is required to perform advanced traffic management activities and analysis in the TMC. The decisions this position makes affect the safety and the flow of traffic on the freeway and the adjacent arterial systems. This position supports WSDOT's mission by operating the region's ITS, which includes a TMS, an ATM system, tunnel control systems, and a toll system. These systems include devices and facilities, such as ramp meters, DMSs, highway advisory radios, express lane facilities, peak-use shoulder lane corridors, tunnel fire and environmental controls, and in-house software, to optimize traffic flow safely and efficiently. This position will provide, update, and maintain training materials on traffic management and tunnel control systems and will serve as a trainer for new and existing staff.

Assigned Work Activities (Duties and Tasks)

Table 9 illustrates the various tasks associated with the duties of an Engineer 3 at WSDOT and the target percentages of time that should be dedicated to completing each duty.

Table 9. WSDOT Duty Statement—Engineer 3.

Percentage of Time (Must Total 100)	Duty	Assigned Tasks in Order of Importance
20	Training, training resources, and documentation	Conducts training for new and current staff on topics including FLOW, ATM, express toll, express lanes, and SCADA. Prepares and maintains training materials derived from SOPs.[37] Conducts continuing education for listed topics and provides remedial materials. Maintains and updates SOPs under the guidance of a supervising engineer.
20	Data retrieval, analysis, and reporting	Performs data retrieval, analysis, and reporting of traffic and tolling data to support the I–405 express toll system and the tolling engineer and assists in other engineering studies. Collects operation data, system logs, and control information to help prepare system performance reports for internal and external customers. Collects, reviews, and archives operator and system logs and digital voice recordings as legal records for SCADA.
15	I–405 express toll operation	Monitors and verifies toll rate and information displays within I–405 express toll system. Responds to blocking incidents or planned closures with appropriate override messaging. Identifies system

Percentage of Time (Must Total 100)	Duty	Assigned Tasks in Order of Importance
		and sign errors, troubleshoots, and escalates to appropriate staff.
12.5	Tunnel SCADA monitoring and operation	Operates the I–90 and SR–99 tunnel central control system, supervising fire and life safety systems using CCTV cameras, traffic detection, incident detection cameras, carbon monoxide sensors, heat detection, and other detection systems. In the event of an incident, follows SOP, as approved by fire marshals, tunnel maintenance, and/or supervising engineers. Employs fire suppression, ventilation, lighting, or other control systems to respond to incidents. Coordinates incident responses with emergency responders, maintenance crews, TMC operators, radio, engineers, PIOs, management, and external agencies. Applies TIM protocols to manage traffic approaching tunnels and divert traffic away on adjacent roadways. Documents and informs staff of incidents, system events, and alarms. Identifies system errors and escalates to appropriate staff and responds according to the SOP. Assists staff during system testing and maintenance.
10	ATM	Monitors dynamic speed reduction for accuracy. Responds to blocking incidents or planned closures with appropriate traffic control and messaging. Identifies system and sign errors, troubleshoots, and escalates to appropriate staff.
7.5	Traffic management (FLOW)	Monitors traffic within the region's highway system via CCTV, traffic management software, CAD, and other incident detection systems. Identifies traffic impacts and employs ITS to communicate, manage demand, and control traffic. Follows guidelines and procedures for diversion, VMS messaging, and incident response. Coordinates with radio, PIOs, maintenance crews, engineers, management, and local agencies. Identifies system and publication errors, troubleshoots, and escalates to appropriate staff.
5	Communications	Uses telephone and radio systems to communicate with WSDOT field crews, Washington State Patrol, local police departments, local transportation agencies, fire departments, ecology departments, etc. Logs all communications and actions performed.

Percentage of Time (Must Total 100)	Duty	Assigned Tasks in Order of Importance
5	I–5 express lane operation	Uses CCTV to identify incidents or disabled vehicles prior to reversal or closure. Identifies damaged or failed equipment and escalates to appropriate staff. Coordinates reversals with field maintenance operators and IRT crews. Identifies opportunities for emergency reversals in response to an incident, escalates to supervisors and management, and coordinates with maintenance and IRT crews.
5	Other	Other work as assigned.

