Organizing for TSMO

Case Study 3: Performance Measurement – Making Data-driven Transportation Decisions Using Performance Measures

July 2019

U.S. Department of Transportation

Federal Highway Administration

Notice

Quality Assurance Statement

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. FHWA-HOP-19-065	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Organizing for TSMO – Case Study 3: Performance Measurement – Making Data-driven Transportation Decisions Using Performance Measures		5. Report Date July 19, 2019 6. Performing Organization Code:
7. Author(s) Lacey Atkins, Olivia R. Brey, Austin Hoekstra, Charles R. Lattimer		8. Performing Organization Report No.
9. Performing Organization Name and Address Atkins North America, Inc. 482 South Keller Rd. Orlando, FL 32810		10. Work Unit No. 11. Contract or Grant No. DTFH6116D00048/0001
12. Sponsoring Agency Name and Address United States Department of Transportation Federal Highway Administration 1200 New Jersey Ave. SE Washington, DC 20590		13. Type of Report and Period 14. Sponsoring Agency Code HOP
15. Supplementary Notes Joseph Gregory (FHWA – HOTM)		

16. Abstract

Given the varying stages of TSMO adoption and advancement, the Federal Highway Administration identified the need for case studies to provide examples of common challenges and best practices for transportation agencies to learn from each other. This is one of 12 case studies developed to support organizing for TSMO. This case study focuses on using performance measures to support TSMO activities. Three agencies with advanced performance measures activities were interviewed: Niagara International Transportation Technology Coalition (NITTEC), Oregon Department of Transportation (ODOT), and New Hampshire Department of Transportation (NHDOT). Each agency provided information on how they collected and used performance measures, their lessons learned, and the next steps to continually improve these efforts.

17. Key Words Capability Maturity Model, Transportation Systems Management and Operations, reliability, performance measurement	18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161. http://www.ntis.gov		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 34	22. Price

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List of Abbreviations and Acronyms

AASHTO .....American Association of State Highway and Transportation Officials
CMM..... Capability Maturity Model
DMS.....Dynamic Message Sign
FHWA.....Federal Highway Administration
ITS..... Intelligent Transportation Systems
KPI..... Key Performance Indicators
MPO.....Metropolitan Planning Organization
NHDOT.....New Hampshire Department of Transportation
NITTEC .....Niagara International Transportation Technology Coalition
ODOT .....Oregon Department of Transportation
SHRP2..... Strategic Highway Research Program 2
TIM ..... Traffic Incident Management
TMC..... Transportation Management Center
TRB.....Transportation Research Board
TSMO ..... Transportation Systems Management and Operations

EXECUTIVE SUMMARY

Transportation systems management and operations (TSMO) provides tools for transportation managers to address safety, system performance, and reliability. TSMO is "an integrated set of strategies to optimize the performance of existing infrastructure through the implementation of multimodal and intermodal, cross-jurisdictional systems, services, and projects designed to preserve capacity and improve security, safety, and reliability of the transportation system.[1]" Through participation in the second Strategic Highway Research Program (SHRP2) workshops, transportation agencies are working to better support TSMO programs. Deploying intelligent transportation systems (ITS), hiring internal information technology staff, and using performance measures for data-driven decisions are just a few examples of the many activities a TSMO program can support.

Given the varying stages of TSMO adoption and advancement, the Federal Highway Administration identified the need for case studies to provide examples of common challenges and best practices for transportation agencies to learn from each other. This is one of 12 case studies developed to support organizing for TSMO. This case study focuses on using performance measures to support TSMO activities.

Three agencies with advanced performance measures activities were interviewed: the Niagara International Transportation Technology Coalition (NITTEC), the Oregon Department of Transportation (ODOT), and the New Hampshire Department of Transportation (NHDOT). Each agency provided information on how they collected and used performance measures, their lessons learned, and the next steps to continually improve these efforts. Some of the best practices identified include:

- NITTEC's performance measure plan that identifies key performance indicators for core functional areas.
- ODOT's data collection and storage through a data warehouse used for access to all available information.
- NHDOT's phased process for collecting and reporting performance measures.

[1] Source: https://ops.fhwa.dot.gov/tsmo/index.htm

CHAPTER 1 – INTRODUCTION

Historically, transportation agencies have managed congestion primarily by funding major capital projects that focused on adding capacity to address physical constraints such as bottlenecks. Operational improvements were typically an afterthought and considered after the new infrastructure was already added to the system. Given the changing transportation landscape that includes increased customer expectations, a better understanding of the sources of congestion, and constraints in resources, alternative approaches were needed. Transportation systems management and operations (TSMO) provides such an approach to overcome these challenges and address a broader range of congestion issues to improve overall system performance. With agencies needing to stretch transportation funding further and demand for reliable travel increasing, TSMO activities can help agencies maximize the use of available capacity and implement solutions with a high benefit-cost ratio. This approach supports agencies' abilities to address changing system demands and be flexible for a wide range of conditions.

Effective TSMO efforts require full integration within a transportation agency and should be supported by partner agencies. This can be achieved by identifying opportunities for improving processes, instituting data-driven decision-making, establishing proactive collaboration, and performing activities leading to development of performance optimization processes.

Through the second Strategic Highway Research Program (SHRP2), a national partnership between the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), and the Transportation Research Board, (TRB), a self-assessment framework was developed based on a model from the software industry. SHRP2 developed a framework for agencies to assess their critical processes and institutional arrangements through a capability maturity model (CMM). CMM uses six dimensions of capability to allow agencies to self-assess their implementation of TSMO principles[1]:

1. Business processes – planning, programming, and budgeting.
2. Systems and technology – systems engineering, systems architecture standards, interoperability, and standardization.
3. Performance measurement – measures definition, data acquisition, and utilization.
4. Culture – technical understanding, leadership, outreach, and program authority.
5. Organization and workforce – programmatic status, organizational structure, staff development, recruitment, and retention.
6. Collaboration – relationships with public safety agencies, local governments, metropolitan planning organizations (MPO), and the private sector.

Within each capability dimension, there are four levels of maturity (performed, managed, integrated, and optimized), as shown in Figure 1. An agency uses the CMM self-assessment to

[1] FHWA, Office of Operations, "Organizing for Reliability – Capability Maturity Model Assessment and Implementation Plans Executive Summary," May 2015. https://ops.fhwa.dot.gov/docs/cmmexesum/sec1.htm

identify their level of maturity in each dimension, to determine their strengths and weaknesses in each dimension, and determine actions they can take to improve their capabilities.

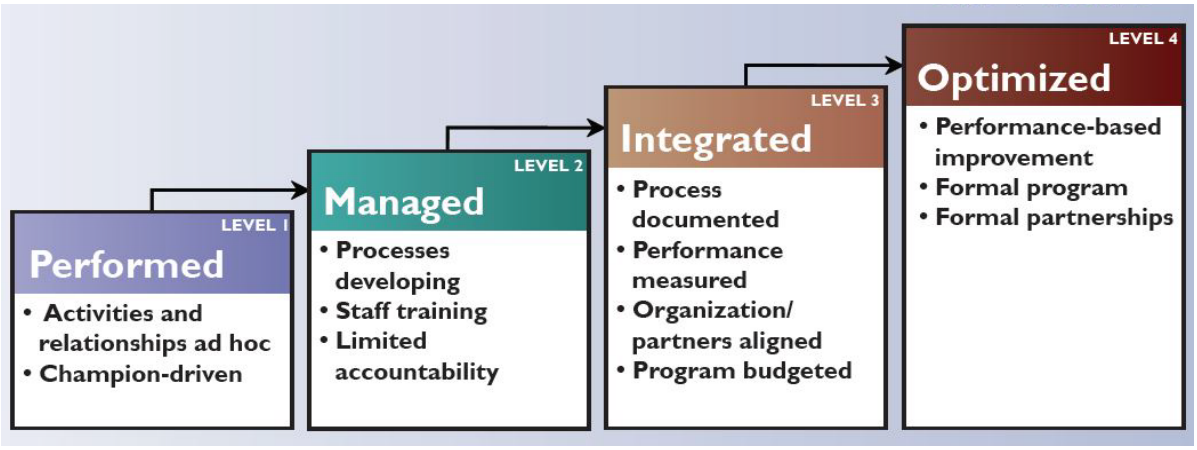


Figure 1. Chart. Four Levels of Maturity
Source: Creating an Effective Program to Advance Transportation System Management and Operations, FHWA Jan 2012

Purpose of Case Studies

In the first 10 years of implementation of the TSMO CMM, more than 50 States and regions used the tool to assess and improve their TSMO capabilities. With the many benefits experienced by these agencies, FHWA developed a series of case studies to showcase leading practices to assist other transportation professionals in advancing and mainstreaming TSMO into their agencies. The purposes of the case studies are to:

- Communicate the value of changing the culture and standard practices towards TSMO to stakeholders and decision-makers.
- Provide examples of best-practices and lessons learned by other State and local agencies during their adoption, implementation, and mainstreaming of TSMO.

These case studies support transportation agencies by showing a wide range of challenges, opportunities, and results to provide proof for the potential benefits of implementing TSMO. Each case study was identified to address challenges faced by TSMO professionals when implementing new or expanding existing practices in the agency and to provide lessons learned.

Identified Topics of Importance

Performance measures are critical to the success of a TSMO program. Performance measures enable an organization to track the internal progress of TSMO to agency processes and achievements as well as monitor and optimize the performance of the transportation network. Performance measures tell the story of TSMO by tracking the optimization of organizational strategic goals, empowering informed transportation decision-making, and conveying a message to internal and external stakeholders on the efficient use of available resources.

Interviews

Agencies were selected for each case study based on prior research indicating that the agency was excelling in particular TSMO capabilities. Care was taken to include a diversity of geographical locations and agency types (departments of transportation, cities, and MPOs) to develop case studies that other agencies could easily relate to and learn from. Interviews were conducted with selected agencies to collect information on the topic for each case study.

Description of Performance Measurement

The success of any TSMO program is tracked through performance measures to manage progress and evaluate if actions are beneficial. The performance measurement dimension of TSMO includes:

- Definition and criteria of each metric.
- How data is, or will be, acquired to track metrics.
- How data will be utilized.
- How data will be analyzed.

Output performance measures are defined to describe the progress and productivity of TSMO activities through a process-oriented method. Strategic goals and objectives are identified through collaboration with internal and external partner agencies that align with regional transportation plans. After evaluation of data acquisition, analytics, and utilization capabilities, performance measures can be identified to correspond with each strategic goal and objective of an organization. The resulting output tracks an organization's progress towards reaching strategic goals.

Outcome performance measures for the transportation network are also tracked. Metrics such as travel time index, incident clearance time, and traffic fatality rates are a few examples of how to track the performance of transportation facilities.

Well-defined measures and the degree to which they are being met help transportation professionals make more informed decisions and prioritize projects based on a monitored rate of success. This information can be used to support benefit-cost analyses and enables continuous improvement through process-based metric selection.

Performance measures drive the success of TSMO programs by allowing agencies to realize and quantify improvements in the short-term through the effective use of TSMO strategies. Metrics that complement the framework of the TSMO program and measure achievements are shared with external agencies and the public to exhibit efficient use of resources.

CHAPTER 2 – BEST PRACTICE EXAMPLES

The Niagara International Transportation Technology Coalition (NITTEC), the Oregon Department of Transportation (ODOT), and the New Hampshire Department of Transportation (NHDOT) participated in previous second Strategic Highway Research Program (SHRP2) efforts. The capability maturity model (CMM) workshops with SHRP2 helped inform them about transportation systems management and operations (TSMO) and how it can apply to their agencies. This chapter highlights several successful initiatives each agency accomplished, specifically regarding performance measurement for TSMO.