IRT = incident response team.

Qualifications

The following qualifications are required for this position:

- Valid, unrestricted WA State driver's license and ability to drive to and work at alternate worksites.
- Strong verbal and written communication skills.
- Ability to work independently and as a part of a team.
- Ability to independently investigate and study necessary info to complete an in-training plan.
- Ability to train new staff members with varying knowledge and backgrounds.
- Strong understanding of computer operations and ability to rapidly multitask between multiple software applications in emergency situations.
- Ability to respond to the TMC within 1 h.

The following qualifications are preferred/desired for this position:

- Prior operation of mission-critical software suites and experience responding to emergency situations and/or previous transportation experience.
- Working knowledge of data collection, analysis, and reporting practices and principles—the ability to analyze and summarize data to create actionable reports for traffic and tolling operations.
- Experience working in a major metropolitan TMC and working knowledge of freeway management practices and principles—the ability to make operational

assessment of freeway flow conditions and derive traffic management strategies and tactics on the fly.

- Detailed knowledge of tunnel environmental system operations and procedures.

- Ability to read, comprehend, and verify contract plans and specifications, including traffic control plans.

Candidates for the in-training position are hired at the Technician 2 level. During the in-training period, candidates must complete selected elements within the in-training program before advancing. Candidates have a 24-mo in-training period before advancing to Technician 3, which may be accelerated; at a minimum, candidates must spend at least 12 months at the Technician 2 level.

OREGON DOT—TRANSPORTATION TELECOMMUNICATION SPECIALIST 1 AND 2[38]

Class Concept and Responsibilities

The transportation telecommunication specialist is responsible for the coordination of highway operation activities by communicating between management, field units, law enforcement, emergency services, State agencies, and the public to maintain safe traffic flow on State highways within a large geographical area and during severe weather conditions and emergencies. Employees monitor a variety of communication equipment and displays to obtain and provide routine and emergency information and services. The transportation telecommunication specialist monitors situations until they are resolved and may be required to provide testimony in legal matters.

The transportation telecommunication specialist functions are performed by operating and monitoring technical equipment located in a transportation operations center. This work is performed in conjunction with emergency services providers, law enforcement, incident response staff, and highway maintenance and operations field staff to ensure life, health, safety, and mobility on Oregon Highways.

The transportation telecommunication specialist operates traffic control equipment and devices to warn transportation system users of hazards and communicate restrictions. This position includes operation of VMSs, highway advisory radio, debris flow warning signs, chain condition drum signs, and remotely operated ramp gates. The position also includes manual operation of variable speed limit systems when necessary.

The transportation telecommunication specialist provides traveler information to the public about current transportation system conditions. This information is distributed to the public through direct channels, including the traveler information website, the 511 phone system, and social media incident alerts. The information is also distributed indirectly through the Traveler Information portal, which makes these reports available to the private sector for delivery to smart phone applications, in-vehicle systems, and other media outlets.[39]

Following is a list of characteristic responsibilities for the type of work associated with this class. The list is not inclusive. Individual positions may perform any combination of the duties listed below and other related duties.

- Perform operations center dispatch. Maintain safe traffic flow within a large geographic area encompassing multiple counties, cities, and towns, especially during severe weather conditions and emergencies, by communicating with management, field units, local and county law enforcement, emergency services, State agencies, and the public.

- Obtain and transmit information using multiple phone lines and radio frequencies for highway, police, and other emergency services by monitoring and operating highway or police channels and prioritizing responses to radio calls. Notify

management and field units of crash locations, complaints, blockages, hazards, spills, general highway maintenance needs, construction, emergency services, and dispatch assistance. Contact emergency response vehicles, tow companies, fire departments, and police agencies. Assist in the coordination of mutual response and share necessary information. Operate notification systems that contact Oregon DOT staff and key external partners.

- Enter incident and emergency information by using codes, maps, and other resources. Maintain computerized log of all communications requiring response, noting time, location, name of person calling, and action taken. Respond to inquiries regarding traffic problems, hazardous conditions, and any other highway-related issues. Query and interpret information from Law Enforcement Data System (LEDS), driver and motor vehicles services, and road and weather reports. Use and disseminate the information.