Niagara International Transportation Technology Coalition (NITTEC)

NITTEC is a coalition of agencies developed to provide real-time traffic and roadway information to improve traffic flows and enhance emergency assistance for motorists. NITTEC includes four international border crossings between Canada and the United States.

Knowledge Through Data

Knowledge through data "is the general rule that NITTEC should collect as much relevant data as possible from as many sources as possible," beginning with NITTEC members and eventually other regional entities.[1] A manifestation of this rule is to establish a data warehouse of the regional transportation network that can be used to assess performance. In addition, as different types of data are added, the data becomes more robust and valuable. More data also gives a clearer picture of performance.

NITTEC recognizes the importance of data. Data is directly connected to performance measures and is important for achieving outcome-driven TSMO. With knowledge provided through data, NITTEC will have a better understanding of not only the transportation network, but how changes in the network affect human behaviors and driving habits. With this in mind, NITTEC is developing a repository of historical data. This has shifted the culture of the agency to value data and will be beneficial for gaining insights in the future.

Robust data and analytics capabilities are critical to informing funding and transportation development. As a public-sector transportation organization, NITTEC has a unique position in how it affects the community, businesses, and residents through its role in guiding strategic objectives and making transportation funding decisions. However, NITTEC does not currently have the capabilities needed to collect and analyze the desired volume of data. To overcome this challenge, NITTEC created a Performance Measures Plan.

Performance Measures Plan

Creation of a Performance Measures Plan helped NITTEC focus on areas appropriate for achieving their near- and long-term goals. The plan identified three types of metrics and

[1] NITTEC, 2017 Performance Measures Plan, 2017

corresponding data recommended for deployment—metrics that illuminate the impact of overall efforts toward broader strategic objectives; metrics that illustrate quantifiable progress toward a defined goal; and data that helps indicate the successful function of certain processes. The plan also evaluated NITTEC's performance measurement practices at that time and found them to be generally lacking in connections to successful strategic objectives, measures of effectiveness, data-sharing among coalition members, and intelligent transportation systems (ITS) devices that collect data. This presented an opportunity for improvement by NITTEC, starting with the development of key performance indicators (KPI).

NITTEC identified KPIs that are relevant to its core operational areas and functions. NITTEC disseminates these KPIs through an annual report. The Performance Measures Plan recognized that these KPIs can be expanded to include more data metrics as well as become connected to outcome-driven management. Figure 2 shows an excerpt from the Performance Measures Plan and details the high-level plan for NITTEC's performance measures approach.

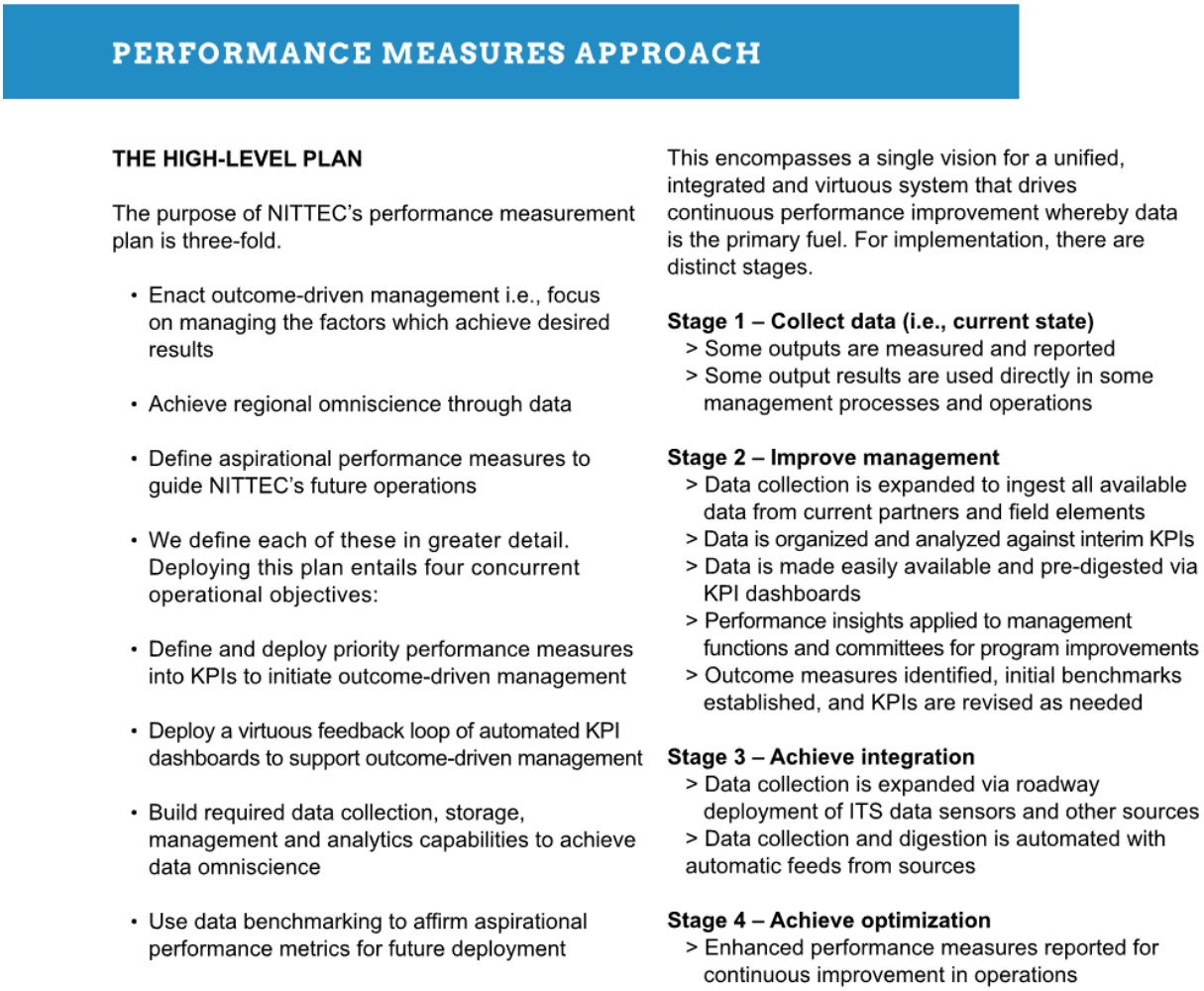


Figure 2. Chart. Performance Measures Approach
Source: 2017 Performance Measures Plan, NITTEC, 2017

Acting on these recommendations helped NITTEC realize the power of data and how it can improve the efficiency of transportation operations. KPI dashboards have made the large amount of data easy to digest for NITTEC and will continue to improve as more performance measures are added and results are seen.

Strategic Plan

Through SHRP2, the NITTEC Strategic Planning Committee realized it was time to update the Strategic Plan, which was last done in 2007. During the process of updating the Strategic Plan, NITTEC also recognized the need for a Performance Measures Plan and a Customer Engagement Plan. The Strategic Plan is the umbrella under which these two plans fall and helps NITTEC achieve their TSMO goals. The Customer Engagement Plan is intended for members of NITTEC as well as the general public. The plan examines services provided for member agencies as well as information disseminated to the public. The Strategic Plan, Performance Measures Plan, and Customer Engagement Plan are separate, but closely related in that they cross-reference each other, and all contribute to the same goal.

By updating the Strategic Plan and adding the other plans, NITTEC realized how much the transportation industry has changed and how these changes impact their organization. They realized that technology and data now play a large role in managing a transportation system and the importance of incorporating this into their strategy. Working on plan updates also helped NITTEC and its partners develop and refine organization goals and gain traction towards achieving them. Figure 3 from the Strategic Plan further describes their goals.

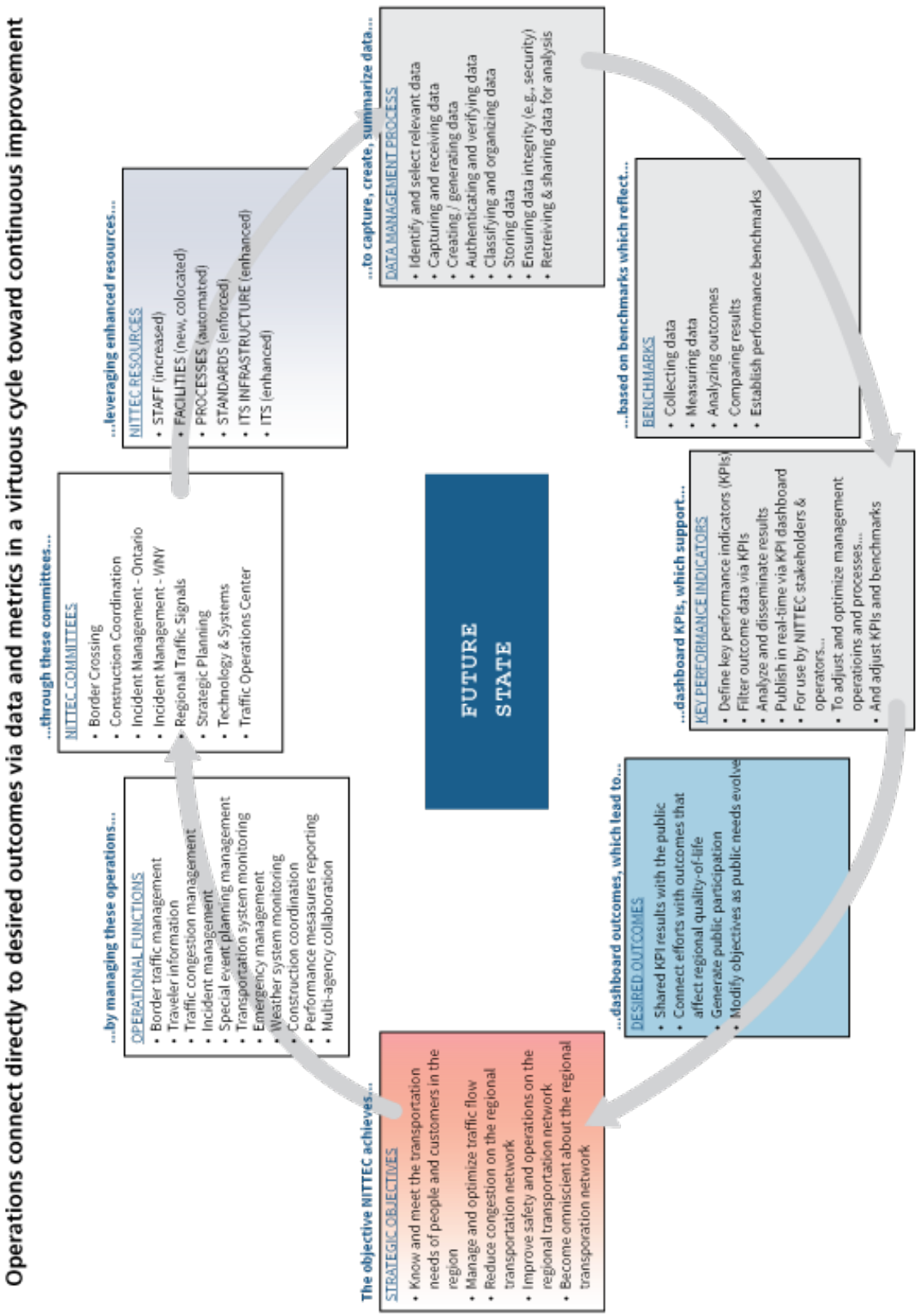


Figure 3. Diagram. Future State of NITTEC
Source: 2017 Strategic Plan, NITTEC, 2017

Oregon Department of Transportation (ODOT)

ODOT supports the State of Oregon's transportation needs through five regional offices. ODOT manages almost 74,000 miles of highways, streets, and roads, as well as over 8,000 bridges, seven commercial airports, 97 public use airports, and 23 marine ports.