Distinguishing Features

The Transportation Telecommunications Specialist job includes a two-level classification series. The responsibilities within the concept and distinguishing features are characteristic of the type and level of work associated with this class. Individual positions may do all or some combination of the responsibilities listed and other related responsibilities.

Level 1

The Transportation Telecommunication Specialist 1 is the first of this two-level series. Employees use standard operating guidelines in the performance of their duties. They must exercise quick, independent judgment in analyzing specific conditions and elements of issues. Variations and uniqueness of situations require research to understand impacts and interrelationships. This job may require variation or deviation from established procedures and practices to meet operational goals and objectives as established by management.

Level 2

The Transportation Telecommunication Specialist 2 is the second of this two-level series.

This job is distinguished by the additional responsibility for overseeing telecommunications staff and the day-to-day operations of the transportation operations center. At this level, employees coordinate, prioritize, and assign work to telecommunications staff. The job is further distinguished by having responsibility for developing and providing training on standard operational guidelines and procedures, reviewing work for adherence to standards and guidelines, and participating in regional and statewide meetings related to transportation operations center operations, standards, and procedures. Job holders use standard operating guidelines in the performance of their duties. They must exercise quick, independent judgment in analyzing specific conditions and elements of issues. Variations and uniqueness of situations require research to

understand impacts and interrelationships. This job may require variation or deviation from established procedures and practices to meet operational goals and objectives as established by management. Employees work with management to identify procedural and practice improvements, recommend unit goals and objectives, and in the absence of or at the request of the manager, may perform QA and QC duties.

Minimum Qualifications and Skills

Transportation Telecommunication Specialist 1

Two yr of public contact experience that includes gathering, relaying, and providing information to others and evaluating activities or incidents and determining an appropriate course of action. One yr of this experience must include receiving and dispatching emergency requests using radio equipment, telephone, and/or computer.

Successful completion of a Certified Emergency Communications Course may substitute for the 1 yr of specialized experience.

The successful candidate must become LEDS certified within 90 d of hire and maintain current certifications.

Required knowledge and skills (KS) include the following:

- Knowledge of spoken and written English.
- Knowledge of office procedures, routines, and work prioritization.
- Knowledge of computer operations.
- Knowledge of road and street systems and how to use map resources to identify geographic locations.
- Skill in active listening to give full attention to what other people are saying, taking time to understand the points being made and asking questions as appropriate.
- Skill using various software packages, such as Microsoft Outlook®, Excel, and Word.
- Skill prioritizing and responding effectively to multiple and frequently simultaneous demands from telephones and other teletype information.
- Skill communicating orally with the public, sometimes while under pressure from varying circumstances and emergency situations.
- Skill engaging in conflict deescalation and dealing with agitated people.

- Skill keeping records, archiving references, and maintaining resources and records.

- Skill using policy or procedure manuals, handbooks, or other types of reference materials and applying the information to specific situations.

- Skill following and relaying written and verbal directions.

- Skill keyboarding to enter and access computer data bases.

Transportation Telecommunication Specialist 2

Three yr of public contact experience—including gathering, relaying, and providing information to others; evaluating activities or incidents; and determining an appropriate course of action—is required. One yr of this experience must include receiving and dispatching emergency requests using radio equipment, telephone, and/or computer. Experience must include at least 1 yr of leadwork responsibilities, including 1 or more yr experience in roadway/highway, bridge, sign, or drawbridge maintenance operations or transportation operations center, TMC, or public safety-related work (police, fire, emergency medical, incident responder, hazardous materials responder, 911 operations, etc.). Additionally, the successful candidate must become LEDS-certified within 90 d of hire and maintain current certifications.

Additional Required Level 2 KS

Skill in monitoring performance of self, individuals, or organizations to make improvements or take corrective action is required.

Skill in active learning to understand the implications of new information for both current and future problem-solving and decisionmaking is required.

KS are required for initial consideration. Some duties performed by positions in this class may require different KS. No attempt is made to describe every KS required for all positions in this class. Additional KS requirements will be explained on the recruiting announcement.

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