Data Warehouse

ODOT has a data warehouse—a set of technologies put in place for data management. This data warehouse is an agency resource used to support the data needs of ODOT's TSMO initiative. As ODOT implemented its TSMO Performance Management Plan, one of the most beneficial outcomes has been migrating the operation systems data into the warehouse. This has been an effective tool for analytics, building reports and dashboards, and monitoring performance measures.

The data warehouse is primarily used for data transformation and storage. ODOT uses Microsoft's Power BI report-building tools, which have been valuable in developing reports to meet their needs.

To support implementation of its traffic incident management goals, ODOT has been developing traffic incident management (TIM) teams. During implementation, ODOT learned the power of data to drive discussions about operations. Without the information that data provides, it was difficult to generate discussions and interest from TIM stakeholders. With data and analytics now available, ODOT has seen an incredible change in discussions and enthusiasm for TIM solutions.

Last year, ODOT performed new training on quick clearance techniques called "push, pull, and drag" for removing vehicles from travel lanes. ODOT is leveraging data available since completing the training to measure the effectiveness of these quick clearance techniques. Some of the performance measurements being considered include the percent of incidents that use the new techniques and the average time benefit of using new techniques. The data is granular enough to sort by individual responders. Figure 4 details ODOT's implementation plan for the TIM program specifically.

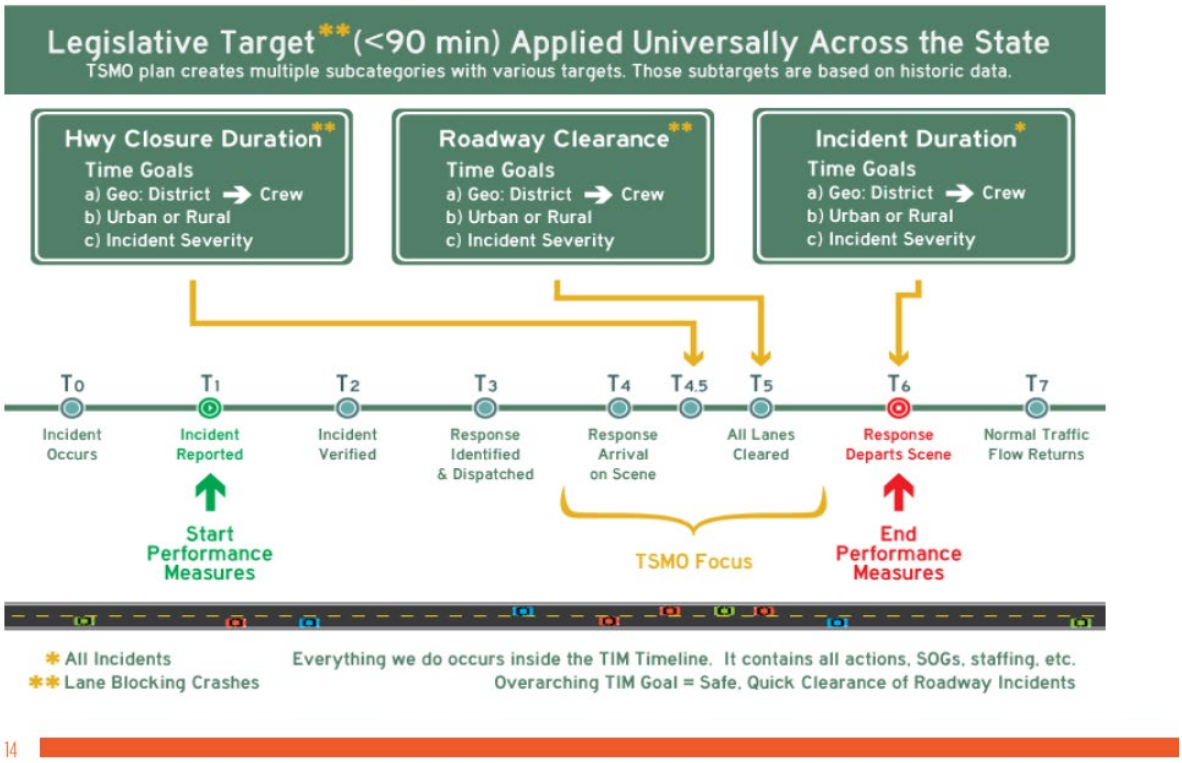


Figure 4. Diagram. TIM Implementation
Source: 2017 Performance Measurement Plan, ODOT, 2017

Signals Inventory

Another area of significant improvement is TSMO asset management. TSMO asset management is much less mature in comparison to other assets such as bridges or pavement. Initially, observations and input from regional staff were relied upon to identify TSMO asset investment needs. This approach failed to provide an accurate picture of TSMO asset condition and condition trends. Using a number of data sources, ODOT was able to provide a more comprehensive view of the condition of TSMO assets in the State. The asset reports now available are useful for identifying project needs and evaluating trends related to asset condition. This included implementation of a new methodology for traffic signal condition rating. All the signals in the State can now be shown on a map along with their condition ratings. Improving access to TSMO asset condition data in an easily understood, visual format has dramatically changed awareness of TSMO asset conditions and the project selection conversation.

Figure 5 lists potential performance measures for asset management from the Performance Measurement Plan.

TSMO PRIORITY LEVEL		HIGH	MEDIUM	LOW
Current TSMO Metric?	Yes	**Asset inventory** **Asset location** **Labor hours**		
	No	**Asset condition and site rating** **Percent asset beyond service life** **Total or percent asset downtime (ATM, VMS & Drum Signs; Signals, Communication)** **Traffic signals remotely monitored** **Percent detection malfunction**	Percent proactive maintenance (ATM, VMS & Drum Signs; Signals) Percent of signs meeting retro reflectivity goals **Percent of illumination beyond service life** **Structure rating (Traffic Structures)**	

Bold performance measures are identified as core performance measures in this program area.

Figure 5. Chart. Asset Management Performance Measures
Source: 2017 Performance Measurement Plan, ODOT, 2017

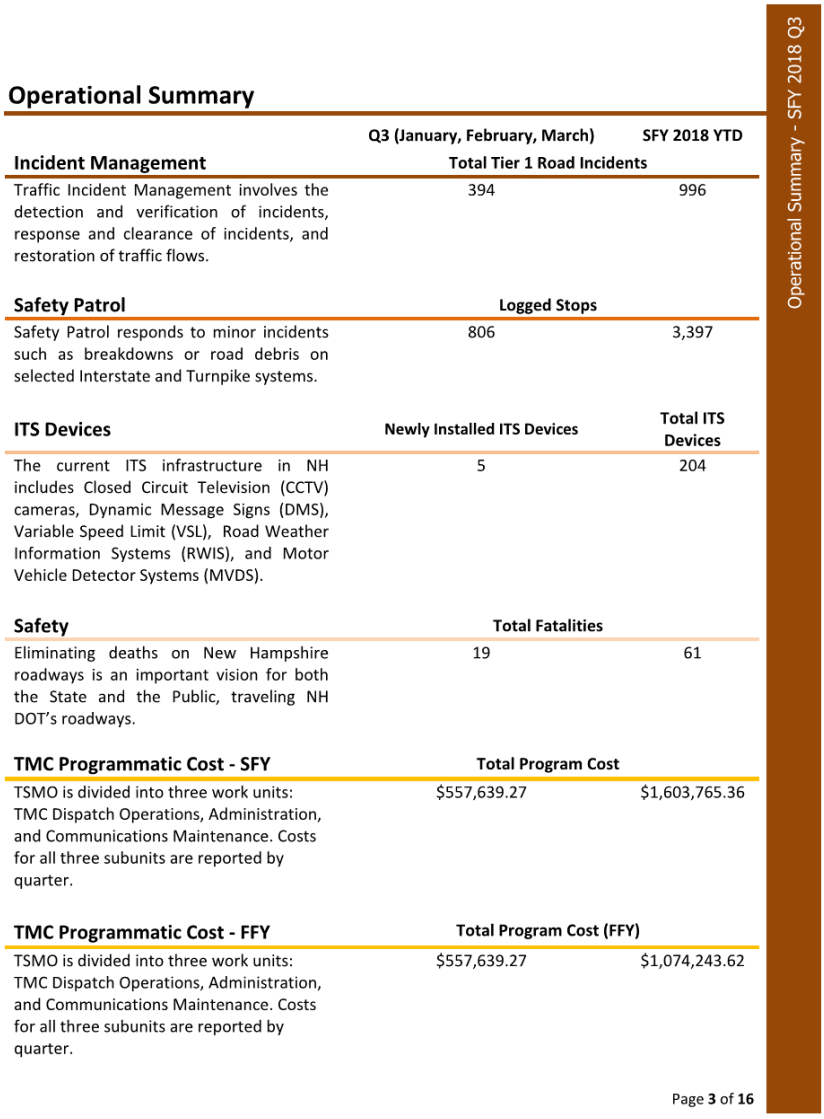
New Hampshire Department of Transportation (NHDOT)

NHDOT supports the transportation needs of the State of New Hampshire through six district offices. NHDOT manages 9,266 lane-miles of highways and roads, 2,169 State bridges, 1,684 municipal bridges, and 25 public airports.

TSMO Bureau Performance Measures

Through SHRP2 efforts and the CMM, NHDOT established a stand-alone TSMO Bureau that reports directly to executive staff. Because of this, TSMO is now included in key meetings and has direct communication and access to leadership.

The TSMO Bureau captures two types of performance measures—public-facing and internal. The bureau captures public-facing measures and displays them online. It reports internal measures through an internal report distributed quarterly. The public-facing measures generally include safety and ITS device information. The internal measures include core data, goals, and costs. Figure 6 provides some of the internal measures included in the report.



Operational Summary - SFY 2018 Q3

Operational Summary

	Q3 (January, February, March)	SFY 2018 YTD
Incident Management	**Total Tier 1 Road Incidents**	
Traffic Incident Management involves the detection and verification of incidents, response and clearance of incidents, and restoration of traffic flows.	394	996
Safety Patrol	**Logged Stops**	
Safety Patrol responds to minor incidents such as breakdowns or road debris on selected Interstate and Turnpike systems.	806	3,397
ITS Devices	**Newly Installed ITS Devices**	**Total ITS Devices**
The current ITS infrastructure in NH includes Closed Circuit Television (CCTV) cameras, Dynamic Message Signs (DMS), Variable Speed Limit (VSL), Road Weather Information Systems (RWIS), and Motor Vehicle Detector Systems (MVDS).	5	204
Safety	**Total Fatalities**	
Eliminating deaths on New Hampshire roadways is an important vision for both the State and the Public, traveling NH DOT's roadways.	19	61
TMC Programmatic Cost - SFY	**Total Program Cost**	
TSMO is divided into three work units: TMC Dispatch Operations, Administration, and Communications Maintenance. Costs for all three subunits are reported by quarter.	$557,639.27	$1,603,765.36
TMC Programmatic Cost - FFY	**Total Program Cost (FFY)**	
TSMO is divided into three work units: TMC Dispatch Operations, Administration, and Communications Maintenance. Costs for all three subunits are reported by quarter.	$557,639.27	$1,074,243.62

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Figure 6. Chart. Operational Summary
Source: 2018 Q3 Corporate Quarterly Report, NHDOT, 2018

The TSMO Bureau has implemented a phased approach for measuring performance. The first phase involves identifying specific measures that are repeatable and generate good data. As the collection of data is established as a regular process, the second phase involves using this data to conduct trend analyses to ascertain if any patterns are occurring. The third phase involves using available data and insights from the trend analyses to set specific performance targets.

Transportation Management Center

The transportation management center (TMC) is part of the TSMO Bureau with a mission to detect, verify, and respond to incidents that affect the State transportation network. Part of the data initiative for NHDOT includes performance measurements for TMC operators. The performance measures specific to TMC operators include the number of incidents, incident clearance time, and average operator response time. The average operator response time refers to

the elapsed time from when an incident was detected or reported and when the public was notified. The public is notified in three ways:

- Advanced traffic management system that provides information to both a 511 website (www.newengland511.org) and to subscribed users of NHDOT's automated email or text alert system, 'My Trips.'
- Social media such as Twitter and Facebook.
- TMC-operated dynamic message signs (DMS).

The performance measures tracked by the TMC and TSMO Bureau are posted on the TMC Operations Dashboard website shown in Figure 7. From the website, the user can select any provided month and a report will be generated that provides detailed data for an array of information including ITS assets deployed, total number of TMC calls received, type of weather information that was disseminated to agencies, and more. This dashboard is accessible by both agency staff and the public. This helps promote trust with the public as well as transparency. Figure 8 is a sample report taken from the dashboard, specifically regarding DMS messages.

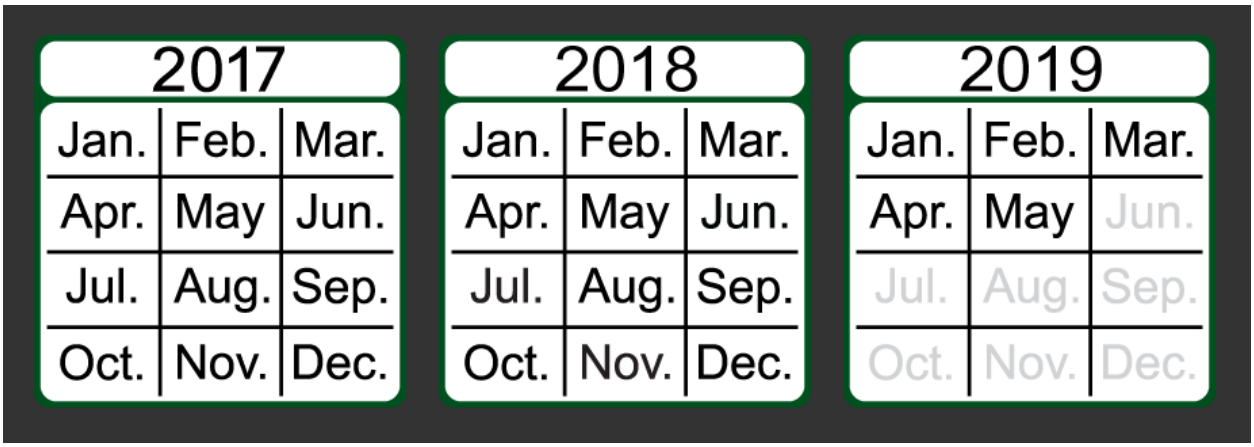
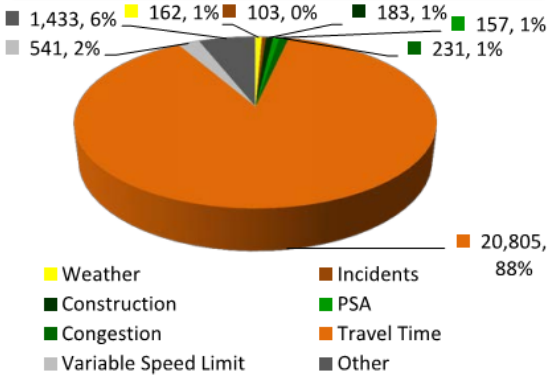


Figure 7. Photo. NHDOT TMC Dashboard
Source: https://www.nhtmc.com/Dashboard/TMC_Operations/

August 2018

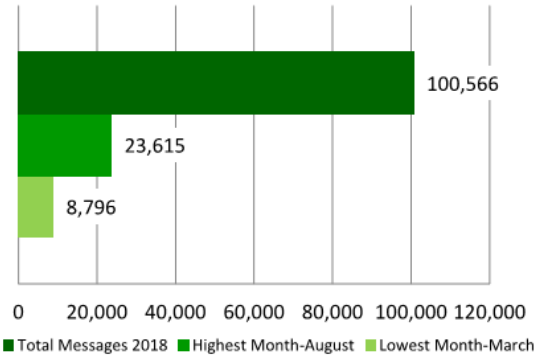
DMS Messages

Current Month - Messages by Type



This graph shows the type of message that were relayed to the public by being displayed on the DMS.

Total Messages - 2017



This graph shows the total messages that were posted to DMS for the year so far.

Current Month - Total Messages Posted by Board

101 W 100.5 VSL D 5	25	93 SM 19.8 VSL D 5	25	95N 14.8 FSDT	60
101 WM 100.5 VSL D 5	25	93 SM 2.2 VSL D 5	25	95N 3.0 FSDT	1,325
101E 114.8 FSV6	281	93 SM 5.2 VSL D5	25	95N 4.6 PSVT	51
101E 130 FSA6	835	93N 0.3 FSD5	1,284	95S 15.4 FSDT	906
101E 53.4 FSV5	44	93N 16.0 VSL D5	25	95S 3.4 FSPT	9
101W 102.6 FSV5	14	93N 16.0 VSL D5 Median	23	95S 7.3 PSVT	42
101W 128 PSV6	29	93N 23.4 FSD5	642	95S 7.6 FSDT	528
293 S 1.4 VSL D 5	25	93N 27.1 PSVT	46	FEE N 1.2 FSVT	1,176
293N 8.8 FSPT	217	93N 32.4 FSVT	79	FEE N 18.8 FSVT	44
293S 1.4 FSD5	66	93N 36.2 FSVT	40	FEE S 8.6 FSPT	16
393 W 1.9 PSV5	5	93N 57.6 FSV3	26	ST N 1.0 FSAT	1,107
4E 98 FSA6	36	93N 7.2 FSD5	1,096	ST S 11.6 FSA6	178
89N 1.8 FSV5	92	93N 82.6 FSV3	13	ST S 24.4 FSVT	145
89N 18.4 FSV5	635	93N 99.6 FSA3	1	ST S 3.4 FSDT	3,658
89N 35.5 FSV2	20	93S 122.2 FSV1	16	ST S 7.8 FSAT	1,671
89N 55.0 PSV2	11	93S 14.4 VSL D5	71		
89S 10.8 FSV5	455	93S 14.4 VSL D5 Median	35		
89S 3.4 FSV5	1,182	93S 23.4 FSD5	991		
89S 55.0 PSV2	14	93S 27.8 FSDT	2,245		
89S 57.5 PSV2	73	93S 30.4 PSVT	40		
93 N 0.3 VSL D 5	25	93S 32.4 FSVT	30		
93 N 2.35 VSL D 5	25	93S 39.0 FSV5	51		
93 N 3.8 VSL D5	25	93S 43.3 PSV5	18		
93 N 6.6 VSL D5	25	93S 48.0 FSV5	33		
93 NM 2.35 VSL D 5	25	93S 68.8 FSV3	20		
93 NM 3.8 VSL D5	25	93S 7.2 FSD5	214		
93 NM 6.6 VSL D5	25	93S 85.4 FSV3	18		
93 S 19.8 VSL D 5	12	93S 99.2 FSA3	129		
93 S 2.2 VSL D 5	25	95N 0.4 FSVT	1,086		
93 S 5.2 VSL D5	25	95N 13.0 FSVT	31		

Figure 8. Chart. Dynamic Message Sign Messages Summary
Source: TMC Monthly Operational Summary, NHDOT, 2018

TMC operators responded very well to these new performance measures. They are able to use performance measures as a way to track their own opportunities for improvement through development of internal-use spreadsheets. Operators also provided details on where additional support or resources could benefit from full implementation of these metrics.

Operators can track delay and other performance measures on specific corridors during certain periods. This helps build the case for funding capital improvements in areas where it is most needed as well as helps remove bottlenecks, increase device uptime, and provides support for maintenance contracts and budget processes.

CHAPTER 3 – SUMMARY

Each transportation agency has different approaches and needs when addressing performance measurement. For some agencies, the emphasis is on data collection and storage, while others place emphasis on data analytics and processing. Both of these components are important when expressing the value of the TSMO program. Collecting and analyzing large amounts of data requires special systems and infrastructure that necessitates dedicated staff and funding. The agencies interviewed for this case study had key lessons learned that support advancement of performance measurement in their TSMO programs:

- Creating a Performance Measures Plan can help an agency align its goals with steps that need to be performed to achieve those goals. Assessing agency needs and deciding how to address those needs in a clear manner helps streamline the process of integrating performance measurement.
- Data is a powerful tool that can be used to drive discussions in many areas of an agency. Taking information that was previously unknown or not distributed and presenting it in a way that is easy to process or visualize can spur big improvements and efficiencies within an agency.
- Acquiring the necessary data equipment and systems and configuring it in an optimal and efficient way is the foundation for effective performance measurement. Having robust data storage and analytic systems can improve the functionality and efficiency of a performance measurement program.

When identifying performance measures as they relate to TSMO, agencies should look at existing data capabilities to track metrics until other resources that improve capturing performance measures become available. Other agencies are encouraged to use the best practices identified in this case study to assist with maturing or developing their own performance measurement initiatives.

REFERENCES

Information used in this case study was gathered from sources noted throughout the report together with the following web sites:

- FHWA's What is Transportation Systems Management and Operations (TSMO)?
  - https://ops.fhwa.dot.gov/tsmo
- AASHTO's TSMO Guidance
  - http://www.aashtotsmoguidance.org/
- FHWA's Organizing and Planning for Operations
  - https://ops.fhwa.dot.gov/plan4ops/
- FHWA's Organizing for Operations Resources
  - https://ops.fhwa.dot.gov/plan4ops/focus_areas/organizing_for_op.htm
- FHWA's Organizing for Reliability – Capability Maturity Model Assessment and Implementation Plans
  - https://ops.fhwa.dot.gov/docs/cmmexesum/sec1.htm
- FHWA's Creating an Effective Program to Advance Transportation Systems Management and Operations, Primer
  - https://ops.fhwa.dot.gov/publications/fhwahop12003/index.htm
- FHWA's Improving Transportation Systems Management and Operations – Capability Maturity Model Workshop White Paper – Performance Measurement
  - https://ops.fhwa.dot.gov/docs/cmmwhitepapers/perfmeas/index.htm
- Additional SHRP2 Resources
  - https://www.fhwa.dot.gov/goshrp2/
- Niagara International Transportation Technology Coalition
  - https://www.nittec.org/
- Oregon Department of Transportation
  - https://www.oregon.gov/ODOT/Pages/index.aspx
- New Hampshire Department of Transportation
  - https://www.nh.gov/dot/

Table 1. Interview Participants and Agencies

Agency	Niagara International Transportation Technology Coalition (NITTEC)	Oregon Department of Transportation (ODOT)	New Hampshire Department of Transportation (NHDOT)
Agency Representative Name:	Athena Hutchins	Galen McGill	Susan Klasen
Agency Representative Title:	Executive Director	Systems Operations and Intelligent Transportation Systems Manager	Traffic Management Center
Agency Representative Email:	ahutchins@nittec.org	Galen.e.mcgill@odot.state.or.us	Susan.klasen@dot.nh.gov
Interview Date:	May 29, 2018	June 18, 2018	July 9, 2018

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July 2019
FHWA-HOP-19-065